A supermultiplier model with two non-capacity-generating autonomous demand components

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Abstract: According to supermultiplier models, economic dynamics are driven by the dynamics of non-capacity-generating autonomous demand components. Since the existing literature suggests several candidates for such components (government expenditures, credit-financed consumption, private residential investments, etc.), it is necessary to analyze how two or more autonomous components can coexist, which is the purpose of the theoretical model and simulations presented herein. We show that a distinction must be made between active and passive components and that the latter should not be confused with induced components, even in a steady state. This discussion about the status of demand components provides both clarification of the term 'semi-autonomous' proposed by Fiebiger (2018) and a response to some criticisms of supermultiplier models on the ground that no component can be autonomous, exogenous or constant in the long run.

Keywords: Autonomous demand, Effective demand, Long run, Supermultiplier.

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1. Introduction

In recent years, there has been a growing interest in supermultiplier models, in which the dynamics of production and capital accumulation are driven by those of non-capacity-generating autonomous demand components, while the rate of capacity utilization converges to its normal value.[2]

As with any other theoretical approaches, the relevance of these models in providing a better understanding of economic phenomena is open to criticism. One of the main criticisms is that related to the autonomous nature of some demand components in the long run. Thus, according to Nikiforos (2018), "in the long run, it is unlikely that 'autonomous expenditure' is really autonomous" (p. 659). A second criticism is based on a counterintuitive outcome of supermultiplier models, namely, the decrease in the share in output of the demand component that is subject to an increase in its growth rate (Skott, 2019). Thirdly, Skott (2017) also questions the speed of the convergence mechanism. The adjustment must be slow enough to avoid Harrodian instability, but this lengthens the time before the model reaches its steady-state equilibrium. The aim of the article is to present a supermultiplier model in a way that provides responses to the first two criticisms focusing on the former two criticisms. Regarding the third criticism, we simply add a few arguments to those already made by Lavoie (2017).

With respect to the nature of so-called autonomous components, we believe that the misunderstandings stem from confusion regarding the difference between the terms 'autonomous' and 'exogenous', whereas the relevant distinction is between 'autonomous' and 'induced' components. While induced components are endogenous by construction, we show that autonomous components can be either exogenous or endogenous, as has already been pointed out by Lavoie (2017, p. 197) and Fazzari et al. (2020), who state

[2] The first formulation of the model was developed by Serrano (1995a, 1995b) and was then completed by Allain (2015), who introduced the mechanism enabling the convergence of the rate of capacity utilization to its normal level.

that "'autonomous' need not mean 'exogenous' or 'constant'" (p. 20). This idea also explains why Fiebiger (2018, 2020) and Fiebiger and Lavoie (2019) propose replacing 'autonomous' with 'semi-autonomous', arguing that "critics [...] have wondered whether any component of effective demand would ever be *fully* autonomous in the real world; hence, the prefix of *semi* as found in Kalecki (1968) seems preferable. Obviously, no one believes that the growth rate of the semi-autonomous expenditures would be a constant value in the real world, even on average" (Fiebiger and Lavoie, 2019, p. 251).[3]

In this article, we go one step further by showing that endogenous autonomous components can even depend on aggregate income,[4] a property that is required when the coexistence of several autonomous components is considered. Our argument leads, among other things, to the clarification of the term 'semi-autonomous' by distinguishing 'active' from 'passive' autonomous components (with the possibility of switching), although we recognize that this distinction is tenuous when the system is in steady-state equilibrium.

Formally, we propose a simple but general supermultiplier model with two non-capacity-generating autonomous demand components. By general, we mean that the two components remain unspecified to focus on the general properties of such models. This approach is necessary due to the existence of many potential candidates in the existing literature: government expenditures (Allain, 2015; Freitas and Christianes, 2020), credit-financed consumption (Freitas and Serrano, 2015; Serrano and Freitas, 2017), capitalists' consumption (Lavoie, 2016; Nah and Lavoie, 2019a, 2019b), private residential investment (Fiebeger, 2018; Fiebiger and Lavoie, 2019), essential goods (Allain, 2019, 2021), consumption out of wealth (Brochier and Macedo e Silva, 2019), exports (Nah and Lavoie, 2017), etc. Consequently, it is necessary to explore how these many candidates can combine their effects in the long run. This is an important issue, especially since it is obvious that two autonomous components cannot grow indefinitely at different rates because the component with the lower growth rate will eventually be eliminated.[5] So far,

[3] However, critics do not seem convinced, as evidenced by Nikiforos' (2018) assertion that "the prefix 'semi' makes a world of difference" (p. 671, fn. 15).

[4] Here, we continue and refine the discussion begun by Allain (2021).

[5] To avoid this problem, Freitas and Christianes (2020) assume "that the rates of growth of the two autonomous demand components [of their model, government expenditures and capitalists consumption] are related in a way that, although they can be different, there is a tendency for them to be equal, on average, over time" (p. 319).

however, there has been no real attempt to explain how it is possible to combine two or more autonomous components. Our article innovates in addressing this issue, giving a central role to our distinction between 'active' and 'passive' autonomous components and to the ability to switch (between active and passive components) as a necessary condition for the model stabilization.

When focusing on the properties of a long-run equilibrium, it is generally accepted that the dynamics leading to this equilibrium should be ignored. Consequently, it could appear that passive autonomous components are eventually induced in the steady state. This point is relevant if the system is led by a solely active autonomous component. However, we show that this point is not always relevant because there are circumstances in which the system is led by the mutual convergence of several passive autonomous components. In this case, which has never been analyzed in the literature on supermultiplier models, the steady-state growth rate is path dependent, and the passive components cannot be considered induced.[6]

Finally, both by the introduction of two (or more) autonomous components and by the distinction between active and passive components, supermultiplier models demonstrate their adaptability to a changing economic reality, where some autonomous components are active in some periods and passive in others and where the equilibrium can be path dependent. However, the main outcomes of the supermultiplier are preserved, namely, the convergence between the rate of capital accumulation and the growth rate of income on the one hand and the convergence of the rate of capacity utilization to its normal level on the other hand.

The rest of this article is organized as follows. Section 2 is devoted to the short-run equilibrium, while the model dynamics and long-run equilibrium are developed in Section 3. Particular attention is paid in both sections to the distinctions between autonomous and induced components on the one hand and between exogenous and endogenous components on the other hand. Due to some complications, the local stability of the model cannot be formally analyzed. We therefore use simulation, the numerical calibration of which is provided in Section 4. Simulation exercises are first implemented assuming a single non-capacity-generating autonomous component (Section 5), which helps

[6] See Brochier and Macedo Silva (2019) for an alternative approach resulting in an endogenous growth rate of the autonomous component.

illustrate the consequences of the distinction between active and passive autonomous components. The second non-capacity-generating autonomous component is introduced in the simulations in Section 6. Some comments about the realism, or lack thereof, of the simulations are also provided in this section. The distinctions among autonomous, induced, exogenous and endogenous terms in long-run analyses are clarified in Section 7 prior to a brief conclusion in Section 8.

2. Short-run equilibrium

We adopt the basic framework of a closed economy, assuming a production function with fixed technical coefficients and no employment constraints as follows:

$$Y = \frac{u}{v} K \tag{1}$$

where Y and K represent the levels of output and capital stock, respectively, while v and u correspond to the capital-to-capacity coefficient and the rate of capacity utilization. Both v and K are assumed to be exogenous in the short run, whereas u and Y are assumed to be endogenous.

