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Abstract

This paper tries to clarify some important aspects around the zero-growth discussion. Starting from an accounting perspective, we analyse the implications of zero growth and clarify the stability conditions of such an economy. This is complemented with a monetary circuit approach – which, like any model, has to respect the national income and financial accounting conventions. The latter allows us to show that a stationary economy, i.e an economy with zero net investment, is compatible with positive profits and interest rates. It is also argued that a stationary economy does not generate systemic financial instability, in the sense of rising or falling financial assets- or financial liabilities-income ratios, if the financial balances of each macroeconomic sector are zero. In order to analyse the dynamic stability of such an economy, we make use of an autonomous demand-led growth model driven by government expenditures. We show that a stable stationary state with zero growth, positive profits, and a positive interest rate is possible. However, the stable adjustment of government expenditure-capital and government debt-capital ratios to their long-run equilibrium values requires specific maxima for the propensity to consume out wealth and for the rate of interest, assuming a balanced government budget and zero retained earnings of the firm sector.

Keywords: Ecological macroeconomics, post-Keynesian economics, stationary-state economics, growth imperative

JEL code: Q01, O44, P10

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1. Introduction

The limit to economic growth imposed by nature has been pointed out by many authors over several decades. Already in the 1970s, the work by Daly (1974), Georgescu-Roegen (1971), and Meadows (1972) warned about the degradation of the earth's carrying capacity. Economic activities are constrained by the first and second law of thermodynamics, the complexity of intertwined natural processes, and the exhaustibility of natural resources. Despite these constraints, about half of the carbon emissions released into the atmosphere from the burning of fossil fuels occurred in the last three decades (Wallace-Wells 2019), and the urgency of transitioning towards an economy that respects planetary boundaries is evident.

Several strands in the literature have different ideas and proposals of how to make such a transition happen and many authors have discussed the associated implications for the economy. Some authors defend the possibility of decoupling economic growth from negative environmental impacts (Asafu-Adjaye et al. 2015, OECD 2015). Others are sceptical and argue that a non-growing or even a de-growing economy is necessary if we are to achieve ecological sustainability (Jackson 2017, Kallis 2011). Largely influenced by the work by Daly (1972, 1996), who presents the concept of a stationary state economy, zero-growth and de-growth proponents suggest that to meet ambitious ecological targets, we will need to go through a process of sustainable de-growth, which involves the downscaling of society's throughput, i.e. a decrease of material production and consumption (Kallis 2011) that will most likely lead to a stagnant or shrinking economy.

The latter might involve such a deep transformation of the economy and society that the possibility of such a transition within a capitalist system has been questioned (Kallis 2011). Specifically, it is argued that growth is a systemic requirement of capitalism (Harvey 2007, Binswanger 2009), in other words, that capitalism is bound to a 'growth imperative'. This involves aspects such as the use of debt, interest, or the eternal search for profit, market share, and accumulation as mechanisms to remain competitive (Kovel 2002, Richters/Siemoneit 2017, 2019).

Several post-Keynesian and ecological economists have also addressed these questions using different types of models and assumptions. Fontana/Sawyer (2013, 2014, 2016), provide important conceptual attempts at integrating ecological constraints into post-Keynesian macroeconomics. They present a simple post-Kaleckian demand-led growth model and distinguish the warranted growth rate and the full employment growth rate from the growth rate allowed by ecological footprint. They argue that these growth rates are independent of each other and that there is no automatic adjustment that aligns them. Since achieving an ecologically sustainable growth rate will require major adjustments of the growth in the capital stock and the effective labour force, economic policy interventions will be crucial for the transition towards ecological sustainability. However, stability issues of (close to) stationary state economies are not examined.

Lange (2018), who analyses the conditions for sustainable economies without growth in different theories, concludes that post-Keynesian theory can be compatible with zero growth.

In a scenario with technological change, reductions in working hours and compensatory wage increases is found to be necessary to avoid rising unemployment. Furthermore, positive profits must be matched with a sufficiently high level of consumption out of profits. Consumption out of profits and out of wages must equal overall income, which in other words means that saving must be equal to zero. However, his study does not include any stability analysis.

Rosenbaum (2015) tackles the issue of stable zero growth and technological progress using a Kaleckian model with fixed capital costs in the simple mark-up pricing function, which is problematic because unit fixed capital costs vary with the level of output. Target rate of return pricing would thus have been an adequate approach. He introduces depreciation, but without differentiating capital scrapping and re-investment from depreciation, in contrast to Bhaduri (1972), Cassetti (2006) and Hein (2021), and discusses different cases for zero growth and its stability. However, as shown by Monserand (2020), there are several further inconsistencies in the model, which means that overall Rosenbaum (2015) is not proving what he claims, i.e. the consistency of positive profits with stable zero growth under certain circumstances. Monserand (2019) provides a more convincing approach of discussing zero or de-growth in a basic neo-Kaleckian distribution and growth model. He analyses the possibility of an equilibrium with a zero or negative rate of accumulation while verifying the Keynesian goods market equilibrium stability condition. He shows that the integration of autonomous consumption and/or government deficits allows for a stable goods market equilibrium with zero investment but positive profits. However he only focuses on the existence and stability of the goods market equilibrium without looking at the financing side and the related issue of financial stability.

Analysing the viability of positive interest rates in a stationary economy, Berg et al. (2015) combine a stock-flow consistent (SFC) model with an input-output approach. They show that an equilibrium, i.e. constant stock-flow ratios, is possible, depending on the parameters regarding the propensity to consume out of wealth and the rate of interest on deposits, which is the only income from financial assets received by households, who also receive all the firms' profits. In their model, the government runs a balanced budget. This is also the case in Cahen-Fourot/Lavoie (2016), who consider an SFC stationary economy and an endogenous determination of debt in the stationary state to show that models with credit-money and positive interest rates are compatible with a stationary economy. They show the latter is possible through the balancing of saving out of income with consumption out of wealth. Similarly, Jackson/Victor (2015) also find that a minimum consumption out of wealth is required for a stationary state in their SFC model with a more differentiated banking sector, including a central bank and commercial banks. However, in Cahen-Fourot/Lavoie (2016) the dynamic adjustment towards the stationary state is not considered, while Berg et al. (2015) and Jackson/Victor (2015) provide numerical robustness checks but no general stability analysis.

