The Macroeconomic Effects of Financialization and the Wage Gap between Blue and White Collar Workers

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28 June 2020

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June 28, 2020

Abstract

In a post-Keynesian growth model with two types of workers (blue and white-collar workers) an attempt is taken to understand changes in financial behaviour and income distribution and their macroeconomic causes and consequences. For a relatively strong speed of adjustment in the financial market and a relatively weak reserve army effect, a stable steady state is achieved in the wage-led demand regime. Unlike Sasaki et. al. (2013), an endogenous and perpetual business cycles may emerge even in the wage-led demand regime. For a relatively strong reserve army effect, a contraction in the wage gap between white and blue-collar employments can make the steady state unstable. On the contrary, in a profit-led demand regime, a rise in the wage gap can destabilize the economy. A rise in the saving propensity of rentiers (and capitalist) is detrimental to aggregate demand and worsens the income distribution. A more regulated labour market and a rise in unionization are desirable as these can mitigate the income inequality.

Keywords: *Financialization, Blue and white-collar workers, Wage gap, Post-Keynesian growth model, Limit cycles*

JEL codes: *E12, E25, E32, E44, J31*

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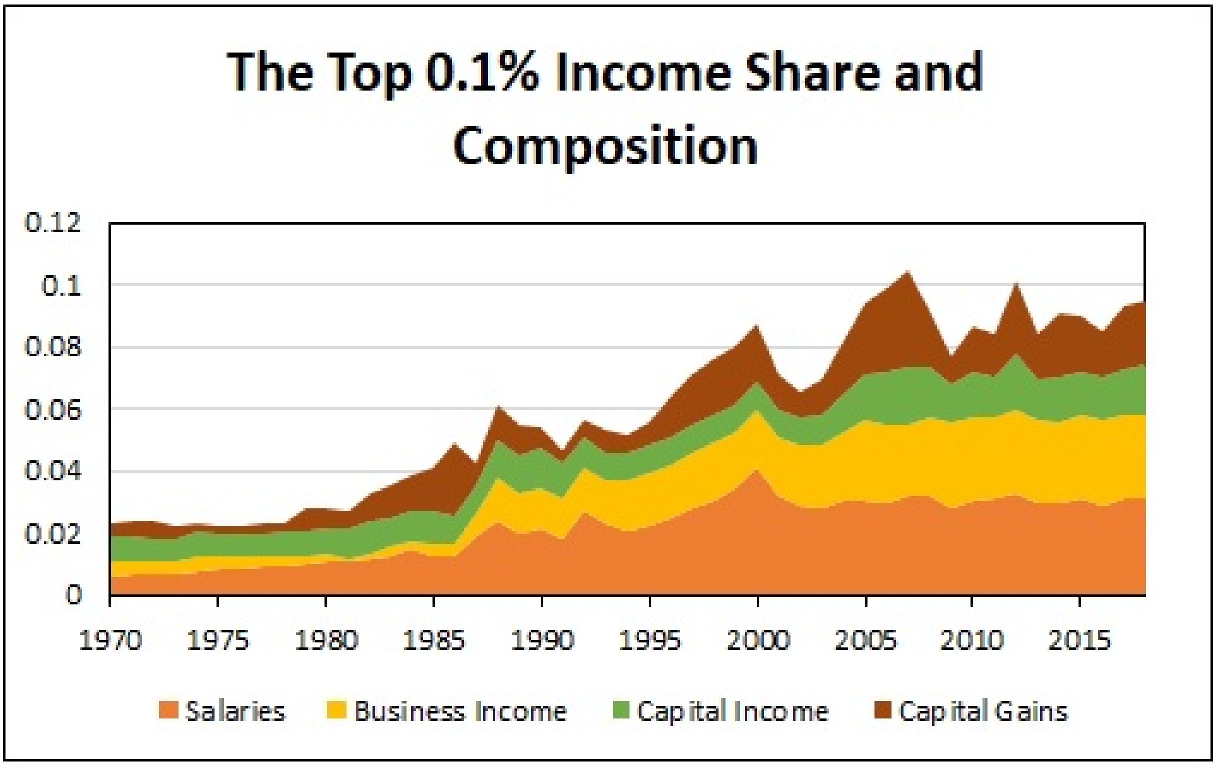
1 Introduction

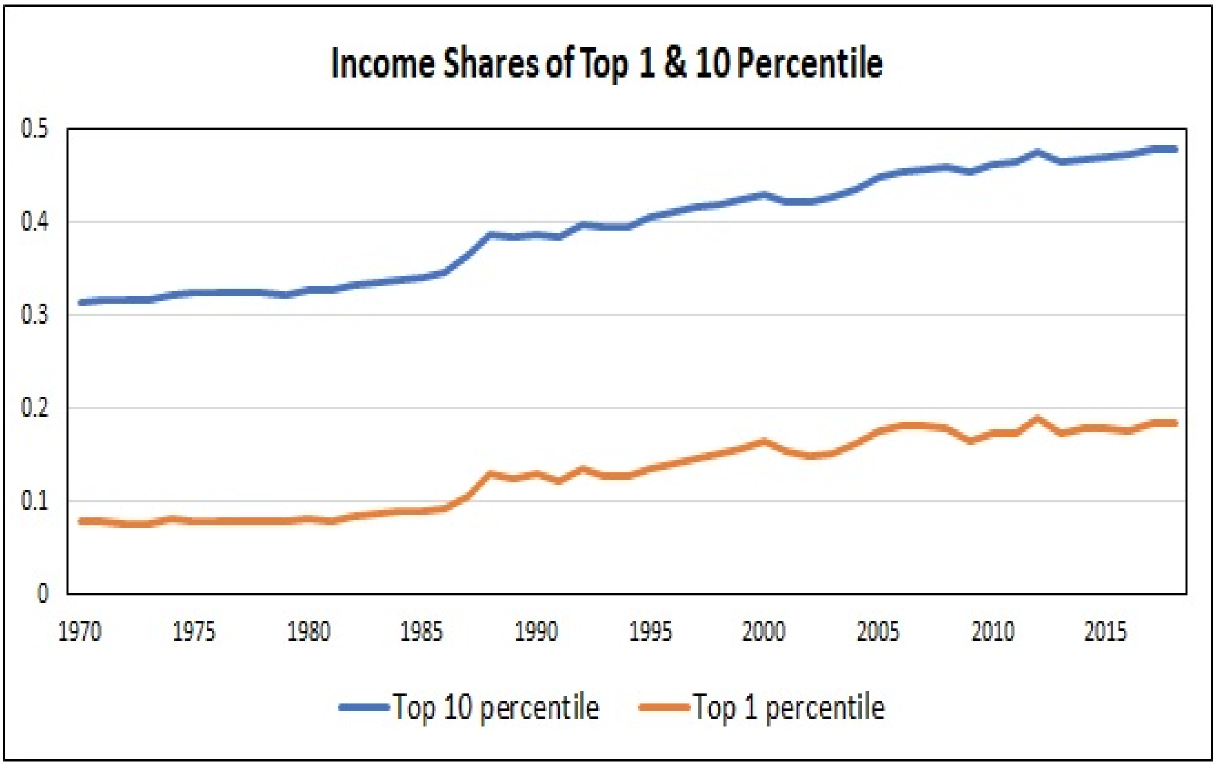
One can observe that since the 1980s there has been a huge deterioration in the functional income distribution in the US economy. The real wage rate increased at a lower rate than labour productivity for the last four decades (Setterfield; 2013, pp. 163). From 67.26% in 1961-73, labour income share declined to 63.66% in 2001-08 (Hein; 2014, pp. 14). The Gini coefficient (before tax) for the US has increased from 0.37 in mid-1970s to 0.46 in mid-2000s (Hein; 2012, pp. 14). Increase in salaries, business income, and capital gains are the main drivers of the rise in the income share of the top 1 percent in the US whereas the share of capital income remains roughly constant (see Figure 1.1). The top 1 percent in the US is comprised of top-level managers, including CEOs of corporations, and financial executives and others such as lawyers, accountants, and middle-high level managers who are professionally tied to them (Dutt; 2016, pp. 365). The ratio between average CEO compensation and average worker wage has risen from 40:1 to 240:1 between 1980 and 2008 with a peak of nearly 300:1 in 2000 (Tavani and Vasudevan; 2014, pp. 121).



Source: Piketty and Saez (2003); author's presentation.

Figure 1.1: The top 0.1 percentile income share and its composition in the United States, 1970-2018.

Figure 1.2 illustrates the pattern of the income share of the top 1 and top 10 percentiles in the United States between 1970 and 2018. There is an upward trend for both the top 1 and the top 10 percentiles' income share. Starting from 0.315 in 1970, the income share



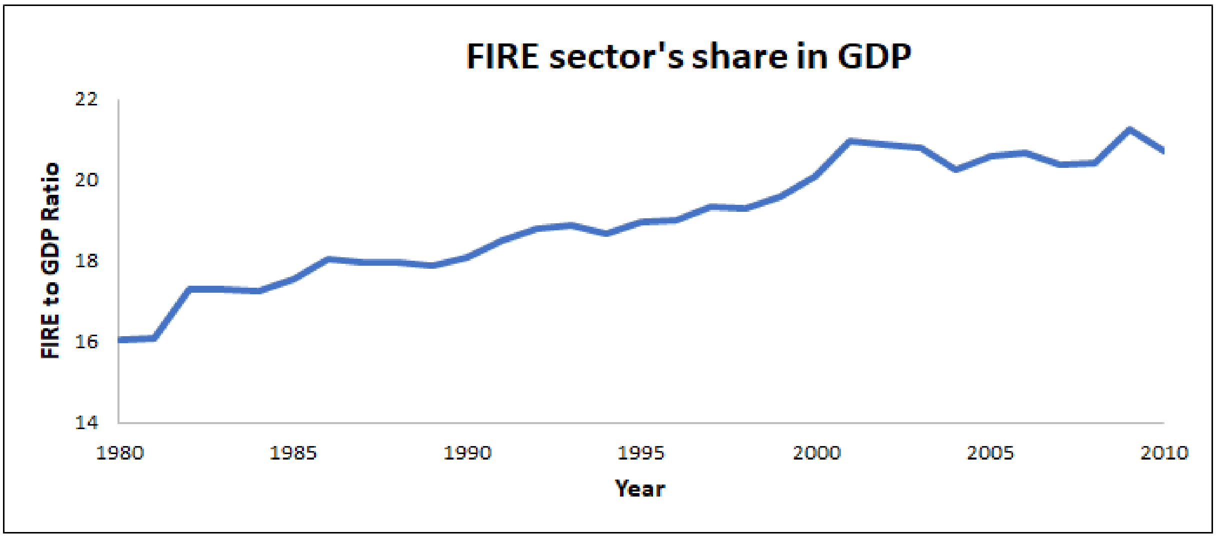
Source: Piketty and Saez (2003); author's presentation.

Figure 1.2: Income Shares (excluding capital gains) of the top 1 and top 10 percentiles in the United States, 1970–2018.

of the top 10 percentile raised to 0.417 in 2007. If the capital gain is included, the income share of the top 10 percentile was 0.326 in 1970 and raised to 0.497 in 2007. On the other hand, the growth rate of the income share of the top 1 percentile is even higher for the same period. The income share of the top 1 percentile (including the capital gain) was 0.090 in 1970 and raised to a peak of 0.228 in 2007 (Piketty and Saez; 2003).

For the period of 1973 to 2007, the total credit market debt to GDP ratio for the US economy has risen from 157.2% to 362.6%. There has been a faster financial sector debt compared to the non-financial sector's and as a consequence financial sector's debt to GDP ratio has risen making the non-financial sector's share to fall (Palley; 2013, pp. 22). A significant emphasis has been given to the finance, insurance, and real estate (FIRE) sector for the last four decades. Contribution of the FIRE sector to GDP has risen from 16.02 percent to 20.37 percent between 1980 and 2007 with a peak of 20.95 in 2001 (see Figure 1.3). Starting with the 1980s there was a sharp rise in the net financial wealth to GDP ratio till 2000 and thereafter a sharp rise in the gross housing wealth to GDP ratio (Onaran et. al.; 2011, pp. 640).

The relationship among aggregate demand (and hence capacity utilization), income distribution, and financialization in the context of two types of workers (blue and white-collar workers) is the main focus of this paper. Therefore, we first focus on the empirically



Source: Economic Report of the President, February 2012, table B-12; author's calculations.

Figure 1.3: FIRE sector's share in GDP (1980-2010)

observed relationship among them. Figures 1.4 shows the counter-clockwise cycles between annual observations of the share of wages (vertical axis) and capacity utilization rate (horizontal axis) from 1980 to 2019. Figure 1.5 presents the clockwise cycles between rentiers' share in income[1] (vertical axis) and the share of wages (horizontal axis). Figure 1.6 demonstrates the cycles between rentiers' share in income (vertical axis) and the rate of capacity utilization (horizontal axis). Here the pattern is somewhat unclear. For some periods we get a clockwise pattern and for some period the counter-clockwise.

Post-Keynesian/ Kaleckian literature usually considers two classes: the capitalist class and the working class and deals with the functional income distribution. Sasaki et. al. (2013) are among a few exceptions. Introducing two types of labour (regular and non-regular employment)[2] in a Kaleckian model, Sasaki et. al. (2013) explain how the expansion of the wage gap between regular and non-regular employment affects the economy. The real wage rate of regular workers, as they assume, is higher than that of non-regular workers. The dynamics of the wage determination mechanism of regular workers are specified explicitly and the wages of non-regular workers are then determined as an exogenous fraction of the real wage rate of regular workers. In the case of a wage-led demand regime, the stability of the steady state is unaffected by the change in the

[1]It is worth noting that the rentiers' share in income (which in turn is equal to the ratio of net dividends and net interest income to the national income) can be used as a proxy for the financialization. For example, according to Hein (2012, pp. 2) financialization on the one hand has been beneficial to a rise in gross profit share which includes retained profits, dividends, and interest payments, and on the other hand to a fall in labour income share. It (financialization) leads to a rise in inequality of wages and top management salaries as well.

