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# Fiscal policy and social infrastructure provision under alternative growth and distribution regimes

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**Abstract**

Recent crises show that the market economy does not function autonomously but needs resilient social, natural, and institutional foundations. Accordingly, fiscal sustainability cannot be ignored, and the government's role in fiscal policy and social infrastructure provision is becoming increasingly important. We build a Kaleckian dynamic model that can comprehensively analyse the growth, distribution, and employment rate of the government's social infrastructure and debt accumulation under alternative growth and distribution regimes. The model allows for not only wage-led growth (WLG) and profit-led growth (PLG) regimes but also labour-market-led (LML) and goods-market-led (GML) distribution regimes. Particular attention is paid to the demand effects of fiscal policy and productivity growth effect of social infrastructure investment. Our model derives the following results. A combination of alternative growth and distribution regimes is important for stability. This demonstrates that the cyclical behaviours of the WLG/GML and PLG/LML regimes are highly contrasting. When government debt also changes in the long run, the Domar condition is required for stability. In contrast to the principally Kaleckian nature, the long-run economic growth rate depends not on demand or fiscal parameters but on supply side parameters determining the natural growth rate. Based on these results, we explain that the government can still play an important role in stabilising the economy, improving the quality of social infrastructure, and achieving a resilient economy.

**JEL Classification** E11. E12, E25, H54, O40

**Keywords** Fiscal policy, social infrastructure, Kaleckian model, growth regime, distribution regime

## 1 Introduction

The global economy has been facing a complex and structural challenge. Global financial crises and the COVID-19 pandemic have revealed the fragility of the economy in different aspects, and climate change signals a fundamental ecological crisis. These crises strongly show that the market economy does not function autonomously, requires resilient social, natural, and institutional foundations, and government policies can enhance them. Achieving economic growth with secured employment as well as fair income distribution continues to be a major concern for policymakers, especially in times of crisis. In addition, fiscal sustainability of a government, remains an important but controversial issue (Reinhart and Rogoff, 2009; Herndon et al., 2014). Crises urge economic theory to shed light on the foundations of the economy and the proactive roles governments can play.

The provision of social common capital in normal times demonstrates resilience in emergencies. Uzawa (2005) highlights three social common capital categories as foundations for the market economy: natural environment, social infrastructure, and institutional capital, encompassing health care and education. The author emphasises that social common capital provides members of society with a cultural and human life, while ensuring the sustainability and stability of an economy. Seguino (2012) underlines three key roles of public investment: stimulating demand and employment, creating productive capacity, and improving human development. Recent empirical analyses have found that government spending boosts economic activities and equitable income distribution, while also inducing private investment demand and significant productivity gains (Obst et al., 2020; Onaran et al., 2022; Oyvat and Onaran, 2022).

Studies have also begun to analyse the roles of government and social infrastructure provision in Keynes-Kaleckian or Classical growth theory. For example, Commendatore et al. (2011) build a Kaleckian wage-led growth model with multiple equilibria, in which the government has productive and unproductive expenditures. They show that when government expenditure raises wages more than its impact on labour productivity, it has an expansionary effect on capacity utilisation and growth rates. Dutt (2013) presents a Keynesian demand-led growth model in which government spending stimulates productivity growth and crowding-in effects for firms' capital accumulation. Ko (2019) and Parui (2021) address the absence of income distribution in Dutt's (2013) model and compare the impacts of a rise in government investment on growth and employment. These models commonly indicate that government expenditures have a positive impact on economic growth. Hein (2018) and Hein and Woodgate (2021) identify the stability conditions in Kaleckian models when the government has the capacity to create autonomous expenditure and debt accumulation. However, they did not consider the subsequent impacts of growth on income distribution or employment. Besides, except for Dutt (2013), they ignore that government consumption and investment have different impacts on demand, distribution, and labour productivity growth.

Tavani and Zamparelli's works (2016, 2017, 2020) are relevant to our study, as their models explicitly incorporate different effects of government spending – consumption, public capital investment, and R&D expenditure. Tavani and Zamparelli (2017) employ demand-led models with public capital, showing that the maximal growth rate is realised at a certain government spending ratio to social capital. In contrast, Tavani and Zamparelli (2016, 2020) use supply-led growth models in the public sector. Tavani and Zamparelli (2016) show that when the wage share is exogenously given by the conventional share, there is a tax rate that maximises the economic growth rate. Their 2020 model incorporates the dual effects of public expenditure on production capacity and labour productivity growth. It also shows that induced technical changes may mitigate the Goodwin cycles and distributional conflicts. However, as their models assume that savings create investment, they do not show the autonomous roles of private investment and the associated demand-led growth mechanisms or their feedback on income distribution. Furthermore, the long-run consequences of fiscal sustainability are not clear.

We build a Kaleckian dynamic model of growth, distribution, and employment rate using the government's social infrastructure and debt accumulation.[1] Compared with the existing literature, our study has the following analytical novelties. First, we consider fiscal policy, including social infrastructure provision, and its effects on alternative growth and distribution regimes. Our model is more comprehensive, allowing for both wage-led growth (WLG) and profit-led growth (PLG) regimes. In addition, growth induces a change in employment, which subsequently changes the profit share either positively or negatively. The positive and negative correlations between employment and profit share are called goods-market-led (GML) and labour-market-led (LML) distribution regimes, respectively. Proaño et al. (2011) and Nishi and Stockhammer (2020a, 2020b) specified the stability conditions for these alternative demand and distribution regimes; however, they did not incorporate the government economic policy. Second, we consider the effects of a proactive fiscal stance, signified by a rise in the tax rate and government propensities to consume and invest under alternative regimes. Both constitute an important part of effective demand in the short run, supporting firms' investment demand. Particular attention has been paid to the productivity growth effects of social infrastructure investment. Our model is different from Tavani and Zamparelli's (2016, 2017a, 2020) models in that we explain the labour productivity effect of social infrastructure not only by its availability per private capital but also per labour input, whereas they explain it only by the first. Additionally, along with these dynamics, government expenditure leads to long-term debt accumulation in the long run. We sequentially elucidate how the stability of demand and distribution regimes is achieved and how it is associated with government debt over different time horizons.

Our model analytically and numerically derived the following results. A combination of alternative growth and distribution regimes is important for stability. The WLG/GML and

[1]The related literature uses social capital, social overhead capital, public capital, social infrastructure, and social common capital in almost the same sense. We call social common capital 'social infrastructure', which on the aggregate represents roads, public transportation, school education, healthcare, skill training system, and so on.

PLG/LML regimes may establish a stable steady-state, whereas the WLG/LML and PLG/GML regimes are unstable. Government expenditures can partially shape the growth regime, and this may avoid such unstable combinations. In addition, our numerical analysis demonstrates that the cyclical behaviours of the WLG/GML and PLG/LML regimes are highly contrasting. When government debt changes, the Domar condition is required for stability. Moreover, the long-run economic growth rate depends not on demand or fiscal parameters, but on supply-side parameters determining the natural growth rate, although our model is Kaleckian with a government sector. Nevertheless, we conclude that the government still plays an important role in stabilising the economy, improving the quality of the social infrastructure, and achieving a resilient economy.

The remainder of this paper is organised as follows. Section 2 builds a dynamic Kaleckian model of growth, distribution, and employment rate using the government's investment in social infrastructure. It also outlines its short-run dynamics, in which the capacity utilisation rate is determined instantaneously. Section 3 proceeds to the analysis of long-run dynamics, in which the capital composition, income distribution, and employment rate move first, sequentially followed by the government debt ratio. Based on this, we visually consider the nature of transitional dynamics using numerical studies and provide economic interpretations. Section 4 concludes the paper. The Appendices provide mathematical proofs of the main propositions.

## 2 Short-run analysis

The following variables are employed in our model: $X_t$: output; $K_t$: private capital stock; $S_t$: social infrastructure stock; $L_t$: labour demand; $N_t$: labour supply; $C_t$: private consumption; $I_t$: firms' investment; $G_{Ct}$: government consumption; $G_{It}$: government investment in social infrastructure; $T_t$: tax revenue; $\chi_t$: social infrastructure-private capital ratio (capital composition), $u_t$: output-capital ratio (capacity utilisation rate), $q_{Lt}$: labour productivity, $w_t$: nominal wage, $p_t$: price, $e_t$: employment rate, $m_t$: profit share ($1-m_t$: wage share), $g_t$: capital accumulation rate, $\delta_t$ : government debt-capital ratio (debt ratio). The subscript $t$ represents the time in a continuous model. A dot over variable $x_t$ means its time derivative (i.e. $\dot{x}_t = dx_t/dt$), and a hat over variable indicates its rate of change (i.e. $\hat{x}_t = \dot{x}_t/x_t$). The above variables are introduced with subscript $t$ to show that they vary with time, but we omit them below for simplicity.

### 2.1 Production, income distribution, and effective demand

We consider a closed economy with household workers, private firms owned by capitalists, and the government sector. We assume that the final goods can be used not only for both consumption and private capital but also the social infrastructure accumulated through government investment. Workers supply labour to private firms and earn wages in return. Firms employ the labour force provided by households and pay wages. Capitalists earn profit by managing firms and receive interest revenue by holding government bonds. Firms produce final goods by using labour and capital stock in the presence of social infrastructure. We formalise the input-output relationship with the following Leontief-type fixed coefficient production function:

$$X = \min(uK, q_L L) \tag{1}$$

where private capital stock and labour inputs are perfect complements. We assume no labour supply constraints and that output is determined by the operating capital stock under the effective demand constraint.

The total value added is distributed to workers and capitalists as wage and profit income, respectively.

$$pX = wL + rpK, \tag{2}$$

where $wL$ is the wage bill and $rpK$ is the profit income. Based on this, we denote profit share as

$$m = 1 - \frac{w}{pq_L} \tag{3}$$

and accordingly, the wage share is expressed by $1 - m$.