With respect to aggregate demand, the distinction between 'induced' and 'autonomous' demand components is at the root of the principle of effective demand. As emphasized by Cesaratto (2016, p. 45), "the Keynesian logic is that, given productive capacity, the autonomous components of aggregate demand or injections in old-fashioned jargon (typically autonomous consumption, investment, government spending, and exports) determine the level of output, while induced consumption and leakages (saving, taxation, and imports) are a result of the income multiplier process." Here, we assume that aggregate demand is composed of four components:

$$Y = C + Z_1 + Z_2 + I \tag{2}$$

Moreover, induced consumption is as follows:

$$C = (1 - s)Y \tag{3}$$

where s corresponds to the propensity to save.[7] Induced consumption results from the decision of households as to how to use their earned income: part of the income is

[7] Price setting, income distribution and taxes are not included because these issues are not central to the present discussion.

consumed through domestic products, and the rest leaks out in the form of saving. Therefore, the levels of both consumption and leakage are induced by the current income level.

Investment (I) is the only capacity-generating demand component. We adopt the basic neo-Kaleckian function, assuming that it depends on the rate of growth expected by entrepreneurs (γ) and on the gap between actual and normal rates of capacity utilization (u_n). Thus, we have the following:

$$I = [\gamma + \gamma_u(u - u_n)]K \tag{4}$$

where $\gamma_u > 0$. In the short run, investment spending is partly autonomous and partly induced: γK represents the amount of the new injections into the system in each period, regardless of the economic situation, while $\gamma_u(u - u_n)K$ shows how this amount is modulated according to the current pressure on capacities. Contrary to induced consumption, the financing of the induced component is not the result of a tradeoff between expenditure and leakage). Indeed, both autonomous and induced investment are financed by households' saving. Therefore, the financing source of a component does not determine whether it is autonomous or induced.

Since part of our attention must remain focused on the distinction between autonomous and induced demand components, it must be pointed out that investment behavior is the only formal difference between the 'neo-Kaleckian' and 'Sraffian' versions of supermultiplier models. Indeed, for the latter, $I = hY$, where $h \in]0,1[$ represents the propensity to invest. Therefore, contrary to neo-Kaleckians, Sraffian authors consider investment as being fully induced in the short run.

Finally, it is assumed that Z_1 and Z_2 are non-capacity-generating autonomous components. We do not specify the type of expenditures involved (public spending, credit-financed consumption, capitalists' consumption, etc.) to preserve the generality of the model. We assume that these components are also financed by households' saving.[8] In addition, we assume that their amount does not depend on the level of current income (otherwise, they would be considered induced).

[8] The financing of I, Z_1 and Z_2 through saving raises the question of financing costs. However, for the sake of simplicity and to keep the model as general as possible, we assume that the financial obligations between agents are zero.

Substituting equations (3) and (4) into (2) and then equation (2) into (1) leads to the short-run equilibrium rate of capacity utilization:

$$u = \frac{v(\gamma - \gamma_u u_n + z_1 + z_2)}{s - v\gamma_u} \tag{5}$$

where each $z_{i=1,2} = Z_i/K$. The denominator of equation (5) is assumed to be positive for the Keynesian stability condition to be fulfilled. Moreover, the numerator is assumed to be positive but lower than the denominator so that $0 < u < 1$.

Unsurprisingly, the comparative static analysis confirms the usual post-Keynesian outcomes: the paradox of thrift occurs because an increase in the propensity to save implies a decrease in both u and the rate of capital accumulation ($g_K = I/K$); similarly, any increase in γ (corresponding to animal spirits) or in the autonomous components (through z_1 or z_2) entails an increase in both u and g_K.

At this point, it is useful to return to the distinction between autonomous and induced components to note, first, that it is transparent in equation (5): injections are in the numerator, whereas the exogenous parameters of the induced components and leakage are in the denominator. A corollary of equation (5) is also that effective demand is zero in the absence of any injections. In addition, the level of leakage adjusts to that of the autonomous components through the multiplier effect: an increase in the amount of injections leads to an increase in income, which in turn leads to an increase in both induced consumption and leakage.

Second, it is necessary to question whether autonomous components can be endogenous. Induced consumption and leakage are endogenous by construction because their current level depends on (is induced by) the current level of economic activity. Consequently, it is tempting to claim that the autonomous components are necessarily exogenous. However, doing so would be a mistake: investment, for instance, can remain autonomous, even if it depends on an endogenous interest rate. Clearly, this is not the issue raised by critics who argue that "to be autonomous, a component of aggregate demand (…) must be exogenous (i.e., independent of other variables in the model, including aggregate income and employment)" (Skott, 2019, p. 234), so that "in the long run, it is unlikely that 'autonomous expenditure' is really autonomous" (Nikiforos, 2018, p. 659). Thus, the following discussion of active fiscal policies is both illuminating and confusing. Indeed, such policies are generally considered discretionary and autonomous. However, they should also be considered endogenous since the level of public spending is set by the government in response to the current economic situation. Specifically, the causality of the decision depends on the level of effective demand that would be reached if the policy were not activated: if this level is low, then the government decides on a high level of public spending, and vice versa. Once the government's decision is made, public spending must be seen as an injection into the system. The causality of these economic mechanisms thus moves from public spending to aggregate income. Moreover, the increase in income caused by the fiscal stimulus generates an increase in induced components (which in turn generates a multiplier effect), whereas the increase in income has no retroactive effect on current public spending. The associated conclusion is that although an active fiscal policy decision is 'dependent' on income, a fiscal stimulus should be considered autonomous. Therefore, an autonomous component can also be endogenous.

At the risk of confusing matters even further, it should be noted that active fiscal policies could instead be specified as an induced component.[9] This last remark echoes the above-mentioned differences between neo-Kaleckians and Sraffians regarding the specification of the investment behavior. These examples lead us to the following comments. First, the conclusions that can be drawn from the above discussion are rather disappointing. While the principle of effective demand is based on the distinction between autonomous and induced components, the theory does not provide objective criteria for making this distinction, the choice of which is then left to the modeler. If stress is placed on the existence of a fairly regular relationship between the level of component spending and the level of income, then the choice should be made for an induced component. In the other cases, the choice is made for an autonomous component, especially if the stress is on the discretionary nature of the decision of the agent, who may or may not decide to

[9] This would be the case if the government's behavior could be specified as a simple rule, $z_1 = \beta + \beta_u(u_n - u)$, assuming that Z_1 represents public spending and that $\beta, \beta_u > 0$. Rearranging equation (5), the resulting equilibrium rate of capacity utilization is as follows:

$$u = \frac{\nu[\gamma + \beta - (\gamma_u - \beta_u)u_n + z_2]}{s - \nu(\gamma_u - \beta_u)}$$

In this case, part of the public spending remains autonomous (the government decides to inject βK into the system in each period, regardless of the economic context), but the part devoted to active fiscal policy becomes induced: the amount of the injections is modulated depending on the economic context.

base the level of spending on income.[10] Of course, the relevance of such a choice is always open to criticism. However, once it has been made by the modeler, the status of each component in the model is clearly defined: either it is an autonomous injection into the system, or it is induced by the current income level. Moreover, the mathematical translation of this status (particularly in the equilibrium equation) is unambiguous. In addition, it must be kept in mind that the principle of effective demand cannot operate if there is no autonomous component.

We return to this crucial issue regarding the distinction between autonomous and induced components in the following section.

3. Model dynamics and long-run equilibrium

Since the parameters of the induced components are assumed to be exogenous, the model dynamics entirely depend on the dynamics of the injections: Z_1, Z_2 and the autonomous part of capital accumulation (γK). Let us start with capital accumulation. Equation (4) has been subject to two important criticisms when applied to long-run analysis: first, this equation oddly suggests that firms could be satisfied with a situation in which the values of the actual and normal rates of capacity utilization remain permanently different from each other, and second, this equation suggests that firms do not mind if their expected growth rate (γ) differs durably from their actual growth rate of capital accumulation (g_K). A joint solution to these two criticisms is to assume that entrepreneurs adjust their growth expectations according to the gap between the actual and normal rates of capacity utilization:[11]

$$\dot{\gamma}_t = \psi\left(g_{K,t-1} - \gamma_{t-1}\right) \tag{6}$$

where $\psi < 1$ corresponds to the speed of adjustment of the entrepreneur's expectations to the rate of capital accumulation. As is well known, the behavior described in equation (6) generates Harrodian knife-edge instability. However, as shown first by Allain (2015),

[10] It may be tempting to oppose discretionary decisions about autonomous components with passive adaptations to current income in the case of induced components. However, this opposition is not so obvious since the parameters of the induced components are also subject to agents' decisions. This is particularly true of the propensity to invest (h), which is assumed to adjust to the economic situation in the Sraffian version of supermultiplier models.

