Kalecki meets Schumpeter: the decline of competition in a demand-led dynamic model

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This paper contributes to the post-Keynesian literature by building a macrodynamic Kaleckian model that incorporates recent evidence on market concentration and its relationship with capital accumulation and income distribution using Schumpeterian insights. This is done in two steps. First, we model a two-dimensional system that sets the dynamics between the wage share and the capital-effective labor supply ratio. We extend the model, in the second step, to a three-dimensional system that incorporates the state-transition function of concentration. Our model suggests that higher market concentration may be associated with a permanent decline in employment, capacity utilization, wage share, and capital accumulation.

Keywords: market concentration, income distribution, capital accumulation, post-Keynesian model.

Área temática: Economia

1 Introduction

In recent decades there has been a noticeable fall in the so-called economic and business dynamism of many advanced economies. A fall in the labor or wage share of GDP and the

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investment rate alongside an increase in market concentration and average markups and profits has been noticed. The decline in the wage share is well documented for the US and many other countries (Autor et al. 2020; Dao et al. 2017; Karabarbounis and Neiman 2014; Piketty 2014).[3] There is also sound evidence that the investment rate has decreased across advanced economies (Gutiérrez and Philippon 2017; IMF 2015). Moreover, labor productivity trends, mainly for the US, show an increase in the productivity gap between frontier and laggard firms, which is also related to weaker aggregate productivity performance (Andrews, Criscuolo, and Gal 2015).

There is a recent literature that associates the salient increase in market concentration across many industries as one of the main causes of the observed downward trends in wage share, investment, and productivity. Grullon, Larkin, and Michaely (2019) report this increase in concentration and find that it is robust to the use of different measures of concentration. They also find that firms in industries with the largest market concentration indexes also presented higher profit margins, which are associated with higher returns to shareholders. Similar findings are also reported in Autor, Dorn, Katz, Patterson, and Van Reenen (2017); Autor et al. (2020); Akcigit and Ates (2019); Eggertsson, Robbins, and Wold (2018); Gutiérrez and Philippon (2017b, 2017a), all of which relate market concentration with one or more of the other observed trends.[4]

The drivers of market concentration, in turn, are diverse. Demographic changes, the nature of new technologies, and looser regulations have all been highlighted as important causes. However, a neo-Schumpeterian analysis would point to the role of higher labor productivity induced by technological change in increasing market concentration (Dosi 1984; Nelson and Winter 1982). This argument is extended, for instance, by Autor et al (2017, 2020), which investigate the relationship between productivity, concentration, and the decrease in the wage shares focusing on "superstar" firms. These firms would be the ones with high productivity and low labor shares, that have dominated the industries where they operate, thus concentrating economic activity in their hands. These studies, as well as Diez, Leigh, and Tambunlertchai (2018), also find evidence that industries with the highest concentrations, with market power determining higher markups and profit margins, present the largest declines in the wage share. Hence, there is evidence of a relationship between productivity, market concentration, and income distribution between profits and wages that needs to be further assessed.

[3] This decline contradicts the idea of constant macro-level stability of the wage share, a phenomenon noticed through the twentieth century that became one of Kaldor (1961)'s stylized facts of growth.

[4] However, this is not the only reasoning put forward. Stansbury and Summers (2020) propose that a better explanation for this macroeconomic scenario of rising profits and lower wages and wage shares relies on the reduction of worker power, rather than increases in firms' market power. The authors provide evidence that measures of reduced worker power are indeed related to lower wage levels, lower wage shares, and reductions of the NAIRU measures. They argue that this proposal explains simultaneously all the trends involving firms' market power and has direct support from the data.

However, these approaches do not consider the role of aggregate effective demand as a constraint on output production, which is a feature of this scenario of increasing market concentration that needs to be taken into account. On the one hand, by definition market concentration means that some firms were more successful than others in capturing a fraction of aggregate effective demand. On the other hand, demand constraints could play different roles in more concentrated markets, like being less able to negatively affect output while also influencing technological diffusion.

These demand aspects may be better analyzed by the post-Keynesian demand-led growth literature, which has as an important feature the interrelation between income distribution and capital accumulation. Regarding the role of the decrease in competition, Lima (2000) incorporates the relationship between market concentration and technological change within this framework to access the long-run dynamics between concentration and income distribution. Rabinovich (2020) also appoints the rise in market concentration as one of the explanations for the puzzle of the low investment-high profits configuration of financialized firms highlighted by this literature. Despite these efforts, the post-Keynesian literature has not yet incorporated the recent trends of growing market concentration accompanied by a declining wage share and slow capital accumulation. Exploring the interrelatedness between these recent trends may be key to understanding the root causes of the poor economic performance of the productive sector in advanced economies. Such an investigation may, hence, shed light on relevant aspects that should be taken into account by policymakers while designing more efficient policies that could help to stimulate capital accumulation and promote a more sustainable and inclusive pattern of growth.

Thus, this paper contributes to the post-Keynesian literature by building a macrodynamic Kaleckian model that describes part of the dynamics of advanced economies in the last decades, highlighting the role of concentration and its relationship with capital accumulation and income distribution inspired by Schumpeterian insights. This is done in two steps. First, we model a two-dimensional system that sets the dynamics between the wage share and the capital-effective labor supply ratio, which constitutes a baseline scenario in which concentration does not evolve endogenously. We extend the model, in the second step, to a three-dimensional system that incorporates the state-transition function of concentration. With this framework, we use numerical simulations to show that not taking into account the endogenous dynamics of market concentration while assessing the relationship between income distribution and capital accumulation may lead to wrong conclusions and bad policy recommendations. This paper also contributes to the literature by advancing a theoretical framework that explores how market concentration at the micro level may have long-lasting effects on key economic indicators at the macro level. Our model suggests that a growing market concentration may be associated with a permanent decline in employment, capacity utilization, wage share, and capital accumulation.

The remainder of the paper is organized as follows. In section (2) we describe the model and how concentration influences markups, capital accumulation, and productivity growth in this framework. Section (3) concerns itself with the short-run dynamics and equilibrium of this model economy. Section (4) focuses on the long-run dynamics between income distribution, capital accumulation, and market concentration, the latter being considered to evolve at first exogenously and then endogenously, and the implications of these relationships. Finally, section (5) concludes.