[2]Sasaki et. al. (2013) consider fixed and variable labour as regular and non-regular employment respectively.

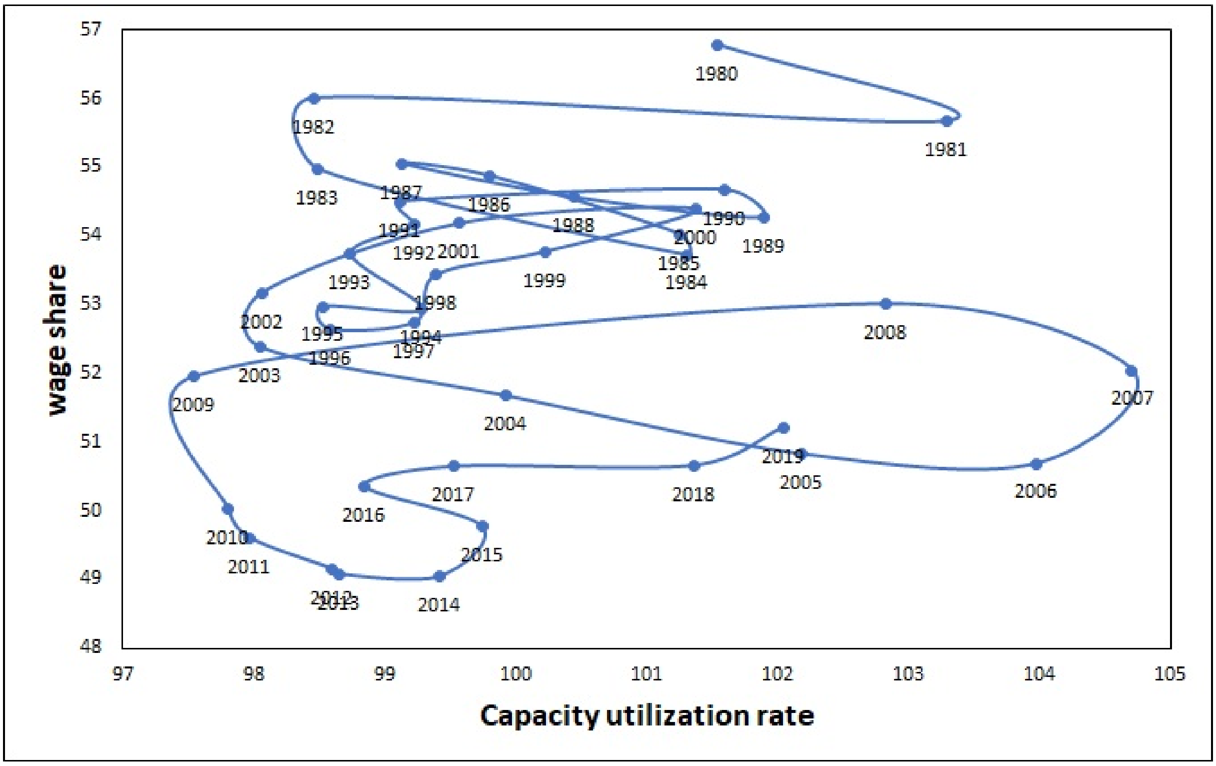


Figure 1.4: Capacity utilization rate and wage share cycles in the US Economy, 1980–2019. Wage share = (wages and salaries / national income)*100; capacity utilization rate = (GDP / potential GDP); potential GDP = Hodrick–Prescott trend of annual GDP, obtained with a smoothing parameter of 100. Source: Computed using US Bureau of Economic Analysis' NIPA Tables 1.1.5. and 1.12 at http://www. bea.gov

wage gap. However, the stability depends negatively on the size of the reserve army effect.[3] When the economy is in a profit-led demand regime, a rise in the wage gap can lead to instability in the economy. For a particular value of the wage gap, endogenous and perpetual business cycles may emerge. The introduction of the minimum wage is desirable as it can mitigate fluctuations of business cycles.

Sonoda and Sasaki (2019) construct a Kaleckian model in which there are institutional differences in employment adjustment and wage determination between regular workers and non-regular workers and investigate how labour market institutions affect the dynamics of income distribution and output. In their model, regular workers carry out collective wage bargaining to secure employment. As the employment adjustment of regular workers is difficult, firms attempt to adjust working hours by reducing the amount of overtime work. However, as firms are unable to reduce labour inputs proportionately, labour productivity of regular workers decreases in a slump but rises in a boom. As the priority of regular workers is to secure employment, regular workers may accept wage cuts during a recession. The real wage rate of the non-regular workers varies positively

[3]By "reserve army effect" they capture the notion that the growth rate of the wage is increasing in the rate of employment.

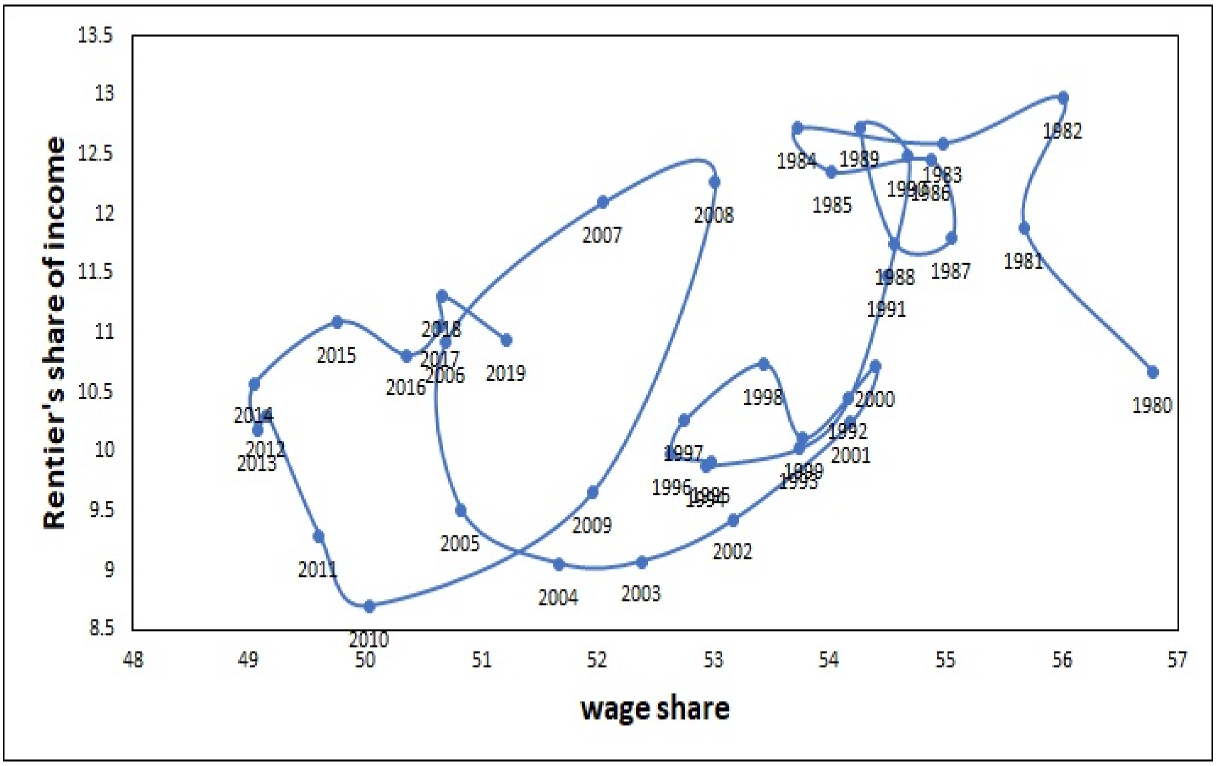


Figure 1.5: Share of wages and rentiers' income share cycles in the US Economy, 1980–2019. Rentiers' share in income = (Net dividends and Net interest income / national income)*100. Source: BEA' NIPA Tables 1.1.5. and 1.12; authors calculation.

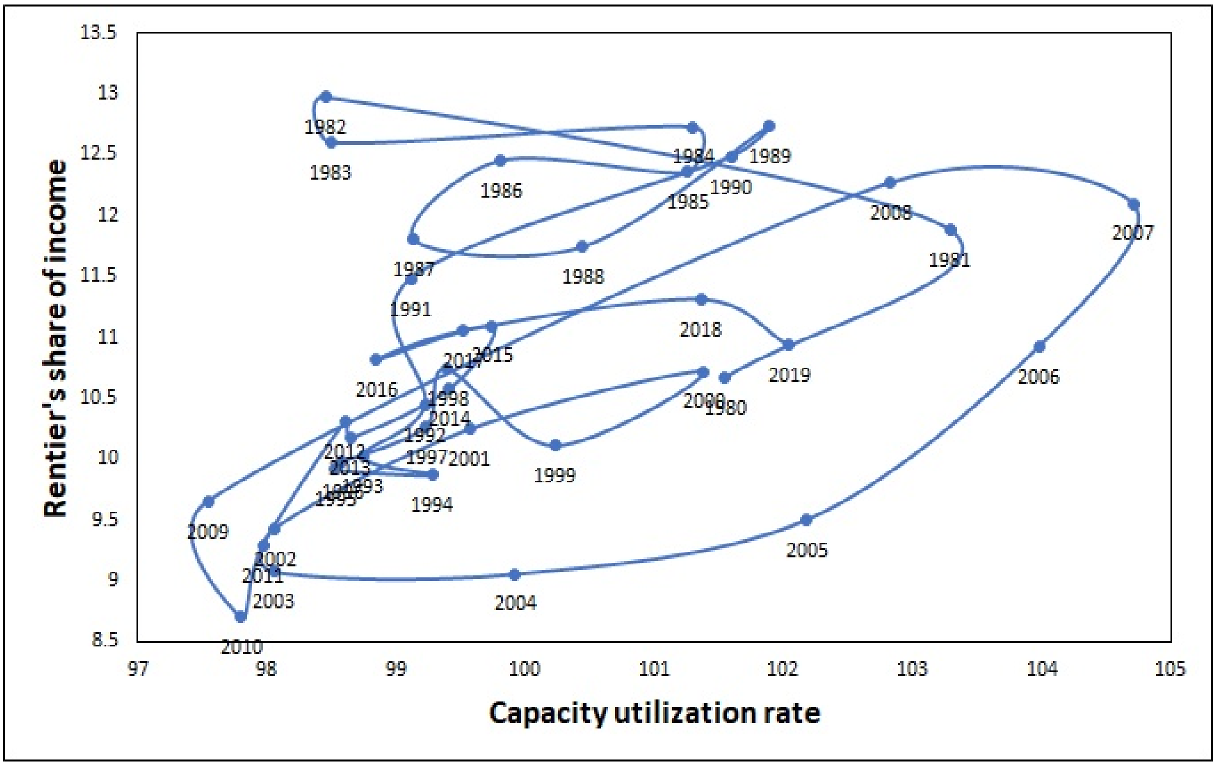


Figure 1.6: Capacity utilization rate and rentiers' income share cycles in the US Economy, 1980–2019. Source: BEA' NIPA Tables 1.1.5. and 1.12; authors calculation.

with the state of the economy. During the boom, as the labour market tightens, their real wage rate increases. On the contrary, the wage rate falls during the recession. If labour unions are concerned only on the interests of regular workers, the fruits of wage bargaining of regular workers and hence the labour unions do not influence the real wage of non-regular workers. On the other hand, if labour union consists of a large number of non-regular workers as well, the real wage rate of regular workers positively may affect the real wage of non-regular workers. If the position of non-regular workers is very weak, for a rise in the real wage rate of regular workers, firms restore the decrease in profits by lowering the real wage rate of non-regular workers. Hence, the rise in the real wage rate of regular workers here happens at the cost of the wage rate of non-regular workers. Therefore, three wage bargaining regimes are possible: regular non-regular independent regime, regular non-regular cooperative regime, and the regular non-regular conflict regime.

Besides workers and capitalists, by introducing a managerial class in a Kaleckian model, Tavani and Vasudevan (2014) analyze the implications of a managerial class for the dynamics of demand and distribution. Managers organize production, supervise workers, and extract the productivity gains from workers. The wage gap dynamics between managers and workers is negatively influenced by the rate of capacity utilization. A rise in the rate of capacity utilization tightens the labour markets and hence dampens the pace of growth of inequality. As managers are more powerful than workers, wage inequality has positive feedback onto itself. Hence, a rise in wage inequality exacerbates the pace of the growth of inequality. However, their model lacks the consideration of financialization dynamics which especially in the context of the US economy plays a crucial role in shaping the economy.

None of the above-discussed literature, however, considers the financial behaviour.[4] In the context of the US economy, considering two types of workers (blue and white-collar) an attempt is taken in this paper for understanding changes in financial behaviour and income distribution and their macroeconomic causes and consequences. Along with the aggregate demand (or the rate of capacity utilization) and the profit share, financialization also influences firms' investment decisions in our model. It (financialization) also affects income distribution. In our model, while firms set their price to narrow the gap between firms' target profit share and the actual profit share, labour unions negotiate to narrow the gap between the labour unions' target profit share and the actual profit share. Following Sasaki et. al. (2013), we assume that the labour unions' target profit share is negatively affected by the rate of capacity utilization. A higher rate of capacity

[4] Introducing endogenous income distribution in a Kaleckian model with profit-sharing, Sasaki (2016) investigates the effect of profit-sharing in the economy. Sasaki (2016) too introduces two types of labour and considers the wage gap between those two types of labour in his analysis. Lavoie (2009), Dutt (2012, 2016), Dutt et. al. (2015), Palley (2015, 2017) are among others who have divided the labour class into two types by introducing the managerial/ supervisory workers.

utilization tightens the labour market and improves workers' demands in bargaining and thus leads workers to set a higher target wage share and hence a lower target profit share. On the other hand, firms' target profit share is an increasing function of the level of financialization. A detailed discussion for this is provided in Section 2. Increasing inequality raises the propensity to speculate by the reniters and consequently the financialization level increases. Unlike Sasaki et. al. (2013), an endogenous and perpetual business cycles may emerge even in the wage-led demand regime. For a strong reserve army effect, a contraction in the wage gap between white and blue-collar employments can make the steady state unstable. On the contrary, in a profit-led demand regime, a rise in the wage gap can destabilize the economy. A rise in the saving propensity of rentiers (and capitalists) is detrimental to aggregate demand, worsens the income distribution, and escalates the financialization level. A more regulated labour market and a rise in unionization are desirable as these can mitigate income inequality.