[11] A dot over a variable is used to indicate a time variation ($\dot{x}_t = x_t - x_{t-1}$). The dynamics are presented in discrete time as in the below simulations.

this instability can be tamed by the stabilizing properties of supermultiplier effects, provided that the value of the ψ parameter remains sufficiently low, a point that is discussed later. Likewise, we postpone the discussion of the status (autonomous or induced) of investment in the long run.

The dynamics of the economy are also subject to the dynamics of each non-capacity-generating autonomous components, Z_1 and Z_2, which are assumed to grow at rates g_1 and g_2, respectively. These two rates are assumed to adjust as follows:

$$\dot{g}_{i,t} = \phi_i\left[\rho_i\left(\bar{g}_i - g_{i,t-1}\right) + (1-\rho_i)\left(g_{Y,t-1} - g_{i,t-1}\right)\right] \qquad (with\ i = 1,2) \qquad (7)$$

where $\phi_{i=1,2}$ is the adjustment speed, and $\rho_{i=1,2}$ is a dummy variable (0 or 1). If $\rho_i = 1$, then the decision of the agent spending Z_i is to bring g_i to an exogenous growth rate, $\bar{g}_i$. If $\rho_i = 0$, then the decision is to make g_i converge to the income growth rate, g_Y. The rationale for such an assumption is that the behavior of some agents may depend in part on the (expected) growth rate of income but may deviate from this growth rate over shorter or longer periods: a government may decide to keep the growth rate of public spending close to g_Y to keep the public deficit constant, but it also may decide to deviate from g_Y over several periods (austerity policy or cyclical stimulus);[12] banks may decide to supply credits at a pace close to g_Y, but financial innovations and other considerations may lead them to increase the pace of credit supply over several periods, etc.

On the basis of this type of behavior, Z_1 and Z_2 should be considered autonomous in the long run. Obviously, Z_i is unambiguously autonomous as long as $\rho_i = 1$ (so that g_i is exogenous), while its status can be open to discussion when $\rho_i = 0$ (so that g_i becomes endogenous). However, we consider that Z_i must be treated as autonomous regardless of the value of ρ_i for the following reasons. First, the change in the value of this dummy variable is assumed to correspond to a discretionary choice by the agent: $\rho_i = 0$ is still a decision, and deciding on $\rho_i = 0$ in some periods does not prevent deciding on $\rho_i = 1$ in other periods. Second, the nature of the decision remains different from that of the induced components, the level of which depends on the current income level: the induced consumption in equation (3) depends on the level of income earned by households, the

[12] With respect to government behavior, it is quite clear that the decision concerns increasing/decreasing spending from one period to the next (thus, the decision is about the growth rate of public spending) rather than setting a 'propensity' to spend the aggregate income (which, unlike for households, is not perceived by the government).

induced part of investment in equation (4) depends on the pressures on production capacities, etc.. These behaviors clearly differ from that which is described in equation (7), where agents are concerned with the dynamics of their expenditures rather than their level relative to income. One could reply by arguing that deciding on $g_i = g_Y$ both determines the growth rate of the Z_i and maintains a constant share of Z_i in income, which is true, but this argument overlooks the fact that agents control their own spending but not the current aggregate income, which is subject to various shocks, including multiplier effects.[13] Fourth, when $\rho_i = 0$ in equation (8), the dynamics of Z_i are based on naïve adaptive expectations: not only does it take several periods for g_i to converge to g_Y, but the dynamics of g_Y also depend on those of g_i. In other words, the trajectory of the economy remains dependent on the dynamics of the injections into the system. Fifth, the last remark makes particular sense when it is assumed that $\rho_1 = \rho_2 = 0$. Indeed, in this case, as the below simulations clearly show, Z_1 and Z_2 cannot be considered induced because their dynamics (their attempts to converge toward g_Y) eventually determine the path-dependent value of g_Y.

The behaviors described in equation (8) are close to what Fiebiger (2018, 2020) and Fiebiger and Lavoie (2019) had in mind when they proposed the term 'semi-autonomous'. However, this term is not entirely satisfactory because it suggests that the status of the Z_i components could change from autonomous to induced, and vice versa. In contrast, the Z_i components are always autonomous according to our argument. We therefore suggest keeping the term autonomous while distinguishing between 'active' (when $\rho_i = 1$) and 'passive' (when $\rho_i = 0$) autonomous components.

The same arguments lead to the proposition that investment should be considered a passive autonomous component because firms' decisions involve the rate of capital accumulation, not the share of investment in output or in income and because of the specification of equations (4) and (6): while γ can be subject to exogenous changes due

[13] The only real exception is consumption, but this is because households receive income and then split it between consumption and leakage. With respect to the induced part of investment in equation (4), it is assumed in our simulation that firms' decision depends on u_{t-1} so that firms face no problems in determining $\gamma_u(u_{t-1} - u_n)$.

to animal spirits in the short run, entrepreneurs are assumed to passively adjust their production capacities to aggregate demand in the long run.[14]

Under the above assumptions, the model dynamics consist of a succession of short-run moving equilibria that satisfy equation (5) at each period. By differentiating equation (5), the dynamics between two successive periods are given as follows:

$$\dot{u} = \frac{v(\dot{\gamma}+\dot{z}_1+\dot{z}_2)}{s-v\gamma_u} \tag{8}$$

where $\dot{z}_{i=1,2} = z_i(g_i - g_K)$. Of course, every deviation in capacity utilization affects the rate of capital accumulation through equation (4) and entrepreneurs' expectations through equation (6).[15]

The conditions for a long-run equilibrium of the rate of capacity utilization are $\dot{\gamma} = \dot{z}_1 = \dot{z}_2 = 0$, which leads to the following:[16]

$$u^* = u_n \tag{9}$$

$$\gamma^* = g_K^* = g_Y^* = g_1^* = g_2^* \tag{10}$$

Most existing supermultiplier models propose a formal analysis of the local stability of the long-run equilibrium, but this is not possible here due to the complications resulting from the combination of the dynamics of γ, z_1 and z_2. Instead, the model dynamics are illustrated through simulation exercises. However, what is already apparent from equation (10) is that the long-run rate of growth of the system depends on the dynamics of the non-capacity-generating autonomous components. If $\rho_1 = 1$ and $\rho_2 = 0$ in equation (8), then g_Y^* converges to $\bar{g}_1$. Conversely, g_Y^* converges to $\bar{g}_2$ if $\rho_1 = 0$ and $\rho_2 = 1$.

Moreover, the system does not stabilize if $\rho_1 = \rho_2 = 1$ and $\bar{g}_1 \neq \bar{g}_2$ (except when the component with the lower growth rate has disappeared), which means that the economic system hardly allows for a lasting conflict between two active components: after some

[14] However, the existing supermultiplier models show that any short-run increase in γ has a permanent effect on the variables in level (K, Y...), although its impact on the growth rate of the economy is only transitory (see Allain (2015) for example).

[15] As already emphasized, our purpose is to keep the specification as simple as possible to focus on some common properties of supermultiplier models. Of course, the use of this type of model to analyze complex phenomena related to economic dynamics (such as financial instability) requires an enriched set of assumptions.

[16] Asterisks denote the long-run equilibrium values of the corresponding endogenous variables. Note that equation (1) allows for specifying $g_Y = g_u + g_K$ and that $g_u = 0$ in the long run.

time, one of these components must become passive so that g_Y^* converges to either $\bar{g}_1$ or $\bar{g}_2$.