2 Framework of the Model

The model deals with a closed economy with no government that produces a single good used for both consumption and investment. Production is carried out combining homogeneous capital and labor as the only two factors of production through a fixed-coefficient technology:

$$Y = \min\{aL, bK\}, \qquad (1)$$

where Y is output, L is employment, and K is the capital stock, while a and b are technical coefficients. Labor productivity a varies endogenously with technological change. Firms operate with planned excess capacity to meet unexpected demand shifts. Thus, since firms produce according to demand, employment is then determined by production:

$$L = \frac{Y}{a}. \quad (2)$$

The economy comprises two classes, firm-owner capitalists and workers, who earn profits and wages, respectively. This implies the following functional distribution of income:

$$Y = \frac{W}{P}L + rK, \qquad (3)$$

where W is the nominal wage, P is the price level, and r is the profit rate. The classes also differ in their savings behavior, with the capitalists saving a constant fraction s of their profits, while workers consume all of their wages (Kaldor 1956; Kalecki 1971; Robinson 1956). From equations (2) and (3), the share of labor in income σ is given by

$$\sigma = \frac{W}{Pa}, \qquad (4)$$

and the profit rate is

$$r = u(1 - \sigma), \quad (5)$$

where u denotes the rate of capacity utilization. The capital-potential output ratio $1/b$ is assumed to be constant and normalized to unity, that is $b = 1$, so that capacity utilization u is given by the output-capital ratio, Y/K.

The market is oligopolistic such that firms determine prices by applying a markup on unit labor costs, aligned with the standard approach of Kalecki (1971), as follows:

$$P = z\frac{W}{a}, \qquad (6)$$

where P is the price level and z is the markup factor (one plus the markup rate). Price and wage inflation, in turn, are determined within a conflicting claims approach.[5] Inflation then arises from inconsistencies between the income shares demanded by workers and firms given the available income. Firms want to increase prices whenever the prevalent markup is below their wished markup. The larger the difference between these markups, the higher the rate of price inflation. From equations (4) and (6), the markup is the reciprocal of the wage share, so that price inflation can be formally represented in terms of a difference between the actual wage share σ and the one targeted by firms σ_f,

$$\hat{P} = \tau(\sigma - \sigma_f), \qquad (7)$$

where $\hat{P}$ is the rate of change in price, $\hat{P} = (dP/dt)(1/P)$, and $0 < \tau \leq 1$ is the speed of adjustment. When firms aim at lower wage shares, they hasten the rate of price inflation, given the actual wage share and their bargaining power. The firm-targeted wage share, in turn, is given by:

$$\sigma_f = \theta_0 - \theta_1 u - \theta_2 c, \qquad (8)$$

where θ_i, $i = 0,1,2$, are constant positive parameters and c is the level of concentration of the market. Demand impacts firms' desired wage share since the level of capacity utilization u impacts the threat other competitors present to the firm, this thread being more important the lower the capacity utilization, discouraging price increases (Dutt 1992; Lima 2004; Rowthorn 1977). Similar to Lima (2000), a higher concentration implies higher market power, which leads firms to desire a higher markup and a lower wage share, following Kalecki (1971) and Steindl (1952) and consistent with evidence found in Autor et al. (2020) and De Loecker, Eeckhout, and Unger (2020).[6] As concentration increases market shares, it reduces the price elasticity of demand so that firms with larger market shares will set higher markup rates.

Wage inflation follows the same pattern as price inflation, depending on the gap between the workers' wage share target σ_w and the actual one:

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[5] Lavoie (2014, p. 549–551) argues that the basic widespread post-Keynesian conflicting claims model of inflation, like Dutt (1992)'s, follows Kalecki (1971) view that inflation and the degree of monopoly are endogenous to the distributional conflict, later summarized by Rowthorn (1977).

[6] Autor et al. (2020) provide empirical support, using micro firm-level panel data, of market concentration being a cause of the fall in the labor share observed in the United States and other advanced economies. They relate market concentration to the rise of superstar firms, which are characterized by high markups and a low labor share of value-added. De Loecker et al. (2020) present consistent results, when using firm-level data for the US since 1955. Their empirical results also relate higher market power, measured by markups, with lower labor shares.

$$\widehat{W} = \beta(\sigma_w - \sigma)\,, \qquad (9)$$

where $\widehat{W}$ is the rate of change of the nominal wage, $\widehat{W} = (dW/dt)(1/W)$, and β accounts for the speed of adjustment, which reflects the institutional framework of the wage settlement process. Therefore, the rate of wage inflation speeds up when, given the actual wage share, workers' target a higher wage share, depending on their bargaining power. Following Rowthorn (1977), Dutt (1992), and Lima (2004), workers targeted wage share is influenced by demand conditions as it increases with the employment rate $e = L/N$, where N is the supply of labor, as follows:

$$\sigma_w = \lambda_0 + \lambda_1 e\,, \qquad (10)$$

where λ_j, $j = 0,1$ are positive parameters. A higher employment rate then allows workers to seek and obtain higher wage inflation, as it increases their power in the bargaining process.

Moreover, the employment rate is related to the state of the goods market because of the fixed-coefficient characteristic of the production function - according to which a short-run increase in output is necessarily accompanied by an increase in employment given labor productivity. Yet, capital stock, labor supply and productivity vary in the long run. Consequently, we follow Dutt (1994) in introducing an additional variable $k = K/Na$, the ratio of capital stock to labor supply in productivity units or capital-effective labor supply ratio. In the short run, k is fixed and positive, so that the employment rate $e = ku$ will vary only with demand.[7]

Firms make accumulation plans despite their current savings so that firms' desired growth rate of the capital stock g_I is given by:

$$g_I = \alpha_0 + \alpha_1 r + \alpha_2 u - \alpha_3 c\,, \qquad (11)$$

where α_h, $h = 0,1,2,3$, are all positive parameters, with α_0 representing animal spirits. Following the Kalecki-Steindl tradition, desired investment depends positively on the rate of capacity utilization, encompassing accelerator effects, and the profit rate, considering the current profit rate as a good index of what to expect in future earnings.