Firms are oligopolistic in the goods market, and they set a mark-up over a unit labour cost to sell their goods. Then, the pricing is given by:

$$p = (1 + \eta)\frac{w}{q_L} \tag{4}$$

where $\eta > 0$ is the markup rate. In the present setting, there is a one-to-one relationship of $m = \frac{\eta}{1+\eta}$ between the profit share and mark-up rate, and the mark-up pricing equation can be denoted as:

$$p = \left(\frac{1}{1-m}\right)\frac{w}{q_L} \tag{5}$$

The government levies taxes on wage and profit incomes at the same rate $\tau \in (0,1)$, which comprises its revenue. Accordingly, tax revenue is

$$T = \tau(wL + rpK) = \tau puK \tag{6}$$

Government expenditure consists of government consumption $G_C$ and investment in social infrastructure $G_I$. Inspired by the empirical findings, we explicitly consider private economic activity as supported by government expenditure in two ways.[2] First, government expenditure is not only a part of effective demand in the short run, but generally helps firms expand investment and the associated capital accumulation through the crowding-in effect. Second, the government invests in social infrastructure, which generates its accumulation, that is, $\dot{S} = G_I$. The social infrastructure eventually supports the efficient production of goods in an economy by enhancing labour productivity growth in the long run. Additionally, our model allows for a government's budget deficit and debt finance when the government's total expenditure exceeds its tax income. The government then pays interest per unit of issued debt to the capitalists who purchase the bonds.

The government's propensity to consume and invest is denoted by $\theta_C$ and $\theta_I$, respectively. Then, we have

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[2] In this regard, Obst et al. (2020) empirically verify that government spending has a positive impact on the private investment in EU 15 countries, excluding Belgium and France.

$$p(G_C + G_I) = (\theta_C + \theta_I)\tau puK \tag{7}$$

where $G_C$=$\theta_C \tau uK$ and $G_I$=$\theta_I \tau uK$, and the size of $\tau$ determines income redistribution from the private sector to the public sector. We call the tax rate and government expenditure propensities $(\tau, \theta_C, \theta_I)$ its ffiscal stance. Because the tax income is $T = \tau puK$, the degree of the government's primary deficit is measured as $\theta_C + \theta_I - 1 > 0$.

For private consumption demand, we assume that workers spend all their disposable income on final goods. Capitalists spend a constant fraction of disposable profit income, and receive interest income from government bonds, which for simplicity we assume they save.[3] Then, private consumption demand is determined as:

$$\frac{C}{K} = (1-\tau)(1-m)u + (1-s)(1-\tau)mu \tag{8}$$

The firms' investment demand is given by the following equation:

$$\frac{I}{K} = \alpha + \beta(1-\tau)m + \gamma\left(\frac{G_C + G_I}{K}\right) \tag{9}$$

and private capital accumulation proceeds per the realised investment $\dot{K} = I$. We assume that firms' investment demand is determined by the after-tax profit share $(1-\tau)m$ and accelerated by the increase in government expenditure. $\alpha > 0$ is a constant term driven by the firm's animal spirits and $\beta > 0$ represents the sensitivity of investment demand to a change in the after-tax profit share. Importantly, private investment demand is complementary to government expenditure, for which sensitivity is measured by $\gamma > 0$. This shows that an increase in government expenditure induces firms' investment and associated capital accumulation in the long run. Thus, we define the size of $\gamma$ as the demand effect of government expenditure. By substituting

[3] More precisely, the capitalists' consumption per physical capital is given by $(1-s)(1-\tau)mu + (1-s_\delta)i\delta$, where $s_\delta$ represents their saving rate of the interest income. Equation (8) obtained by imposing $s_\delta$ is unity. If $s_\delta$ is not zero, there will be feedback from long-run change in the debt ratio to the capacity utilisation rate. However, it simply complicates the analysis and the related economic interpretation.

Equation (7) into Equation (9), the firms' investment demand is:

$$g \equiv \frac{I}{K} = \alpha + \beta(1-\tau)m + \gamma(\theta_C + \theta_I)\tau u \tag{10}$$

Tax rate $\tau$ has a double effect on private investment demand and associated capital accumulation. A rise in the tax rate directly restrains firms' investment demand by reducing the expected profit share, while its rise indirectly induces investment by expanding government expenditure, namely, the crowding-in effect. Thus, fiscal stance $(\tau, \theta_C, \theta_I)$ is important for effective demand determination.[4]

## 2.2 Existence and stability of short-run steady state

The short run is a period when the effects of firms' capital accumulation rate and government's social infrastructure and debt accumulation have not yet begun to be realised, and the demand and supply for goods are exclusively adjusted by the change in capacity utilisation rate $u$. Then, the short-run equilibrium in the goods market can be represented by

$$\frac{X}{K} = \frac{C + I + G_C + G_I}{K} \tag{11}$$

By substituting Equations (7), (8), and (10), we obtain the short-run steady-state condition in the rate of capacity utilisation term:

$$u = \frac{\alpha + \beta(1-\tau)m}{sm(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)} \tag{12}$$

Substituting this value into Equation (10), the short-run capital accumulation rate is obtained as:

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[4] Our investment function is close to Bhaduri and Marglin's (1990), of which the linear version is basically presented by $\frac{I}{K} = \alpha + \beta m + \varphi u$. Even if we additionally incorporate the accelerator effect (i.e. $\varphi u$) into our model, we get $\frac{I}{K} = \alpha + \beta(1-\tau)m + (\gamma(\theta_C + \theta_I)\tau + \varphi)u$. Increasing the analytical complication does not change the quantitative implication.

$$g = \frac{(\alpha + \beta(1-\tau)m)\big(sm(1-\tau) - \tau(\theta_C + \theta_I - 1)\big)}{sm(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)} \tag{13}$$

and the associated Keynesian stability condition is

$$m > \frac{\tau}{s(1-\tau)}\big((1+\gamma)(\theta_C + \theta_I) - 1\big) \tag{14}$$

This ensures a positive and economically meaningful value for the capacity utilisation and capital accumulation rates. In the short run, the steady-state capacity utilisation rate rises following a fall in saving rate $s$ and profit share $m$. Thus, the paradoxes of thrift and cost hold true. An increase in the propensities of government consumption and investment $\theta_C$, $\theta_I$ equally stimulates capacity utilisation rates, raising the capital accumulation rate in the short run. A rise in the tax rate $\tau$ for each income increases the capacity utilisation rate, whereas its impact on capital accumulation is mixed.

Identifying growth regimes is important for elucidating the nature of long-run dynamics. A growth regime refers to the relationship between changes in income distribution and the economic growth rate. By differentiating $g$ with respect to $m$, we observe two growth regimes according to the following criterion:

$$\frac{dg}{dm} = \frac{(1-\tau)}{\Big(sm(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)\Big)^2} F(m) \tag{15}$$

where

$$F(m) \equiv am^2 + bm + c \gtreqless 0 \tag{16}$$

and

$$a = (s - s\tau)^2\beta$$

$$b = -2s(1-\tau)\tau\beta((1+\gamma)(\theta_C + \theta_I) - 1)$$

$$c = \tau(\tau\beta(\theta_C + \theta_I - 1)((1+\gamma)(\theta_C + \theta_I) - 1) - s\alpha\gamma(\theta_C + \theta_I))$$

Thus, WLG and PLG regimes were established for $F(m) < 0$, and $F(m) > 0$, respectively. The absolute value of $F(m)$ determines the degree of being wage-led and profit-led, which play important roles in stability analysis. Appendix 1 shows that there is a unique profit share $\widetilde{m}$ that switches the growth regime between WLG and PLG in a domain. In this case, the economy may have multiple steady-state conditions. Note that the fiscal stance parameters ($\tau$, $\theta_C$, and $\theta_I$) are included in $F(m)$. Thus, the government's fiscal stance may shape the type of growth regime that plays an important role in stabilising the unstable growth regime in Subsection 3.3.

## 3 Long-run analysis

### 3.1 Long-run dynamics with social infrastructure accumulation

The long run is a period in which the accumulation of firms' capital and the government's social infrastructure and its associated effects begin to fully realise. During this period, tax revenue varies according to the change in income distribution, affecting the size of government expenditure. Government expenditure stimulates effective demand, whereas the accumulation of social infrastructure enhances labour productivity growth. Moreover, they induce changes in the income distribution and employment rates. Finally, the government accumulates debt based on the gap between government expenditure and tax income. Thus, the capacity utilisation rate, income distribution, and employment rate are all endogenously determined first as fast variables, whereas the government's debt ratio evolves as a slow variable following the fast variables. Fiscal sustainability is based on whether the government's debt-to-GDP ratio converges to a certain level.

The government spends tax revenue on investment in social infrastructure $G_I$ by $\theta_I$, which generates the accumulation of social infrastructure $\dot{S}$. Then, the social infrastructure grows at the following rate:

$$g_S = \frac{\dot{S}}{S} = \frac{\theta_I \tau u}{\chi}, \tag{17}$$

where $\chi = \frac{S}{K}$ is the capital composition (i.e. social infrastructure–private capital ratio), and $u$ is instantaneously determined by Equation (12). For simplicity, we do not consider the depreciation rates of the capital stock or social infrastructure. Then, the dynamics of the capital composition $\chi$ are given by:

$$\frac{\dot{\chi}}{\chi} = \frac{\dot{S}}{S} - \frac{\dot{K}}{K} \tag{18}$$

By substituting Equations (12), (13), and (17) into (18), we obtain

$$\dot{\chi} = \left[ \frac{(\alpha + \beta(1-\tau)m)\big(\tau\theta_I - \big(sm(1-\tau) - \tau(\theta_C + \theta_I - 1)\big)\chi\big)}{\big(sm(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)\big)} \right] \tag{19}$$

In formalising the long-run effects of social infrastructure, we assume that labour productivity growth improves as per social infrastructure per private physical capital and per employed labour. Thus, labour productivity is endogenously determined as:

$$q_L = A \left(\frac{S}{K}\right)^{\varepsilon_1} \left(\frac{S}{L}\right)^{\varepsilon_2} \tag{20}$$

where $\varepsilon_1 \in (0,1)$ is the constant elasticity of labour productivity to social infrastructure per unit of private capital, and $\varepsilon_2 \in (0,1)$ is that per unit of employed labour. $A$ represents the exogenous determinants of labour productivity, which grow at a constant rate of $\hat{A} = \varepsilon_0$. For example, social infrastructure is embodied in public capital as roads and public transportation, backing efficient logistics. It also includes broad institutional capital such as school education, healthcare, and skill training support. The availability of this kind of capital per person supports more productive work (Oyvat and Onaran, 2022; Onaran et al., 2022); thus, as these effects are complementary to each other, and labour productivity is defined so. Equation (20) expresses the productivity effects of social infrastructure, each of which is measured by $\varepsilon_1$ and $\varepsilon_2$. These are exogenous parameters but would naturally differ according to the quality and attractiveness of government infrastructure provision. The better the quality or the more innovative the project, the higher these values, and vice versa.