Richters/Siemoneit (2017) have clarified in their review of several models that a stationary state with positive profits and interest rates is only possible under the condition that each sector is running neither financial deficits nor surpluses.[1] The latter means that there are no retained

[1] Their review includes Berg et al. (2015), Binswanger (2009, 2015), Cahen-Fourot/Lavoie 2016), Douthwaite (2000), Farley et al (2013), Godley/Lavoie (2007), Jackson/Victor (2015), and Lietaer et al (2012).

profits in the corporate sector, that there are balanced government budgets, and that saving out of household income is compensated for by consumption out of wealth – in an open economy we would also need a current account balance. Only under these conditions will the ratios of financial assets or liabilities to income (or the capital stock) remain constant. However, Richters/Siemoneit (2017) do not examine the dynamic stability of a zero-growth equilibrium.

Our paper aims at clarifying the requirements for the macroeconomic stability of a zero-growth economy in a systematic way. We will only focus on the goods market equilibrium and on systemic financial stability in the sense of constant and stable asset- or debt-capital (or –income) ratios for a closed one-good economy without technological change. Extending the models to the open economy will be left for future work. The same is true for the issues of full employment in a zero-growth economy, as well as technological change, productivity growth and structural change. These last issues are, in our view, important to discuss—in particular, the traverse towards a sustainable economy. However, we will not attempt to do so here. Our contribution is thus rather modest and basic, but we hope to contribute to a clarification of these fundamental concerns.

Having in mind the requirement pointed out by Richters/Siemoneit (2017), we begin by outlining the macroeconomic implications for zero growth from a macroeconomic accounting perspective in Section 2. In Section 3, we will analyse these requirements in a monetary circuit approach which, of course, obeys national accounting conventions, but more explicitly traces the monetary flows in the model economy from credit creation for initial finance to credit repayment and destruction. In Section 4, we will then analyse the dynamic stability of a zero-growth economy, including private saving and investment functions, as well as endogenously determined government expenditures- and government debt-capital ratios in the long run. We will do so by making use of an autonomous demand-led growth model driven by government expenditures. Section 5 will summarise and conclude.

2. An accounting perspective on stable zero growth

Departing from an accounting perspective, in this section we seek to clarify the requirements for stable zero growth, with regard to the goods market and the financial market. For the stability of the goods market, effective demand must be sufficient to generate and reproduce stationary output over time. From national income accounting, we know that output (Y) is given as the sum of private consumption out of rentiers' income (C_R) and out of wages (C_W), government consumption expenditures (G), net investment (I), revenues from exports of goods and services (Ex), and expenditures on imports of goods and services (Im), all variables in real terms:

$$Y = C_R + C_W + G + I + Ex - Im \tag{1}$$

For a stationary economy at some target level of output consistent with ecological sustainability (Y^T), we need zero net investment, i.e. I=0:

$$Y^T_{I=0} = C_R + C_W + G + Ex - Im \quad (2)$$

The financial balances of the different macroeconomic sectors, that is, the private sector (composed of workers' and capitalists'/rentiers' households and the corporate sub-sectors), the public sector,[2] and the external sector, should be balanced at the stationary target level of output to avoid ever-rising debt-income ratios of any sector – as has also been clarified by other authors such as Richters/Siemoneit (2017).

Again, from national income accounting, we have that output is equal to the sum of total wages (W) and total profits ($\Pi=\Pi_F+R$), where the latter is the sum of retained profits (Π_F) and distributed profits equal to rentiers' income (R). Assuming that both wages and profits are taxed, wages can be split into net wages and taxes on wages ($W=W^n+T_W$), retained profits into net retained profits and taxes on retained profits ($\Pi^T_F=\Pi^n_F+T_F$), and distributed profits into rentiers' net income and taxes on rentiers' income ($R=R^n+T_R$):

$$Y = C_R + C_W + G + I + Ex - Im = \Pi^n_F + T_F + R^n + T_R + W^n + T_W \quad (3)$$

From this we obtain:

$$\begin{aligned} &\Pi^n_F - I + R^n - C_\Pi + W^n - C_W + T_W + T_F + T_R - G + Im - Ex \\ &= FB_F + FB_R + FB_W + FB_G + FB_f \\ &= 0 \end{aligned} \quad (4)$$

with $FB_F=\Pi^n_F-I$ as the corporate financial balance, $FB_R=S_R=R^n-C_\Pi$ as the rentiers' households' financial balance, equivalent to saving out of rentiers' income, $FB_W=S_W=W^n-C_W$ as the workers' households' financial balance, equivalent to saving out of wages, $FB_G=T_W+T_F+T_R-G=T-G$ as the government financial balance, and $FB_f=Im-Ex$ as the foreign sector financial balance. Alternatively, since total private saving in our economy is $S=\Pi^n_F+S_R+S_W$, and taking $T=T_W+T_F+T_R$, equation (4) can also be written in the more familiar way as:

$$S - I + T - G + Im - Ex = FB_P + FB_G + FB_f = 0 \quad (5)$$

which means that, from a macroeconomic accounting perspective, the sum of the financial balances of the private, government, and foreign sectors have to be equal to zero. However, for a financially stable zero growth economy at the output level Y^T, each sector's financial balance must be equal to zero. Otherwise, some sectors would build up financial assets over time whereas others would accumulate the counterpart financial liabilities. We would hence see

[2] We would argue that even for a government which can issue debt in its own currency and which is supported by a national central bank, ever rising government debt-income ratios pose some financial instability risk in an open economy with capital mobility.