Desired investment is also taken to depend negatively on the degree of market concentration c, $c = (0,1)$, although this influence could also be positive, being an open empirical question. This implies that the market power that comes with concentration affects investment decisions. In this case, we state that this effect is negative, as with less competition, firms have higher market power and thus have fewer incentives to invest. This negative link between concentration and investment finds empirical support on the

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[7] The derivation of the employment rate is $e = \frac{L}{N} = \frac{L}{Y}\frac{K}{N}\frac{Y}{K} = ku$.

literature that investigates the weakness of capital investment in advanced economies, especially in the US. For instance, Gutiérrez and Philippon (2017a, 2017b) and Crouzet and Eberly (2019) provide empirical evidence that declining competition has an important role in the decline of investment in many industries.

The technological parameters are given at a point in time as a result of previous dynamics. Yet, they change over time with the growth of labor productivity, with the following specification:

$$\hat{a} = \gamma_0 + \gamma_1 c + \gamma_2 d \,, \qquad (12)$$

where γ_i are positive parameters, $\hat{a}$ is the growth rate of productivity, and d is the rate of technological diffusion of the industry. Equation (12) indicates that the positive effect that concentration has on productivity can be reinforced or counteracted by how the diffusion of technology from the leaders to the laggards occurs.

There is evidence that concentration could influence productivity either positively or negatively (Autor et al. 2020; Gutiérrez and Philippon 2019). Here we are considering only the "Schumpeterian effect" of competition on productivity through technological innovation, according to which a higher concentration can facilitate and generate technological innovation by assuring that the firms have enough resources to pursue innovation and then assuring that the firm will appropriate the profits of such innovation in case of success by preventing imitation (Schumpeter [1912] 1934, 1942). Furthermore, we follow recent evidence of how industries that became more concentrated also presented an increase in productivity, as showed by Autor et al. (2020). However, there is also evidence that this firm-level productivity did not increase overall levels of productivity, which has slowed down in West advanced economies (Syverson 2017). In this model, we encompass this trend by incorporating the possibility of declining diffusion of technology as an explanation for the lack of productivity gains from concentration. This declining diffusion argument is consistent with empirical evidence present in Andrews et al. (2015) and has been highlighted by the literature that incorporates Schumpeterian insights (Akcigit and Ates 2019; Dosi 1984; Nelson and Winter 1982). Diffusion d is thus defined as

$$d = \delta_0 + \delta_1 g \,, \qquad (13)$$

where δ_j are positive parameters, with δ_0 encompassing the body of regulations (antitrust, patenting policies, incentives) and relevant technological characteristics that affect the level of diffusion. For instance, a relevant regulation effect is the weakening in antitrust enforcement law in the last decades, especially in the US (Grullon, Larkin, and Michaely 2019). Moreover, when it comes to technological features, many sectors have become intensive in data-dependent processes and focused on "intangible capital" (Crouzet and Eberly 2019). Both of these changes contribute to slowing down the pace of technological diffusion. Also, we follow Lima (2000) in relating diffusion with growth through δ_1 since, from the demand side, diffusion would depend on income and its rate of growth.

From the definition of how technological diffusion is determined in (13) and employed in (11), we can look again at the growth of labor productivity in equation (12). Concentration then has an indirect negative effect on productivity along with the positive direct effect showed in (12). By allowing the ambiguity of the overall effect, we aim to make the model more general such that this determination will remain an empirical question.

Since firms operate with planned excess capacity, the equality between desired investment and savings will be assured by adjustments in the rate of capacity utilization. The available savings will determine the growth rate of the capital stock, such that assuming away capital depreciation we obtain:

$$g_S = sr , \qquad (14)$$

where g_S is aggregate savings normalized by the capital stock. Finally, since the rate of capacity utilization equals the output-capital ratio, the growth of capital accumulation also stands for the growth rate of this economy.

3 Short-Run Equilibrium

In the short run, the stock of capital K, the nominal wage W, the price level P, concentration c, and labor productivity a are constant. Since adjustments in the rate of capacity utilization ensure the equality between investment and savings, in the goods market short-run equilibrium we have $g_I = g_S$. Substituting (5) in (11) and (14), from the equilibrium condition we solve for the short-run equilibrium value of the rate of capacity utilization u^*, obtaining

$$u^* = \frac{\alpha_0 - \alpha_3 c}{(s-\alpha_1)(1-\sigma)-\alpha_2} . \; (15)$$

We ensure short-run stability assuming a positive denominator in equation (15) above, $(s-\alpha_1)(1-\sigma)-\alpha_2 > 0$. This implies aggregate savings being more responsive than desired investment to changes in capacity utilization to eliminate rather than exacerbate excess demand or supply. Also, $u \in (0,1)$ implies a positive numerator in (15), that is, $\alpha_0 > \alpha_3 c$.

From expression (15), everything else held constant, the partial effect of changes in the wage share and market concentration is given by:

$$u^*_\sigma = \frac{\partial u^*}{\partial \sigma} = \frac{(s-\alpha_1)u^*}{(s-\alpha_1)(1-\sigma)-\alpha_2} > 0 , \; (16)$$
$$u^*_c = \frac{\partial u^*}{\partial c} = \frac{-\alpha_3}{(s-\alpha_1)(1-\sigma)-\alpha_2} < 0 . \; (17)$$

The partial derivative (16) shows that an increase in the wage share affects the capacity utilization positively, that is, raises the level of activity. This means that the modeled economy operates in a wage-led effective demand regime, as is standard in Kaleckian models. According to (17), in turn, a higher concentration implies a lower capacity utilization, following the investment dynamics in which, given u, when the market becomes more concentrated investment declines.

The short-run equilibrium rate of capital accumulation g^* is obtained substituting (15) into (14), which results in

$$g^* = su^*(1-\sigma)\,. \qquad (18)$$

Expression (18) allows for obtaining the following partial derivatives:

$$g_\sigma^* = \frac{\partial g^*}{\partial \sigma} = s[u_\sigma^*(1-\sigma) - u^*] > 0\,, \qquad (19)$$

$$g_c^* = \frac{\partial g^*}{\partial c} = s(1-\sigma)u_c^* < 0\,, \qquad (20)$$

both of which indicate how the accumulation and growth rates, as well as the profit rate - following the assumption that workers do not save and capitalists save a positive fraction of their income - move in the same direction as the rate of capacity utilization when faced with changes in the wage share and concentration.