Finally, simulations show that the system should converge to a path-dependent equilibrium if $\rho_1 = \rho_2 = 0$. In this case, the steady-state rate of growth g_Y^* depends on the respective dynamics of g_1, g_2 and γ. Therefore, although it is a passive component, the investment can hardly be considered induced in the long run because its level and dynamics contribute to the determination of g_Y^*.

Noting $Z = Z_1 + Z_2$, substituting equations (14) and (15) into equation (7) also results in the following:

$$z^* = z_1^* + z_2^* = \frac{su_n}{v} - g_Y^* \tag{11}$$

At this stage, the long-run equilibrium is not fully identified since the shares of z_1^* and z_2^* in z^* remain unknown. This problem is overcome in the simulations, where we exogenously impose the shares of the initial period.

Finally, substituting $u = u_n$ and $K = Z/z^*$ into equation (1) yields the following steady-growth path of output:

$$Y = \frac{u_n}{su_n - vg_Y^*} Z \tag{12}$$

where the fraction represents 'the' supermultiplier, i.e., the long-run relationship between the level (or deviation) of the aggregate non-capacity-generating autonomous component and the level (or deviation) of production.[17] According to equation (12), the paradox of thrift still occurs in the long run. Moreover, the supermultiplier negatively depends on the growth rate of the aggregate autonomous component, which is equal to g_Y^* in the steady-state equilibrium (as stated above, g_Y^* can be equal to $\bar{g}_1$ or $\bar{g}_2$; it can also be the result of path dependency).

Finally, the comparison of equations (8) and (12) compels us to ask again whether investment is autonomous or induced in the long run. In equation (8), the dynamics of the rate of capacity utilization from one period to another clearly depend on the changes in injections of investment spending. In contrast, according to equation (12), the only injections into the system are due to Z_1 and Z_2. Therefore, it is tempting to infer that

[17] Note also that the inverse of the fraction gives the share of Z in the output.

investment should be considered induced in the long run. However, this is not as obvious since there are circumstances in which the rate of capital accumulation contributes to the determination of g_Y^* in the denominator in equation (12).

The results of the theoretical model suggest the consideration of different scenarios depending on the assumptions on the dynamics of the two non-capacity-generating autonomous components. In the following, we implement two sets of simulations, assuming first that $Z_2 = 0$ and then that initially, $z_1^* = z_2^* = z^*/2$. The next section presents the numerical calibration of these simulations.

4. Numerical calibration

The first row of Table 1 summarizes the values of the exogenous static parameters, while the second row gives the initial rates of the growth rate and the speeds of adjustment. Initially, all the aggregates are assumed to grow at the same rate of 3%. With an adjustment speed of 0.12, the non-capacity-generating components are assumed to fill approximately one-eighth of the gap with the income growth rate in each period.

Table 1. Parameters and initial values of variables for simulations				
$u_n = 0.85$	$v = 1.5$	$\gamma_u = 0.25$	$s = 0.5$	
$g_{i=1,2} = 0.03$	$\bar{g}_1 = 0.04$	$\bar{g}_2 = 0.03$	$\phi_{i=1,2} = 0.12$	$\psi = 0.101$

The value of the adjustment speed of entrepreneurs' growth expectations (ψ) is chosen with reference to pre-existing neo-Kaleckian supermultiplier models in which the local stability condition corresponds to $\psi < z^*$, where $z^* = 0.253$. On this basis, the choice of ψ is subject to a tradeoff: the higher the value of ψ is, the shorter the duration of the oscillation period between two dates at which $u = u_n$; however, the higher the value of ψ is, the greater the amplitude of the oscillations (i.e., the difference between u_n and the extreme values taken by u). Moreover, since $\psi < z^*$corresponds to a local condition, it no longer holds when u is far from u_n. Therefore, if ψ is too high (while remaining below z^*), then the oscillations are explosive, and the model becomes unstable. Here, $\psi = 0.4 \times z^* = 0.101$ means that entrepreneurs try to close approximately 10% of the gap between γ and g_K in each period.

Such a value should not convince Skott (2017), who considers that "it would seem reasonable to assume that expected growth has closed half the gap (…) within something like 2 years," which leads him to suggest that ψ should be equal to 0.35. From Skott's point of view, a value of ψ that is too low is a serious limitation to the relevance of supermultiplier models.[18] However, he offers no argument to support his 'reasonable assumption' of a rapid adjustment, while a relatively low value of ψ can be justified on economic grounds. Indeed, according to Freitas and Serrano (2015, p. 270), a "drastic adjustment [in γ through ψ] is highly unrealistic, both because of the durability of fixed capital (which means that producers want normal utilization only on average over the life of equipment and not at every moment) and also because producers know that demand fluctuates a good deal and therefore do not interpret every fluctuation in demand as indicative of a lasting change in the trend of demand." Moreover, we fully agree with Lavoie's response to Skott's criticism: our theoretical model should be considered a "*prototype*, as it leaves aside several key determinants of economic activity and abstract from the world complexity" (Lavoie, 2017, p. 195). For example, it is likely that reasoning in a closed economy and neglecting imports leads to an unrealistically high value of the multiplier, which would exaggerate the reaction of firms when they try to adjust their capacities, thus artificially generating the instability of the model. In our opinion, simulations can hardly be used to refute a theoretical model because of the absence of epistemic rules governing such use. At best, simulation exercises can provide an illustration of the type of dynamics that can be generated by a given set of assumptions.

5. Simulations assuming only one non-capacity-generating autonomous demand component

In this section, assuming that $Z_2 = 0$, we momentarily return to the usual framework of most supermultiplier models that include only one autonomous component (Z_1). In the first scenario (scenario A), we assume that $\rho_1 = 1$ over the entire analysis period in equation (7). Therefore, $\bar{g}_1$ increases from 0.03. The Z_1 autonomous component can then be considered active.

Figure 1 shows the resulting dynamics of the growth rate of aggregate income (g_Y), the rate of capital accumulation (g_K), and the growth rate expected by entrepreneurs (γ), while Figure 2 shows the dynamics of the rate of capacity utilization (u). As predicted by the theoretical model, all growth rates are attracted by $\bar{g}_1$ (which is the so-called

[18] Skott (2017) compares his own suggestion ($\psi = 0.35$) to the value that by an approximate calculation, would fit Lavoie's (2016) model; that is, $\psi < 0.0325$.

'supermultiplier effect'), and the rate of capacity utilization is returning to its normal level (which results from the combination of the stabilizing supermultiplier effect with the destabilizing Harrodian behavior of firms, provided that the value of ψ is not too high in equation (6)).

According to the principle of effective demand, the former reaction to the increase in g_1 is an increase in output (both u and g_Y increase). The rapid increase in the rate of accumulation is first the result of the increase in u. Only then do firms reconsider their expectation regarding the growth rate. Concerning the utilization rate, u increases during 6 periods to peak at approximately 0.883; then, the decline is quite strong for approximately 10 periods before a deceleration, leading to a slow monotonic convergence towards u_n.