The remainder of the paper is organized as follows. Section 2 outlines the structure of the model and derives the fundamental equations for the analysis. Section 3 analyses the steady state of the dynamical system, shows that limit cycles can occur and conducts some comparative statics analysis. Section 4 presents the existence of limit cycles through the use of numerical simulations. Section 5 offers some concluding remarks.

2 The model

We assume a simple one-sector, closed economy, neo-Kaleckian growth model in which the economy consists of two types of workers (white-collar and blue-collar), capitalists, and rentiers. Neither government intervention nor technical progress is there, and there is no depreciation of capital stock. Income is distributed between wages and profits as

$$Y = W + R \tag{2.1}$$

where, Y is nominal income, W is nominal wage income and R is nominal profit income. Workers have only one source of income- wages, and they spend all the wages on consumption. On the other hand, capitalists get the entire profit, a part of which is retained by the capitalists (R_C) and the rest is distributed as dividends (paid on equity held by rentiers (R_{Div})) and as interest payment (paid on debt to the rentiers (R_{Int})). Thus total distributed profit (R_R) consists of dividends and the interest payments to the rentiers. This argument is captured in the next equation as

$$R = R_C + R_{Int} + R_{Div} = R_C + R_R \tag{2.2}$$

Dividing both sides of the above equation with respect to the nominal value of capital stock we get the rate of profit as a summation of capitalists' profit rate (r_C) and rentiers' profit rate (r_R) i.e.

$$r = r_C + r_R \tag{2.3}$$

We assume that both the capitalists and rentiers consume a part of their earnings and save the rest. For simplicity, let's assume capitalists and rentiers have the same savings rate s.[5] Hence the saving function for the entire economy can be represented as

$$S = sR_C + sR_R = s(R_C + R_R) = sR$$

$$\implies \frac{S}{K} = g_s = s\frac{R}{K} = sr = smu, \quad s \in (0,1) \tag{2.4}$$

where r represents the rate of profit, m represents the profit share and u represents the capacity utilization rate.

Let us assume that the white-collar employment L_w is related to the potential output, while the blue-collar employment L_b is related to the actual output.

$$L_w = \alpha Y^F, \quad \alpha > 0 \tag{2.5}$$

$$L_b = \beta Y, \quad \beta > 0 \tag{2.6}$$

where α and β are positive constants. Following Sasaki et. al. (2013) we assume that the white-collar employees are not hired and fired frequently even if output fluctuates. Rather, white-collar employment changes when scale of plants changes, and scale of plants changes when the potential output changes. As a result, white-collar employment, rather that actual output, depends on the potential output. On the contrary, we assume blue-collar employment depends on actual output and very frequently is fired or hired depending on output fluctuations. We assume that the ratio of the potential output to the capital stock ($\frac{Y^F}{K}$) is fixed. Without any loss of generality, if we assume that the ratio of the potential output to the capital stock is equal to unity i.e. if $\frac{Y^F}{K} = 1$ then the capacity utilization rate can be represented as the ratio of actual output to capital stock i.e. $u = \frac{Y}{K}$.[6] For rest of the paper we assume $\frac{Y^F}{K} = 1$. The ratio of the white-collar employment to the blue-collar employment is $\frac{L_w}{L_b} = \frac{\alpha}{\beta u}$. Higher the capacity utilization rate, higher is the blue-collar workers employed and hence lower is the ratio of white to blue-collar employment. As long as α and β are constants, an equilibrium degree of capacity utilization determines the equilibrium ratio of white to blue-collar employment. $\frac{\beta}{\alpha}$ is the ratio at full capacity of the blue-collar to white-collar workers.

[5] Thus effectively the retained profit of fimrs/capitalists is then sR_c which they use for investment purposes.

[6] Capacity utilization rate $= u = \frac{Y}{Y^F} = \frac{Y}{K}.\frac{K}{Y^F} = \frac{Y}{K}$, as we assume $\frac{Y^F}{K} = 1$.

In line with Bhaduri and Marglin (1990), Marglin and Bhaduri (1990), and Sasaki et. al. (2013), we assume that the firms' investment function is an increasing function of the capacity utilization rate u and the profit share m. However, we also assume that the firms' investment function is a decreasing function of the financialization level Ω.

To make the model as simple as possible following Dumenil and Levy (2004), we define the concept of financialization as the growth of financial enterprises, the increasing involvement of non-financial enterprises in financial operations, the holding of large portfolios of shares and other securities by households and so on. We also assume that financialization is associated with the notion of 'shareholder value orientation'.[7] Regarding the effects of financialization on investment behaviour, the increased role of shareholders in the firm and the 'owner-manager conflict' is highlighted by some authors (Crotty, 1990; Boyer, 2000; Stockhammer, 2004, 2006; Dallery, 2009). Because of financialization, as Stockhammer and Grafl (2010) point out, firms also face a higher degree of uncertainty, which may make physical investment projects less attractive. Financialization causes higher dividends or interest payments that have a negative effect on investment (Hein (2006, 2007, 2008a, 2008b), Lavoie (1995, 2008), Lavoie and Godley (2002), van Treeck (2009a, 2009b), Skott and Ryoo (2008)). According to Hein (2012), increasing shareholder power vis-à-vis management and workers impose short-termism on management and cause a fall in managements' animal spirits with respect to real investment in capital stock and long-run growth of the firm (preference channel). On the other hand, shareholders put pressure on firms for higher distribution of profits. As a consequence, there is a higher dividend payout ratio and hence a lower retention ratio. Also, a lower contribution of new equity issues to the financing of investment, or even share buybacks is possible now. All of these drain internal means of finance for real investment purposes (internal means of finance channel). Each of these 'preference' and 'internal means of finance' channels poses a negative effect on firms' real investment in capital-stock and hence the long-run growth of the economy. Orhangazi(2008) discusses the impact of financialization on real capital accumulation in the US economy using firm-level data from 1973 to 2003 and finds a negative relationship between real investment and financialization. Two channels are there for explaining this negative relationship: first, a rise in financial investment and financial profit opportunities by changing the incentives of firm managers and directing funds away from the real investment may crowd out real investment. Second, by decreas-

[7] According to Lazonick and O'Sullivan (2000; pp. 13), there is a transformation of US corporate strategy from retaining the profit and reinvesting it for growth purposes to downsizing the labour forces and distributing the corporate earnings to shareholders. The notion of 'shareholder value orientation' captures this very change in the objective of firm management. For more on 'shareholder value' see Froud et. al. (2000) as well. Note that the notion of financialization adopted here is similar to Parui (2020). In the context of the US economy, Parui (2020) focuses on how technological change and financialization evolves and how the interaction between the dynamics of technological change and financialization leads to fragility and instability in the economy.

ing available internal funds, shortening the planning horizons of the firm management, and increasing uncertainty, increased payments to the financial markets may reduce the real investment. All of the above arguments are taken into account for explaining the investment demand by assuming that firms' investment demand is a decreasing function of financialization level Ω. Thus the ratio of the real investment I to the capital stock can be denoted as,

$$\frac{I}{K} = g_d = g_d(u, m, \Omega), \quad g_{du} > 0, g_{dm} > 0, g_{d\Omega} < 0, \tag{2.7}$$

where g_{du} represents the partial derivative of investment function with respect to the rate of capacity utilization, g_{dm} denotes the partial derivative of investment w.r.t. profit share and $g_{d\Omega}$ represents the partial derivative of investment w.r.t. financialization level. We assume that capacity utilization rate changes in accordance with the difference between investment and savings i.e.

$$\dot{u} = \phi(g_d - g_s), \quad \phi > 0 \tag{2.8}$$

where the parameter ϕ denotes the speed of adjustment in the goods market.

Now let us focus on the average labour productivity. Average labour productivity can be expressed as

$$a = \frac{Y}{L} = \frac{Y}{L_w + L_b} = \frac{Y}{\alpha Y^F + \beta Y} = \frac{u}{\alpha + \beta u} \tag{2.9}$$

Note that from equation (2.9) it is clear that the average labour productivity (a) is an increasing function of the capacity utilization rate. In the steady state as u is constant, the corresponding average labour productivity is constant too. Nominal wage rate of the white-collar labour (w_w), we assume, is higher than the blue-collar labour (w_b). We also assume

$$w_w = \gamma w_b, \quad \gamma > 1 \tag{2.10}$$

So the average wage of the economy is

$$w = \frac{w_w L_w + w_b L_b}{L} = \left[\frac{\gamma\alpha + \beta u}{\alpha + \beta u}\right] w_b = \Gamma(u).w_b, \quad \Gamma(u) = \frac{\gamma\alpha + \beta u}{\alpha + \beta u} \tag{2.11}$$

Now we focus on the dynamics of profit share. We assume that firms set their price to narrow the gap between firms' target profit share (m_f) and the actual profit share (m), and accordingly, the price changes. Labour unions negotiate so as to narrow the gap between the labour unions' target profit share (m_w) and the actual profit share, and accordingly, the nominal blue-collar employment wage changes. The two assumptions can be mathematically expressed as follows:

$$\frac{\dot{p}}{p} = \theta(m_f - m), \quad m_f \in (0, 1), \ \theta \in (0, 1) \tag{2.12}$$

$$\frac{\dot{w}_b}{w_b} = (1-\theta)(m - m_w), \quad m_w \in (0,1) \tag{2.13}$$

Here, θ and $(1-\theta)$ represents the bargaining power of the firms and the labour unions respectively.

According to Hein (2012, pp. 2), financialization has been favourable to a rising gross profit share (which includes retained profits, dividends, and interest payments) and adverse to a rise in labour income share. It (financialization) is also conducive to rising inequality of wages and top management salaries. Falling bargaining power of trade unions, increasing profit claims forced particularly by increasingly powerful rentiers, and a change in the sectoral composition of the economy in favour of the financial corporate sector, as Hein (2012, pp. 2) points out, are the major reasons behind this. Therefore we can safely assume that firms' target profit share (m_f) is an increasing function of financialization i.e.

$$m_f = m_f(\Omega), \quad m_{f\Omega} > 0. \tag{2.14}$$

$m_{f\Omega}$ represents the partial derivative of firms' target profit share with respect to the financialization level. We assume that the white-collar labours do not directly participate in the bargaining process between workers and firms. This is because their reward based on short-run performance-related pay schemes, bonuses, stock option programs, etc. on the one hand incentivize them to be in alignment with the interest of shareholders.[8] On the other hand, as white-collar workers get a fixed proportion of more wages than blue-collar workers, a higher wage rate to the blue-collar workers is beneficial for the white-collar workers too. These two together may lead them to be passive in the bargaining process. Moreover, more financialized the economy is, stronger is the "capitalists-rentiers-managements nexus" and so higher will be the inequality of wages between white-collar workers (managers) and blue-collar workers.

Following Sasaki et. al. (2013), considering the reserve army effect, we assume that m_w is negatively affected by the rate of capacity utilization. For a given capital stock, a higher rate of capacity utilization is associated with a higher level of output which in turn is associated with a higher level of blue-collar employment. So for a fixed level of blue-collar labour supply, there is a one-to-one relation between degree of capacity utilization and the employment rate. Thus, as u rises, workers' demands in bargaining rise, and this leads workers to set a higher target wage share and hence a lower target profit share.[9] Thus,

$$m_w = m_w(u), \quad m_{wu} < 0. \tag{2.15}$$

[8] Hein (2012, pp. 2).

[9] One can argue that a higher rate of capacity utilization can be associated with the bargaining power of labour unions vis-à-vis firms. Although this may be true, for simplicity we assume away this possibility. Rather, we assume that the bargaining power of labour unions vis-à-vis firms depends on some institutional features such as labour law.

m_{wu} represents the partial derivative of m_w w.r.t. capacity utilization rate. We know the wage share $=\frac{wL}{pY}=1-m$. Differentiating both side and rearranging it we get,

$$\frac{\dot{m}}{1-m}=\frac{\dot{p}}{p}+\frac{\dot{a}}{a}-\frac{\dot{w}}{w} \tag{2.16}$$

Using equations (2.11), (2.13), and (2.15), rate of change of average wage rate is given as

$$\frac{\dot{w}}{w}=\frac{\dot{w}_b}{w_b}-\frac{(\gamma-1)\alpha\beta\dot{u}}{(\gamma\alpha+\beta u)(\alpha+\beta u)} \tag{2.17}$$

$$\implies \frac{\dot{w}}{w}=(1-\theta)[m-m_w(u)]-\frac{(\gamma-1)\alpha\beta\dot{u}}{(\gamma\alpha+\beta u)(\alpha+\beta u)} \tag{2.18}$$

From equation (2.9), the rate of change of average labour productivity is expressed as,

$$\frac{\dot{a}}{a}=\frac{\alpha\dot{u}}{(\alpha+\beta u)u} \tag{2.19}$$

Stockhammer (2015) points out that increasing inequality (in particular the growth of small group of super-rich individuals) has raised the propensity to speculate. This occurs because as income rises, the consumption possibilities get exhausted and speculative use of wealth increases. So higher inequality (here the profit share m is used to represent the inequality) leads to more engagement in speculation by the reniters and as a result more is the financialization process. However an increase in the financialization level has a self limiting effect i.e. a rise in the financialization level *ceteris paribus* reduces its rate of increase in future. The following equation captures this argument.

$$\dot{\Omega}=\mu\left[h(m)-\Omega\right],\ h_m>0,\ \mu>0 \tag{2.20}$$

where Ω represents the level of financialization and μ represents the speed of adjustment of the financial market. Let us assume that there is a level of financialization ($h(m)$) at which the economy would settle in the equilibrium. The level of financialization varies according to the difference between $h(m)$ and the actual level of financialization, Ω. *Ceteris paribus*, whenever $h(m)$ is above the actual level, the actual level rises and vice versa. h_m, partial derivative of h w.r.t. m, represents the speculation propensity of the group of super-rich (mainly rentiers in our model) due to a change in profit share.