Then, the structural form for labour productivity growth rate is

$$\hat{q}_L = \varepsilon_0 + \varepsilon_1(g_S - g) + \varepsilon_2(g_S - g_L) \tag{21}$$

Due to the short-run steady state and production function, we have

$$u^*K = X = q_L L \tag{22}$$

and the labour demand rate is $g_L = g - \hat{q}_L$. By solving for the labour demand growth rate $g_L$, we obtain:

$$g_L = \frac{(1+\varepsilon_1)g - (\varepsilon_1 + \varepsilon_2)g_S - \varepsilon_0}{1-\varepsilon_2}, \tag{23}$$

and get the reduced form for labour productivity growth rate as:

$$\hat{q}_L = \left(\frac{\varepsilon_1 + \varepsilon_2}{1-\varepsilon_2}\right)(g_S - g) + \frac{\varepsilon_0}{1-\varepsilon_2} \tag{24}$$

Meanwhile, the dynamics of the income distribution are derived using the mark-up pricing equation (5) as:

$$\dot{m} = (1-m)(\hat{p} - \hat{w} + \hat{q}_L). \tag{25}$$

We dynamically determine the income distribution based on the two types of Phillips curves (Asada et al., 2006), where wage and price inflation spiral each other. This framework details how income distribution is determined through cumulative changes in wages, prices, and labour productivity growth. According to the standard Phillips curve, the rate of change in wages and prices reacts to the deviation of the (un)employment rate from its natural rate, which does not accelerate inflation. We consider that the change in wage is indexed to price inflation and productivity growth, and an increase in the unit labour cost is passed through to price inflation by oligopolistic firms. Thus, wage and price inflation rates are partially determined by the tightness of the labour market, as measured by the employment gap. However, wage inflation is partly compensated by the indexation mechanism to ensure an adequate wage rate when productivity growth or price inflation occurs, whereas the dynamic cost pass-through mechanism partly determines price inflation.[5] The structural forms for the wage and price inflation

[5] We do not explore how the natural employment rate and the expected wage and price inflation rates are determined, and instead focus on the long-run effects of government expenditure. Nishi (2022) examines cyclical dynamics caused by endogenous change in natural employment rate in a growth regime approach, but does not incorporate government sector, whereas we explicitly incorporate its role and effects.

rates are:

$$\hat{w} = \mu_1(e - e_n) + \nu_1(\hat{p} + \hat{q}_L) \tag{26}$$

$$\hat{p} = \mu_2(e - e_n) + \nu_2(\hat{w} - \hat{q}_L), \tag{27}$$

where $e_n$ is the natural employment rate, which is assumed constant. Wage and price inflation rates react to the employment gap $e - e_n$ by $\mu_1 > 0$ and $\mu_2 > 0$, respectively. $\nu_1 \in (0,1)$ represents the degree of wage indexation to price inflation and labour productivity growth. Similarly, $\nu_2 \in (0,1)$ represents the degree of a firm's dynamic cost pass-through.

Solving these equations for price and wage inflation rates, we get

$$\hat{p} = \frac{\mu_2 + \nu_2\mu_1}{1 - \nu_1\nu_2}(e - e_n) - \frac{\nu_2(1 - \nu_1)}{1 - \nu_1\nu_2}\hat{q}_L \tag{28}$$

$$\hat{w} = \frac{\mu_1 + \nu_1\mu_2}{1 - \nu_1\nu_2}(e - e_n) + \frac{\nu_1(1 - \nu_2)}{1 - \nu_1\nu_2}\hat{q}_L \tag{29}$$

By substituting these equations into Equation (25), we obtain the dynamics of income distribution as:

$$\dot{m} = (1 - m)\left((\rho_p - \rho_w)(e - e_n) + \rho_q\left[\left(\frac{\varepsilon_1 + \varepsilon_2}{1 - \varepsilon_2}\right)(g_S - g) + \frac{\varepsilon_0}{1 - \varepsilon_2}\right]\right), \tag{30}$$

where

$$\rho_P \equiv \frac{\mu_2(1 - \nu_1)}{1 - \nu_1\nu_2} > 0$$

$$\rho_W \equiv \frac{\mu_1(1 - \nu_2)}{1 - \nu_1\nu_2} > 0$$

$$\rho_P - \rho_W = \frac{\mu_2(1 - \nu_1) - \mu_1(1 - \nu_2)}{1 - \nu_1\nu_2} \lesseqgtr 0$$

$$\rho_q \equiv \frac{(1 - \nu_1)(1 - \nu_2)}{1 - \nu_1\nu_2} > 0$$

Equation (30) embodies the income distribution regime linking the change in employment rate and profit share (and wage share). Note that profit share reacts both positively and negatively to a change in the employment gap. It increases, but the wage share decreases according to the positive gap in employment rates when $\rho_P - \rho_W > 0$, and vice versa when $\rho_P - \rho_W < 0$. Regarding the income distribution regime, we call $\rho_P - \rho_W > 0$ goods-market-led (GML) distribution regime and $\rho_P - \rho_W < 0$ labour-market-led (LML) distribution regime.[6] The GML regime is shaped by the effect of large $\mu_2$ and $\nu_2$ and small $\mu_1$ and $\nu_1$, meaning that the rate of change in price inflation is larger than that in nominal wages when there is an employment gap. Namely, the driving force is pricing in the goods market, where firms have strong pass-through power of unit labour cost, and accordingly price inflation is more sensitive to the employment gap than wage inflation. Conversely, the LML regime is shaped by the effect of large $\mu_1$ and $\nu_1$ and small $\mu_2$ and $\nu_2$, meaning that the rate of change in nominal wages is larger than that in price inflation when there is an employment gap. Namely, the driving force is wage determination in the labour market, where workers have strong bargaining power to index price inflation and productivity gain; accordingly, wage inflation is more sensitive to the employment gap than price inflation.

Next, with Equation (22), the actual employment rate is determined by

$$e = \frac{u^* K}{q_L N} \tag{31}$$

and the labour demand rate changes according to $g_L = g - \hat{q}_L$. Using Equations (24) and (31), the change in the employment rate is given by

$$\dot{e} = e\left(g - \left(\frac{\varepsilon_1 + \varepsilon_2}{1 - \varepsilon_2}\right)(g_S - g) - \frac{\varepsilon_0}{1 - \varepsilon_2} - n\right), \tag{32}$$

the third state variable in our dynamic system. Equation (32) shows that the growth in the employment rate is led by private capital accumulation, but it is weakened by the productivity effect

[6] Alternatively, the LML is called the profit-squeeze distributive regime (Barbosa-Filho and Taylor, 2006) because a rise in overall economic activity levels decreases the profit share. Lavoie (2022, p. 405) calls the GML a Classical or Cambridge case after Kaldor and Robinson's argument on forced saving and the LML, a Radical case after the Radical economists emphasising the profit-squeeze mechanism.

of social infrastructure accumulation during transitional dynamics.

Finally, we define the dynamics of the government debt ratio. In our model, the government sector depends on debt finance, as its expenditure always exceeds its revenue. The government also makes interest payments to capitalists based on debt stock. Then, the government budget constraint or the dynamics of debt is defined as:

$$\begin{aligned}\dot{D} &= (\theta_C + \theta_I)\tau puK + i\delta pK - \tau puK \\ &= (\theta_C + \theta_I - 1)\tau puK + i\delta pK, \qquad (33)\end{aligned}$$

where $i$ is the nominal interest rate on the existing debt and $\theta_C$ and $\theta_I$ are discretionary moves over unity according to the government's fiscal stance. Although we do not explicitly formalise monetary policy, the interest rate is supposed to be exogenously controlled by the monetary authority.

Thus, the government debt ratio in real terms $\delta = \frac{D}{pK}$, is an endogenous variable in our dynamic model,[7] namely,

$$\frac{\dot{\delta}}{\delta} = \frac{\dot{D}}{D} - \hat{p} - g \qquad (34)$$

Hence, with Equation (33) we have

$$\dot{\delta} = (\theta_C + \theta_I - 1)\tau u + i\delta - (\hat{p} + g)\delta \qquad (35)$$

We approach the long-run dynamics of government debt based on economic growth, distribution, and employment rate in a sequential way. We consider growth, distribution, and employment rate as fast variables, whereas government debt ratio is a slow variable which changes as a result of the fast variables. Thus, the rates of capacity utilisation, inflation, and output growth will follow the long-run steady-state values in our model in determining the dynamics of the debt ratio (35). The principal reason is to elucidate the conditions in which the stability of demand

[7] Because we assume that the potential output-capital ratio is unity, we have $K = \bar{X}$. Thus, the government debt ratio is equal to $\delta = \frac{D}{p\bar{X}}$, which economically reflects the ratio of government debt to the potential GDP.

and distribution regimes may also guarantee that of the government debt in the long run, while maintaining mathematical traceability.

### 3.2 Existence of long-run steady state

Our differential equation system consists of the fast variables of capital composition $\chi$ (Equation 19), profit share, $m$ (Equation 25), and the employment rate $e$ (Equation 32), where quantity adjustment in the goods market is instantaneous (Equation 12). Based on these steady-state values, the slow variable of the government debt ratio eventually changes (see Equation 35).