Figure 1. Dynamics of growth rates (scenario A)

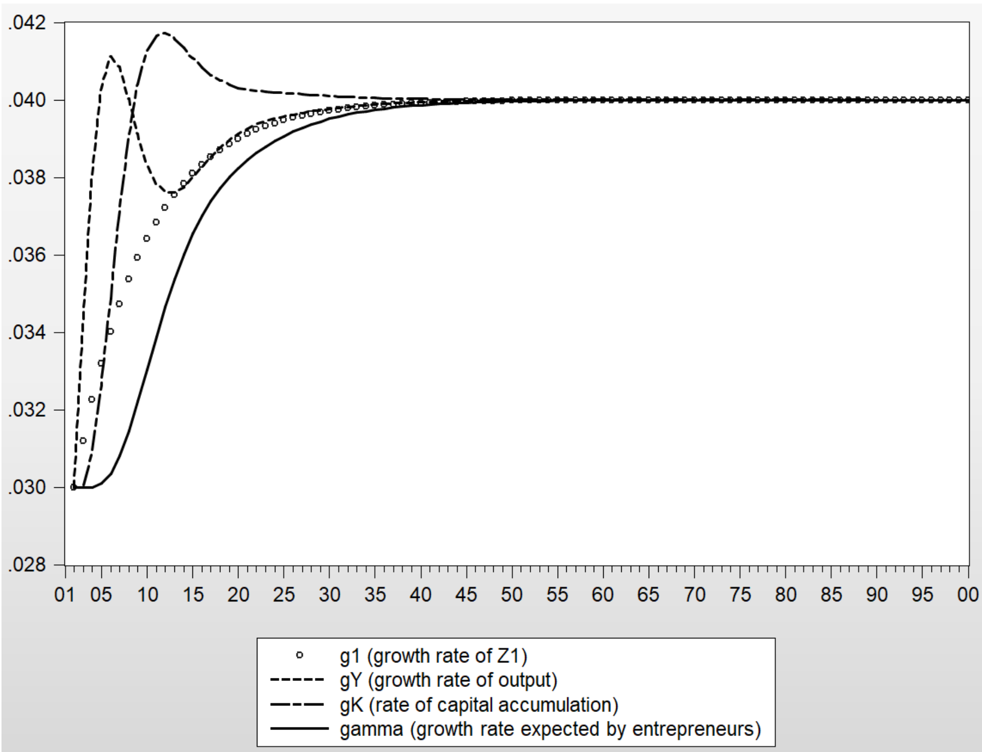
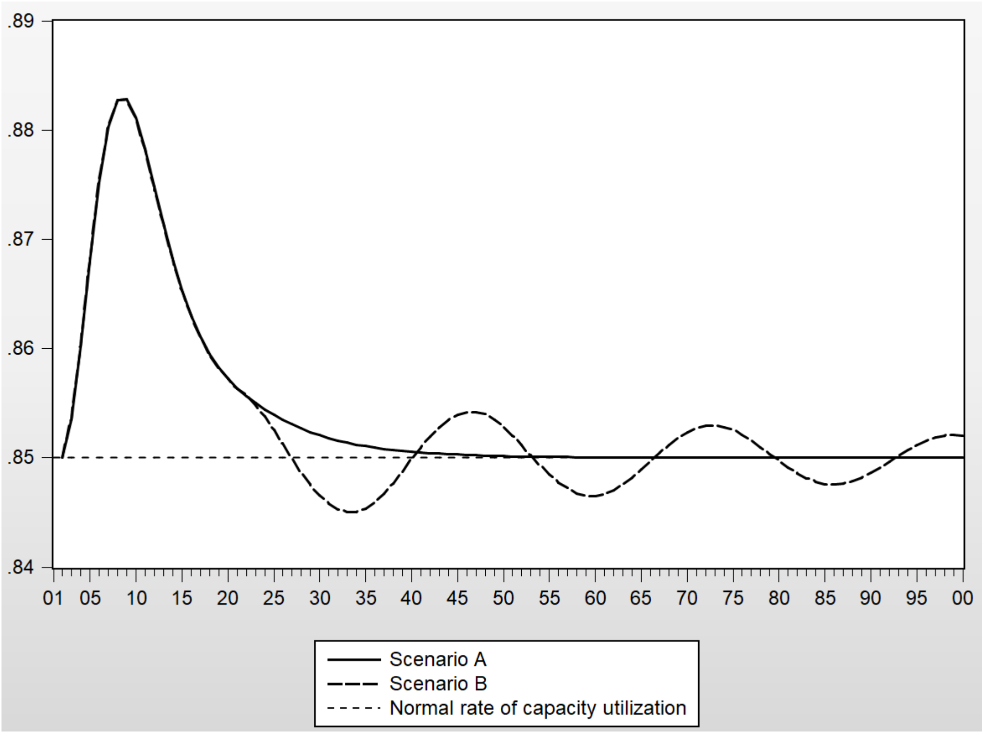


Figure 2. Dynamics of the rate of capacity utilization (scenarios A and B)



Finally, it is interesting to examine the changes in the shares of aggregate demand in the long run. By construction, the share of induced consumption remains constant over time (50%). In addition, the convergence of g_K toward $\bar{g}_1$ corresponds to an increase in the share of investment of 0.018 percentage points (from 5.3% to 7.1%), which is necessarily offset by an equal decrease in the share of the non-capacity-generating autonomous component, Z_1 (from 44.7% to 42.9%).[19]

Scenario B is a variant of scenario A in which it is assumed that $\rho_1 = 1$ over a subperiod before it switches to 0: Z_1 becomes a passive autonomous component when $\rho_1 = 0$ after 20 periods. The resulting dynamics are shown in Figures 2 and 3. Because the effort to increase and maintain the value of g_1 at a high level does not last as long as in scenario A, the growth rates of the economy all converge to a value($g_Y^* = 0.0387$) that is less than $\bar{g}_1$. In addition, it can be shown that the long-run steady state also depends on the behavior of firms: a different value of the adjustment speed of entrepreneurs' expectations (ψ)

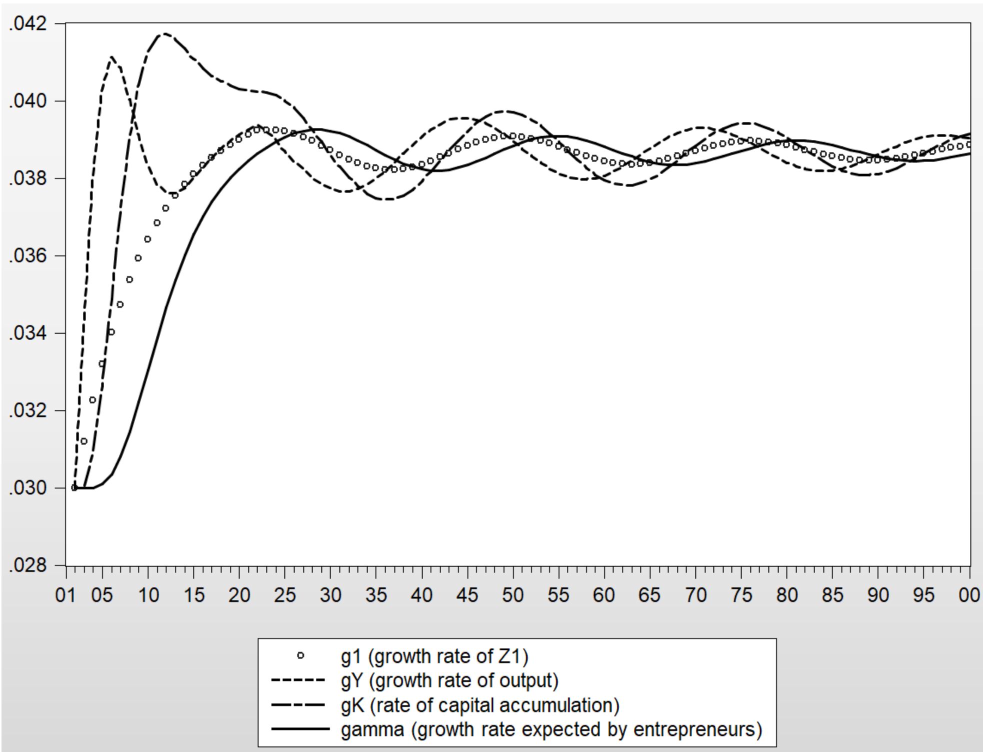
[19] The necessity of this result stems from the logic analysis of output shares in $Y = C + I + Z_1$. Substituting equations (1) and (3) results in $1 - s + (g_K + z_1)v/u_n = 1$, where $(1 - s)$ corresponds to the constant share of induced consumption in aggregate demand. Any increase in g_K therefore results in a decrease in z_1, and vice versa. Obviously, this result is consistent with equation (11), which shows a decreasing relationship between z^* and g_Y^*.

leads to a different level of the equilibrium rate of growth, g_Y^*. This is because, as long as the model is not stabilized (i.e., as long as $\gamma \neq g_1 \neq g_Y$), the pace of firms' injections into the system differs from that of Z_1-spending agents. However, the 'passive' behavior of these two types of agents (agents spending Z_1 trying to adjust to g_Y, while entrepreneurs try to adjust to g_K) allows them to converge gradually to the same expectation, which is $g_Y^* = 0.0337$ in our simulation. Obviously, the relative slowness of the mutual convergence of agents' expectation takes time, which explains the long-lasting dampened oscillations in both growth rates and the rate of capacity utilization.