4 Long-Run Dynamics

We now explore the dynamical feedback effects that relate income distribution, capital accumulation, and market concentration in the long run. This section is then divided into two. First, we model the dynamical interaction between income distribution and capital accumulation, when the degree of concentration is kept constant. Second, we relax this hypothesis and consider how the degree of concentration varies in time following changes in the technological sphere to investigate how this addition changes the stability conditions of the first scenario.

4.1 The two-dimensional system

In the long run, the short-run equilibrium values of the variables will always be met with the economy moving over time through changes in these variables. We follow this over-time behavior of the system by looking into the dynamics between the short-run state variables wage share σ and the ratio of capital stock to labor supply in productivity units k, while at first considering the degree of concentration c as constant. From the definition of these variables, we obtain the following differential equations:

$$\hat{\sigma} = \widehat{W} - \hat{P} - \hat{a}\,, (21)$$

$$\hat{k} = \widehat{K} - \widehat{N} - \hat{a}\,, \qquad (22)$$

where the over-hats indicate time-rates of change. Substituting (9), (7), (12), (13), and

(18) in the system (21) and (22) yields:

$$\hat{\sigma} = \beta(\lambda_0 + \lambda_1 u^* k - \sigma) - \tau(\sigma - \theta_0 + \theta_1 u^* + \theta_2 c) - [\gamma_0 + \gamma_1 c + \gamma_2(\delta_0 + \delta_1 g^*)]\,, \quad (23)$$
$$\hat{k} = g^* - n - \big(\gamma_0 + \gamma_1 c + \gamma_2(\delta_0 + \delta_1 g^*)\big)\,, \quad (24)$$

where u^* and g^* are given by equations (15) and (18), respectively, and n is the growth rate of labor supply. We are assuming that n adjusts to the difference between the growth rate and the growth of productivity:

$$n = \mu(k - k^*) + g - \hat{a}\,, \qquad (25)$$

where μ is the speed of adjustment. Assuming an infinitely elastic labor supply,[8] the growth rate of the labor force must be equal to the growth in demand minus the growth in labor productivity, that is, $n = g - a$.[9] However, we assume that whenever the capital-effective labor supply ratio, k, is above a certain equilibrium level, k^*, a greater number of jobs are created, attracting workers at the current wage which, in turn, is assumed to be higher than the subsistence wage adjusted by the transition premium. We also assume that $k^* = \psi g$ is the k associated with the growth of the equilibrium labor supply which is determined by the growth in demand (adjusted by a proportionality constant, ψ). That is, whenever the capital-effective labor supply ratio k rises above $k^* = \psi g$, this generates an increase in jobs, thus attracting workers until $k = k^*$.

Thus, upon substitution of (25) equation (24) becomes:

$$\hat{k} = \mu(k - \psi g^*)\,, \qquad (26)$$

Equations (23) and (26) form an autonomous two-dimensional non-linear system of differential equations in which the rates of change of σ and k depend on the levels of these variables and the parameters of the system. Solving for the long-run equilibrium with $\hat{\sigma} = \hat{k} = 0$ yields a non-linear isocline for the former, and a vertical line for the latter in the relevant (σ, k) space. Still, there is at least one non-trivial equilibrium solution (σ^*, k^*) obtained from the system resolution. The local stability of this equilibrium can be examined through its Jacobian matrix of partial derivatives, as detailed in Appendix A. We observe that the system yields a stable equilibrium depending on parametric conditions.

Beyond the analytical investigation of this framework in Appendix A, we opt for improving the visualization of transition dynamics and its considerable feedback effects through

[8] The hypothesis of infinitely elastic labor supply may apply to both advanced and developing economies. In the case of an advanced economy, we can assume that any restriction on domestic labor supply can be met by foreign workers migrating. In the case of developing economies, we can assume the existence of a dual economy à la Lewis composed of a modern capitalist sector and a traditional subsistence sector. Given that the traditional sector has an infinitely elastic supply of labor, the growth of the modern sector always manages to absorb labor from the traditional sector.

[9] Let there be $e = L/N = (L/Y)(Y/N)$. In rates of change, we have $\hat{e} = g - n - a$. In equilibrium, we have $\hat{e} = 0$ and, therefore, $n = g - a$.

numerical simulations. The parametric specification used in this simulation is in Appendix B. Our intent with this calibration is not to replicate the behavior of a specific real economy or to offer a quantitative prediction of any variable of such as economy. To find these values and compare different sectors or economies would be an interesting exercise, but it is not the purpose of this study. We aim instead to illustrate the qualitative dynamics of the model, which will contribute to a better understanding of the causalities identified here and thus provide an outline of testable hypotheses. Moreover, many parameters have not yet been studied empirically simply because they are first being investigated here. Thus, our strategy was to adopt standard values when they were available and calibrate the others internally to obtain certain initial values of the variables. Still, this chosen specification yields the convergence of the variables of interest to plausible values. Figure (1) illustrates this representation of the model. The parametric specification is in Table (7.1).