The long-run steady state for fast variables is a solution of the simultaneous equations for $\dot{\chi} = 0$, $\dot{m} = 0$, and $\dot{e} = 0$. It follows from Equations (19), (25), and (32) that the nontrivial steady-state values for capital composition, profit share, and employment rate must satisfy the following relationship:

$$\chi^* = \frac{\tau\theta_I}{sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1)} \tag{36}$$

$$e^* = e_n - \left(\frac{\rho_q}{\rho_P - \rho_W}\right)\left(\frac{\varepsilon_0}{1-\varepsilon_2}\right) \tag{37}$$

$$\frac{(\alpha + \beta(1-\tau)m^*)\big(sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1)\big)}{sm^*(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)} = n + \frac{\varepsilon_0}{1-\varepsilon_2} \tag{38}$$

and the capacity utilisation rate in the long-run is

$$u^* = \frac{\alpha + \beta(1-\tau)m^*}{sm^*(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)}, \tag{39}$$

which is also constant because profit share $m$ reaches a steady state. The conditions for the existence of long-run steady states are presented in Appendix 1. If these conditions are satisfied, then Equations (36) and (38) simultaneously guarantee economically meaningful values for capital composition and profit share. In addition, the employment rate was independently determined using Equation (37).

Finally, the dynamics of the government's debt ratio follow Equation (35), which is eventually determined by the steady-state values of the fast variables. When the steady state of the fast variables is stable, the economy has the following unique steady-state value for the government debt ratio:

$$\delta^* = \frac{\tau(\theta_C + \theta_I - 1)(\alpha + \beta(1-\tau)m^*)}{\left(sm^*(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)\right)\left(n + \frac{\mu_1(1-\nu_2)}{\mu_1(1-\nu_2) - \mu_2(1-\nu_1)}\left(\frac{\varepsilon_0}{1-\varepsilon_2}\right) - i\right)} \quad (40)$$

The stability condition is provided in the next section and appendices, but when it is guaranteed, the long-run steady state can be characterised as follows. First, the model may generate multiple steady states, in which one is a WLG regime and the other is a PLG regime depending on the initial value of the profit share.

Second, the long-run growth rate is equal to the natural growth rate, determined by the supply side parameters. Using Equation (38), the economic growth rate and the accumulation rate of social infrastructure are equally given by

$$g^* = n + \frac{\varepsilon_0}{1-\varepsilon_2}, \quad (41)$$

where supply-side parameters, such as autonomous productivity growth $\varepsilon_0$, productivity effect of social infrastructure $\varepsilon_2$ per employed worker, and labour force $n$ play a dominant role. Surprisingly, from a Kaleckian perspective, the demand parameters do not actually have any impact on the economic growth rate, and the paradox of thrifts and costs does not arise in the long run.

Third, the fiscal stance does not impact the long-run rates of economic growth or employment. Of course, different fiscal stances may have a temporary effect on the growth rates of social infrastructure and output during transitional dynamics, as Equation (19) embodies. However, in the long-run steady state, the impacts of fiscal stance parameters are accommodated by changes in capital composition and income distribution, as Equations (36) and (38) show.[8]

Fourth, the actual employment rate is ultimately determined by productivity and wage-

[8] However, we still believe the government plays important roles, as we explain in Subsection 3.5.

price parameters, and is independent of demand parameters. This persistently deviates from the exogenous natural rate as $\frac{\rho_q}{\rho_P-\rho_W}\hat{q}_L^*$. Additionally, the change in the steady-state value of labour productivity growth has different impacts on the profit share as the sign of $\rho_P - \rho_W$, namely, the type of income distribution regime.

Finally, the price and wage inflation rates remain constant and are given as:

$$\hat{p}^* = \frac{\mu_2(1-\nu_1)}{\mu_1(1-\nu_2)-\mu_2(1-\nu_1)}\left(\frac{\varepsilon_0}{1-\varepsilon_2}\right) \tag{42}$$

$$\widehat{w}^* = \frac{\mu_1(1-\nu_2)}{\mu_1(1-\nu_2)-\mu_2(1-\nu_1)}\left(\frac{\varepsilon_0}{1-\varepsilon_2}\right) \tag{43}$$

and the real wage grows at the steady-state rate of labour productivity growth $\frac{\varepsilon_0}{1-\varepsilon_2}$. If an economy has a GML regime $\rho_P - \rho_W > 0$, the steady-state inflation rates tend to be deflationary to a positive labour productivity growth rate, but if an economy has an LML regime $\rho_P - \rho_W < 0$, the steady-state inflation rates tend to be inflationary. As discussed below, different inflation pressures have important implications for the stability of the government's debt ratio.

### 3.3 Stability of long-run steady state

This section introduces the main propositions and discusses their economic implications; Appendix 2 provides the detailed proofs.

**Proposition 1.** The steady state is a saddle path unstable in an economy with WLG/LML and PLG/GML regimes.

**Proposition 2.** The steady state of an economy under PLG/LML regimes is locally and asymptotically stable.

**Proposition 3.** If the degree of being wage-led is sufficiently weak in an economy with WLG/GML regimes, the steady state of the economy is locally and asymptotically unstable. In contrast, if the degree of being wage-led is sufficiently strong, the local and asymptotic stability of the steady state depends on the elasticity of labour productivity to social infrastructure per physical capital $\varepsilon_1$. Precisely,

(1) When the elasticity of labour productivity to social infrastructure per physical capital $\varepsilon_1$ is sufficiently small (i.e. $\varepsilon_1 < \varepsilon_{1N}$), the local and asymptotic stability of the steady state is guaranteed.

(2) When the elasticity of labour productivity to social infrastructure per physical capital $\varepsilon_1$ is moderate (i.e. $\varepsilon_{1N} < \varepsilon_1$) in this combination, the local and asymptotic stability of the steady state is guaranteed for $\varepsilon_1 \in (\varepsilon_1, \varepsilon_1^*)$, but not for $\varepsilon_1 \in (\varepsilon_1^*, \varepsilon_{1D})$. Moreover, a limit cycle occurs by Hopf bifurcation for $\varepsilon_1$ sufficiently close to $\varepsilon_1^*$

Once the fast variables reach a steady state, the dynamics of the government debt ratio follow. When the stability conditions for fast variables are satisfied under the PLG/LML or WLG/GML regimes, we can also obtain Proposition 4.

**Proposition 4.** The long-run steady state of the government's debt ratio is locally and asymptotically stable, as long as the nominal economic growth rate is higher than the nominal interest rate.

These propositions have economic implications. First, a combination of growth and distribution regimes is important for achieving economic stability. Proaño et al. (2011) and Nishi and Stockhammer (2020a, 2020b) identify the potential instability (Proposition 1) of an economy with WLG/LML regimes and an economy with PLG/GML regimes.[9] In contrast, our model

[9] An intuitive interpretation of instability in an economy with WLG and LML regimes is given as follows. Suppose a positive shock arises on the actual employment rate $e$. Then, in an economy with LML regime, a positive employment gap stimulates wage inflation more than price inflation, leading to a decrease in profit share $m$ and an

elucidates that the government's fiscal stance can avoid such instability through double changes in expenditure propensities affecting the type of growth regime. If the government sequentially raises these parameters, an economy is more likely to be a PLG regime, whereas its sequential fall makes it more WLG, each of which is enhanced by raising and lowering the tax rate, respectively. The former is effective for WLG/LML regimes to avoid inherent instability, whereas the latter is effective for PLG/LML regimes. This is a corollary effect of fiscal policy with social infrastructure provision, which differs from the conventional Keynesian countercyclical fiscal policy. Hence, the fiscal stance potentially matters in stabilising unstable combinations.[10]

Second, the steady state of an economy with PLG/LML regimes is always stable (Proposition 2); however, the stability of WLG/GML regimes is conditional, where the productivity effect of social infrastructure per physical capital measured by $\varepsilon_1$ plays a crucial role (Proposition 3). It

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increase in wage share. A rise in wage share continuously expands economic growth rate $g$ in WLG regime. Consequently, there is a further rise in the actual employment rate $e$. Potential instability of an economy with PLG and GML regimes can be explained by the same token (i.e. a rise in $e$ leads to a rise in $m$, which positively stimulates $g$ and there is a subsequent rise in $e$).

[10] Note that the changes in expenditure propensity must be double because our model does not analytically determine the impact of a single change on the growth regime determination. For instance, the signs of $\frac{\partial F(m)}{\partial \theta_I}$, $\frac{\partial F(m)}{\partial \theta_C}$, and $\frac{\partial F(m)}{\partial \tau}$ are not uniquely determined. The sequential impacts are explained as follows. The fiscal stance parameters ($\tau$, $\theta_C$, and $\theta_I$) are included in $F(m)$ of Equation (16), implying that the change in them partially affects the type of growth regime. Then, by sequentially differentiating $F(m)$ with respect to $\theta_C$, and $\theta_I$, and by Young's theorem we get:

$$\frac{\partial}{\partial \theta_C}\left(\frac{\partial F(m)}{\partial \theta_I}\right) = \frac{\partial}{\partial \theta_I}\left(\frac{\partial F(m)}{\partial \theta_C}\right) = 4\beta(1+\gamma)\tau > 0$$

Thus, a sequential rise (fall) in these parameters makes an economy more PLG(WLG)-wise, promoted further by raising and lowering the tax rate, respectively. Note that the order of sequential policy is important for stabilising unstable regime combinations. If tax policy comes first, the effect of changes in expenditure propensities does not arise until all fiscal stance parameters change.

does not affect any steady-state values because private capital eventually grows at the same rate as social infrastructure. However, the size of $\varepsilon_1$ does have a lasting effect on labour productivity growth during transitional dynamics after the shock. If it is too strong, it may destabilise the steady state in WLG/GML regimes.

Furthermore, Proposition 4 indicates the Domar condition (Domar, 1944). Naturally, a higher economic growth rate helps to satisfy this condition, but the distribution regime particularly matters for because it also affects the nominal economic growth rate through the steady-state inflation rate. This inflation rate tends to be deflationary in the GML regime, which makes it difficult to satisfy the stability condition. By contrast, as it tends to be inflationary in the LML regime, the stability condition is easier to guarantee.[11] If the Domar condition is satisfied, although the absolute amount of government debt changes over time, the debt ratio converges to a certain level. Then, as the debt ratio and capital composition remain constant, social infrastructure $S$, output $X$, and government debt $\frac{D}{p}$ grow at the same rate.