These outcomes lead us to the conclusion that the long-run equilibrium growth rate of the economy is path dependent if ρ_1 turns to 0 while the agents' expectations are still divergent: in this case, g_Y^* converges to a value that depends on g_1, γ and their respective adjustment speeds.

Finally, it is worth noting that the magnitude of the changes in the share of Z_1 in output is somewhat smaller in scenario B than in scenario A (+0.015 for the share of investment and −0.015 for the share of Z_1).

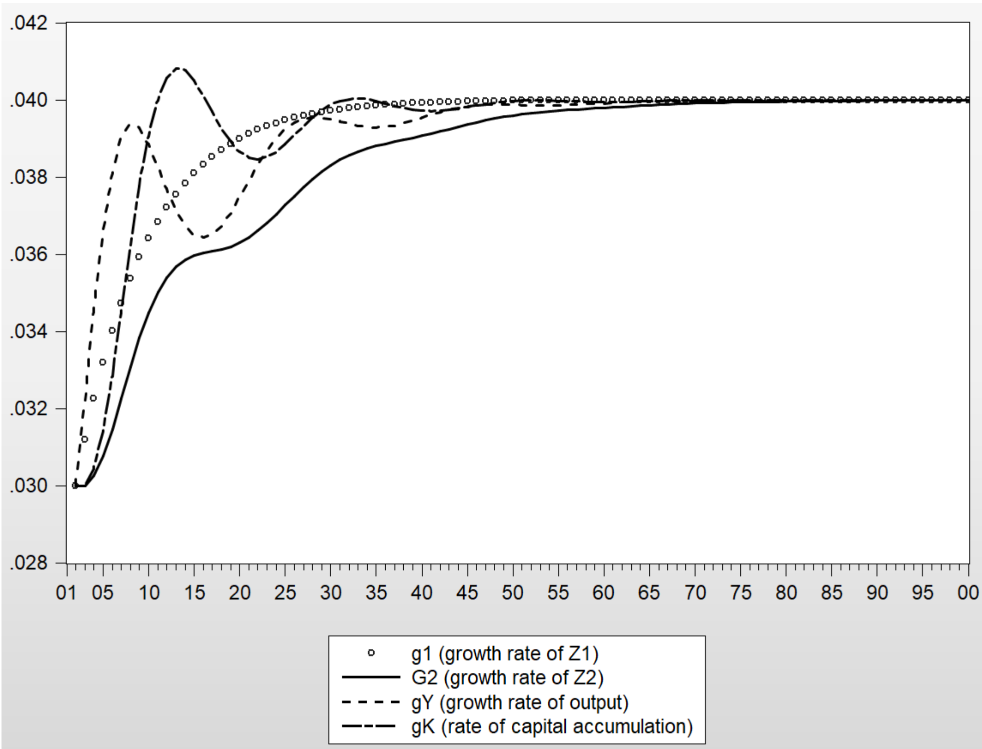
Figure 3. Dynamics of growth rates (scenario B)



6. Simulations assuming two non-capacity-generating autonomous demand components

We now assume that $Z_{i=1,2} > 0$ and that initially, $z_{i=1,2} = z/2 = 0.127$. The corresponding shares of Z_1 and Z_2 in output are 0.224. In scenario C, $\rho_1 = 1$ and $\rho_2 = 0$ over the entire analysis period: g_1 gradually increases from 0.03 to 0.04, while g_2 is assumed to passively adjust. Figure 4 summarizes the effects on the growth rates of the system.[20] Again, they are all attracted by g_1, so the economy is driven by the dynamics of the active autonomous component, Z_1. However, the convergence is slower than before, mainly because the adjustment delay of g_2 adds up to that of γ. These delays also result in a slower convergence of the rate of capacity utilization (Figure 5). Furthermore, the simulation shows that the increase in the share of investment (+0.018 percentage points, as before) is now accompanied by a decrease in the share of Z_2 (−0.017 percentage points) while the share of Z_1 does not change significantly (+0.000 percentage points).[21]

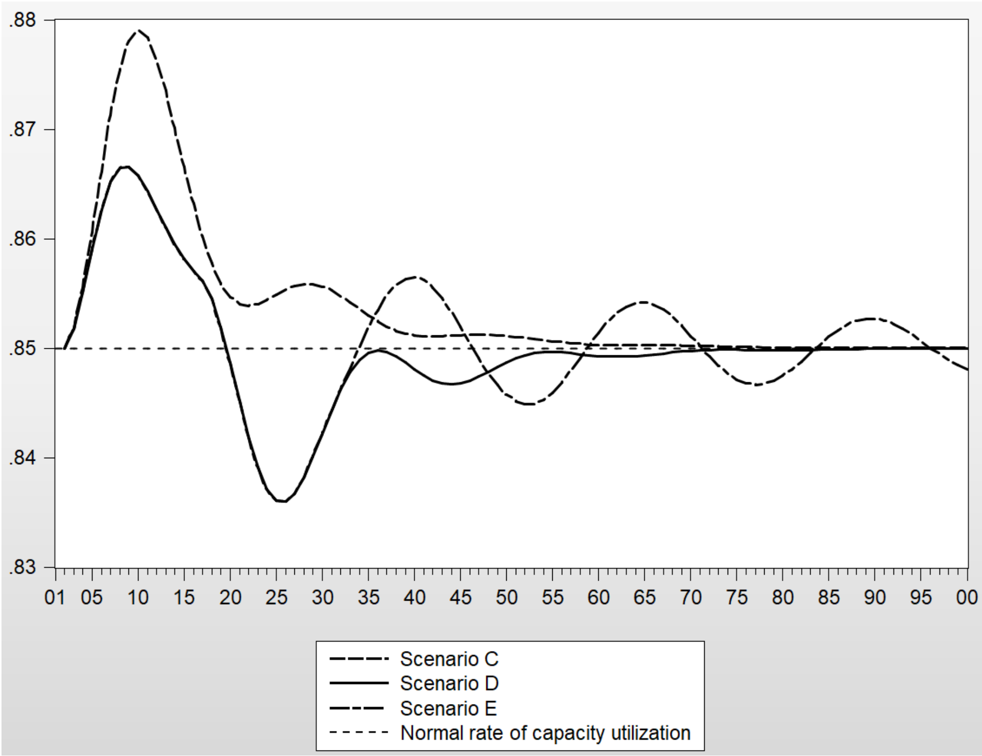
Figure 4. Dynamics of growth rates (scenario C)



[20] We do not show the γ trajectory to keep the figure readable.

[21] Substituting equations (1) and (3) in aggregate income ($Y = C + I + Z_1 + Z_2$) results in the income sharing $1 - s + (g_K + z_1 + z_2)v/u_n = 1$.