rising financial assets-income ratios, as well as increasing financial liabilities-income ratios, violating our condition for the financial stability of a stationary economy. Returning to equation (4), this implies that saving out of rentiers' and workers' net incomes have each to be zero (S_R=S_W=0), governments will have to run a balanced budget (T-G=0), net exports and hence the current account have to be equal to zero, too (Ex-Im=0). Furthermore, since in a stationary state economy net investment is equal to zero, retained profits must also be zero ($I=\Pi_F^n=0$). For the stationary state target level of output from equation (2) this implies:

$$Y_{I=0}^T = C_R + C_W + G = R^n + W^n + T_R + T_W = R^n + W^n + T \tag{6}$$

Since retained profits have to be zero, there are no taxes on these profits anymore, and taxes are now given as the sum of taxes on rentiers' income and taxes on wages ($T=T_R+T_W$). From a national accounting perspective, it must be the case that total net profits are equal to rentiers' net income and rentiers' consumption:

$$\Pi^n = R^n = C_R \tag{7}$$

Positive profits and a positive interest rate are thus consistent with a stationary economy. In the next section, we will confirm these results by taking a closer look at the related financial flows in a monetary circuit approach.

3. Zero growth in a monetary circuit model

In this section, we will complement the accounting perspective with a monetary circuit approach, similar to but more explicitly than Fontana/Sawyer (2013, 2014, 2016).[3] This approach is firmly based on the view of endogenous credit money, and a key feature is the role of the banking sector in its ability to create money. Expenditures can only happen if the economic agent is able to finance such expenditure, i.e. if the agent has access to credit money, which can be generated by the banking sector 'out of nothing'.

The simple model for a pure credit economy without a central bank and hence without central bank money is composed of five sectors, as shown in the balance sheet matrix in Table 1. We have a commercial banking sector which is able to generate short-term credit (B^S), as well as to grant long-term credit (B). Other sectors may hold deposits with the banking sector, where such deposits are the most liquid financial asset. Below we will assume that the interest rate on short-term credit and deposits is zero and that any interest on long-term credit received by banks is immediately transferred to the rentiers as the owners of the banks. The second sector is a firm sector whose capital stock (K) is long-term financed by equity held by shareholders/rentiers (E_R) and by the firms themselves as accumulated retained earnings (E_F). The firm sector thus does not issue debt and is not financing its capital stock by long-term credit. The government

[3] On the Monetary Circuit School see Bossone (2001, 2003), Graziani (1989, 1994, 2003), Hein (2008, Chapter 10.2), Lavoie (2014, Chapter 4.3), Lavoie and Seccareccia (2016), and Seccareccia (1996, 2003), for example.

sector is the indebted sector in our model and issues long-term bonds held by rentiers and by banks. The rentiers' households hold equity issued by the firms, long-term bonds issued by the government and may also hold deposits with the banks. The workers' households do not hold any assets nor issue liabilities. The stock accounting consistency requires:

$$K = E_F + E_R \tag{8}$$

Table 1: Balance sheet matrix for a zero-growth closed economy						
	Workers' households	Rentiers' households	Firms	Government	Banks	Σ
Deposits		$+D_R$			$-D_R$	0
Loans		$+B_{GR}$		$-(B_{GR}+B_{GB})$	$+B_{GB}$	0
Equity		$+E_R$	$-E_R$			
Capital			K			K
Σ	0	$+E_R+B_{GR}+D_R$	$+E_F$	$-(B_{GR}+B_{GB})$	0	$K = E_F+E_R$

For a zero-growth equilibrium economy, with zero net investment (I=0) and with initial government debt and thus interest payments of the government to the rentiers (iB_{GR}), our accounting equation (6) for income and expenditures becomes:

$$Y^T_{I=0} + iB_{GR} = C_R + C_W + G + iB_{GR} = R^n + W^n + T_R + T_W = R^n + W^n + T \tag{9}$$

Furthermore, from Section 2, we know that the prevention of systemic financial stability requires that the financial balances of each sector have to be equal to zero. This means that retained profits of the firm sector are zero and the rentiers receive all the profits as dividends. Saving out of workers' and out of rentiers' income need to be zero, too. This means that workers and rentiers have to spend their net income after taxes for consumption goods. Furthermore, the government will have to run a balanced budget:

$$\Pi = R \tag{10}$$

$$R - T_R = R^n = C_R \tag{11}$$

$$W - T_W = W^n = C_W \tag{12}$$

$$T_R + T_W = T = G + iB_{GR} \tag{13}$$

Figure 1 shows the four phases of the monetary circuit for a zero-growth economy with initial government debt, where F represents firms, Gov the government, HH_R rentiers' households, and HH_W workers' households. In the first phase of the circuit, short-term initial finance (with no interest rate being charged on such finance) is provided from the banks to the firms (B^S_F) and to the government (B^S_G). The initial finance for firms consists of wages and profits/dividends to be paid in advance to workers' and rentiers' households (B_F^S=wN+Π). The initial finance for the governments consists of planned government consumption expenditures plus government interest payments on the stock of debt to the rentiers (B_G^S=G+iB_{GR}).

The initial finance allows income payments to be made in advance to the rentiers' and workers' households in the second phase. In our case, this would correspond to the interest payments from the government to the rentiers (iB_{GR}), the profits/dividends from the firms to the rentiers (Π), and wages paid by firms, which are equal to the nominal wage rate multiplied by the number of employed persons (W=wN).

Income received then allows for expenditures in the third phase (i.e. the reflux phase). Rentiers and workers' pay taxes (T_R, T_W) to the government and spend their net incomes on consumption goods (C_R=R^n, C_w=W^n). The government now also spends its initial finance on government consumption (G).

The expenditures in the third phase make sure that the firms and the government receive the funds which enables them in the fourth phase to repay initial finance and hence short-term credit to the banks and thus to close the circuit. In the course of the monetary circuit, profits of firms have been realised. A positive interest rate on government debt is consistent with a stable stationary economy since interest payments are compensated by tax revenues.