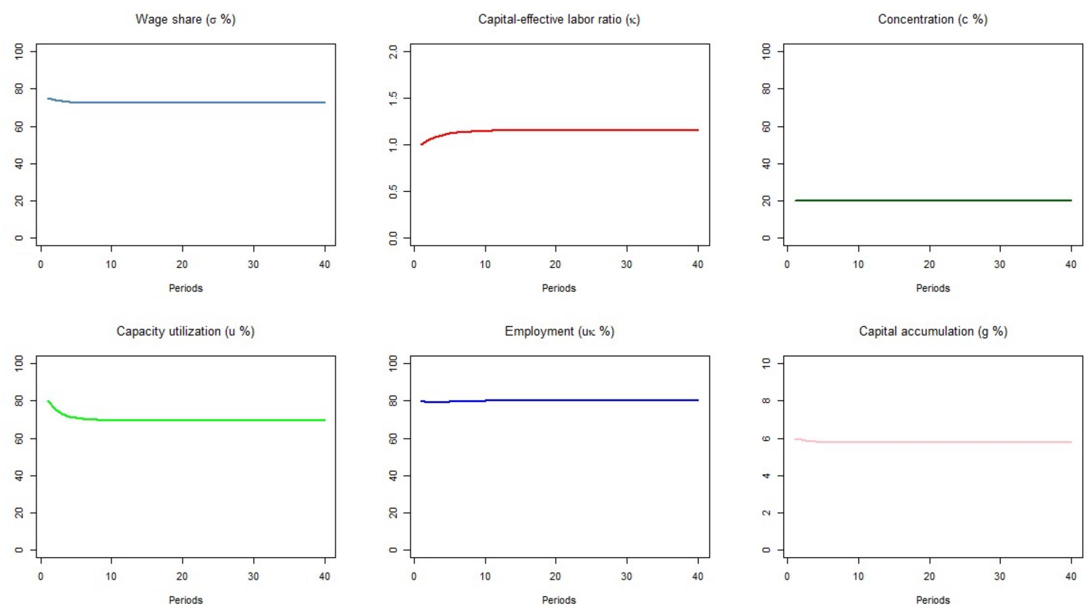

Figure 1 - Two-dimensional system

In Figure (1), the model starts out of equilibrium at the initial conditions of $k = 1$, $\sigma = 0.75$, and $c = 0.2$. As the model converges to equilibrium, by definition concentration is kept exogenous and thus constant, but the wage share slightly decreases and the capital effective-labor supply ratio increases. With this process, there is a decline in capacity utilization, with a small increase in employment and no great alteration in capital accumulation.

Figure (2) shows how an exogenous shock in the degree of concentration c, with an increase of 0.2, affects the main variables of the system. As expected from the theoretical and empirical literature, an increase in concentration would have a depressing effect on most of the variables. The new equilibrium after the shock is characterized by a smaller wage share, capital-effective labor output ratio, which in turn lead to smaller capacity utilization and employment rate. However, contrary to what the existing literature as Crouzet and Eberly (2019) and Gutiérrez and Philippon (2017a) predict, in this version of the model where concentration is exogenous, a decrease in competition has a positive effect on the accumulation rate. We can see how this is possible taking the derivative of the equilibrium accumulation rate in relation to concentration on the long run, which yields:

$$g_c^* = s(1-\sigma)u_c^* - s^*\sigma_c^* \,. \qquad (27)$$

From this expression, we see that for the concentration shock to have a negative effect on the accumulation rate, the decrease in capacity utilization would have to be larger than the decrease in the wage share. When the opposite happens, as in this configuration of the model, we get a higher accumulation rate following an increase in concentration that nonetheless decreases both capacity utilization and wage share.

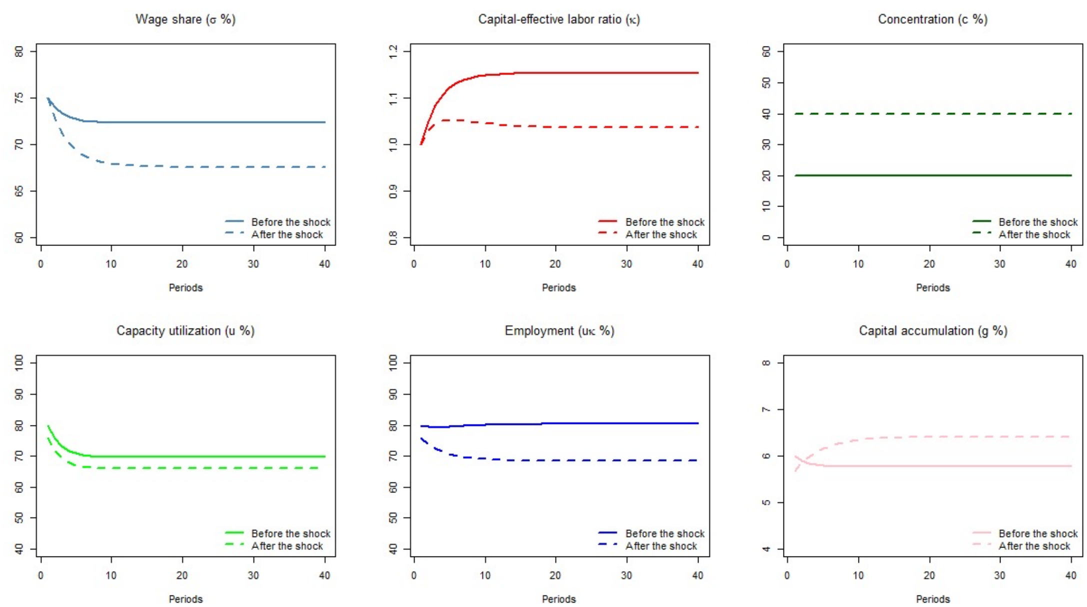

Figure 2 - Two-dimensional system - concentration shock

We now proceed to check how the dynamic of the system changes when considering the degree of concentration evolving through time alongside distribution and the capital effective-labor supply ratio, which is a likely scenario of interaction. In the next section then we relax the hypothesis of a constant c and evaluate the resulting three-dimensional system.

4.2 The three-dimensional system

We now consider how the degree of concentration evolves with time and its dynamic behavior toward the time-rates of change of the wage share and capital accumulation. We define the dynamics of concentration in the following linear way:

$$\hat{c} = \rho_0 + \rho_1 k - \rho_2 d - \rho_3 c \,, \quad (28)$$

where ρ_h are all positive parameters. The rate of change in concentration is assumed to be positively related to the capital effective-labor supply ratio, while negatively related to the degree of diffusion. A higher level of capital effective-labor supply ratio imposes a barrier to entry to possible competitors, as it entails a higher initial level of capital stock that also makes an entry riskier. Moreover, a higher capital requirement can impose higher costs both of financing and maintenance, which creates a disadvantage for smaller firms and makes them more likely to be acquired by larger firms. However, the persistence of these advantages depends on the diffusion of capital and technology in the industry. The higher the diffusion, the faster innovation can be copied, and the faster the competitive advantages will be lost and the market will become more competitive (Dosi 1988; Nelson and Winter 1978, 1982).

We also assume that a higher level of concentration decreases its rate of change, as firms with larger competitive advantages will have fewer incentives to speed up the expansion of this advantage. The indivisibility of capital may discourage large firms to keep expanding their market share if this demands a higher rate of capital accumulation, materialized in more expensive machines and new plants that would not be necessarily profitable so that firms may opt for not pursuing higher market shares. As for ρ_0, it could imply that concentration has autonomous growth, which is not possible because $c = [0,1]$. However, since k, d, and c are all strictly positive, ρ_0 can be seen as a proportionality parameter. Thus, we define the dynamics of $\hat{c}$ as a linear approximation of its non-linear behavior, such that ρ_0 captures all structural or intangible factors that affect this dynamic.