### 3.4 Numerical study

We have solved the analytical model for the main variables sequentially. However, as these variables change simultaneously in reality, it is reasonable to consider their long-run behaviours concurrently.

Relaxing this assumption and using a numerical study, this section considers simultaneous changes in endogenous variables and compares the initial and new steady states to determine their impact on the steady state.

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[11] We have $\rho_P - \rho_W = -\frac{\mu_1(1-\nu_2)-\mu_2(1-\nu_1)}{1-\nu_1\nu_2} \lesseqgtr 0$ in Equation (30) to determine the income distribution regimes. As Equations (42) and (43) show, the opposite sign of the numerator rules whether an economy is inflationary or deflationary in steady states.

**Table 1.** Baseline parameters values for PLG/LML and WLG/GML regimes

| | $\alpha$ | $\beta$ | $\gamma$ | $\tau$ | $\theta_C$ | $\theta_I$ | $s$ | $i$ | $e_n$ |
|---|---|---|---|---|---|---|---|---|---|
| PLG/LML | 0.01 | 0.1 | 0.02 | 0.2 | 0.45 | 0.65 | 0.2 | 0.01 | 0.95 |
| WLG/GML | 0.02 | 0.02 | 0.05 | 0.2 | 0.45 | 0.65 | 0.2 | 0.01 | 0.95 |
| | $\varepsilon_0$ | $\varepsilon_1$ | $\varepsilon_2$ | $n$ | $\mu_1$ | $\mu_2$ | $\nu_1$ | $\nu_2$ | $m_0$ |
| PLG/LML | 0.025 | 0.01 | 0.0025 | 0.02 | 0.6 | 0.04 | 0.5 | 0.5 | 0.375 |
| WLG/GML | 0.025 | 0.01 | 0.0025 | 0.02 | 0.04 | 0.6 | 0.05 | 0.05 | 0.275 |

Table 1 summarises the baseline values for the parameters that establish the PLG/LML and WLG/GML regimes. First, we provide these values for Equations (19), (25), (32), and (35). These parameters are chosen to ensure not only the stability of the fast variables, but also the Domar condition for the debt ratio for each combination. Second, using these parameters and some initial values, we derive tentative steady-state values for $(\chi^*, m^*, e^*, \delta^*)$, which we subsequently use as the initial steady state for differential equation systems to be observed.[12] Finally, by pushing a 1% positive shock to the relevant parameters at time $t = 10$, we visually follow the subsequent transitional dynamics. We show the transitional dynamics of PLG/LML and WLG/GML for $t = 1000$ and $t = 300$, respectively. These periods are chosen only for visually clear illustration, and the path eventually converges to a new steady state in both cases with time. We report the impacts of changes in fiscal stance parameters, which is a highlight of this paper, to save space and figures, and the effects of the other parameters are summarised in Table 2.

[12] The baseline parameters are selected to generate stable different regimes, and our purpose is to visually observe the transitional dynamics. Even if some of them are chosen in light of economically reasonable values, they are not the ones obtained by calibration with real data. Similarly, the initial values for profit share $m_0$ are chosen to be sufficiently close to the associated steady states. In doing so, a particular initial value of the profit share is necessary to get the PLG and WLG regimes, because our model may generate multiple steady states.

**Table 2.** Results for comparative statics

| | Fiscal stance | | | Supply-side | | | Demand-side | |
|---|---|---|---|---|---|---|---|---|
| | $\theta_C$ | $\theta_I$ | $\tau$ | $\varepsilon_0$ | $\varepsilon_2$ | $n$ | $\alpha$ | $s$ |
| $g^*$ | 0 | 0 | 0 | + | + | + | 0 | 0 |
| $\chi^*$ | $+^{PL}$ ; $-^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $-^{PL}$ ; $+^{WG}$ | $-^{PL}$ ; $+^{WG}$ | $-^{PL}$ ; $+^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $-^{PL}$ ; $+^{WG}$ |
| $m^*$ | $-^{PL}$; $+^{WG}$ | $-^{PL}$; $+^{WG}$ | $-^{PL}$; $+^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $-^{PL}$ ; $+^{WG}$ | $+^{PL}$ ; $-^{WG}$ |
| $e^*$ | 0 | 0 | 0 | $+^{PL}$ ; $-^{WG}$ | $+^{PL}$ ; $-^{WG}$ | 0 | 0 | 0 |
| $\delta^*$ | + | + | $+^{PL}$ ; $-^{WG}$ | $-^{PL}$ ; $+^{WG}$ | $-^{PL}$ ; $-^{WG}$ | $-^{PL}$ ; $-^{WG}$ | $+^{PL}$ ; $-^{WG}$ | $-^{PL}$ ; $+^{WG}$ |

Note: Superscripts $PL$ and $WG$ refer to the combination of PLG/LML regimes and WLG/GML regimes, respectively. Notations without superscriptions indicate results that hold for both combinations.

Figure 1 shows the transitional path to a new steady state in the PLG/LML regimes after a 1% positive shock to $\theta_C$, $\theta_I$, and $\tau$ on the (a) economic growth rate, (b) capital composition, (c) profit share, (d) employment rate, and (e) government debt ratio. As Equations (37) and (41) indicate, an increase in government expenditure propensities does not generally increase the long-run economic growth rate or employment rate. However, it positively impacts the capital composition $\chi$ while decreasing the profit share $m$. We confirm that capital composition and income distribution absorb changes in the fiscal stance parameters. The transitional path shows cyclical behaviours, and a change in government investment propensity $\theta_I$ generates the most fluctuating path, followed by consumption propensity $\theta_C$ and tax rate $\tau$. Graph (f) reports the combined plot for wage share $(1 - m)$ and employment rate $(e)$ on the x- and y-axes, respectively. It shows clockwise cycles known as Goodwin cycles (Goodwin, 1967). As Barbosa-Filho and Taylor (2004) and von Arnim and Barrales (2015) also show, a PLG regime with a Marxian profit squeeze mechanism (similar to the LML regime here) can generate these cycles. Our analysis shows that such Goodwin cycles may also arise, even when a government sector exists in an economy with PLG/LML regimes. Finally, the government's debt ratio expands cyclically, reaching a higher ratio than that in the initial state.