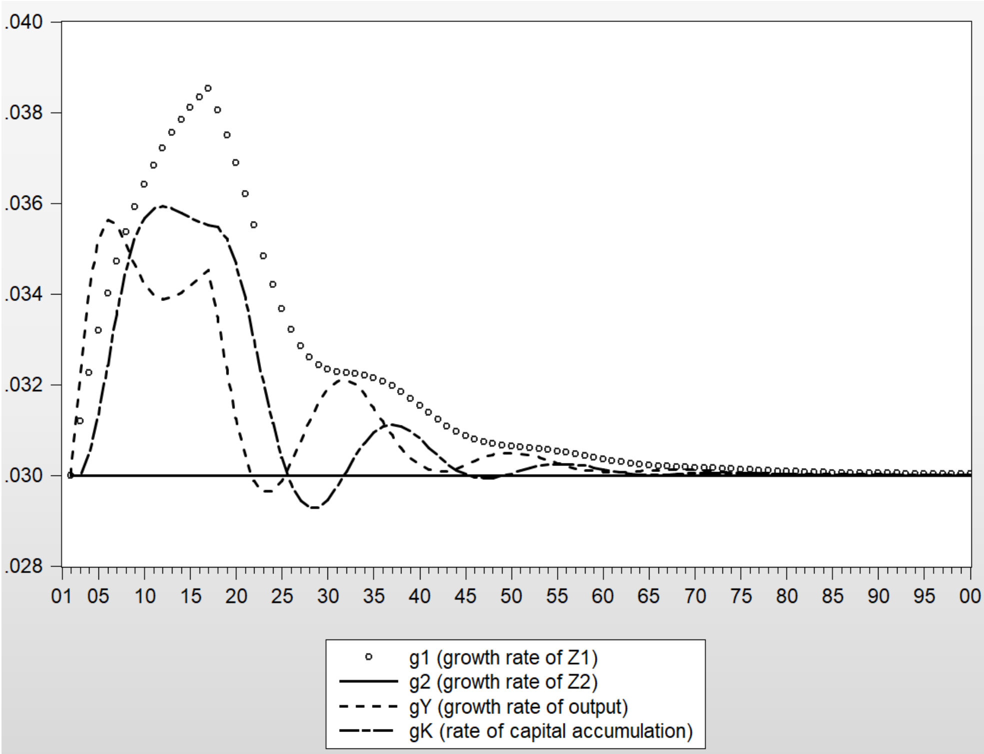
Figure 5. Dynamics of the rate of capacity utilization (scenarios C, D and E)



In scenario D, we assume that both $\rho_1 = \rho_2 = 1$ and $\bar{g}_1 > \bar{g}_2$ (the two components are active). The model cannot stabilize if this difference holds permanently, or rather, z_2 converges to zero and the model switches to scenario A. To avoid this issue, we assume that Z_1 becomes passive (ρ_1 turns to 0) from the 16th period on. The behavioral assumptions of the model are too general to provide an endogenous justification for such a change. However, this may be due to the concern of the Z_1-spending agents who become aware of both the increase in the gap of g_1 over g_Y (since the increase in the latter stops after 5 periods) and the increase in Z_1's share in output. As a result, all the growth rates of the economy are now attracted by $\bar{g}_2 = 0.03$ (Figure 6). The relaxation of the effort on g_1 also results in a faster adjustment of the rate of capacity utilization to its normal value (Figure 5). The question of whether or not the adjustment is very fast depends in part on when ρ_1 turns to 0. Moreover, since g_1 is durably higher than g_Y, this configuration leads to an increase in the share of Z_1 in output (+0.020 percentage points). Obviously, this increase is totally offset by the decline in the share of Z_2 in this model, where the share of investment remains unchanged in the long run. In addition, it should be noted that although g_Y^* and u_n eventually return to their initial values, the transitory increase in g_1

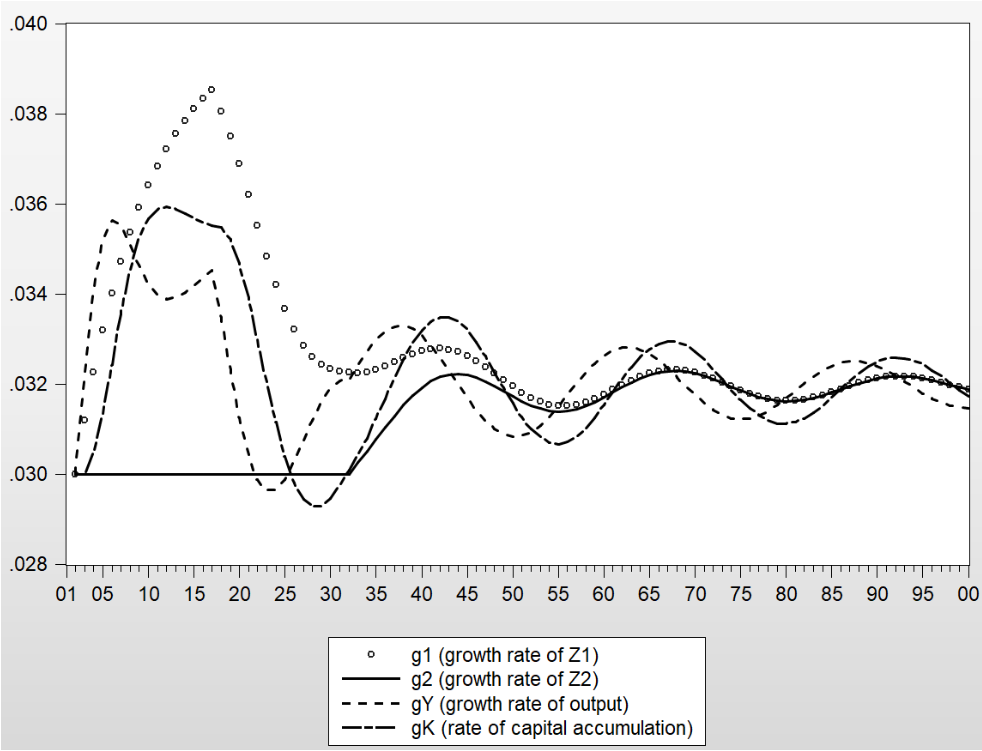
has permanent effects on the variables in levels: both Y and K are now on a higher path than they would have been if g_1 had remained constant throughout the analysis period.

Figure 6. Dynamics of growth rates (scenario D)



Eventually, scenario E assumes that $\rho_1 = \rho_2 = 1$ for some time and, then, that $\rho_1 = 0$ after 15 periods, while $\rho_2 = 0$ after 30 periods. Thus, the two autonomous components are passive after this date. In the long run, all the growth rates converge toward a value that differs from $\bar{g}_1$ and $\bar{g}_2$ (Figure 7). The explanation is the same as in scenario B above: the system reaches its long-run rate of growth ($g_Y^* = 0.032$) only when the expectations of the agents (those who spend Z_1 and Z_2 as well as entrepreneurs who accumulate capital) all match each other; here too, the long-lasting dampened oscillations are due to the time needed for these expectations to converge. Once again, the steady-state equilibrium is path dependent from the passive adjustments in the injections introduced into the system at each period. Moreover, it can be noted that the increases in the output shares of investment (+0.004) and of Z_1 (+0.016) are offset by the decrease in the share of Z_2 (−0.020).

Figure 7. Dynamics of growth rates (scenario E)



Before returning to the distinction between autonomous and induced demand components, it is useful to ask whether our simulations are satisfactory given the amplitude and duration of the oscillations until the system reaches its new steady-state equilibrium. Actually, while the amplitudes remain realistic and even slightly too small (for example, the deviation between u and $u_n$never exceeds 3.3 percentage points), the durations needed for the system to stabilize may seem too long. However, several arguments can be provided to justify that this is not necessarily a fatal problem. First, as already pointed out, the simulated model must be considered a prototype: as a very simplified representation of reality, it neglects many complications that could have an impact on the dynamics (or the inertia) of the economic system. Second, the behavioral assumptions that govern the adjustments in the growth rates of autonomous demand components in equations (6) and (7) are also very simplistic. Moreover, they are based on naïve adaptive expectations which are well known to stretch the stabilization time of any model. The problem is likely to arise particularly when all the autonomous components are passive, so that the adjustment relies on the slow mutual convergence of agents' expectations. Third, in the simulations, stabilization seems to be effective only when $u = u_n$ and all growth rates are equal to each other. In reality, these conditions are never met since the economy is always subject to many different shocks. By analogy, we could admit the existence of corridors within which the model could be considered stabilized (for example, $u_n \pm 5\%$), which would lead us to consider that the stabilization durations are not too long. Finally, the model ignores how long a period lasts: Does it last a year? A semester? A quarter? Moreover, each agent is likely to adopt his or her own periodization (the relevant duration is probably shorter for revising firms' investment decisions than for government spending, for example). Once again, our model offers nothing more than a simplistic prototype of reality.