Figure 1: A monetary circuit for a zero-growth economy with a government and without interest on initial finance

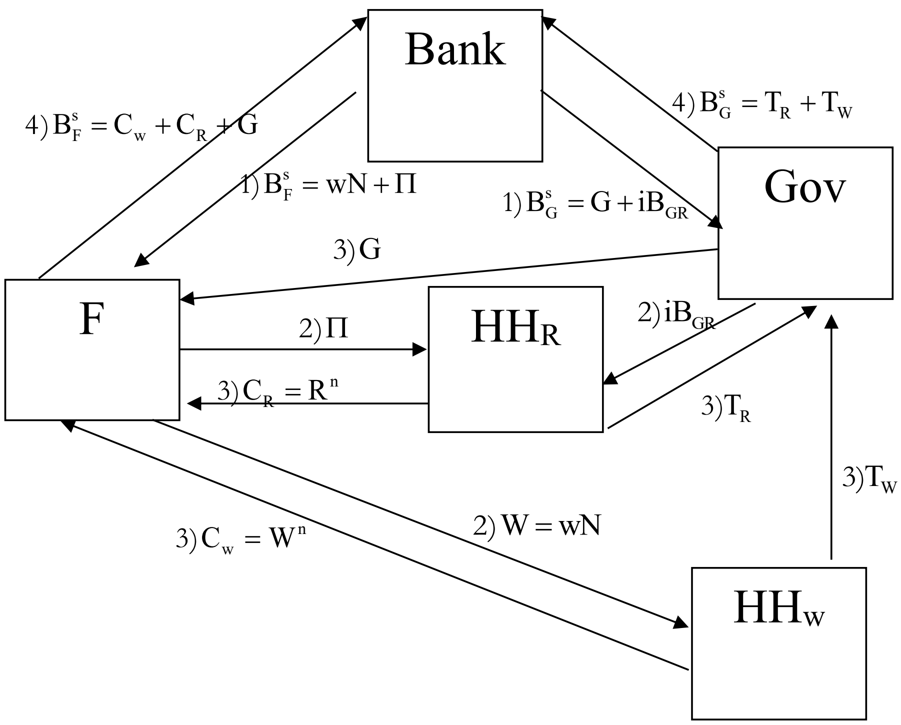


Table 2 presents the transaction flow matrix for our simple zero-growth economy. It displays the transactions between different sectors within a period and reflects the structure of the national accounting system. The first seven rows represent output Y from the spending and income approach and show for each sector zero net saving. The lower part represents the changes in financial assets and liabilities between sectors, the sum of which for each sector also has to be zero in a stable stationary economy, in which no sector should build up financial assets or liabilities. Of course, the portfolio structure of each sector may change, within the constraints given by consistent accounting. For example, if liquidity preference of the rentiers' household rises and they prefer to hold more deposits instead of government bonds, this implies (given a constant net asset position) that they have to reduce credit granted to the government while banks increase their long-term credit to the government. In other words, in a stable zero-growth economy, portfolio shifts are possible as long as net saving of each sector remains zero.

Table 2: Transaction flow matrix for a zero-growth closed economy

	Workers' house-holds	Rentiers' households	Firms' current	Firms' capital	Government	Banks	Σ
Taxes	$-T_W$	$-T_R$			$+T_W+T_R$		0
Government consumption			+G		-G		0
Consumption	$-C_W$	$-C_R$	$+C_W+C_R$				0
Investment							0
Wages	+W		-W				0
Retained profits							0
Distributed profits/dividends		+Π	-Π				
Interest payments		$+R_G$			$-R_G$		0
Σ	0	0	0	0	0	0	0
Change in deposits		$-/+dD_R$				$+/-dD_R$	0
Change in loans		$-/+dB_{GR}$			$+/-B_{GR}$ $+/-B_{GB}$	$-/+dB_{GB}$	0
Change in equity		$-/+dE_R$		$+/-dE_F$			0
Σ	0	0	0	0	0	0	0

4. An autonomous demand-led growth model with zero growth

Having so far clarified the properties of a stationary economy from an accounting and a monetary circuit perspective, including the related stock consistencies, we will now integrate these properties into a dynamic model. For this purpose, we will use an autonomous demand-led growth model, a type of model which has become popular in heterodox macroeconomics and which has recently been merged with the Kaleckian distribution and growth models.[4] These models are based on the work by Serrano (1995a, 1995b), who proposed a 'Sraffian supermultiplier' model driven by autonomous demand. This model was later developed and applied by other Sraffian authors, such as Cesaratto (2015), Cesaratto et al. (2003), Cesaratto/Di Bucchianico (2020), Dejuan (2005), Deleidi/Mazzucato (2019), Di Bucchianico (2021), Fazzari et al. (2013, 2020), Freitas/Christianes (2020), Freitas/Serrano (2015, 2017), Girardi/Pariboni (2016), Pariboni (2016), Vieira Mandarino et al. (2020), among others. Starting with Allain (2015) and Lavoie (2016), Kaleckian authors, such as Allain (2019, 2021), Dutt (2019, 2020), Hein (2018), Hein/Woodgate (2021), Lavoie/Nah (2020), Nah/Lavoie (2017, 2019a, 2019b) and Palley (2019) have also applied this type of model by introducing a Sraffian supermultiplier process into some variants of the Kaleckian distribution and growth models. In general terms, these models have tried to explain growth episodes through the growth of an autonomous demand component, such as autonomous consumption, residential investment, exports, or government expenditures.[5] Kaleckian authors have also shown that autonomous demand growth can tame Harrodian instability under some weak conditions and that the paradox of thrift and the potential paradox of costs can also hold for the long-run growth path when the economy convergences towards some normal rate of capacity utilisation, even if not affecting the long-run growth rate.