By substituting equations (2.4) and (2.7) in equation (2.8); and also equations (2.12), (2.14), (2.18) and (2.19) in (2.16); and from equation (2.20) we can obtain the following dynamic equations with respect to the capacity utilization rate, the profit share and the level of financialization.

$$\dot{u}=\phi\left[g_d(u,m,\Omega)-smu\right],\ \ \phi>0 \tag{2.21}$$

$$\dot{m} = -(1-m)\left[m - \theta m_f(\Omega) - (1-\theta)m_w(u) - f(u,\gamma).\dot{u}\right] \tag{2.22}$$

$$\dot{\Omega} = \mu\left[h(m) - \Omega\right] \tag{2.23}$$

where $f(u,\gamma) = \frac{\alpha\gamma}{(\gamma\alpha+\beta u)u}$, $f_u(u,\gamma) < 0$ and $f_\gamma(u,\gamma) = \frac{\alpha\beta}{(\alpha\gamma+\beta u)^2} > 0$.

3 Steady state analysis

In the steady state $\dot{u} = \dot{m} = \dot{\Omega} = 0$. From equations (2.21), (2.22), and (2.23) we get simultaneous equations with respect to u^*, m^* and Ω^* as

$$g_d(u^*, m^*, \Omega^*) = sm^*u^* \tag{3.1}$$

$$m^* = \theta m_f(\Omega^*) + (1-\theta)m_w(u^*) \tag{3.2}$$

$$\Omega^* = h(m^*). \tag{3.3}$$

We assume that there exists a unique set of $u^* \in (0,1)$, $m^* \in (0,1)$, and $\Omega^* > 0$ that simultaneously satisfies equations (3.1), (3.2) and (3.3). The equilibrium capacity utilization rate, profit share and the equilibrium level of financialization depend on the bargaining power, the target profit share of firms, and the target profit share of labour unions. However, the steady state does not depend on the parameters, ϕ, γ, α and β.

To analyze the local stability of the long-run equilibrium, we linearize the system of differential equations (2.21), (2.22), and (2.23) around the equilibrium and get

$$\begin{pmatrix} \dot{u} \\ \dot{m} \\ \dot{\Omega} \end{pmatrix} = \begin{pmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ 0 & J_{32} & J_{33} \end{pmatrix} \begin{pmatrix} u - u^* \\ m - m^* \\ \Omega - \Omega^* \end{pmatrix} \tag{3.4}$$

where the elements of the Jacobian matrix $\boldsymbol{J}$ are given by

$$J_{11} = \frac{\partial \dot{u}}{\partial u} = \phi\left[g_{du} - sm\right] \tag{3.5}$$

$$J_{12} = \frac{\partial \dot{u}}{\partial m} = \phi\left[g_{dm} - su\right] \tag{3.6}$$

$$J_{13} = \frac{\partial \dot{u}}{\partial \Omega} = \phi g_{d\Omega} < 0 \tag{3.7}$$

$$J_{21} = \frac{\partial \dot{m}}{\partial u} = (1-m)\left[(1-\theta)m_{wu} + f(u,\gamma)J_{11}\right] \tag{3.8}$$

$$J_{22} = \frac{\partial \dot{m}}{\partial m} = -(1-m)\left[1 - f(u,\gamma)J_{12}\right] \tag{3.9}$$

$$J_{23} = \frac{\partial \dot{m}}{\partial \Omega} = (1 - m)\left[\theta m_{f\Omega} + f(u, \gamma) J_{13}\right] \tag{3.10}$$

$$J_{31} = \frac{\partial \dot{\Omega}}{\partial u} = 0 \tag{3.11}$$

$$J_{32} = \frac{\partial \dot{\Omega}}{\partial m} = \mu h_m > 0 \tag{3.12}$$

$$J_{33} = \frac{\partial \dot{\Omega}}{\partial \Omega} = -\mu < 0 \tag{3.13}$$

All the above elements are evaluated at the long-run equilibrium. We omit "$*$" to avoid troublesome notations.

Assumption 1. *$sm > g_{du}$.*

This means that the responsiveness of savings to the capacity utilization rate is larger than that of investments. This assumption makes the quantity adjustment of the goods market stable. Note that Assumption 1 ensures $J_{11} = \frac{\partial \dot{u}}{\partial u} < 0$.

Definition 1. *Whenever $[g_{dm} - su] < 0$ holds, the steady state is called the wage-led demand regime. On the other hand, when $[g_{dm} - su] > 0$ holds, the steady state is called the profit-led demand regime.*

If the responsiveness of investment to the profit share is less than that of savings, then the steady state exhibits the wage-led demand regime. On the other hand, if the responsiveness of the investment to the profit share is more than that of savings, the steady state exhibits the profit-led demand regime. Depending on which regime is realized in the steady state, the wage-led demand regime or the profit-led demand regime, we have $J_{12} < 0$ or $J_{12} > 0$.

Assumption 2. $\{1 - \theta m_{f\Omega} h_m\} > 0$.

Throughout this paper we assume $\{1 - \theta m_{f\Omega} h_m\} > 0$. As $\theta \in (0, 1)$, if $m_{f\Omega}$ and h_m are not very large, $\{1 - \theta m_{f\Omega} h_m\} > 0$ is very much possible.

In what follows, we explain equations (3.8), (3.9), and (3.10) now. J_{21} represents the effect of an increase in the capacity utilization rate on a change in the profit share. A change in the profit share consists of change in price, average wage and average labour productivity (see equation (2.16)). Equation (2.12) depicts that the rate of change in price is unaffected with respect to the capacity utilization rate. From equation (2.11), the rate of change in average wage is decomposed into the rates of change in blue-collar workers' wages and in $\Gamma(u)$. The rate of change in blue-collar workers' wages is positively related to the capacity utilization rate through the reserve army effect (see equation (2.13) and (2.15)). Each unit rise in u, from equation (2.13), raise blue-collar workers wage by $-(1-\theta)m_{wu}$ unit. Similarly, for every unit change in u, from equation (2.17), the rate of change in $\Gamma(u)$ changes by $\frac{(\gamma-1)\alpha\beta}{(\gamma\alpha+\beta u)(\alpha+\beta u)}\frac{\partial \dot{u}}{\partial u}$ unit. As a result, the average wage rate of workers rises by $-\{(1-\theta)m_{wu}+\frac{(\gamma-1)\alpha\beta}{(\gamma\alpha+\beta u)(\alpha+\beta u)}\frac{\partial \dot{u}}{\partial u}\}$ unit (as $m_{wu}<0$, and from assumption 1, $\frac{\partial \dot{u}}{\partial u}<0$). On the other hand, from equation (2.19), the rate of change in average labour productivity decreases by $\frac{\alpha}{(\alpha+\beta u)u}\frac{\partial \dot{u}}{\partial u}$ unit. Note that $\{\frac{(\gamma-1)\alpha\beta}{(\gamma\alpha+\beta u)(\alpha+\beta u)}+\frac{\alpha}{(\alpha+\beta u)u}\}=\frac{\alpha\gamma}{(\alpha\gamma+\beta u)u}=f(u,\gamma)$ and so due to a rise in u, the rate of change in $\Gamma(u)$ and the rate of change in average labour productivity together yield $f(u,\gamma)\frac{\partial \dot{u}}{\partial u}$. Finally, summing up these effects, we find that the rate of change in the profit share is negatively affected by the capacity utilization rate as $\frac{\partial}{\partial u}(\frac{\dot{m}}{1-m})=[(1-\theta)m_{wu}+f(u,\gamma)\frac{\partial \dot{u}}{\partial u}]<0$.

J_{22} represents the effect of an increase in the profit share on a change in the profit share itself. A change in the profit share consists of change in price, average wage and average labour productivity (see equation (2.16)). Equation (2.12) depicts that due to a change in the profit share, the rate of change in price falls by θ unit. For each unit change in m, from equation (2.13), blue-collar workers wage must rise by $(1-\theta)$ unit. Similarly, for every unit change in m, from equation (2.17), the rate of change in $\Gamma(u)$ changes by $\frac{(\gamma-1)\alpha\beta}{(\gamma\alpha+\beta u)(\alpha+\beta u)}\frac{\partial \dot{u}}{\partial m}$ unit. This change may be positive or negative depending on whether the economy is in a wage-led demand regime (i.e. $\frac{\partial \dot{u}}{\partial m}<0$) or in an profit-led demand regime (i.e. $\frac{\partial \dot{u}}{\partial m}>0$). On the other hand, from equation (2.19), the rate of change in average labour productivity changes by $\frac{\alpha}{(\alpha+\beta u)u}\frac{\partial \dot{u}}{\partial m}$ unit. As $\{\frac{(\gamma-1)\alpha\beta}{(\gamma\alpha+\beta u)(\alpha+\beta u)}+\frac{\alpha}{(\alpha+\beta u)u}\}=\frac{\alpha\gamma}{(\alpha\gamma+\beta u)u}=f(u,\gamma)$, for a rise in m, the rate of change in $\Gamma(u)$ and the rate of change in average labour productivity together yield $f(u,\gamma)\frac{\partial \dot{u}}{\partial m}$. Finally, summing up these effects, we find that the rate of change in the profit share is affected by the share of profit itself as $\frac{\partial}{\partial m}(\frac{\dot{m}}{1-m})=[-\theta-(1-\theta)+f(u,\gamma)\frac{\partial \dot{u}}{\partial m}]=[-1+f(u,\gamma)\frac{\partial \dot{u}}{\partial m}]$. If the economy is in a wage-led demand regime, $\frac{\partial \dot{u}}{\partial m}<0$ and hence $\frac{\partial}{\partial m}(\frac{\dot{m}}{1-m})$ is unambiguously negative. However, if the economy is in an profit-led demand regime $\frac{\partial \dot{u}}{\partial m}>0$ and hence the final result is ambiguous.

J_{23} represents the effect of an increase in the financialization level on the change in the profit share. Equation (2.12) depicts that due to a change in the financialization level, the rate of change in price rises by $\theta m_{f\Omega}$ unit. From equation (2.13), however, blue-collar workers wage rate is unaffected by the change in financialization level. Rather, for every unit change in Ω, from equation (2.17), the rate of change in $\Gamma(u)$ changes by $\frac{(\gamma-1)\alpha\beta}{(\gamma\alpha+\beta u)(\alpha+\beta u)}\frac{\partial \dot{u}}{\partial \Omega}$ unit. On the other hand, from equation (2.19), the rate of change in average labour productivity falls by $\frac{\alpha}{(\alpha+\beta u)u}\frac{\partial \dot{u}}{\partial \Omega}$ unit (as $\frac{\partial \dot{u}}{\partial \Omega}<0$). Hence, for a rise in Ω, the rate of change in $\Gamma(u)$ and the rate of change in average labour productivity together yield $f(u,\gamma)\frac{\partial \dot{u}}{\partial \Omega}$. Finally, summing up these effects, we find that the rate of change in the profit share is affected by the financialization level as $\frac{\partial}{\partial \Omega}(\frac{\dot{m}}{1-m})=[\theta m_{f\Omega}+f(u,\gamma)\frac{\partial \dot{u}}{\partial \Omega}]$ which is ambiguous in sign.

The characteristic equation of the Jacobian matrix J is given by

$$\lambda^3 + a_1\lambda^2 + a_2\lambda + a_3 = 0 \tag{3.14}$$

where λ denotes a characteristic root. Each coefficient of equation (3.14) is given by

$$a_1 = -\mathrm{tr}\boldsymbol{J} = -(J_{11} + J_{22} + J_{33}), \tag{3.15}$$

$$a_2 = \begin{vmatrix} J_{22} & J_{23} \\ J_{32} & J_{33} \end{vmatrix} + \begin{vmatrix} J_{11} & J_{13} \\ 0 & J_{33} \end{vmatrix} + \begin{vmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{vmatrix} = J_{22}J_{33} - J_{23}J_{32} + J_{11}J_{33} + J_{11}J_{22} - J_{12}J_{21}, \tag{3.16}$$

$$a_3 = -\det\boldsymbol{J} = J_{32}(J_{11}J_{23} - J_{13}J_{21}) - J_{33}(J_{11}J_{22} - J_{12}J_{21}) \tag{3.17}$$

where $-a_1 = \mathrm{tr}\boldsymbol{J}$ denotes the trace of $\boldsymbol{J}$; a_2 , the sum of the principal minors' determinants; and $-a_3 = \det\boldsymbol{J}$, the determinant of $\boldsymbol{J}$.