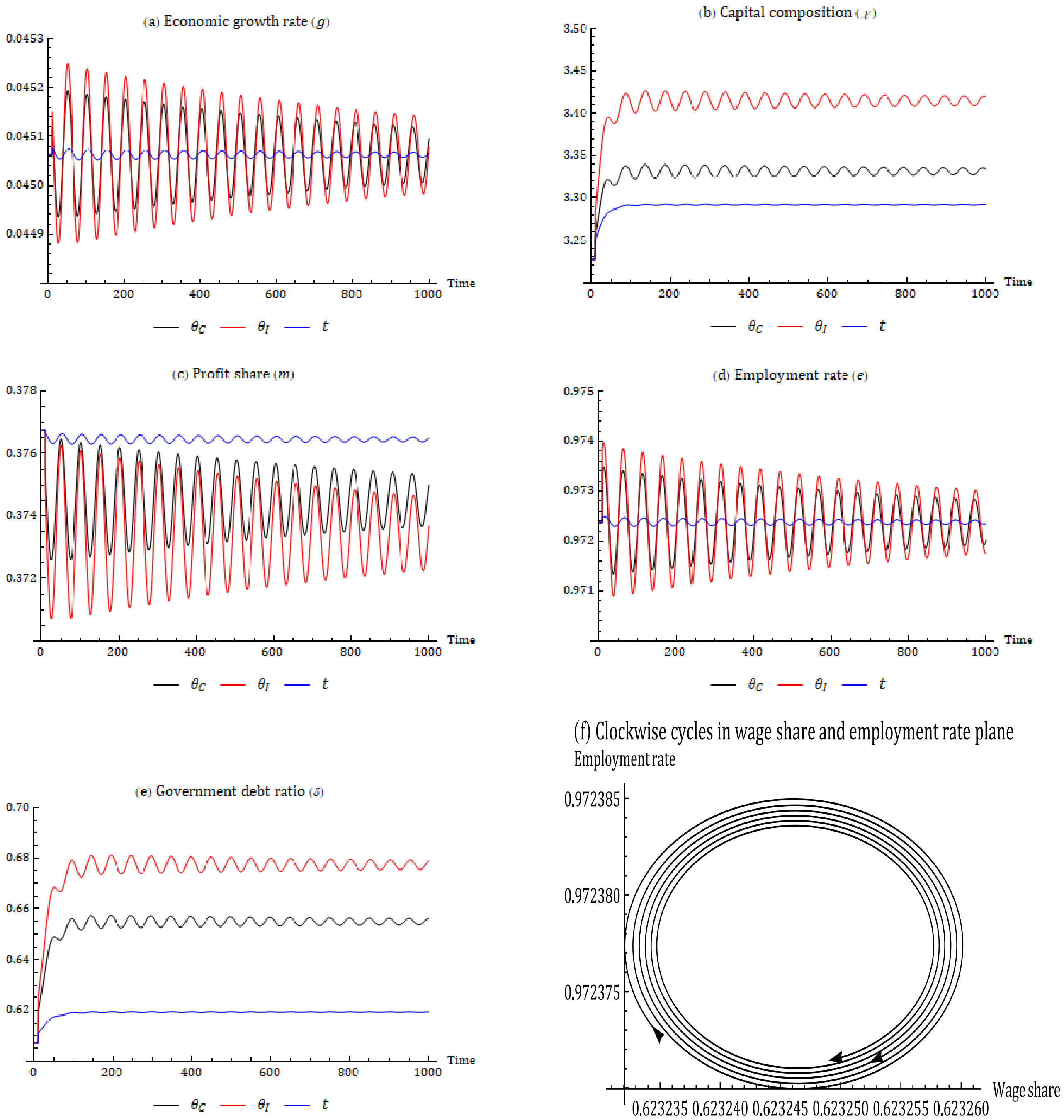


**Fig. 1.** Cyclical convergence to steady state in PLG/LML regimes

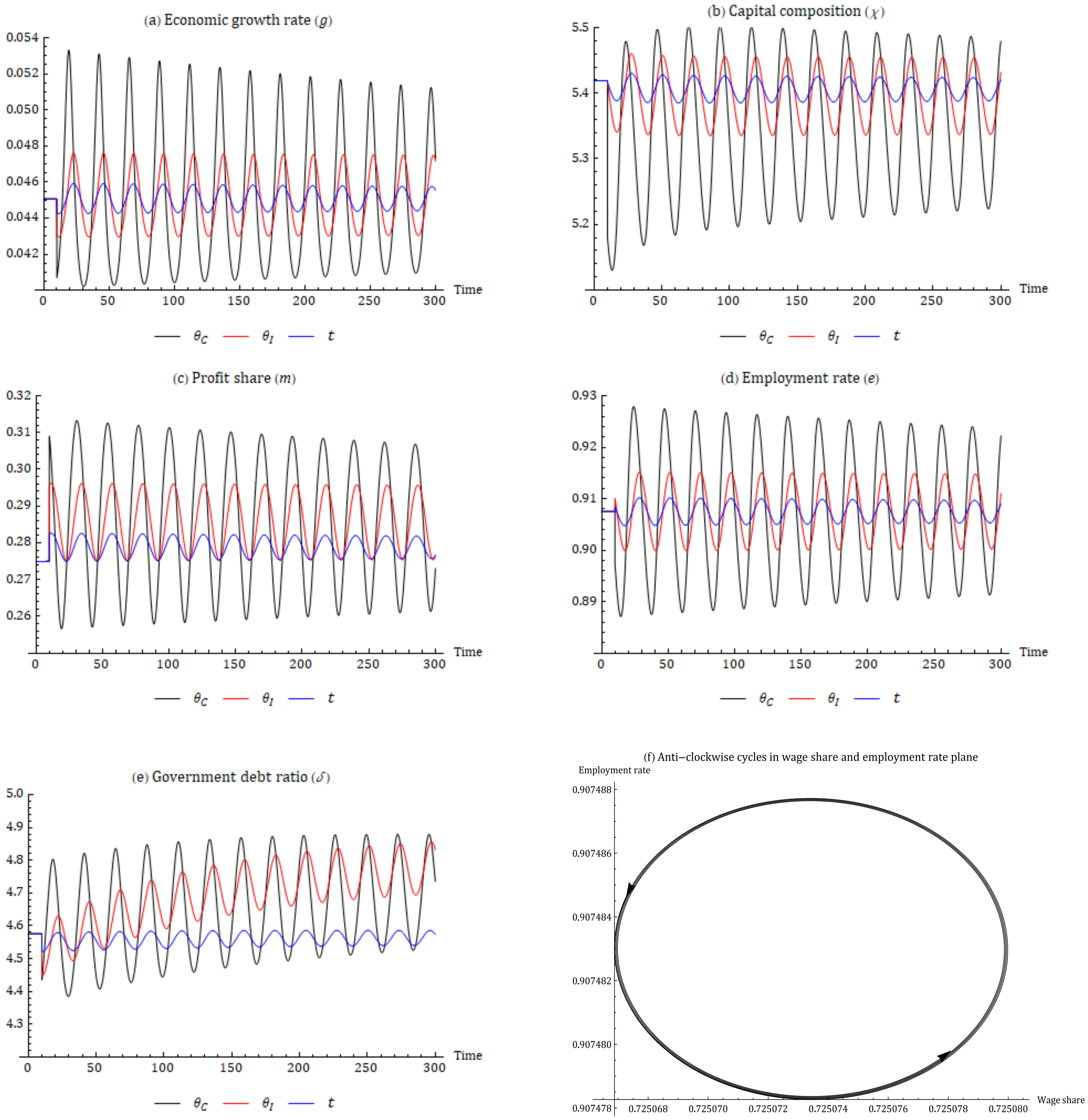


**Fig. 2.** Cyclical convergence to steady state in WLG/GML regimes

Figure 2 shows the transitional path to a new steady state in the WLG/GML regimes after the same shocks as those in Figure 1.[13] Indeed, long-run economic growth and employment

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[13] Our analytical study reveals that an economy with WLG/GML regimes may be unstable depending on the value of $\varepsilon_1$. If we solve our model in the same sequential way as in Subsection 3.2, the system of fast variables may

rates are independent of an increase in the fiscal stance parameters in these regimes. They simply generate cyclical behaviours of endogenous variables, of which the magnitude is the highest for $\theta_C$, followed by the consumption propensity $\theta_I$ and tax rate $\tau$. In contrast to the PLG/LML regimes, paradoxically, a rise in fiscal stance parameters negatively impacts the capital composition $\chi$ while increasing the profit share $m$.[14] Additionally, Graph (f) plots the wage share and employment rate in a similar manner as above. This shows that the WLG/GML regimes generate anticlockwise cycles, in contrast to the cycles in the PLG/LML regimes. Thus, this numerical study elucidates that an economy shows different business cycles in its growth and distribution regimes. Finally, the government's debt ratio cyclically increases due to a rise in expenditure propensities but decreases due to a higher tax rate.

### 3.5 Economic interpretation

Our theoretical and numerical analyses show that the effects of different shocks on cyclical behaviours in transitional dynamics and steady states depend on the combination of growth and

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generate limit cycles when the bifurcation parameter $\varepsilon_1$ is sufficiently close to $\varepsilon_1^* = 0.516262$. Therefore, in the numerical study in Subsection 3.4, we set a sufficiently lower value for $\varepsilon_1^*$ than the bifurcation value and consider the associated dynamic behaviours of endogenous variables. Although a further analytical approach to identify the stability condition for 4D system is not possible, if we set a sufficiently higher value for $\varepsilon_1$ than the bifurcation value, the transitional dynamics of an economy with WLG/GML regimes are divergent.

[14] For instance, a rise in $\theta_I$ eventually decreases the capital composition in the WLG regime. This is because its impact is accommodated by a rise in profit share, which lowers the capital composition. A rise in $\theta_I$ initially pushes $\chi$ up according to Equation (36) but simultaneously, $m$ increases to accommodate this impact in WLG regime, as Equation (38) shows. Then, $\chi$ is lowered due to the rise in $m$. Because the subsequent negative impact on $\chi$ is stronger than the initial positive impact on it, the value of capital composition in the new steady-state is lower than the initial state in WLG regime. The opposite mechanism arises in PLG regime for the impact of the fiscal stance. A rise in $\theta_I$ initially pushes $\chi$ up but decreases $m$ in PLG regime; a higher $\chi$ is further induced by the fall in $m$. Thus, the value of capital composition in the new steady-state is higher than the initial state in the PLG regime.

distribution regimes. Surprisingly, even in Kaleckian models, government intervention has little impact on the long-run economic growth and employment rates. A proactive fiscal stance causes fluctuations in the macroeconomic variables, leading to an increase in the government debt ratio. There are two theoretical reasons for this finding. First, when the employment rate reaches a steady state, the economic growth rate is equal to the sum of labour supply and labour productivity growth rates. Second, these parameters are determined independently of fiscal stance. Therefore, supply side parameters play a crucial role in determining long-run economic growth and employment rates.

What then is the government's role? Even if a proactive fiscal stance does not increase growth or employment rates, our model implies that it is still important for the following three reasons.

First, a certain growth regime is required to ensure the stabilisation of an economy with a distributional regime. Of these, we emphasise that the size of government expenditure is related to growth regime determination. Specifically, sequential rises (falls) in government expenditure may alter the WLG regime to the PLG regime (or the PLG to the WLG). These effects are enhanced by raising and lowering the tax rates, respectively. These policies are particularly important when an economy has an LML distribution regime for the former and GML distribution regime for the latter. Thus, the government is still responsible for guaranteeing stability by controlling the fiscal stance, to realise an appropriate growth regime based on the distributional regime.

Second, the quality of social infrastructure must be improved to enhance the productivity effects of its accumulation. Parameter $\varepsilon_1$ is concerned with stability, and $\varepsilon_2$ defines the growth and employment rates. They are exogenous in our model, but, in reality, their magnitude varies according to the efficiency of government investment in infrastructure. Even if the size of the social infrastructure per worker or capital is quantitatively the same, qualitatively more effective investment projects are associated with higher productivity. In particular, the higher effectiveness of social infrastructure investment per worker, as reflected by $\varepsilon_2$, increases the growth and employment rates. Hence, our results show that the government should increase the quality of human-related social investments such as education, healthcare, and job training for long-term growth.

Finally, social infrastructure provision *per se* is important for building a resilient and sustainable market economy. For example, the institutional capital of healthcare enhances resilience against a pandemic, whereas environmental capital mitigates climate change. These effects are not explicitly stipulated in the model but are important for sustainable economic growth. Fiscal stance effectively affects capital composition $\chi$, which represents the relative size of social infrastructure in a market economy. Note, however, that the effect of the fiscal stance depends on the combination of alternative regimes. As Table 2 shows, a proactive fiscal stance increases the capital composition in the PLG/LML regimes, whereas only a tax cut is effective in increasing it in the WLG/GML regimes. In both cases, although fiscal policy does not affect the long-run growth rate, social infrastructure provision is of great benefit. The market economy works stably based on social and natural foundations, and fiscal policies play an important role in strengthening these foundations and building a resilient economy.

## 4 Conclusion

We build a Kaleckian dynamic model of growth, distribution, and employment rate, in which government expenditure generates a crowding-in effect, social infrastructure provision, and debt accumulation. Focusing on the effects of changes in fiscal stance, we elucidate the driving force for economic growth and stability properties under alternative growth and income distribution regimes.