Sraffian supermultiplier models and the integration of autonomous demand growth into Kaleckian models have been critically discussed, in particular because of the implied full endogeneity of investment with respect to output growth, i.e. fully induced investment, and it has been questioned whether any type of expenditure growth can be fully autonomous with respect to variation of income and output in the long run, for which these models have been designed (Nikiforos 2018, Skott 2019). Of course, these are valid concerns. Nonetheless, we consider an autonomous demand-led growth model driven by government expenditures as a useful starting point for the analysis of the stability of zero growth. Indeed, there are doubts regarding the long-run autonomy of (parts of) consumption, residential investment and exports with regard to output and income growth, in particular because of the endogeneity of the ability to long-term finance these expenditures independently of current income. However, these concerns are less valid for government expenditures, in particular if governments can issue debt in domestic currency, as has been argued by Hein (2018) and Hein/Woodgate (2021). Furthermore, treating private investment as fully induced by demand growth allows for an endogenous adjustment of the private sector to politically enforced zero growth, although some readers might consider this mechanism as too easy, avoiding the difficult problem of imposing zero net investment and zero retained earnings on the corporate sector.

Our autonomous demand-led growth model is inspired by Hein (2018) and Hein/Woodgate (2021), which are among the first autonomous demand-led growth models explicitly addressing financial dynamics and stability. The dynamic model will build on the closed economy model structure developed in the previous sections. We will also introduce taxes as in Dutt (2020),

[4] See for example, the recent special issues in *Metroeconomica*, 2019, 70 (2) and in the *Review of Keynesian Economics*, 2020, 8 (3).

[5] See Girardi/Pariboni (2016), Girardi et al. (2020), Fiebiger (2018), Fiebiger/Lavoie (2019), Perez-Montiel/Manera (2020) and Perez-Montiel/Pariboni (2021) for some empirical applications.

and following our requirements derived above, a balanced government budget, as in Allain (2015). To simplify the model, only taxes on capital income are considered. The model structure can thus also be presented by the balance sheet matrix in Table 1, ignoring deposits, and by the transaction flow matrix in Table 2, ignoring taxes on wages and potential changes in the portfolio composition in the lower part of that table.

In the short run, defined by given government expenditures- and government debt-capital ratios, the model may generate a goods market equilibrium with positive capital accumulation and saving rates. In the long run, however, when government expenditures- and government debt-capital ratios become endogenous, the model converges towards the autonomous growth rate of government expenditures, which is set equal to zero. We examine the conditions under which this long-run convergence will lead to stable equilibria for government expenditures- and government debt-capital ratios – and thus to a stable stationary economy with positive profits and a positive rate of interest.

In the model, the pre-tax profit share in production ($h=\Pi/Y^P$) is determined by mark-up pricing of firms in an oligopolistic goods market. With given institutional conditions in the goods market, prices are constant, and we can set the price level at p=1, such that nominal and real variables coincide. Since retained earnings in a stable stationary economy have to be zero, rentiers receive all the profits from production (hY_P) and the interest paid by the government on the stock of debt (iB_G). We assume that workers do not save and only rentiers, with a given tax rate (t_R), save a fraction of their net income after taxes $[(1-t_R)(hY_P+iB_G)]$ according to their propensity to save (s_R). Furthermore, they consume a fraction of their wealth (B+K) according to their propensity to consume out of wealth (c_{RW}), which in effect lowers their saving out of current income accordingly. Normalising all variables by the firms' capital stock, such that we have a rate of capacity utilisation ($u=Y_P/K$), a government debt-capital ratio ($\lambda=B_G/K$), a profit rate in production ($r=\Pi/K=hu$), the saving rate ($\sigma=S/K$) is given as:

$$\begin{aligned}\sigma &= s_R(1-t_R)(hu+i\lambda)-c_{RW}(1+\lambda) \\ &= s_R(1-t_R)hu+\lambda\left[is_R(1-t_r)-c_{RW}\right]-c_{WR}, \\ &0<s_R\leq 1, 0<c_{RW}\end{aligned} \tag{14}$$

Firms adjust the capital stock via net investment (I) according to the expected trend rate of growth of output and sales, such that potential output given by the capital stock grows in line with expected demand. They will slow down (accelerate) the rate of capital accumulation ($g=I/K$) whenever the actual rate of capacity utilisation falls short of (exceeds) the normal or the target rate of utilisation (u_n):

$$g=\alpha+\beta(u-u_n),\quad \beta>0 \tag{15}$$

Government expenditures (G) for goods and services grow at a rate γ and drive our model. The government expenditures-capital ratio ($b=G/K$) is given as:

$$b = \frac{G_0 e^{\gamma t}}{K} \tag{16}$$

Since we assume that only rentiers' income is being taxed, the tax-capital ratio (τ=T/K) is given by:

$$\tau = t_R\left(hu + i\lambda\right), \quad 0 \leq t_R < 1 \tag{17}$$

Hence, we obtain the following balanced budget condition required for stable long-run zero growth, which, for the sake of simplicity, we also assume to hold for the short run:

$$\tau = t_R\left(hu + i\lambda\right) = b + i\lambda \tag{18}$$

In a stationary economy with a stock of government debt inherited from the past and a positive rate of interest to be paid on that debt, governments thus need a primary surplus in order to run a balanced budget.