7. Autonomous and induced components in the long run

The purpose of this section is to draw conclusions from the simulations regarding the distinction between autonomous and induced components in the long run. First, while non-capacity-generating components for which $\rho_i = 1$ over the entire analysis period (Z_1 in scenarios A and C and Z_2 in scenario D) should unambiguously be considered autonomous, this is no longer as obvious when $\rho_i = 0$ over all or part of the analysis period. In scenario C, $g_2 = \bar{g}_1$ in the steady-state equilibrium (and the reverse in scenario D): the decision of Z_2-spending agents regarding their injections depends on their expectations of g_Y, and any change in Y results in a proportional change in Z_2 because these expectations are fulfilled. Consequently, Z_2 could be considered an induced component. However, key differences persist with respect to the other induced components. On the one hand, the decision is about the growth rate of the expenditure, while on the other hand, it is about the relative level of expenditure. Moreover, while the behavior regarding induced components is assumed to be invariant, this is not the case for Z_2-spending agents, who can opt for active behavior whenever they want. In fact, what is important in economic dynamics is not that certain components are passive in some periods but that they become active in other periods.

Scenarios B and E even lead to larger differences between induced and passive autonomous components because the long-run equilibrium growth rate depends on the dynamics of the Z_i components and of investment. More precisely, g_Y^* results from the identical behavior of agents to gradually adjust the pace of their injections to the growth rate of aggregate income. The important aspect here is not that an increase in Y generates increases in both Z_i and I but that g_Y is determined by the mutual convergence of the injections in Z_i and I. Therefore, although $\dot{\gamma}$ and $\dot{g}_i$ are now endogenous, both investment and the Z_i components should be considered autonomous rather than induced.[22] Note that if all these components are considered induced, then we would be faced with an incoherent Keynesian model because without any injections into the system, the multiplier mechanism would disappear, and effective demand would be zero.

Second, an argument put forward by Skott (2019) to criticize supermultiplier models is that they predict a change in the shares of output in the wrong direction; i.e., the share of the autonomous component decreases when its growth rate increases. Indeed, rearranging equation (12) leads to the following:

$$\frac{Z}{Y} = \frac{su_n - vg_Y^*}{u_n} \tag{13}$$

where g_Y^* is equal to the growth rate of the aggregate autonomous component in the long run. This prediction is illustrated by scenarios A and B. Since Skott considers public spending to be autonomous but observes data showing the increase (and not the decrease) in its share in output, he concludes that supermultiplier models are misspecified and should be rejected. Applied to private residential investment, whose share in output has remained broadly constant since the 1960s in the United States, Skott concludes that this is an indication that it is an induced component.

However, equation (13) does not provide any prediction on the output shares of Z_1 and Z_2 that constitute Z. As shown in scenarios C, D and E, these shares can increase, decrease or even remain constant. Therefore, analyzing the changes in the share of aggregate demand can hardly help determine whether or not a demand component is autonomous.

In other words, Skott's (2019) criticism does not reveal a structural weakness of supermultiplier models but only points out that two autonomous components or more must be included for these models to provide good predictions for output shares. In scenario C, for instance, the increase in g_1 has no significant impact on Z_1's share in output because it is Z_2, whose growth rate gradually converges to $\bar{g}_1$, that absorbs the decrease in Z/Y. This scenario could then illustrate the relative constancy in the share of residential investment in output. In contrast, in scenarios D and E, the resistance of Z_2 to the

[22] Note that there is no reason to decree that I is more or less autonomous than the Z_i components (when $\rho_i = 0$) since the agents adopt identical behaviors. Moreover, this conclusion applies to the neo-Kaleckian versions of supermultiplier models but not to the Sraffian versions in which, as we have already pointed out, investment is assumed to be induced in both the short and long runs.

acceleration in Z_1 spending results in an increase in the share of Z_1 in output. These scenarios could therefore illustrate an increase in the share of government consumption mentioned by Skott (2019).

Third, since autonomous expenditures are financed out by leakage, the agents in charge of Z_i can change their behavior when they are worried about their ability to obtain this financing. This could be the kind of story told in scenarios C, D and E if we assume that Z_1 represents public consumption. The government first adopts a countercyclical policy by setting $\bar{g}_1 > g_Y$. If the economy does not offer too much resistance (i.e., if g_2 converges to $\bar{g}_1$ as in scenario C), then the government may be confident about financing its spending because both g_Y converges to $\bar{g}_1$ and Z_1/Y decreases. In contrast, in the case of resistance (i.e., if $g_2 = \bar{g}_2$ as in scenarios D and E), the worry may increase both because g_Y no longer converges to $\bar{g}_1$ and Z_1/Y increases, causing the abandonment of the active fiscal policy.[23] Therefore, whatever the scenario, considering government expenditures as autonomous in a supermultiplier model does not mean that governments draft their budget without reference to the expected rate of growth, contrary to the criticism of Nikiforos (2018), who doubts that autonomous expenditures are truly autonomous in the long run.

Finally, the above discussion shows that the ability to switch (between active and passive) is a necessary condition for the growth rates of the various autonomous components not to differ from each other for too long. Moreover, the discussion also suggests that the issue of financing autonomous components could be one explanation for changes in their status (from active to passive or vice versa).

8. Conclusion

Given that existing supermultiplier models suggest several candidates as non-capacity-generating autonomous components (government expenditures, credit-financed consumption, private residential investments, primary needs consumption, etc.), the question arises as to how two or more components can coexist. We have therefore developed a general supermultiplier model including two such components. Faced with the evidence that the two autonomous components cannot be active for too long at the

[23] Note that scenario D and E can tell a quite different story: knowing the resilience of the economy and the lag for g_Y to adjust to g_1, the government targeting some growth rate for the aggregate income (say, $g_Y^{\#}$) may opt for $\bar{g}_1 > g_Y^{\#}$ for a while and then return to a passive policy when g_Y is close to $g_Y^{\#}$.

same time, we propose the clarification of the term 'semi-autonomous' adopted by Fiebiger (2018, 2020) and Fiebiger and Lavoie (2019) as making a distinction between active and passive autonomous components: the growth rate of the former is assumed to be exogenous, while that of the latter is assumed to converge to the income growth rate.

In the long-run equilibrium, some properties of passive autonomous components are similar to those of induced components. However, an in-depth discussion leads us to the conclusion that several key differences persist between them: for the former, the decision relates to the rate of growth of expenditure, whereas it relates to the level of expenditure for induced components; passive components can become active at any time; when no component is active, the long-run equilibrium growth rate of income is path dependent, as it results from the mutual convergence of several passive autonomous components. This last property also suggests that investment should be considered a passive autonomous component.

Eventually, our theoretical model and simulations promote a flexible use of supermultiplier models to analyze economic dynamics as a succession of short-run moving equilibria: economic growth can be driven by an active autonomous component in some periods and by a different component in other periods; the coexistence of two or more active components is destabilizing but also affects the income shares of these components, which can explain why some of them shift from active to passive. Moreover, the income growth rate can converge either to the exogenous growth rate of an active autonomous component or to a path-dependent rate if no component is active. In all these cases, the key results of supermultiplier models can be fulfilled: on the one hand, the convergence between the rate of capital accumulation and the growth rate of output and, on the other hand, the convergence of the rate of capacity utilization to its normal level.

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