The necessary and sufficient condition for the local stability is that all characteristic roots of the Jacobian matrix must have negative real parts, which, from Routh–Hurwitz condition, is equivalent to $a_1 > 0$, $a_2 > 0$, $a_3 > 0$, and $a_1a_2 - a_3 > 0$. Let us investigate whether these inequalities hold. We arrange the coefficients with respect to ϕ as follows.

$$a_1(\phi) = -\underbrace{\{(g_{du} - sm) + (1-m)f(u,\gamma)(g_{dm} - su)\}}_{\equiv A \gtreqless 0}\phi + \underbrace{(1 - m + \mu)}_{\equiv B > 0} = -A\phi + B. \tag{3.18}$$

$$\begin{aligned} a_2(\phi) &= E - C\phi = +\underbrace{(1-m)\mu\{1 - \theta m_{f\Omega}h_m\}}_{\equiv E>0} \\ &-\underbrace{[\underbrace{(1-m+\mu)(g_{du} - sm)}_{-} + \underbrace{(1-m)\mu f h_m g_{d\Omega}}_{-} + \underbrace{(1-m)\{\mu f + (1-\theta)m_{wu}\}}_{+/-}\underbrace{(g_{dm} - su)}_{+/-}]}_{\equiv C \gtreqless 0}\phi \end{aligned} \tag{3.19}$$

$$\begin{aligned} a_3(\phi) &= -D\phi \\ &= -\underbrace{(1-m)\mu\left[\{1 - \theta m_{f\Omega}h_m\}(g_{du} - sm) + (1-\theta)m_{wu}\{h_m g_{d\Omega} + (g_{dm} - su)\}\right]}_{\equiv D \gtreqless 0}\phi. \end{aligned} \tag{3.20}$$

$$a_1a_2 - a_3 \equiv \xi(\phi) = \underbrace{AC}_{+/-}\phi^2 - \underbrace{(AE + BC - D)}_{+/-}\phi + \underbrace{BE}_{+} \tag{3.21}$$

$AE + BC - D$ can be represented as

$$
\begin{aligned}
AE + BC - D = &\underbrace{(1-m+\mu)^2(g_{du}-sm)}_{-} \\
&+\underbrace{(1-m)\mu h_m\{(1-m+\mu)-(1-\theta)m_{wu}\}g_{d\Omega}}_{-} \\
&+(1-m)[\underbrace{(1-m)\mu f\{1-\theta m_{f\Omega}h_m\}-(1-\theta)m_{wu}\mu}_{+}]\underbrace{(g_{dm}-su)}_{+/-} \\
&+(1-m)[\underbrace{(1-m+\mu)\{\mu f+(1-\theta)m_{wu}\}}_{+/-}]\underbrace{(g_{dm}-su)}_{+/-}
\end{aligned}
\tag{3.22}
$$

$$
\begin{aligned}
\implies AE + BC - D = &\underbrace{(1-m+\mu)C}_{+/-} - \underbrace{(1-m)(1-\theta)h_m\mu m_{wu}g_{d\Omega}}_{+} \\
&+(1-m)[\underbrace{(1-m)\mu f\{1-\theta m_{f\Omega}h_m\}-(1-\theta)m_{wu}\mu}_{+}]\underbrace{(g_{dm}-su)}_{+/-}
\end{aligned}
\tag{3.23}
$$

3.1 Wage-led demand regime

Suppose the economy is in a wage-led demand regime. So, $J_{12} < 0$. This implies (from equation (3.9)) that $J_{22} < 0$. So $A < 0$ and hence equation (3.18) yields $a_1 > 0$.

Ceteris paribus, a not so strong (i.e. either a weak or a moderate) reserve army effect is required for D to be negative. As in the wage-led demand regime $\{h_m g_{d\Omega} + (g_{dm} - su)\} < 0$, and as $m_{wu} < 0$, if the reserve army effect (m_{wu}) is relatively weak (i.e. either a small or a moderate value of $|m_{wu}|$) then $\{1 - \theta m_{f\Omega} h_m\}(g_{d\Omega} - sm)$ (which is negative) dominates $(1-\theta)m_{wu}\{h_m g_{d\Omega} + (g_{dm} - su)\}$ (which is positive) and as a result D becomes negative and $a_3 > 0$ holds (see equation (3.20)). On the other hand a strong reserve army effect makes a_3 negative and hence the steady state becomes unstable.

However a_2 is still ambiguous. Suppose $\{\mu f + (1-\theta)m_{wu}\} > 0$. This ensures C to be negative and so $a_2 > 0$ holds. On the other hand, $\{\mu f + (1-\theta)m_{wu}\} < 0$ is associated with the ambiguous sign of C. So depending on the sign of $\{\mu f + (1-\theta)m_{wu}\}$ two cases are possible.

Case 1: $\boldsymbol{\{\mu f + (1-\theta)m_{wu}\} > 0}$. This is possible when the speed of adjustment in the financial market is relatively strong and the reserve army effect is relatively weak.

Proposition 1. *Suppose the economy is in a wage-led demand regime. Suppose $\{\mu f + (1-\theta)m_{wu}\} > 0$ and $D < 0$. Then, irrespective of the size of ϕ, the long-run equilibrium is locally stable.*

Proof. See Appendix A.1. □

Let us discuss Proposition 1 intuitively. Suppose due to any reason the capacity utilization rate exceeds its steady state value. From equation (3.5), the capacity utilization rate must fall under the direct stable effect. On the other hand the rise in the capacity utilization rate decreases the profit share due to equation (3.8). As a result, from equation (3.6) (as the economy is in a wage-led demand regime $J_{12} < 0$) the capacity utilization rate rises. This is the first indirect unstable effect. A fall in the profit share reduces the desired level of financialization and hence through equation (3.12) the financialization level falls. This fall in the financialization level through equation (3.7) increases the capacity utilization rate. This is the second indirect unstable effect. If the reserve army effect is weak, the profit share falls marginally due to the weak negative effect of J_{21}. As a consequence, through these two indirect unstable effect the capacity utilization rate increases by a small amount. Hence these indirect unstable effects are dominated by the direct stable effect and as a result the economy becomes stable.

$$u \uparrow \Longrightarrow \; m \downarrow \; \text{(here } m_{wu} \text{ is weak)} \; \Longrightarrow \begin{cases} \quad u \uparrow \\ \Omega \downarrow \Longrightarrow \; u \uparrow \end{cases} \quad \text{(destabilizing indirect effects)}$$

$$u \uparrow \Longrightarrow \; u \downarrow\downarrow \text{(stabilizing direct effect which dominates here)}$$

Case 2: $\boldsymbol{\{\mu f + (1-\theta) m_{wu}\} < 0}$. This is possible for a relatively weak speed of adjustment in the financial market and a relatively strong reserve army effect.

When $\{\mu f + (1-\theta) m_{wu}\} < 0$, in the wage-led demand regime, $C \gtrless 0$ can hold (see equation (3.19)).

Proposition 2. *Suppose the economy is in a wage-led demand regime. Suppose* $\{\mu f + (1-\theta) m_{wu}\} < 0$, $C < 0$ *and* $D < 0$. *Then, irrespective of the size of* ϕ *the long-run equilibrium is locally stable.*

Proof. See Appendix A.2. □

Proposition 2 is obtained when μ and f are small and the reserve-army effect (m_{wu}) is not very weak (so that $\{\mu f + (1-\theta) m_{wu}\} < 0$ hold, but m_{wu} is weak enough to make $C < 0$ and $D < 0$).

Proposition 3. *Suppose the economy is in a wage-led demand regime. Suppose* $\{\mu f + (1-\theta) m_{wu}\} < 0$, $C > 0$, $\phi < \frac{E}{C}$ *and* $D < 0$. *Then, a limit cycle occurs when the speed of adjustment of the goods market equals to some critical value.*

Proof. See Appendix A.3. □

Proposition 3 can be obtained when μ and f are small and the reserve-army effect (m_{wu}) is moderately strong (so that $\{\mu f + (1-\theta)m_{wu}\} < 0$, $C > 0$, but m_{wu} is weak enough to make D negative).

When the economy is in a wage-led demand regime, in Sasaki et. al. (2013), a weak reserve army effect ensures local stability whereas if the reserve army effect is strong, the steady state becomes locally unstable. In our model, however, although for an unconditional stability a weak reserve army effect is necessary, it is not sufficient. Along with a weak reserve army effect, a smaller value of speculation propensity of the rentiers (i.e. a smaller value of h_m) is also required (otherwise D will be positive). If we consider a conditional stability (where the stability is contingent upon the speed of adjustment of the goods market), a relatively strong reserve army effect can be associated with a conditional local stability (see Proposition 3). Further, unlike Sasaki et. al. (2013), a limit cycle can emerge even in the wage-led demand regime (see Proposition 3).

3.2 Profit-led demand regime

Suppose the economy is in a profit-led demand regime and so $J_{12} > 0$. Here $\{h_m g_{d\Omega} + (g_{dm} - su)\} \gtrless 0$. If $\{h_m g_{d\Omega} + (g_{dm} - su)\} > 0$, then D is unambiguously negative and so $a_3 > 0$. If $\{h_m g_{d\Omega} + (g_{dm} - su)\} < 0$, $D \gtrless 0$. When the reserve army effect is relatively weak, then D becomes negative.

***Case 1*: $\{\mu f + (1-\theta)m_{wu}\} > 0$.**

Here as $\{\mu f + (1-\theta)m_{wu}\} > 0$, $C \gtrless 0$. As $J_{12} > 0$, $A \gtrless 0$. Suppose $D < 0$. Then the following sub-cases are possible.

Proposition 4. *Suppose the economy is in a profit-led demand regime. Suppose $\{\mu f + (1-\theta)m_{wu}\} > 0$, $C < 0$, $A < 0$ and $D < 0$. Then, $(AE + BC - D) < 0$ ensures the economy to be locally stable whereas for $(AE + BC - D) > 0$, a limit cycles occur when the speed of adjustment of the goods market equals to some critical values.*

Proof. See Appendix A.4. □

Proposition 5. *Suppose the economy is in a profit-led demand regime. Suppose $\{\mu f + (1-\theta)m_{wu}\} > 0$, $D < 0$ but A and C are not having negative signs together. Suppose when $C > 0$, $\phi < \frac{E}{C}$ and when $A > 0$, $\phi < \frac{B}{A}$. Then a limit cycle occurs when the speed of adjustment of the goods market equals to some critical value.*

Proof. See Appendix A.5. □

***Case 2*: $\{\mu f + (1-\theta)m_{wu}\} < 0$.**

In a profit-led demand regime $\{\mu f + (1-\theta)m_{wu}\} < 0$ ensures C to be negative (see equation (3.19)).

Proposition 6. *Suppose the economy is in a profit-led demand regime. Suppose $\{\mu f + (1-\theta)m_{wu}\} < 0$, $A < 0$ and $D < 0$. Then, $(AE + BC - D) < 0$ ensures the economy to be locally stable whereas for $(AE + BC - D) > 0$, limit cycles occur when the speed of adjustment of the goods market equals to some critical values.*

Proof. See Appendix A.6. $\square$

Proposition 7. *Suppose the economy is in a profit-led demand regime. Suppose $\{\mu f + (1-\theta)m_{wu}\} < 0$, $A > 0$, $\phi < \frac{B}{A}$, and $D < 0$. Then a limit cycle occurs when the speed of adjustment of the goods market equals to some critical value.*

Proof. See Appendix A.7. $\square$

Let us discuss Propositions 4-7 intuitively. Suppose due to any reason the capacity utilization rate exceeds its steady state value. From equation (3.5), the capacity utilization rate must fall under the direct stable effect. On the other hand the rise in the capacity utilization rate decreases the profit share due to equation (3.8). As a result, from equation (3.6) (as the economy is in a profit-led demand regime $J_{12} > 0$) the capacity utilization rate falls. This is the first indirect but stable effect. A fall in the profit share reduces the financialization level through equation (3.12). This fall in the financialization level through equation (3.7) increases the capacity utilization rate. This is the second indirect effect which is unstable. If the reserve army effect is weak, the profit share falls marginally due to the weak negative effect of J_{21}. As a consequence, these indirect effects are dominated by the direct (stabilizing) effect and so the economy becomes stable (first part of Proposition 4). However, if reserve army effect is not very weak, whether the destabilizing effect (second indirect effect) dominates the stabilizing effect (the direct effect and the first indirect effect) depends on the the speed of adjustment of the goods market ϕ.

$$u \uparrow \Longrightarrow m \downarrow \Longrightarrow \begin{cases} u \downarrow \text{ (stabilizing indirect effect)} \\ \Omega \downarrow \Longrightarrow u \uparrow \text{ (destabilizing indirect effect)} \end{cases}$$

$$u \uparrow \Longrightarrow u \downarrow \text{(stabilizing direct effect)}$$

3.3 Wage gap between blue and white-collar workers

Now we focus on the parameter γ that represents the wage gap between blue and white-collar workers. Although γ does not affect the steady state, but it can affect the overall stability in the economy.

Note that, a_1 is a linear function of f and f is a function of γ.

$$a_1 \equiv a_1(f) = -\phi\left[g_{du} - sm\right] + (1-m)\left[1 - f.\phi\left\{g_{dm} - su\right\}\right] + \mu$$

$$= \underbrace{\{(1-m+\mu) - \phi(g_{du} - sm)\}}_{\equiv F>0} - \underbrace{\{(1-m)\phi(g_{dm} - su)\}}_{\equiv G \gtrless 0} f = F - Gf \tag{3.24}$$

If the economy is in a wage-led demand regime, $G < 0$ and so irrespective of the size of f, a_1 is positive. On the other hand, if the economy is in an profit-led demand regime, G is positive and so $a_1 \gtrless 0$ depending on $f \lessgtr \frac{F}{G}$.

Rearranging equation (3.19) we get a_2 as a linear function of f as $a_2 \equiv a_2(f)$

$$\begin{aligned} &= \underbrace{\underbrace{(1-m)\mu\{1 - \theta m_{f\Omega} h_m\}}_{+} - \left\{ \underbrace{(1-m+\mu)(g_{du} - sm)}_{-} + \underbrace{(1-m)(1-\theta) m_{wu}(g_{dm} - su)}_{+/-} \right\}\phi}_{\equiv M \gtrless 0} \\ &\qquad - \underbrace{(1-m)\mu\phi\{h_m g_{d\Omega} + (g_{dm} - su)\}}_{\equiv N \gtrless 0} f \\ &= M - Nf \end{aligned} \tag{3.25}$$

If the economy is in a wage-led demand regime, $\{(1-m)(1-\theta)m_{wu}(g_{dm} - su)\} > 0$ and so $M \gtrless 0$ occurs. Beside, $\{h_m g_{d\Omega} + (g_{dm} - su)\} < 0$ and so $N < 0$ holds. If $M > 0$ holds, irrespective of the size of f, a_2 becomes positive. However, if $M < 0$ holds, $a_2 \gtrless 0$ depending on whether $f \gtrless f_1 = \frac{M}{N}$. Note that in the wage-led demand regime, a relatively strong reserve army effect is required to make M negative. On the other hand, when the reserve army effect is weak, $\{(1-m)(1-\theta)m_{wu}(g_{dm} - su)\}$ is dominated by the other two terms and as a consequence M becomes positive.