4.1 Short-run equilibrium

In the short run firms will vary capacity utilisation to adjust output to demand, with given government expenditures- and debt-capital ratios. With a balanced government budget, the goods market equilibrium is given by:

$$\begin{aligned} &\sigma + \tau = g + b + i\lambda \\ &\sigma = g \end{aligned} \tag{19}$$

The Keynesian/Kaleckian stability condition for the short-run goods market equilibrium is:

$$\frac{\partial \sigma}{\partial u} - \frac{\partial g}{\partial u} > 0 \quad \Rightarrow \quad s_R\left(1 - t_R\right) - \beta > 0 \tag{20}$$

From equations (14), (15), (16), (18) and (19), we obtain the short-run goods market equilibrium rate of capacity utilisation with a balanced government budget:

$$u^* = \frac{\alpha - \beta u_n + c_{RW} + \left[c_{RW} - s_R\left(1 - t_R\right)i\right]\lambda}{s_R\left(1 - t_R\right)h - \beta} \tag{21}$$

The corresponding short-run equilibrium values for the rate of profit and the rate of accumulation are:

$$r^* = hu^* = \frac{h\left\{\alpha - \beta u_n + c_{RW} + \left[c_{RW} - s_R\left(1 - t_R\right)i\right]\lambda\right\}}{s_R\left(1 - t_R\right)h - \beta} \tag{22}$$

$$g^* = \frac{\left(\alpha - \beta u_n\right)s_R\left(1 - t_R\right)h + \beta\left\{c_{RW} + \left[c_{RW} - s_R\left(1 - t_R\right)i\right]\lambda\right\}}{s_R\left(1 - t_R\right)h - \beta} \tag{23}$$

Furthermore, from the balanced budget condition in equation (18), we can get the rate of utilisation associated with this balanced budget:

$$u = \frac{b + \left(1 - t_R\right)i\lambda}{t_R h} \tag{24}$$

From equations (21) and (24) we obtain for the short-run equilibrium tax rate required for a balanced budget:

$$t_R^* = \frac{\left(s_R h - \beta\right)\left(b + i\lambda\right)}{h\left(\alpha - \beta u_n + c_{RW} + s_R b\right) + \left[c_{RW} h + \left(s_R h - \beta\right)i\right]\lambda} \tag{25}$$

Using this equilibrium tax rate, we can re-write our short-run equilibrium values for the rates of capacity utilisation, profit and capital accumulation as follows:

$$u^* = \frac{\alpha - \beta u_n + c_{RW}\left(1 + \lambda\right) + s_R b}{s_R h - \beta} \tag{26}$$

$$r^* = \frac{h\left[\alpha - \beta u_n + c_{RW}\left(1 + \lambda\right) + s_R b\right]}{s_R h - \beta} \tag{27}$$

$$g^* = \frac{\left(\alpha - \beta u_n\right)s_R h + \beta\left[c_{RW}\left(1 + \lambda\right) + s_R b\right]}{s_R h - \beta} \tag{28}$$

Figure 2 illustrates a possible short-run equilibrium. As can be seen, in the short run, firms' assessment of the trend rate of growth may be different from the growth rate of autonomous demand, which is set to zero here. Therefore, even if we had zero net financial balances of each sector at the normal rate of capacity utilisation (i.e. a balanced government budget and consumption out of wealth exactly compensating saving out of rentiers' income), capacity utilisation will deviate from the normal rate, and capital accumulation, saving and growth may hence be positive in the short run.

Figure 2: Short-run equilibrium

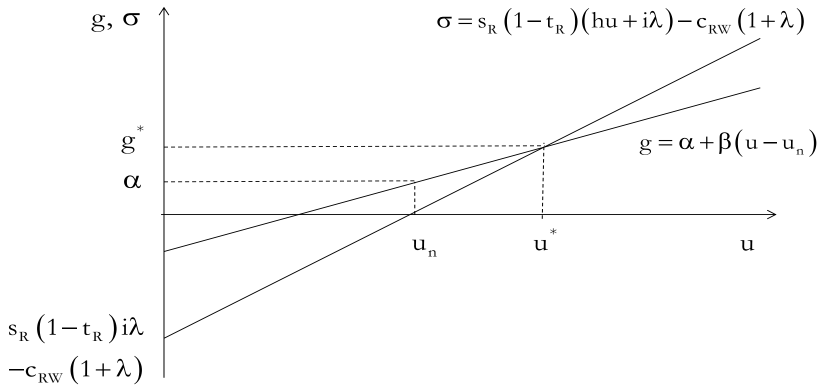


Table 3 below contains the short-run comparative statics of our model, which are of the usual neo-Kaleckian type. The paradox of thrift holds, we have positive wealth effects on all endogenous variables, and aggregate demand is wage-led. Higher tax rates and higher government expenditures are expansionary (balanced budget multiplier), higher interest rates are contractionary with an exogenous tax rate, as in equations (21) – (23), because of an inverse relationship with government expenditures. However, if government expenditures are exogenous, a higher interest rate has no effect, as in equations (26) – (28). A higher tax rate or higher government expenditures are expansionary, the same is true for a higher government-debt capital ratio if government expenditures are exogenous.

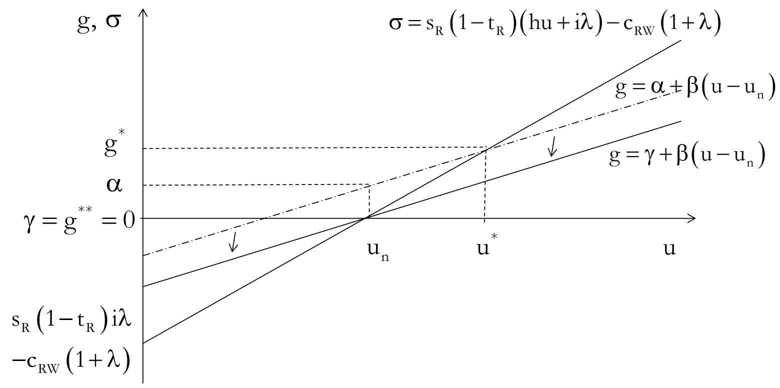
4.2 Long-run equilibrium

In the long run, following Dutt's (2019, 2020) proposal of 'rational' or—more appropriately expressed—'reasonable' expectations on behalf of the firms, expectations about the trend rate of growth of the economy adjust to the autonomous growth rate of government expenditures, equal to zero in our model economy:

$$\alpha = \gamma = 0 \tag{29}$$

We should thus see an adjustment of the goods market equilibrium toward the normal rate of capacity utilisation and the autonomous growth rate of government expenditures, as shown in Figure 3.