Upon substitution of (13) in (28), we obtain

$$\hat{c} = \rho_0 + \rho_1 k - \rho_2(\delta_0 + \delta_1 g) - \rho_3 c\,, \qquad (29)$$

which alongside equations (26) and (23) form a three-dimensional non-linear system in which the rates of change of σ, k, and c depend on the levels of these variables and the parameters of the system. The local stability of the equilibrium solution (σ^*, k^*, c^*) is verified in the Appendix A, yielding the possibility of stable equilibrium. Figure (3) illustrates when stability is reached.

In Figure (3), the model starts from the same initial conditions of the two-dimensional system in Figure (1), $k = 1$, $\sigma = 0.75$, and $c = 0.2$. By converging to the equilibrium, the wage share decreases and the capital effective-labor supply ratio increases, with a decline in capacity utilization, employment, and capital accumulation. Since concentration is endogenous, it converges to its equilibrium value, greater than the initial one. In comparison with the two-dimensional system, when we add concentration evolving endogenously, the system reaches an equilibrium with a lower wage share, capacity utilization, and capital accumulation, and here employment also decreases, in opposition to the increase plotted in Figure (1). The results of the three-dimensional system better fit the empirical evidence that motivates this paper (Eggertsson, Robbins, and Wold 2018; Akcigit and Ates 2019; Gutiérrez and Philippon 2017).

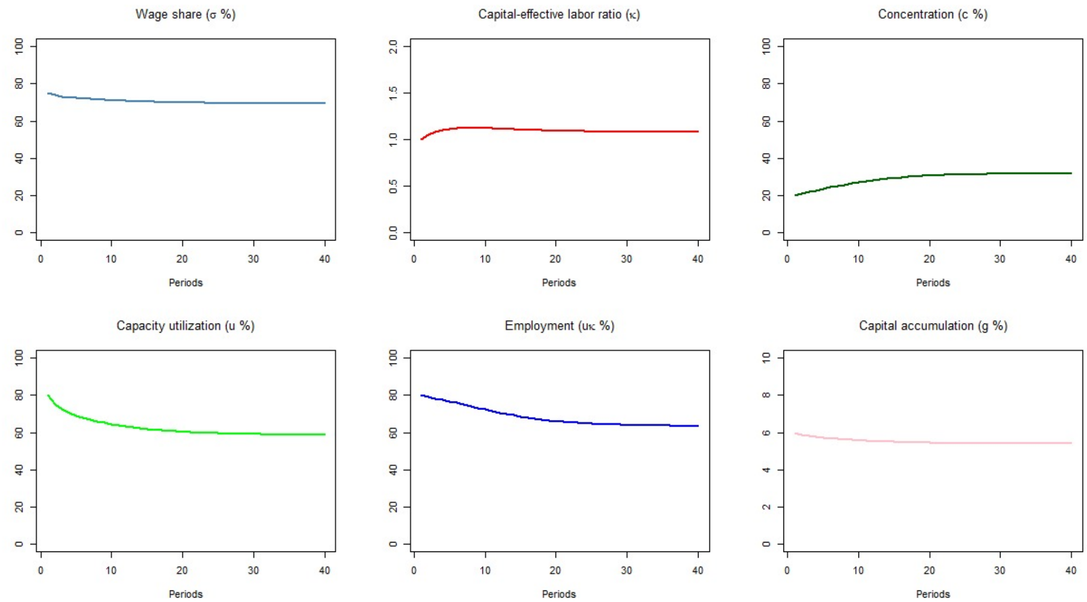

Figure 3 - Three-dimensional system

Taking the stable case, we will explore how this new system is affected by an exogenous increase in concentration. In this case, this would be a shock in the autonomous component of the dynamic equation for concentration, which is ρ_0, but at the same magnitude of the last shock, an increase of 0.2. Figure (4) shows how the variables of the system are affected. This exogenous increase in concentration leads to a decrease in all the variables considered.

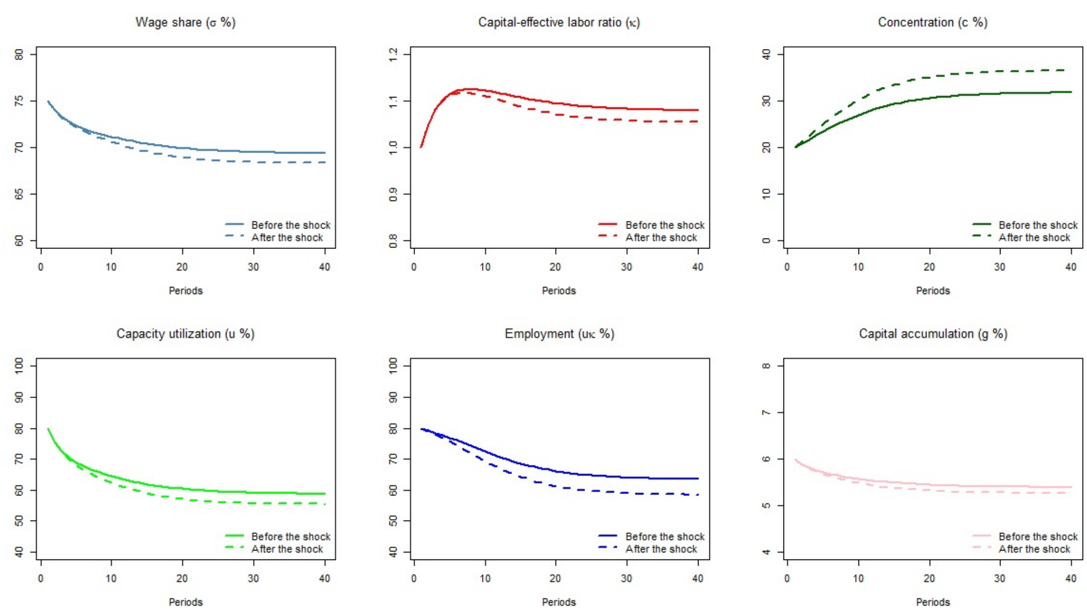

Figure 4 - Three-dimensional system - concentration shock

In comparison with Figure (2), the main different result of Figure (4) is how, when we consider concentration evolving through time alongside the other state variables, for the same parametric configuration, an exogenous increase in concentration now leads to a decrease in the capital accumulation rate. This result is more compatible with the empirical motivation of this model, which is the current case of many advanced economies marked by trends of higher concentration but smaller investment rates and wage shares. Thus, this comparative static exercise implies that the three-dimensional system, which considers the time-evolution of concentration, is closer to the empirical evidence, while the two-dimensional system is prone to generate wrong conclusions.