If the economy is in a profit-led demand regime, $\{(1-m)(1-\theta)m_{wu}(g_{dm} - su)\} < 0$ and so $M > 0$ occurs. However, $\{h_m g_{d\Omega} + (g_{dm} - su)\} \gtrless 0$ and so $N \gtrless 0$ holds. If $\{h_m g_{d\Omega} + (g_{dm} - su)\} < 0$ holds, irrespective of the size of f, a_2 becomes positive. However, if $\{h_m g_{d\Omega} + (g_{dm} - su)\} > 0$ holds, $a_2 \gtrless 0$ depending on whether $f \lessgtr f_1 = \frac{M}{N}$.

However, a_3 does not depend on f. Hence, we can get the following propositions related to the wage gap between two types of workers.

Proposition 8. *Suppose the economy is in an wage-led demand regime, and $D < 0$. Then for a relatively strong reserve army effect, a contraction in the wage gap between white and blue-collar employments can make the steady state unstable.*

Proof. See Appendix A.8. ☐

Proposition 9. *Suppose the economy is in an profit-led demand regime, and $D < 0$. Then, an expansion of the wage gap between white and blue-collar employments can make the steady state unstable.*

Proof. See Appendix A.9. ☐

Proposition 8 says that in case of a relatively strong reserve army effect, an increase in the wage gap is essential to make the economy stable whereas a decrease in the wage-gap leads to the instability in the economy. On the contrary, an increase in the wage gap, in terms of stability, makes the economy more vulnerable in the profit-led demand regime (Proposition 9). As a consequence, to ensure stability in the economy, a shrink in the wage gap between white and blue-collar labours are desirable in the profit-led demand regime.

3.4 Comparative statics

For comparative statics analysis, we assume the economy is in a stable steady state. Differentiation of equations (3.1), (3.2) and (3.3) w.r.t. s yields,

$$\frac{du}{ds} = \frac{\overbrace{mu\{1-\theta m_{f\Omega}h_m\}}^{+}}{\underbrace{(g_{du}-sm)(1-\theta m_{f\Omega}h_m)+(1-\theta)m_{wu}\{h_m g_{d\Omega}+(g_{dm}-su)\}}_{-}} < 0 \tag{3.26}$$

$$\frac{dm}{ds} = \frac{\overbrace{(1-\theta)mum_{wu}}^{-}}{\underbrace{(g_{du}-sm)(1-\theta m_{f\Omega}h_m)+(1-\theta)m_{wu}\{h_m g_{d\Omega}+(g_{dm}-su)\}}_{-}} > 0 \tag{3.27}$$

$$\frac{d\Omega}{ds} = \frac{\overbrace{(1-\theta)mum_{wu}h_m}^{-}}{\underbrace{(g_{du}-sm)(1-\theta m_{f\Omega}h_m)+(1-\theta)m_{wu}\{h_m g_{d\Omega}+(g_{dm}-su)\}}_{-}} > 0 \tag{3.28}$$

For stability $a_3 > 0$ must hold. From equation (3.20), for a_3 to be positive D must be negative and for D to be negative $[\{1-\theta m_{f\Omega}h_m\}(g_{du}-sm)+(1-\theta)m_{wu}\{h_m g_{d\Omega}+(g_{dm}-$

$su)\}]$ has to negative. Therefore we assume $[\{1-\theta m_{f\Omega}h_m\}(g_{du}-sm)+(1-\theta)m_{wu}\{h_m g_{d\Omega}+(g_{dm}-su)\}] < 0$. As $\{1-\theta m_{f\Omega}h_m\} > 0$, from equation (3.26) we conclude that as s rises the rate of capacity utilization falls. On the other hand, as $m_{wu} < 0$, (from equation (3.27)) a rise in s worsens income inequality vis-à-vis workers. Similarly, equation (3.28) reveals that a rise in s increases the financialization level. Thus as long as the economy is in a stable steady state, irrespective of the regime, the paradox of thrift holds. However, a rise in s increases the income inequality vis-à-vis blue-collar workers and escalates the financialization level.

Differentiation of equations (3.1), (3.2) and (3.3) w.r.t. θ yields,

$$\frac{du}{d\theta} = \frac{\overbrace{\overbrace{-(m_f - m_w)}^{-}\overbrace{\{h_m g_{d\Omega} + (g_{dm} - su)\}}^{+/-}}^{+/-}}{\underbrace{(g_{du} - sm)(1 - \theta m_{f\Omega}h_m) + (1-\theta)m_{wu}\{h_m g_{d\Omega} + (g_{dm} - su)\}}_{-}} \gtrless 0 \tag{3.29}$$

$$\frac{dm}{d\theta} = \frac{\overbrace{(m_f - m_w)(g_{du} - sm)}^{-}}{\underbrace{(g_{du} - sm)(1 - \theta m_{f\Omega}h_m) + (1-\theta)m_{wu}\{h_m g_{d\Omega} + (g_{dm} - su)\}}_{-}} > 0 \tag{3.30}$$

$$\frac{d\Omega}{d\theta} = \frac{\overbrace{h_m(m_f - m_w)(g_{du} - sm)}^{-}}{\underbrace{(g_{du} - sm)(1 - \theta m_{f\Omega}h_m) + (1-\theta)m_{wu}\{h_m g_{d\Omega} + (g_{dm} - su)\}}_{-}} > 0 \tag{3.31}$$

A rise in the bargaining power of firms can have positive effect on the capacity utilization rate depending on whether $\{h_m g_{d\Omega} + (g_{dm} - su)\}$ is positive or not. In the wage-led demand regime, $\{h_m g_{d\Omega} + (g_{dm} - su)\}$ is unambiguously negative and so $\frac{du}{d\theta} < 0$. However, in the profit-led demand regime, effect of a rise in the bargaining power of firms on the equilibrium degree of capacity utilization is ambiguous and $\frac{du}{d\theta} \gtrless 0$ depending on whether $\{h_m g_{d\Omega} + (g_{dm} - su)\} \gtrless 0$. As $m_f > m_w$, equation (3.30) says that a rise in the bargaining power of firms ultimately leads to a rise in the profit share. For last several decades in the US economy there has been institutional changes which has been less supportive to workers bargaining power by reducing the incidence of unionism[10] and the credibility of the "threat effect" of unionism (Stansbury and Summers (2020)). Therefore institutional changes such as a stringent labour law and more regulated labour market which favours the blue-collar workers can mitigate the income inequality. Also note that, as $m_f > m_w$ and $h_m > 0$, a rise in the bargaining power of firms vis-à-vis blue-collar workers ultimately leads to the enhancement of the level of financialization (see equation (3.31)).

[10]There has been a decline in private sector union membership rate from over one third at its peak in the 1950s to 6% in 2019 (Stansbury and Summers (2020, pp. 9)).

4 Numerical simulations

In this section, using some numerical examples we show that limit cycles can occur. For this, we first specify the functional forms of equations (2.7), (2.14), (2.15) and (2.20). We assume these functions as follows:

$$g_d(u, m, \Omega) = u^{\delta} m^{\varepsilon} \Omega^{\psi}, \quad \delta > 0, \varepsilon > 0, \psi < 0 \tag{4.1}$$

$$m_f(\Omega) = i + j\Omega, \quad i > 0, j > 0 \tag{4.2}$$

$$m_w(u) = k - lu, \quad k > 0, l > 0 \tag{4.3}$$

$$h(m) = \sigma_0 + \sigma_1 m, \quad \sigma_0 > 0, \sigma_1 > 0 \tag{4.4}$$

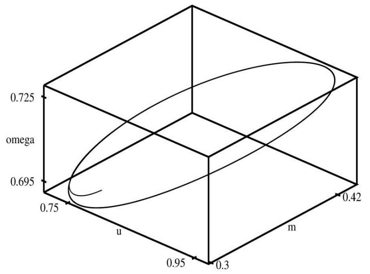
Note that the purpose of this numerical study is not to calibrate a real economy. Rather, the primary objective is to confirm whether the model produces the limit cycle and to observe its basic properties. Therefore, the values introduced below are set for these purposes to obtain economically meaningful outcomes. Numerical values of parameters along with values of initial conditions and steady state values are provided in Table 4.1. For each case, we draw the solution path from $t = 0$ to $t = 200$.

Table 4.1: List of parameters, initial values, and equilibrium values

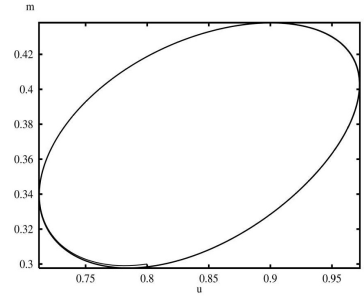
	Parameters															
	δ	ε	ψ	s	θ	i	j	k	l	α	γ	β	σ_0	σ_1	μ	$\hat{\phi}$
Pr. 5 *III* part	0.5	2.2	-1.2	0.5	0.4	0.5	0.3	0.8	0.8	1	3	1.2	0.6	0.3	2	4.35
Pr. 5 *II* part	0.5	2.2	-1.2	0.5	0.4	0.5	0.3	0.8	0.8	1	3	1.2	0.6	0.3	0.53	4.2
Pr. 7	0.5	2.2	-1.2	0.5	0.4	0.5	0.3	0.8	0.8	1	3	1.2	0.6	0.3	0.3	3.617

	Initial Values			Equilibrium Values		
	$u(0)$	$m(0)$	$\Omega(0)$	u^*	m^*	Ω^*
III part of Proposition 5	0.8	0.3	0.7	0.82682	0.36839	0.71052
II part of Proposition 5	0.8	0.4	0.6	0.82682	0.36839	0.71052
Proposition 7	0.8	0.3	0.7	0.82682	0.36839	0.71052

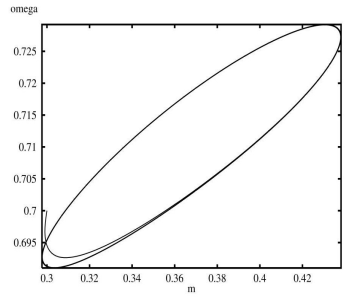
***III* Part of Proposition 5:** For *III* part of Proposition 5 we get $\frac{J_{11}}{\phi} = -0.092097004 < 0$, $\frac{J_{12}}{\phi} = 0.4960969 > 0$, $\frac{J_{13}}{\phi} = -0.25721488 < 0$, $\{\mu f + (1-\theta) m_{wu}\} > 0$. $A = 0.192686771 > 0$, $B = 2.63161 > 0$, $C = 0.088209669 > 0$, $E = 1.21774408 > 0$, $D = -0.366168421 < 0$, $\hat{\phi} < \frac{B}{A} = 13.657450308$, $\hat{\phi} < \frac{E}{C} = 13.805108825$. So all the conditions required for the *III* part of Proposition 5 are satisfied.



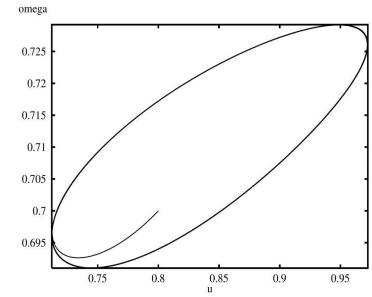
(a) Solution paths in (u, m, Ω) plane



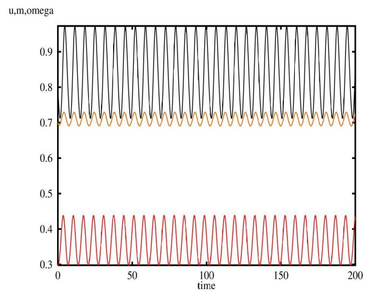
(b) Solution paths in (u, m) plane



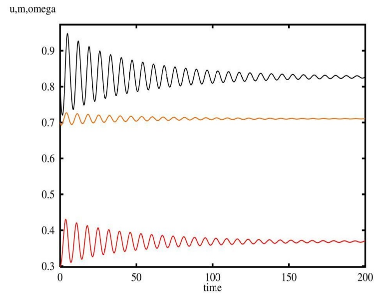
(c) Solution paths in (m, Ω) plane



(d) Solution paths in (u, Ω) plane



(e) Transitional dynamics of III part of Proposition 5 (when $\phi = \hat{\phi} = 4.2$)



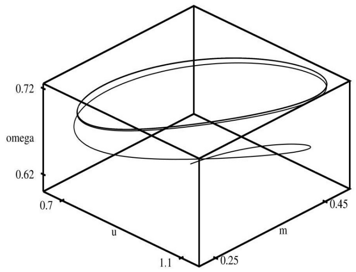
(f) Transitional dynamics of III part of Proposition 5 (when $\phi = 4$).

Figure 4.1: III part of Proposition 5

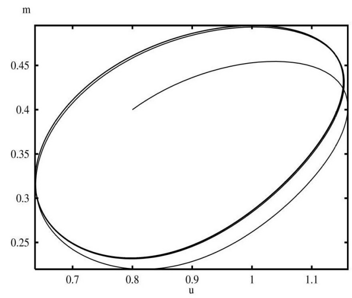
Figure 4.1a displays the the Hopf bifurcation in a three-dimensional space. Figure 4.1b, 4.1c, and 4.1d show cyclical patterns in the (u, m), (m, n), and (u, n)-planes. In the (u, m) and (u, Ω)- planes, clockwise cycles emerge whereas in the (m, Ω)- plane, counterclockwise cycle emerges. Finally, Figure 4.1e shows the transitional dynamics of the rate of capacity utilization (black colour) and the profit share (red colour) and the level of financialization (orange colour). Considering $\phi = 4 < \hat{\phi}$ we get the transitional dynamics for the stable steady state in Figure 4.1f.