Figure 3: Long-run equilibrium



For the long-run equilibrium, we have to consider that the government expenditure- and debt-capital ratios are endogenous. Their time rates of change $\dot{x}=\partial x/\partial t$ are given as:

$$\dot{b} = b(\gamma - g) = b\left[\gamma - \alpha - \beta\left(u^{*} - u_{n}\right)\right] \tag{30}$$

$$\dot{\lambda} = b + i\lambda - \tau - \lambda g \tag{31}$$

A balanced budget ($b+i\lambda-\tau=0$) turns equation (31) to:

$$\dot{\lambda} = -\lambda g = -\lambda\left[\alpha + \beta\left(u^{*} - u_{n}\right)\right] \tag{32}$$

For the long-run equilibrium, we need $\dot{b}=0$ and $\dot{\lambda}=0$ in equations (30) and (32). This generates the trivial long-run equilibrium, with r_n as the normal rate of profit, i.e. the rate of profit at normal capacity utilisation:

$$u^{**} = u_{n} \tag{33}$$

$$r^{**} = hu_{n} = r_{n} \tag{34}$$

$$g^{**} = \gamma = 0 \tag{35}$$

$$b^{**} = 0 \tag{36}$$

$$\lambda^{**} = 0 \tag{37}$$

However, we can also derive more meaningful long-run equilibria for our model in which we have positive government expenditures- and debt-capital ratios. Plugging the long-run equilibrium rate of capacity utilisation from equation (33) into the into the short-run goods market equilibrium rate of capacity utilisation from equation (21) gives:

$$u_n = \frac{\alpha + c_{RW} + \left[c_{RW} - s_R\left(1-t_R\right)i\right]\lambda}{s_R\left(1-t_R\right)h} \tag{38}$$

Rearranging, and including the long-run requirement of a stationary economy (α=γ=0), provides the long-run equilibrium government debt-capital ratio:[6]

$$\lambda^{**} = \frac{s_R\left(1-t_R\right)hu_n - c_{RW}}{c_{RW} - s_R\left(1-t_R\right)i} \tag{39}$$

Furthermore, from the balanced budget condition in equation (18), using equations (33) and (39), we obtain:

$$b^{**} = t_R h u_n - \left(1-t_R\right)i\lambda^{**} = t_R h u_n - \frac{\left(1-t_R\right)i\left[s_R\left(1-t_R\right)hu_n - c_{RW}\right]}{c_{RW} - s_R\left(1-t_R\right)i} \tag{40}$$

In what follows, we will examine the dynamic stability of the non-zero equilibria in equations (39) and (40) making use of the dynamic equations (30) and (32) and the short-run goods market equilibrium in equation (26). The corresponding Jacobian matrix is given by:

$$J = \begin{pmatrix} \frac{\partial \dot{b}}{\partial b} & \frac{\partial \dot{b}}{\partial \lambda} \\ \frac{\partial \dot{\lambda}}{\partial b} & \frac{\partial \dot{\lambda}}{\partial \lambda} \end{pmatrix} \tag{41}$$

Evaluated at the long-run equilibrium values b^{**} and λ^{**}, we get:

$$\frac{\partial \dot{b}}{\partial b} = \frac{-\beta s_R b^{**}}{s_R h - \beta} \tag{30a}$$

$$\frac{\partial \dot{b}}{\partial \lambda} = \frac{-\beta c_{RW} b^{**}}{s_R h - \beta} \tag{30b}$$

[6] The same results can be derived by starting from the goods market equilibrium formulation in equation (26) together with equations (18) for the balanced government budget and (33) for the long-run equilibrium rate of capacity utilisation.

$$\frac{\partial \dot{\lambda}}{\partial b} = \frac{-\beta s_R \lambda^{**}}{s_R h - \beta} \tag{32a}$$

$$\frac{\partial \dot{\lambda}}{\partial \lambda} = \frac{-\beta c_{RW} \lambda^{**}}{s_R h - \beta} \tag{32b}$$

For the local stability in this 2x2 dynamic system, the trace of the Jacobian has to be negative and the determinant needs to be non-negative. For our system we get:

$$TrJ^{**} = \frac{\partial \dot{b}}{\partial b} + \frac{\partial \dot{\lambda}}{\partial \lambda} = \frac{-\beta s_R b^{**}}{s_R h - \beta} - \frac{-\beta c_{RW} \lambda^{**}}{s_R h - \beta} = \frac{-\beta\left(s_R b^{**} + c_{RW}\lambda^{**}\right)}{s_R h - \beta} \tag{42}$$

$$DetJ^{**} = \frac{\partial \dot{b}}{\partial b}\frac{\partial \dot{\lambda}}{\partial \lambda} - \frac{\partial \dot{b}}{\partial \lambda}\frac{\partial \dot{\lambda}}{\partial b} = 0 \tag{43}$$

A determinant equal to zero implies that we have a zero root model, with a continuum of locally stable equilibria. Since $s_R h$-β>0 has to hold for short-run goods market equilibrium stability, positive long-run equilibrium values for the government expenditures- and debt ratios b^{**} and λ^{**} ensures that $TrJ^{**}<0$, such that we have a stable long-run equilibrium.

We thus have to look at the conditions for positive equilibrium values for b^{**} and λ^{**} in equations (39) and (40). For $\lambda^{**}>0$ in equation (39), we need:

$$s_R\left(1-t_R\right)hu_n > c_{RW} > s_R\left(1-t_R\right)i \quad \Rightarrow \quad r_n > \frac{c_{RW}}{s_R\left(1-t_R\right)} > i \tag{44a}$$

or

$$s_R\left(1-t_R\right)hu_n < c_{RW} < s_R\left(1-t_R\right)i \quad \Rightarrow \quad r_n < \frac{c_{RW}}{s_R\left(1-t_R\right)} < i \tag{44b}$$

Since condition (44b) implies that the rate of interest on safe government bonds exceeds the rate of profit in production, which will make production difficult to sustain, given the 'risks and troubles' involved here, we will continue with condition (44a).