The model shows two types of growth and distribution regimes (WLG and PLG regimes, and LML and GML distribution regimes) in the short run, and their combination principally matters for the long-run stability of an economy. An economy with WLG/GML or PLG/LML regimes may realise a stable steady state. In contrast, an economy with WLG/LML or PLG/GML regimes is unstable. The government's fiscal stance partially shaped the growth regime. Against these instabilities, the sequential rise or fall in government expenditure propensities (i.e. $\theta_I$ and $\theta_C$) may be effective so that an appropriate growth regime is realised according to the distributional regime. Because of these dynamics, the government accumulates debt. The Domar condition is required to establish long-run convergence of the government's debt ratio.

Regarding the effects of social infrastructure, the size of elasticity $\varepsilon_1$ reflecting the productivity growth effect of its accumulation per physical capital, is related to the stability in WLG/GML regimes, although it does not ultimately affect the economic growth rate. The effect of social infrastructure provision per employed worker, measured by $\varepsilon_2$ determines the long-run economic growth in stable regimes. This has different consequences for the convergence of the government's debt ratio as per the distribution regime. A rise in $\varepsilon_2$ increases the steady-state wage and price inflation rates in the LML regime, contributing to ensuring the Domar condition, whereas it decreases them in the GML regime, making it difficult to realise fiscal sustainability. Accordingly, a lower interest rate is required in the GML regime than that in the LML regime.

This study analytically and numerically showed that demand- and distribution-driven growth work during transitional dynamics, but that long-run economic growth rate is independent of these parameters. Instead, natural growth rate plays a dominant role. Nevertheless, this does not mean that the fiscal stance or broad government role is irrelevant to long-run economic performance and social sustainability. Our model shows that government has a positive policy impact on resilient macroeconomic performance. First, we highlight that the government may ensure stability by controlling the fiscal stance so that an appropriate growth regime is realised based on the distributional regime. Second, it can still improve the quality of the social infrastructure to enhance its productivity effects and the associated rise in growth and employment rates. Finally, social infrastructure provision, through changes in fiscal stance, contributes to the enhancement of the economy's social and natural foundations and in turn to resilient and sustainable growth. Hence, its provision matters both quantitatively and qualitatively to realise these purposes.

## Appendices

### Appendix 1. Conditions for existence of long-run steady states

The long-run steady state must simultaneously satisfy Equations (36), (37), and (38). As shown in Equation (38), an economy may have two potential growth regimes: the shape of the economic growth rate is a convex quadrant in the domain of

$$m \in \left(\frac{\tau}{s(1-t)}\big((1+\gamma)(\theta_C+\theta_I)-1\big), 1\right) \tag{A1}$$

Therefore, a unique profit share $\tilde{m}$ switches the growth regime from WLG to PLG in this domain, and the actual growth rate (i.e. the LHS of Equation (38)) takes the minimum value there. The minimum growth rate is represented by:

$$g_{\tilde{m}} \equiv \frac{(\alpha+\beta(1-\tau)\tilde{m})\big(s\tilde{m}(1-\tau)-\tau(\theta_C+\theta_I-1)\big)}{s\tilde{m}(1-\tau)-\tau\big((1+\gamma)(\theta_C+\theta_I)-1\big)} \tag{A2}$$

Hence, if

$$g_{\tilde{m}} < n + \frac{\varepsilon_0}{1-\varepsilon_2} \tag{A3}$$

is satisfied in the above domain, the economy has two steady-state values for profit share and the associated growth regimes (i.e. WLG for smaller profit share and PLG for larger profit share). Of course, the value of a larger profit share must be less than unity to be economically meaningful. Then, the capital composition is determined by Equation (36) according to the steady-state profit share. Independently, the employment rate is principally given by the parameters in Phillips curves.

### Appendix 2. Proof of propositions 1 to 4

The dynamic system consists of Equations (19), (25), and (32), for which the Jacobian matrix $J^*$ evaluated at the long-run steady state is given as follows.

$$j_{11} = \frac{\partial \dot{\chi}}{\partial \chi} = -\frac{(\alpha + \beta(1-\tau)m^*)(sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1))}{sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1)}$$

$$j_{12} = \frac{\partial \dot{\chi}}{\partial m}$$

$$= -\frac{s(1-\tau)\tau(\alpha + \beta(1-\tau)m^*)\theta_I}{(sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1))(sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1))}$$

$$j_{13} = \frac{\partial \dot{\chi}}{\partial e} = 0$$

$$j_{21} = \frac{\partial \dot{m}}{\partial \chi}$$

$$= -\frac{(1-m^*)(\alpha + \beta(1-\tau)m^*)(\varepsilon_1 + \varepsilon_2)(sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1))^2 \rho_q}{\tau(1-\varepsilon_2)\theta_I(sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1))}$$

$$j_{22} = \frac{\partial \dot{m}}{\partial m} = -\frac{(1-m^*)s(1-\tau)(\alpha + \beta(1-\tau)m^*)(\varepsilon_1 + \varepsilon_2)\rho_q}{(1-\varepsilon_2)(sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1))}$$

$$j_{23} = \frac{\partial \dot{m}}{\partial e} = (1-m^*)(\rho_P - \rho_W)$$

$$j_{31} = \frac{\partial \dot{e}}{\partial \chi} = \frac{e^*(\alpha + \beta(1-\tau)m^*)(\varepsilon_1 + \varepsilon_2)(sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1))^2}{\tau(1-\varepsilon_2)\theta_I(sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1))}$$

$$j_{32} = \frac{\partial \dot{e}}{\partial m} = e^*\left(\left(\frac{1+\varepsilon_1}{1-\varepsilon_2}\right)\frac{\partial g}{\partial m} - \left(\frac{\varepsilon_1 + \varepsilon_2}{1-\varepsilon_2}\right)\frac{\partial g_s}{\partial m}\right)$$

$$j_{33} = \frac{\partial \dot{e}}{\partial e} = 0$$

Note that, for simplicity, the steady-state value of $\chi^*$ is substituted into the Jacobian matrix elements to obtain these values.

The characteristic equation associated with the Jacobian matrix can be defined by

$$\lambda^3 + a_1\lambda^2 + a_2\lambda + a_3 = 0, \qquad (A4)$$

where $\lambda$ is the characteristic root. Coefficients $a_1$, $a_2$, and $a_3$ are given as:

$$a_1 = g^*\left(1 + \frac{s(1-m^*)(1-\tau)(\varepsilon_1 + \varepsilon_2)\rho_q}{(1-\varepsilon_2)\big(sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1)\big)}\right) \qquad (A5)$$

$$a_2 = -\frac{e^*(1-m^*)(1-\tau)(\rho_P - \rho_W)}{(1-\varepsilon_2)\left(sm^*(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)\right)^2}\left(F(m^*) + \omega_1\varepsilon_1 + \omega_2\varepsilon_2\right) \qquad (A6)$$

and

$$a_3 = -\frac{e^*(1-m^*)g^*(1-\tau)}{\left(sm^*(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)\right)^2}(\rho_P - \rho_W)F(m^*), \qquad (A7)$$

where

$$F(m^*) \equiv am^{*2} + bm^* + c \gtreqless 0$$

$$\omega_1 \equiv s(\alpha + \beta(1-\tau)m^*)(sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1)) > 0$$

$$\omega_2 \equiv (sm^*(1-\tau) - \tau(\theta_C + \theta_I - 1))(s\alpha + \tau\beta((1+\gamma)(\theta_C + \theta_I) - 1)) > 0$$

According to the Routh–Hurwitz criterion, the necessary and sufficient condition for the local asymptotic stability of the long-run steady state is:

$$a_1 > 0, a_2 > 0, a_3 > 0, and\ a_1a_2 - a_3 > 0, \qquad (A8)$$

where $a_1 > 0$ is obvious under our assumptions, whereas the rest of the conditions are not *a priori* clear. Based on these preliminaries, we proceed to the proof of the propositions in order.

**Proof of proposition 1.** An economy with a WLG regime has $F(m^*) < 0$, whereas that with a PLG regime has $F(m^*) > 0$. In addition, $\rho_P - \rho_W < 0$ in the LML regime, whereas $\rho_P - \rho_W > 0$ in the GML regime. Based on the combination of these regimes, an economy with the WLG, LML, or PLG and GML regimes does not satisfy $a_3 > 0$.

Q.E.D.

**Proof of proposition 2.** In an economy with PLG/LML regimes, we have $F(m^*) > 0$ and $\rho_P - \rho_W < 0$. Then, as the signs of both $\omega_1$ and $\omega_2$ are positive, $a_2 > 0$ and $a_3 > 0$ are ensured. Regarding $a_1a_2 - a_3$, we have

$$a_1a_2 - a_3 = \frac{e^*g^*(1-m^*)(1-\tau)(\rho_P - \rho_W)}{(1-\varepsilon_2)\left(sm^*(1-\tau) - \tau\big((1+\gamma)(\theta_C + \theta_I) - 1\big)\right)^2} \cdot \Theta, \qquad (A9)$$

where

$$\Theta \equiv F(m^*)(1-\varepsilon_2) - \left(1 + \frac{(1-m^*)s(1-\tau)(\varepsilon_1+\varepsilon_2)\rho_q}{(1-\varepsilon_2)(sm^*(1-\tau)-\tau(\theta_C+\theta_I-1))}\right)(F(m^*)+\omega_1\varepsilon_1+\omega_2\varepsilon_2)$$

As $\rho_P - \rho_W < 0$ in the LML regime, the sign for $\Theta$ must be negative. Suppose $\Theta$ is negative; then, we have

$$F(m^*)(1-\varepsilon_2) < \left(1 + \frac{(1-m^*)s(1-\tau)(\varepsilon_1+\varepsilon_2)\rho_q}{(1-\varepsilon_2)\big(sm^*(1-\tau)-\tau(\theta_C+\theta_I-1)\big)}\right)(F(m^*)+\omega_1\varepsilon_1+\omega_2\varepsilon_2) \quad (A10)$$

It follows from this inequality that the following condition must be satisfied

$$\frac{(1-m^*)s(1-\tau)(\varepsilon_1+\varepsilon_2)\rho_q}{(1-\varepsilon_2)\big(sm^*(1-\tau)-\tau(\theta_C+\theta_I-1)\big)} > -\left(\frac{F(m^*)\varepsilon_2+\omega_1\varepsilon_1+\omega_2\varepsilon_2}{F(m^*)+\omega_1\varepsilon_1+\omega_2\varepsilon_2}\right) \quad (A11)$$

Because $\omega_1 > 0$, $\omega_2 > 0$, and $F(m^*) > 0$ in the PLG regime, the sign of the RHS is always negative. In contrast, the value of the LHS is always positive, satisfying the above inequality. Hence, $a_1 a_2 - a_3 > 0$ was also ensured under the PLG/LML regimes.