The significance of the difference between the two systems is that the different results lead to different implications when motivating the study and design of policies. Considering the model where concentration evolves with time, the main takeaway is that promoting competition also needs to be a concern when thinking about strategies for growth with redistribution. Hence, institutions and regulations, for instance, those related to antitrust policies, need to be included in these strategies.

Furthermore, when it comes to the theoretical literature that inspired this framework, although we established Schumpeterian-inspired insights in the model, the resulting transition dynamics does not reinforce a standard Schumpeterian hypothesis that concentration could drive innovation that will in turn lead to a virtuous growth path. In this case, the Kaleckian features of the model are the most prominent and drive this result, mainly because of how these features are linked to highlighting the role of income distribution and effective demand.

5 Concluding Remarks

This paper contributes to the post-Keynesian literature by developing a macro model that encompasses some of the recent trends on the effects of market concentration on the wage share and capital accumulation and how the three are related. We also consider labor productivity induced by technological innovation as endogenous, positively related to concentration and the rate of technological diffusion. Concentration influences desired investment negatively, while the accumulation rate influences diffusion positively. Firms operate with planned excess capacity so that in the short run the equality between investment and savings will happen through adjustments in the rate of capacity utilization, which also responds negatively to an increase in the degree of concentration.

This model allows us to analyze the dynamic relationship between the processes of income distribution, capital accumulation, and concentration in the long run. The two-dimensional system that sets the dynamics between the wage share and capital-effective labor supply ratio constitutes a baseline scenario in which concentration does not evolve endogenously. However, this situation could be not very representative, given that there is evidence that the degree of concentration evolves with income distribution and capital accumulation. Therefore, we extend the model to a three-dimensional system that incorporates the state transition function of concentration. This function relates the growth of concentration to technological change positively through productivity growth, while negatively with diffusion and the level of concentration.

We simulate the models and thus conduct comparative static analyses of the effects of an exogenous concentration shock in the two scenarios. In both cases, an exogenous increase in concentration leads to a decrease in the wage share and the capital-effective labor ratio, leading to smaller capacity utilization and employment rate. However, while in the two-dimensional system the result is an increase in capital accumulation, when we add concentration evolving endogenously, this shock also leads to a decrease in capital accumulation. The latter result is more compatible with the empirical literature that motivates this paper, which favors the strategy of using a three-dimensional system to study the relationship between market concentration on the wage share and capital accumulation. The two systems also lead to different policy implications. In light of these consequences, including concentration in a demand-led model and analyzing its long-run effects indicates its usefulness to think about adding competition-enhancing policies to a policy plan that aims at growth and redistribution.

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Appendix A - Stability analysis

A.1 Two-dimensional system

Equations (23) and (24) form an autonomous two-dimensional non-linear system of differential equations in which the rates of change of σ and k depend on the levels of these variables and the parameters of the system. Solving for the long-run equilibrium with $\hat{\sigma} = \hat{k} = 0$, we obtain the equilibrium solution (σ^*, k^*). The stability of this equilibrium is assessed through the following Jacobian matrix given by:

$$J(\sigma,k) = \begin{bmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{bmatrix} \quad (30)$$

$$J_{11} = \frac{\partial\hat{\sigma}}{\sigma} = \beta(\lambda_1 u_\sigma^* k - 1) - \tau(1 + \theta_1 u_\sigma^*) - (\gamma_2 \delta_1 g_\sigma^*), \quad (31)$$

$$J_{12} = \frac{\partial\hat{\sigma}}{\partial k} = \beta\lambda_1 u^* > 0, \quad (32)$$

$$J_{21} = \frac{\partial\hat{k}}{\partial\sigma} = -\mu\psi g_\sigma^* < 0, \quad (33)$$

$$J_{22} = \frac{\partial\hat{k}}{\partial k} = \mu > 0. \quad (34)$$

From $J(\sigma,k)$, we see that only (31) has an ambiguous sign. Equation (32) indicates that an increase in the ratio of capital to labor supply in productivity units will raise the rate of increase of the wage share by raising the employment rate and consequently the wage share desired by workers. Equation (33) indicates that the effect of an increase in the wage share on the rate of change of k is positive, because it affects positively growth rate. Equation (34) in turn, shows that since an increase in k does not affect concentration, the wage share or capacity utilization, it thereby does not affect the rates of accumulation and productivity growth, consequently not affecting its rate of growth.

Lastly, equation (31) shows how an increase in the wage share could either decrease or increase its rate of change. This direction depends mainly on the impact of the wage share on the rate of capacity utilization, as the wage shares desired by workers and firms, as well as productivity growth, depend directly or indirectly on capacity utilization. The wage shares claimed by workers and firms respectively rise and decline with an increase in capacity utilization due to a higher wage share. This increase also raises productivity growth through its indirect positive effect on diffusion. Yet, the term J_{11} would only be positive in case the weight of the workers' claims for higher wages is relatively strong, or if diffusion is weak, implying a small diffusion coefficient $\gamma_2\delta_1$.

To ensure stability of the two-dimensional system (26) and (23), two conditions need to be fulfilled. First, the partial derivative J_{11} should be negative, thus yielding a negative trace. This sign depends on the relative bargaining power of capitalists and workers and the degree of technological diffusion. Facing an increase in the wage share, workers bargaining power could be high enough to outweigh the opposing effects of higher capacity utilization on the firms' demands and on productivity through higher diffusion. In this case, J_{11} would be positive, which would cause an unstable spiral of wage share growth. The second condition requires that

$$|J_{12}J_{21}| > |J_{11}J_{22}|, \quad (35)$$

which yields a positive determinant of the Jacobian matrix $J(\sigma, k)$.