In order for λ^{**}, and b^{**} to assume positive values in equation (40) it is necessary that $\frac{t_R hu_n\left[c_{RW} - s_R\left(1-t_R\right)i\right] - \left(1-t_R\right)i\left[s_R\left(1-t_R\right)hu_n - c_{RW}\right]}{c_{RW} - s_R\left(1-t_R\right)i} > 0$, which implies:

$$\frac{c_{RW} t_R hu_n}{\left(1-t_R\right)\left(s_R hu_n - c_{RW}\right)} > i \quad \Rightarrow \quad \frac{c_{RW}}{s_R\left(1-t_R\right)} > \frac{ir_n}{t_R r_n + \left(1-t_R\right)i} = \frac{i}{t_R + \left(1-t_R\right)i/r_n} \tag{45}$$

Since $r_n > i$ implies that $\frac{i}{t_R + (1-t_R) i / r_n} > i$, for positive and stable long-run equilibria for both b^{**} and λ^{**} in a stationary economy, we need:

$$s_R (1-t_R) h u_n > c_{RW} > \frac{s_R (1-t_R) i h u_n}{t_R r_n + (1-t_R) i} \tag{46}$$

which is equivalent to:

$$h u_n > \frac{c_{RW}}{s_R (1-t_R)} > \frac{i h u_n}{t_R h u_n + (1-t_R) i} \quad \Rightarrow \quad r_n > \frac{c_{RW}}{s_R (1-t_R)} > \frac{i}{t_R + (1-t_R) i / r_n} \tag{47}$$

The normal rate of profit, i.e. the rate of profit at normal capacity utilisation, has to exceed the rate of interest scaled by the denominator in (47), in order to allow the propensity to consume out of wealth to assume a value consistent with stable long-run equilibrium.

The comparative dynamics for changes in the long-run equilibrium with respect to exogenous parameters are also summarised in Table 3. In the long run, utilisation is given by the normal rate and capital accumulation and growth by the zero growth rate of autonomous government expenditures. Of course, a higher target rate of utilisation raises the long-run equilibrium rate of capacity utilisation, and a higher profit share raises the long-run equilibrium profit rate. The propensities to save out of rentiers' income and to consume out of wealth, as well as the interest rate and the tax rate have no effects on the long-run equilibrium rates of utilisation and accumulation, and only affect long-run equilibrium government expenditures- and debt-capital ratios, usually with opposite directions.

Table 3: Response of long-run stable zero growth equilibrium towards changes in exogenous variables in the short run and in the long run

	short run			***long run***				
	u^*	r^*	g^*	u^{**}	r^{**}	g^{**}	$b^{**} > 0$	$\lambda^{**} > 0$
s_R	–	–	–	0	0	0	–	+
c_{RW}	+	+	+	0	0	0	+	–
h	–	–	–	0	+	0	+/–	+
u_n	–	–	–	+	+	0	+/–	+
i	–	–	–	0	0	0	–	+
t_R	+	+	+	0	0	0	+	–
b	+	+	+					
λ	+	+	+					

Note: In the short-run, there are two cases regarding t_R and b: In case 1, t_R is exogenous while b is endogenous, while in case 2, b is exogenous and t_R endogenous. Rows 5 and 6 represent the first case and row 7 the second case.

5. Conclusions

In this paper we started with the assumption that zero growth may emerge as a possibility to tackle the climate crisis and other environmental constraints. After a short review of some of the related literature, we tried to contribute to the debate of long-run stability of zero growth with positive profits and a positive rate of interest in a capitalist, monetary production economy. We have focussed on the stability of the goods market equilibrium and on the prevention of systemic financial instability, in the sense of cumulative increases in financial assets- or financial liabilities-income ratios, for a closed economy without technical change. Whereas the stable goods market equilibrium requires sufficient demand generation to sustain a constant level of production and income, systemic financial stability requires zero financial balances of each macroeconomic sector. This implies a corporate sector with zero investment does not retain any profits, that saving of private households out of income is exactly balanced by consumption out of wealth and that the government runs a balanced budget in the long run.

We have analysed the requirements for zero growth from a national income accounting perspective, and we have shown that zero growth, positive profits and a positive rate of interest are consistent with each other. Then we complemented this analysis and supported our results with a monetary circuit approach. Of course, none of these approaches contains behavioural equations, so in the final step we thus analysed the short- and long-run stability of zero growth within a Kaleckian autonomous demand-led growth model. In this model, net investment responds to deviations of capacity utilisation from target utilisation in the short run, but adjusts to sales growth expectations determined by autonomous government expenditures growth in the long run. For the sake of simplicity, we have assumed that governments balance their budget not only in the long run, but also in the short. The growth rate of government expenditures – set equal to zero – determines the growth rate of the system. For stable adjustment of government expenditures-capital and government debt-capital ratios to their positive long-run equilibrium values we have derived specific maxima for the propensity to consume out wealth and the rate of interest. Within these limits, stable zero growth with positive profits and a positive rate of interest are thus possible.

Of course, our analysis has only addressed some very basic issues. The analysis was limited to a closed economy, but the basic principles could be applied to an open economy, too. Furthermore, we have only addressed goods market and systemic financial stability in a one-good economy without technological change. Issues of structural change, also in an international dimension, technical progress, and maintaining full employment under these conditions have not been tackled. These issues, in our view, are important for discussing the traverse towards a sustainable economy, in particular. Moreover, despite showing the conditions for stability, we did not delve into the political feasibility of our findings. We have shown that a stable zero-growth economy with positive profits and a positive interest rate is possible. However, meeting the related conditions might imply a significant transformation of capitalism – to what degree remains open for further debate. Our contribution is thus rather modest and basic, but we hope to have contributed to a clarification of these basic concerns.

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