Q.E.D.

**Proof of proposition 3.** It Note that the steady-state values were independent of $\varepsilon_1$. In an economy with WLG/GML regimes, we have $F(m^*) < 0$ and $\rho_P - \rho_W > 0$. It follows from Equation (A6) that we need:

$$F(m^*) + \omega_1\varepsilon_1 + \omega_2\varepsilon_2 < 0 \quad (A12)$$

to ensure $a_2 > 0$. Because $\omega_1\varepsilon_1 + \omega_2\varepsilon_2 > 0$, the absolute value of $F(m^*)$, which we call the degree of being wage-led, must be sufficiently large. In other words, if the degree of wage-led is sufficiently weak and $\omega_1\varepsilon_1 + \omega_2\varepsilon_2 > |F(m^*)|$, we have $a_2 < 0$ and one of the stability conditions is violated.

Conversely, if the degree of being wage-led is sufficiently strong and $\omega_1\varepsilon_1 + \omega_2\varepsilon_2 < |F(m^*)|$, we have $a_2 > 0$ in the following conditions:

$$0 < \varepsilon_1 < \varepsilon_{1D} \equiv -\left(\frac{F(m^*)+\omega_2\varepsilon_2}{\omega_1}\right) \quad (A13)$$

where the sign of $\varepsilon_{1D}$ is positive by a sufficiently strong degree of wage-led.

Meanwhile, because $\rho_P - \rho_W > 0$ in an economy with a GML regime, we need $\Theta > 0$ to satisfy $a_1 a_2 - a_3 > 0$. Thus, the following conditions must be guaranteed:

$$\frac{(1-m^*)s(1-\tau)(\varepsilon_1+\varepsilon_2)\rho_q}{(1-\varepsilon_2)\big(sm^*(1-\tau)-\tau(\theta_C+\theta_I-1)\big)} > -\left(\frac{F(m^*)\varepsilon_2+\omega_1\varepsilon_1+\omega_2\varepsilon_2}{F(m^*)+\omega_1\varepsilon_1+\omega_2\varepsilon_2}\right) \qquad (A14)$$

where the denominator of the RHS is negative for $a_2 > 0$.

Let us consider both sides of inequality (A14) as a function of $\varepsilon_1$, which does not affect the steady-state values of our system, and illustrate them on a plane coordinate in Figure A1 below. Taking the value of $\varepsilon_1$ on the x-axis, the plot of the LHS has a positive slope and intercept. For the RHS of inequality (A14), by differentiating it with respect to $\varepsilon_1$ in a row, we obtain

$$\frac{\partial RHS}{\partial \varepsilon_1} = -\frac{F(m^*)(1-\varepsilon_2)\omega_1}{(F(m^*)+\omega_1\varepsilon_1+\omega_2\varepsilon_2)^2} > 0$$

and

$$\frac{\partial^2 RHS}{\partial \varepsilon_1^2} = \frac{-2F(m^*)(1-\varepsilon_2)\omega_1^2}{(F(m^*)+\omega_1\varepsilon_1+\omega_2\varepsilon_2)^3} > 0$$

Therefore, the plot of the RHS of Inequality (A14) shows an increasing curve, asymptotically approaching the value of $\varepsilon_{1D}$.

Meanwhile, the sign of the numerator in (A14) is not obvious, and we may have:

$$F(m^*)\varepsilon_2+\omega_1\varepsilon_1+\omega_2\varepsilon_2 \gtreqless 0 \qquad (A15)$$

that is,

$$\varepsilon_1 \gtreqless \varepsilon_{1N} \equiv -\left(\frac{F(m^*)+\omega_2}{\omega_1}\right)\varepsilon_2 = -\varepsilon_2 \qquad (A16)$$

where it happens to be $\frac{F(m^*)+\omega_2}{\omega_1} = 1$. Remark the following relationship is confirmed:

$$\varepsilon_{1D} - \varepsilon_{1N} = -\frac{F(m^*)}{\omega_1}(1-\varepsilon_2) > 0, \qquad (A17)$$

and we always have $\varepsilon_{1D} > \varepsilon_{1N}$ in the WLG regime. Clearly, the value of both sides in Equation (A14) is zero when $\varepsilon_1 = \varepsilon_{1N} = -\varepsilon_2$ holds. Observing them together, we can find a unique value of $\varepsilon_1^* > 0$ between $0$ and $\varepsilon_{1D}$ guarantees that the value of LHS is equal to that of RHS, realising

$a_1 a_2 - a_3 = 0$. These arguments are illustrated graphically in Figure A1.

Thus, the following properties emerge according to the value of $\varepsilon_1$: for $0 < \varepsilon_1 < \varepsilon_1^*$, the value of LHS is larger than that of RHS in Inequality (A14), and we have $a_1 a_2 - a_3 > 0$. However, if $\varepsilon_1^* < \varepsilon_1 < \varepsilon_{1D}$ we have $a_1 a_2 - a_3 < 0$. Accordingly, there also exists a unique value of $0 < \varepsilon_1^* < \varepsilon_{1D}$, on which $a_1 a_2 - a_3 = 0$ is established. Thus, a limit cycle occurs by Hopf bifurcation for $\varepsilon_1$ sufficiently close to $\varepsilon_1^*$ for the combination of WLG/GML regimes.

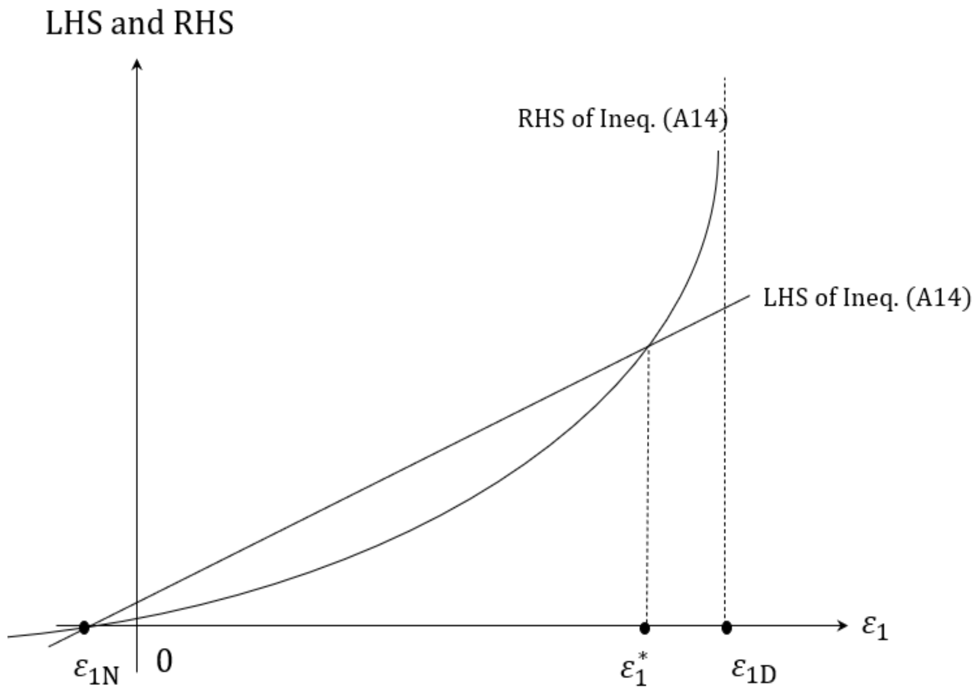


**Fig. A1.** Parameter configuration for stability condition $a_1 a_2 - a_3$.

If $0 < \varepsilon_1 < \varepsilon_1^*$, then both $a_2 > 0$ and $a_1 a_2 - a_3 > 0$ are guaranteed. If $\varepsilon_1^* < \varepsilon_1$, then both $a_1 a_2 - a_3 > 0$ are violated. Moreover, if $\varepsilon_{1D} < \varepsilon_1$, then $a_2 > 0$ is violated.

Q.E.D.

**Proof of proposition 4.**

The dynamics of the debt ratio is

$$\dot{\delta} = (\theta_C + \theta_I - 1)\tau u^* + i\delta - (\hat{p}^* + g^*)\delta \qquad (A18)$$

where the rates of capacity utilisation rate, inflation, and output growth as the fast variables will all follow the long-run steady-state values given by Equations (36), (37), and (38), respectively. By substituting them into Equation (35), we obtain

$$\dot{\delta} = \frac{(\theta_C + \theta_I - 1)\tau(\alpha + \beta(1-\tau)m^*)}{sm^*(1-\tau) - \tau((1+\gamma)(\theta_C + \theta_I) - 1)} + i\delta - \left(n + \frac{\mu_1(1-\nu_2)}{\mu_1(1-\nu_2) - \mu_2(1-\nu_1)}\left(\frac{\varepsilon_0}{1-\varepsilon_2}\right)\right)\delta \quad (A19)$$

It has the following unique steady-state value $\delta^*$ shown by Equation (40). The steady-state of the government's debt ratio is locally and asymptotically stable if

$$\frac{d\dot{\delta}}{d\delta} < 0 \quad (A20)$$

is ensured at the steady state. Hence, we have

$$i < n + \frac{\mu_1(1-\nu_2)}{\mu_1(1-\nu_2) - \mu_2(1-\nu_1)}\left(\frac{\varepsilon_0}{1-\varepsilon_2}\right), \quad (A21)$$

which is equivalent to

$$i < \hat{p}^* + g^* \quad (A22)$$

This shows that the nominal economic growth rate is higher than the nominal interest rate or that the economic growth rate is higher than the real interest rate.

Q.E.D.

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