***II* Part of Proposition 5:** For II part of Proposition 5 we get $\{\mu f + (1 - \theta) m_{wu}\} = 0.001698841 > 0$, $\frac{J_{11}}{\phi} < 0$, $\frac{J_{12}}{\phi} > 0$, $\frac{J_{13}}{\phi} < 0$, $A > 0$, $B > 0$, $E > 0$, $D = -0.097034632 < 0$, but $C = -0.1299254451 < 0$. So all the conditions required for the II part of Proposition 5 are satisfied.

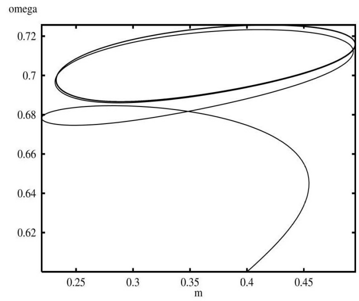
Figure 4.2a displays the the Hopf bifurcation in a three-dimensional space. Figure 4.2b, 4.2c, and 4.2d show cyclical patterns in the (u, m), (m, n), and (u, n)-planes. In the (u, m) plane, clockwise cycles emerge whereas in the (m, Ω)- plane, counterclockwise cycle emerges. However, the pattern is not clear for (u, Ω) plane. Figure 4.2e shows the transitional dynamics of the rate of capacity utilization (black colour) and the profit share (red colour) and the level of financialization (orange colour). Finally, Figure 4.2f displays the transitional dynamics for the stable steady state.



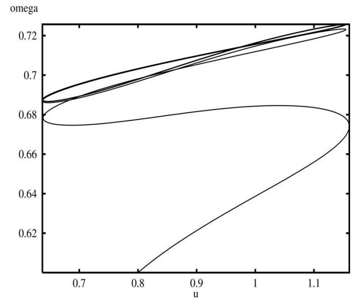
(a) Solution paths in (u, m, Ω) plane



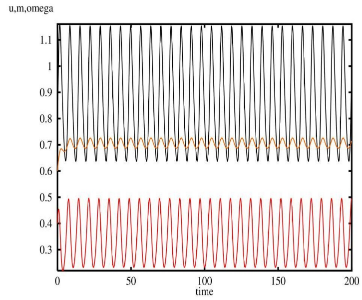
(b) Solution paths in (u, m) plane



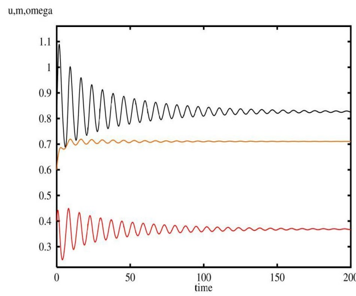
(c) Solution paths in (m, Ω) plane



(d) Solution paths in (u, Ω) plane



(e) Transitional dynamics of III part of Proposition 5 (when $\phi = \hat{\phi} = 4.2$)



(f) Transitional dynamics of II part of Proposition 5 (when $\phi = 3.5$)

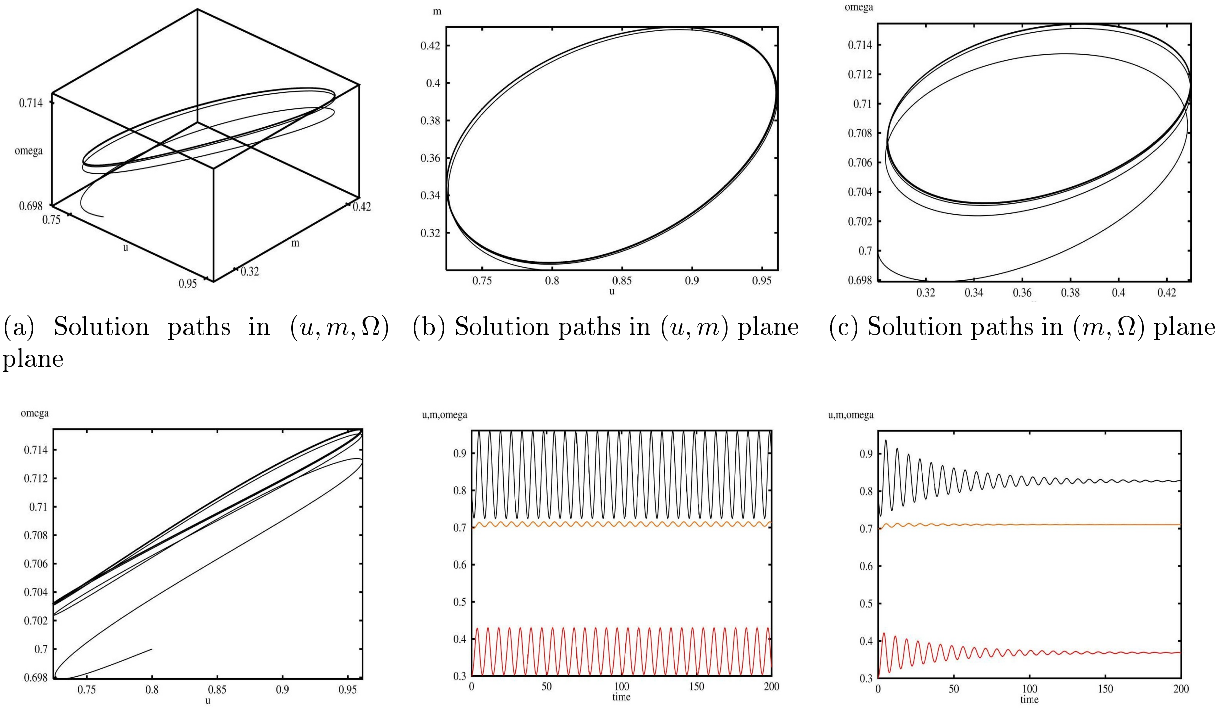
Figure 4.2: II part of Proposition 5

Proposition 7: For Proposition 7 we get $\{\mu f + (1-\theta)m_{wu}\} = -0.207340279 > 0$, $\frac{J_{11}}{\phi} < 0$, $\frac{J_{12}}{\phi} > 0$, $\frac{J_{13}}{\phi} < 0$, $A = 0.19268677 > 0$, $B = 0.93161 > 0$, $E = 0.182661612 > 0$, $D = -0.054925263 < 0$, and $C = -0.164055292 < 0$. Also note that here $\hat{\phi} = 3.515 < \frac{B}{A} = 4.834841516$. So all the conditions required for Proposition 7 are satisfied.

Figure 4.3a displays the the Hopf bifurcation in a three-dimensional space. Figure 4.3b, 4.3c, and 4.3d show cyclical patterns in the (u, m), (m, n), and (u, n)-planes. In the (u, m) plane, clockwise cycles emerge whereas in the (m, Ω)- plane, counterclockwise cycle emerges. Although, the pattern is not clear for (u, Ω) plane. Finally, Figure 4.3e shows the transitional dynamics of the rate of capacity utilization (black colour) and the profit share (red colour) and the level of financialization (orange colour). Considering $\phi = 3.9 < \hat{\phi}$ we get the transitional dynamics for the stable steady state in Figure 4.3f. Considering $\phi = 3.3 < \hat{\phi}$ we get the transitional dynamics for the stable steady state in Figure 4.3f.

Note that our finding related to the clockwise cycle in the $(u, m)-$plane (in Figures 4.1b, 4.2b, and 4.3b) is consistent with Sasaki et. al. (2013)[11] , Barbosa-Filho and

[11] By using Hodrick-Prescott filter for smoothing the date of capacity utilization and profit share for Japan for the period 1980-2007, Sasaki et. al. (2013) finds that there is a clockwise movement in the capacity utilization and the profit share. See Sasaki et. al. (2013, pp. 68).



(a) Solution paths in (u, m, Ω) plane

(b) Solution paths in (u, m) plane

(c) Solution paths in (m, Ω) plane

(d) Solution paths in (u, Ω) plane

(e) Transitional dynamics of Proposition 7 (when $\phi = \hat{\phi} = 3.617$)

(f) Transitional dynamics of Proposition 7 (when $\phi = 3.3$).

Figure 4.3: Proposition 7

Taylor (2006)[12], Zipperer and Skott (2011), and opposite to that of Sasaki (2013)[13]. Our finding also supports the empirical result we get (see Figure 1.4). Our finding related to the counter-clockwise cycles in the $(m, \Omega)-$plane in Figures 4.1c, 4.2c, and 4.3c are consistent with the empirical result in Figure 1.5. Finally, we get clockwise cycle in the $(u, \Omega)-$plane in Figure 4.1d, although the pattern is somewhat unclear in Figure 4.2d, and 4.3d. These are also consistent with our empirical findings in Figure 1.6.

5 Conclusion

Introducing two types of workers in the post-Keynesian growth model, we investigated changes in financial behaviour and income distribution and their macroeconomic causes and consequences. We showed that when the speed of adjustment in the financial market

[12]Barbosa-Filho and Taylor (2006) find a counter clockwise cycle in the capacity utilization and the labour share in national income in the US economy since 1929.

[13]Sasaki (2013) incorporates the rate of employment and income distribution dynamics of Goodwin, independent investment function and oligopolistic mark-up pricing from Kalecki, and the reserve-army and reserve-army-creation effects from Marx and analyses the stability and the occurrence of cycles in the three dimensional system of utilization, profit share, and the employment rate. There is a counter-clockwise cycle in the $(u, m)-$plane in his empirical as well as the numerical simulation finding related to Japan.

is relatively strong and the reserve army effect is relatively weak a stable steady state is achieved in the wage-led demand regime. However, unlike Sasaki et. al. (2013), an endogenous and perpetual business cycles may emerge even in the wage-led demand regime. In the wage-led demand regime if the reserve army effect is relatively strong, a contraction in the wage gap between white and blue-collar employments can make the steady state unstable. On the contrary, in a profit-led demand regime, a rise in the wage gap can destabilize the economy. A rise in the saving propensity of rentiers and capitalist decreases the rate of capacity utilization, worsens the income distribution vis-à-vis workers, and rises the level of financialization. A rise in the bargaining power of firms vis-à-vis blue-collar workers also leads to a fall in the wage share and a rise in the level of financialization. Our result in this matter conforms the findings of Stansbury and Summers (2020). A more regulated labour market and a rise in unionization are desirable as these can mitigate the income inequality.

Needless to say, there are few limitations in our model. First, we focused on neither the dynamics of income share of rentiers nor the dynamics of income share of white-collar labour explicitly. Second, there is no perpetual technical progress in our model. Third, no government intervention is considered. These are, however, left for future research.

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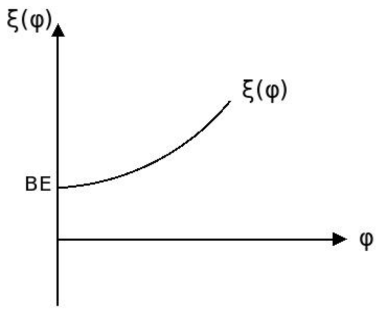
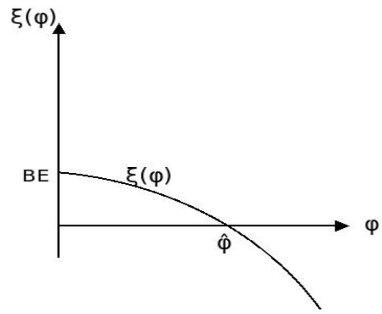
A Appendix

A.1 Proof of Proposition 1

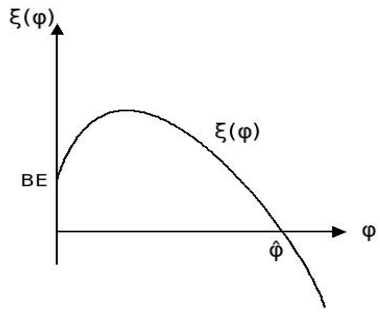
Proof. As the economy is in a wage-led demand regime, $a_1 > 0$. $\{\mu f + (1-\theta)m_{wu}\} > 0$ implies $C < 0$, which in turn ensures $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. As $C < 0$, from equation (3.23) in the wage-led demand regime we get $(AE + BC - D) < 0$. Thus $a_1a_2{-}a_3 \equiv \xi(\phi) = \underbrace{AC}_{+}\phi^2 - \underbrace{(AE + BC - D)}_{-}\phi + \underbrace{BE}_{+} > 0$. So all the conditions of stability (i.e. $a_1 > 0$, $a_2 > 0$, $a_3 > 0$, and $a_1a_2 - a_3 > 0$ (see Figure A.1a for the diagram of $a_1a_2{-}a_3$)) are satisfied, no matter what happens to the size of ϕ. □



(a) $AC > 0$ and $(AE{+}BC{-}D) < 0$



(b) $AC < 0$ and $(AE + BC - D) > 0$



(c) $AC < 0$ and $(AE + BC - D) < 0$

Figure A.1: Diagram of $a_1a_2{-}a_3 \equiv \xi(\phi)$: wage-led demand regime

A.2 Proof of Proposition 2

Proof. As the economy is in a wage-led demand regime, $a_1 > 0$. $\{\mu f + (1-\theta)m_{wu}\} < 0$ implies $C \gtrless 0$. Here $C < 0$ which in turn ensures $a_2 = E{-}C\phi > 0$. $D < 0$ ensures $a_3 > 0$. As $C < 0$, from equation (3.23) in the wage-led demand regime we get $(AE{+}BC{-}D) < 0$. Thus $a_1a_2{-}a_3 \equiv \xi(\phi) = \underbrace{AC}_{+}\phi^2 - \underbrace{(AE + BC - D)}_{-}\phi + \underbrace{BE}_{+} > 0$. So all the conditions of stability (i.e. $a_1 > 0$, $a_2 > 0$, $a_3 > 0$, and $a_1a_2 - a_3 > 0$ (see Figure A.1a for the diagram of $a_1a_2{-}a_3$)) are satisfied, no matter what happens to the size of ϕ. □

A.3 Proof of Proposition 3

Proof. As the economy is in a wage-led demand regime, $a_1 > 0$. $C > 0$ and $\phi < \frac{E}{C}$ ensure $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. From equation (3.23), as $C > 0$, here $(AE + BC - D) \gtrless 0$. Thus $a_1a_2 - a_3 \equiv \xi(\phi) = \underbrace{AC}_{-}\phi^2 - \underbrace{(AE + BC - D)}_{+/-}\phi + \underbrace{BE}_{+} \gtreqless 0$.