A.2 Three-dimensional system

The local stability of the equilibrium solution (σ^*, k^*, c^*) can be verified with the following Jacobian matrix:

$$J(\sigma,k,c) = \begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{bmatrix} \quad (36)$$

$$J_{11} = \frac{\partial\hat{\sigma}}{\partial\sigma} = \beta(\lambda_1 u_\sigma^* k - 1) - \tau(1 + \theta_1 u_\sigma^*) - (\gamma_2\delta_1 g_\sigma^*), (37)$$

$$J_{12} = \frac{\partial\hat{\sigma}}{\partial k} = \beta\lambda_1 u^* > 0, (38)$$

$$J_{13} = \frac{\partial\hat{\sigma}}{\partial c} = \beta\lambda_1 u_c^* k - \tau(\theta_1 u_c^* + \theta_2) - (\gamma_1 + \gamma_2\delta_1 g_c^*), (39)$$

$$J_{21} = \frac{\partial\hat{k}}{\partial\sigma} = -\mu\psi g_\sigma^* < 0, (40)$$

$$J_{22} = \frac{\partial\hat{k}}{\partial k} = \mu > 0. (41)$$

$$J_{23} = \frac{\partial\hat{k}}{\partial c} = -\mu\psi g_c^* > 0, (42)$$

$$J_{31} = \frac{\partial\hat{c}}{\partial\sigma} = -\rho_2\delta_1 g_\sigma^* < 0, (43)$$

$$J_{32} = \frac{\partial\hat{c}}{\partial k} = \rho_1 > 0, \quad (44)$$

$$J_{33} = \frac{\partial\hat{c}}{\partial c} = -\rho_2\delta_1 g_c^* - \rho_3. (45)$$

Considering that we already discussed the signs of the derivatives that appeared in the two-dimensional matrix $J(\sigma, k)$, we now look into the signs of the additional partial derivatives of the three-dimensional Jacobian matrix. Equation (39) shows that an increase in concentration could either increase or decrease the rate of change of the wage share and that this effect is mostly mediated through the negative impact on capacity utilization. A smaller capacity utilization decreases employment, by decreasing the rates of growth and technological innovation, which decreases workers' bargaining power and their claims to a higher wage share. However, a higher concentration affects both firms' desired markup and productivity growth positively on its own and negatively through capacity utilization, thus having an ambiguous effect on price inflation and productivity growth and thereby on the growth rate of distribution. Equation (42)'s negative sign is given by the negative impact of changes in concentration on the rate of growth.

Regarding how changes in σ, k, and c affect the growth rate of concentration, equation (43) shows that the effect of an increase in the wage share is negative, slowing down concentration. Equation (44) shows that increases in the capital-effective labor supply ratio increases the growth rate of concentration, as specified in the construction of the model. Finally, from equation (45) we see that an increase in the degree of concentration decreases its growth rate unless the higher concentration decreases diffusion enough to counteract the negative direct effect of the level of concentration on its rate of growth.

The necessary and sufficient Routh-Hurwitz conditions for local stability, evaluated at the equilibrium, are the following:

1. $Tr(J) = J_{11} + J_{22} + J_{33} < 0$, (46)
2. $Det(J_1) + Det(J_2) + Det(J_3) = J_{22}J_{33} - J_{23}J_{32} + J_{11}J_{33} - J_{13}J_{31} + J_{11}J_{22} - J_{12}J_{21} > 0$, (47)
3. $Det(J) = J_{11}J_{22}J_{33} + J_{12}J_{23}J_{31} + J_{13}J_{21}J_{32} - J_{13}J_{22}J_{31} - J_{11}J_{23}J_{32} - J_{12}J_{21}J_{33} < 0$, (48)
4. $-Tr(J)[Det(J_1) + Det(J_2) + Det(J_3)] + Det(J) > 0$. (49)

All four conditions can be simultaneously satisfied depending mainly on the relationship between the forces of concentration and the ones of diffusion. From equation (28), diffusion acts to diminish the growth of concentration. However, since a higher concentration leads to a lower growth rate and, thus, a lower diffusion, this effect can be destabilizing in the system. For instance, if this indirect concentration effect over diffusion is high enough in comparison with the effect of the level of concentration, it makes it more likely that an increase in concentration would increase its rate of growth. This positive effect, in turn, implies a positive partial derivative J_{33} in (45). However, this derivative being negative is a necessary, although not sufficient, condition for the system to be stable. A negative J_{33} is necessary for a negative trace to Jacobian matrix $J(\sigma, k, c)$, ensuring that the first Routh-Hurwitz criterion, in equation (46), is attended.

Moreover, diffusion is also important for the remaining conditions to be attended. If diffusion, expressed by $\gamma_2\delta_1 g_c^*$, is bigger than concentration tendencies, expressed by γ_1, an increase in concentration would cause a decrease in productivity growth. This fall in productivity would, in turn, increase the growth rates of the wage share and the ratio of capital stock to labor supply in productivity units. This effect makes it more likely that the partial derivative J_{13} is positive. This specification of the Jacobian matrix $J(\sigma, k, c)$ makes it likely to attend the second and third stability criteria, in equations (47) and (48), respectively.

The fourth criterion, described in equation (49), although still ambiguous from a purely analytical analysis, depends highly on the attendance of the other stability criteria. Furthermore, a higher parameter ρ_3, which influences the effect of the level of concentration on its growth rate, makes this condition more easily satisfied. Given that $J_{33} < 0$, a higher ρ_3 would increase $|J_{33}|$, increasing $|Tr(J)|$, the sum $Det(J_1) + Det(J_2) + Det(J_3)$ and $|Det(J)|$, which are the first three stability conditions. This increase, therefore, will be higher on $-Tr(J)[Det(J_1) + Det(J_2) + Det(J_3)]$ than on $|Det(J)|$, making the fourth condition more likely to be fulfilled.

Appendix B - Parametric specification

Parameters and initial values

Parameter and variables	Value
α_0	0.04
α_1	0.03
α_2	0.02
α_3	0.01
α_4	0.04
ϕ	0.3
β	0.1
λ_0	0.8
λ_1	0.5
τ	0.5
θ_0	0.7
θ_1	0.02
θ_2	0.02
γ_0	0.01
γ_1	0.08
γ_2	0.07
δ_0	0.01
δ_1	0.05

Parameter and variables	Value
δ_2	0.09
μ	0.3
ψ	0.2
ρ_0	0.08
ρ_1	0.05
ρ_2	0.5
ρ_3	0.4
σ_0	0.75
k_0	1
c_0	0.2

Source: Author’s elaboration.