Suppose $(AE + BC - D) > 0$. Then at $\phi = \hat{\phi} > 0$, $a_1a_2 - a_3 \equiv \xi(\phi) = 0$ (see Figure A.1b). Further, $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}} \neq 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$.

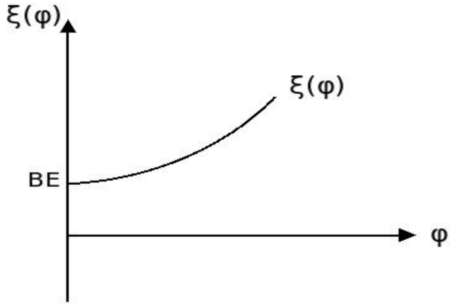
Now suppose $(AE + BC - D) < 0$. Then at $\phi = \hat{\phi} > 0$, $a_1a_2 - a_3 \equiv \xi(\phi) = 0$ (see Figure A.1c). Further, $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}} \neq 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$. □

A.4 Proof of Proposition 4

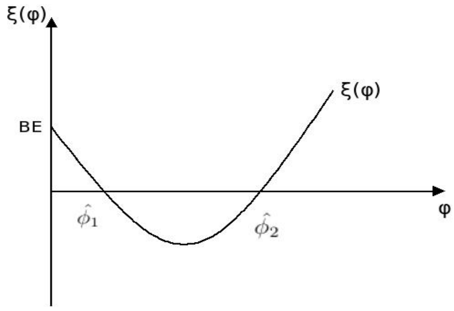
Proof. $A < 0$ implies $a_1 > 0$. $C < 0$ implies $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. From equation (3.23), as $C < 0$, in the profit-led demand regime $(AE + BC - D) \gtrless 0$. Thus $a_1a_2 - a_3 \equiv \xi(\phi) = \underbrace{AC}_{+}\phi^2 - \underbrace{(AE + BC - D)}_{+/-}\phi + \underbrace{BE}_{+} \gtreqless 0$. Suppose $(AE + BC - D) < 0$. Then $a_1a_2 - a_3 \equiv \xi(\phi) > 0$ (see Figure A.2a). So all the conditions of stability (i.e. $a_1 > 0$, $a_2 > 0$, $a_3 > 0$, and $a_1a_2 - a_3 > 0$) are satisfied, no matter what happens to the size of ϕ.

Now suppose $(AE + BC - D) > 0$.

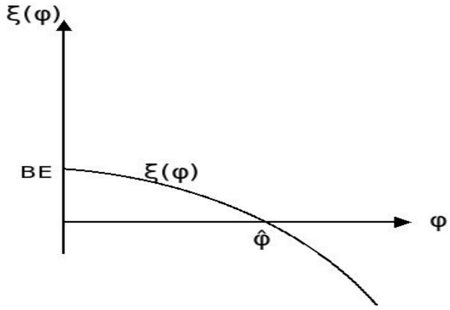
The quadratic function $\xi(\phi)$ is convex and its intercept is positive. Suppose the discriminant of $\xi(\phi) = 0$ is positive. Then equation $\xi(\phi) = 0$ has two positive real roots: $\hat{\phi}_1$ and $\hat{\phi}_2$. For $\phi \in (0, \hat{\phi}_1)$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 > 0$; for $\phi \in (\hat{\phi}_1, \hat{\phi}_2)$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 < 0$; and for $\phi > \hat{\phi}_2$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 > 0$. Hence the Hopf bifurcation occurs at $\phi = \hat{\phi}_1$ and $\phi = \hat{\phi}_2$ (see Figure A.2b). Indeed, at $\phi = \hat{\phi}_1$ and $\phi = \hat{\phi}_2$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 = 0$. Further, $\frac{\partial\xi(\phi)}{\partial\phi} = 2AC\phi - (AE + D - BC)$ and so $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}_1} = \{\underbrace{2AC\hat{\phi}_1}_{+} - \underbrace{(AE + D - BC)}_{+}\} < 0$ and $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}_2} = \{\underbrace{2AC\hat{\phi}_2}_{+} - \underbrace{(AE + D - BC)}_{-}\} > 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}_1$ and $\phi = \hat{\phi}_2$. □



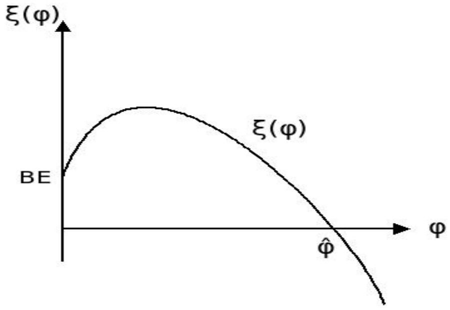
(a) $AC > 0$ and $(AE + BC - D) < 0$



(b) $AC > 0$ and $(AE + BC - D) > 0$



(c) $AC < 0$ and $(AE + BC - D) > 0$



(d) $AC < 0$ and $(AE + BC - D) < 0$

Figure A.2: Diagram of $a_1a_2 - a_3 \equiv \xi(\phi)$: profit-led demand regime

A.5 Proof of Proposition 5

Proof. Three situations are possible here. First, where $A < 0$ but $C > 0$; second, where $A > 0$ but $C < 0$; and third, where A and C both are positive. Let us discuss all those cases step by step.

I. Here $A < 0$ but $C > 0$. $A < 0$ implies $a_1 > 0$. $C > 0$ and $\phi < \frac{E}{C}$ together imply $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. From equation (3.23), as $C > 0$, $A < 0$, and as the economy is in a profit-led demand regime, $(AE + BC - D) \gtrless 0$. Thus $a_1a_2 - a_3 \equiv \xi(\phi) = \underbrace{AC}_{-}\phi^2 - \underbrace{(AE + BC - D)}_{+/-}\phi + \underbrace{BE}_{+} \gtreqless 0$. Suppose $(AE + BC - D) > 0$. Then at $\phi = \hat{\phi}$, $a_1a_2 - a_3 \equiv \xi(\phi) = 0$ (see Figure A.2c). Further, $\frac{\partial \xi(\phi)}{\partial \phi} = 2AC\phi - (AE + BC - D)$ and so $\frac{\partial \xi(\phi)}{\partial \phi}\big|_{\phi = \hat{\phi}} < 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$.

Now assume $(AE + BC - D) < 0$. Then at $\phi = \hat{\phi}$, $a_1a_2 - a_3 \equiv \xi(\phi) = 0$ (see Figure A.2d). Further, $\frac{\partial \xi(\phi)}{\partial \phi}\big|_{\hat{\phi}} \neq 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$.

II. Here $A > 0$ but $C < 0$. $A > 0$ and $\phi < \frac{B}{A}$ together imply $a_1 > 0$. $C < 0$ implies $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. From equation (3.23), as $C < 0$, $A > 0$, and as the economy is in a profit-led demand regime, $(AE+BC-D) \gtrless 0$. Thus $a_1a_2-a_3 \equiv \xi(\phi) = \underbrace{AC}_{-}\phi^2 - \underbrace{(AE+BC-D)}_{+/-}\phi + \underbrace{BE}_{+} \gtreqless 0$. Suppose $(AE+BC-D) > 0$. Then at $\phi = \hat{\phi}$, $a_1a_2-a_3 \equiv \xi(\phi) = 0$ (see Figure A.2c). Further, $\frac{\partial\xi(\phi)}{\partial\phi} = 2AC\phi - (AE+BC-D)$ and so $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}} < 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$.

Now assume $(AE+BC-D) < 0$. Then at $\phi = \hat{\phi}$, $a_1a_2-a_3 \equiv \xi(\phi) = 0$ (see Figure A.2d). Further, $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\hat{\phi}} \neq 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$.

III. Here A and C both are positive. $A > 0$ and $\phi < \frac{B}{A}$ together imply $a_1 > 0$. $C > 0$ and $\phi < \frac{E}{C}$ together imply $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. As $A > 0$, $C > 0$,and $D < 0$, here $(AE+BC-D) > 0$. Thus $a_1a_2-a_3 \equiv \xi(\phi) = \underbrace{AC}_{+}\phi^2 - \underbrace{(AE+BC-D)}_{+}\phi + \underbrace{BE}_{+} \gtreqless 0$. The quadratic function $\xi(\phi)$ is convex and its intercept is positive. Suppose the discriminant of $\xi(\phi) = 0$ is positive. Then equation $\xi(\phi) = 0$ has two positive real roots: $\hat{\phi}_1$ and $\hat{\phi}_2$. For $\phi \in (0, \hat{\phi}_1)$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 > 0$; for $\phi \in (\hat{\phi}_1, \hat{\phi}_2)$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 < 0$; and for $\phi > \hat{\phi}_2$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 > 0$. Hence the Hopf bifurcation occurs at $\phi = \hat{\phi}_1$ and $\phi = \hat{\phi}_2$ (see Figure A.2b). Indeed, at $\phi = \hat{\phi}_1$ and $\phi = \hat{\phi}_2$, we have $a_1 > 0$, $a_2 > 0$, $a_3 > 0$ and $a_1a_2 - a_3 = 0$. Further, $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}_1 \text{ or } \phi=\hat{\phi}_2} \neq 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}_1$ and $\phi = \hat{\phi}_2$. □

A.6 Proof of Proposition 6

Proof. $A < 0$ implies $a_1 > 0$. As the economy is in a profit-led demand regime, $\{\mu f + (1-\theta)m_{wu}\} < 0$ ensures C to be negative which in turn implies $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. From equation (3.23), as $C < 0$, $A < 0$, and the economy is in a profit-led demand regime, $(AE+BC-D) \gtrless 0$. Thus $a_1a_2-a_3 \equiv \xi(\phi) = \underbrace{AC}_{+}\phi^2 - \underbrace{(AE+BC-D)}_{+/-}\phi + \underbrace{BE}_{+} \gtreqless 0$. Rest of the proof is same as in A.4. □

A.7 Proof of Proposition 7

Proof. $A > 0$ and $\phi < \frac{B}{A}$ together imply $a_1 > 0$. $\{\mu f + (1-\theta)m_{wu}\} < 0$ ensures C to be negative which in turn implies $a_2 = E - C\phi > 0$. $D < 0$ ensures $a_3 > 0$. From equation (3.23), as $C < 0$, $A > 0$, and the economy is in a profit-led demand regime, $(AE + BC - D) \gtrless 0$. Thus $a_1a_2 - a_3 \equiv \xi(\phi) = \underbrace{AC}_{-}\phi^2 - \underbrace{(AE + BC - D)}_{+/-}\phi + \underbrace{BE}_{+} \gtreqless 0$.

Suppose $(AE + BC - D) > 0$. Then at $\phi = \hat{\phi}$, $a_1a_2 - a_3 \equiv \xi(\phi) = 0$ (see Figure A.2c). Further, $\frac{\partial\xi(\phi)}{\partial\phi} = 2AC\phi - (AE+BC-D)$ and so $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\phi=\hat{\phi}} < 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$.

Now assume $(AE+BC-D) < 0$. Then at $\phi = \hat{\phi}$, $a_1a_2 - a_3 \equiv \xi(\phi) = 0$ (see Figure A.2d). Further, $\frac{\partial\xi(\phi)}{\partial\phi}\big|_{\hat{\phi}} \neq 0$. Thus, all conditions of Hopf bifurcation are satisfied. As a result, there exists a continuous family of non-constant, periodic solutions of the system around $\phi = \hat{\phi}$. □

A.8 Proof of Proposition 8

Proof. Suppose the economy is in an wage-led demand regime. Equation (3.25) yields $a_2 = M - Nf$. If $M > 0$ holds, irrespective of the size of f, a_2 becomes positive. However, when the reserve army effect is strong, $M < 0$ holds and therefore $a_2 \gtrless 0$ depending on whether $f \gtrless f_1 = \frac{M}{N}$. As $f_\gamma(u,\gamma) = \frac{\alpha\beta}{(\alpha\gamma+\beta u)^2} > 0$, A fall in the wage gap leads to a fall in f and when f falls below $\frac{M}{N}$, a_2 becomes negative and the economy becomes unstable. □

A.9 Proof of Proposition 9

Proof. Suppose the economy is in an profit-led demand regime and $\{h_m g_{d\Omega} + (g_{dm} - su)\} > 0$ holds. Equation (3.25) yields $a_2 = M - Nf$. As $f_\gamma(u,\gamma) = \frac{\alpha\beta}{(\alpha\gamma+\beta u)^2} > 0$, A rise in the wage gap raises f and when f rises beyond $\frac{M}{N}$, a_2 becomes negative and the economy becomes unstable.

On the other hand, equation (3.24) yields G is positive and so $a_1 \gtrless 0$ depending on $f \lessgtr \frac{F}{G}$. As a rise in the wage gap raises f. When f rises beyond $\frac{F}{G}$, a_1 becomes negative and the economy becomes unstable irrespective of the sign of $\{h_m g_{d\Omega} + (g_{dm} - su)\}$. □