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Abstract

In this paper, we build a fully specified parsimonious Sraffian supermultiplier stock-flow consistent model (SSM-SFC) with two non-capacity creating autonomous expenditure: residential investment and debt-financed consumption. Our model represents a closed and without government economy with working and capitalist households and only the latter are not not credit constrained. The introduction of residential investment implies that our SSM-SFC model has two real assets: firms' productive capital and households' real estate. The numerical simulation experiments report the main standard Sraffian supermultiplier growth models results: (i) income distribution affects growth rate only during the traverse; (ii) autonomous expenditures alone affects long-term growth rate and; (iii) utilization rate moves towards the normal one. As a particular result, residential investment growth rate increase implies a decrease of real estate share in total real assets. Therefore, this model introduces both housing and asset bubbles on Sraffian supermultiplier agenda and extends the range of autonomous expenditures alternatives.

Keywords: Residential Investment; Sraffian supermultiplier; Asset bubble; Stock-Flow Consistent approach.

1 Introduction

Sraffian supermultiplier growth model (SSM) establishes an important role to non-capacity creating (NCC) autonomous expenditures. Serrano (1995) — and also more recent papers (Freitas and Serrano, 2015) — presents the SSM model in a rather parsimonious way as an alternative closure within the demand-led growth model agenda (Serrano and Freitas, 2017). In summary, SSM describes a demand-led growth pattern led by NCC autonomous expenditures. FALAR MAIS SOBRE O SUPER

More recently, SSM has been introduced to Post-Keynesian authors by Allain (2015) and Lavoie (2016). Different NNC autonomous expenditures have been included in this framework: debt-financed (Pariboni, 2015; Fagundes and Freitas, 2018; Mandarino, 2018) and financial wealth-financed consumption (Brochier and Macedo e Silva, 2019); government expenditures (Allain, 2015) and; exports (Nah and Lavoie, 2017). Nevertheless, housing — another NCC autonomous expenditure — has been systematically neglected. Despite its absence in theoretical grounds, there is a growing empirical literature highlighting its macrodynamic relevance (Leamer, 2007; Jordà *et al.*, 2014; Fiebiger, 2018; Fiebiger and Lavoie, 2018). One way to connect residential investment with the SSM model is through houses' own interest rate proposed by Teixeira (2015). This particular real interest rate is the relevant one for house investors (households) and allow us to include asset bubble in a SSM-friendly framework. FALAR SOBRE A TAXA PRÓPRIA NA INTRODUÇÃO?

In this paper, we include residential investment into the the Sraffian supermultiplier model within a SFC framework. Section 2 reviews heterodox growth models with NCC autonomous expenditures and highlight the lack of housing playing the leading role of the dynamics. In Section 3 we present our SSM-SFC model with two real assets: firms' capital and household' real estate. The analytical solution is presented in Section 4 in order to assess stability condition since residential investment growth rate is now described by houses' own interest rate. Next, in Section 5, we evaluate both traverse and steady-state dynamics through numerical simulations. The experiments are: decrease in wage-share (Section 5.1); increase in real estate inflation (Section 5.2) and; a increase in interest rate (5.3). Section 6 offers some concluding remarks.

2 The lack of housing in demand-led growth models

Recently, there is an effort to include SSM in Post-Keynesian strands (Allain, 2015; Lavoie, 2016). Some authors started to explore the consequences of introducing different NCC autonomous expenditures through modifications in the canonical Kaleckian model in the long-run[1]. In this Section, we will analyze which NCC has been included and its consequences. Since this models depart from SSM closure — at least in the long-run —, we will emphasize its particularities only if present non-standard results.

Allain (2015) considers tax-financed government consumption growing at an exogenous rate as NCC autonomous expenditure. In this model, tax rate adjusts endogenously so government budget remains balanced. Hein (2018) argues that Allain (2015) does not explores the implications for government deficits/debt dynamics. Thus, embeds Allain's (2015) contribution in a SFC framework in which government expenditures is now financed by credit creation/high powered money, keeping up with the canonical neo-Kaleckian investment function. This model has two non-standard results: (i) paradox of debt; and (ii) non-convergence of utilization rate to the normal one. The former occurs due to the inclusion of both real and financial assets into the model. The latter is a consequence of neo-Kaleckian investment function, so NCC autonomous expenditures plays a leading role temporally.

Brochier and Macedo e Silva (2019) was the first effort to introduce SSM model in a fully specified SFC framework. They present a non-parsimonious model in which wealth-financed consumption plays the leading role. The results are at odds with the standard SSM model: income distribution affects fully-adjusted position growth rate. In other words, paradoxes of thrift and costs are held despite convergence of utilization rate to the normal one. Although causal mechanisms are not clear — considering the complexity of this model — it is a possible exception to what has been presented so far.

Dutt (2006), Palley (2010) and Hein (2012) present a model in which debt-financed consumption under standard neo-Kaleckian assumptions. Thus, stability is reached only if NCC autonomous consumption grows at the same rate of capital accumulation which means that this expenditure is not really autonomous. Pariboni (2015) presents an SSM alternative in which this causality is reversed so accumulation gradually converges towards debt-financed growth rate. Mandarino (2018) also build a debt-financed-led growth model in a SFC framework and reports both SSM standard results and paradox of debt.

Nah and Lavoie (2017) — similar to Dejuán (2017) — introduce exports as the main driver of growth. Despite reporting standard SSM results as well, their model has different accumulation regimes (profit-led or wage-led) depending on how real exchange rate reacts to changes in income distribution.

Even though these works highlight the relevance of some NCC autonomous expenditures, residential investment has been systematically neglected. To be fair, Zezza (2008) — and latter Nikolaidi (2015) — includes housing in a SFC growth model. However, as a result of neo-Kaleckian investment specification, residential investment only plays a secondary role on dynamics. Teixeira (2015) includes residential investment in a SSM alternative. To do so, describes its growth rate by the so-called houses' own interest rate. This particular real interest rate depicts debt service and capital gains effects in households' net worth simultaneously. Teixeira (2015, p. 53) argues that this is the relevant real interest rate for households since it stands for the real cost in real estate from buying real estate. Therefore, houses' own interest rate allows us to include both asset bubbles and residential investment growth rate specification in SSM model, which motivates building the model in the third section.

From this literature review, we report an absence of residential investment-led growth models, ~~despite its relevance to macroeconomic dynamics as shown by empirical literature (Leamer, 2007; Jordà *et al.*, 2014; Fiebiger, 2018; Fiebiger and Lavoie, 2018~~). The next section will present a first attempt to fill this gap: a fully specified parsimonious SSM-SFC residential investment-led model which its growth rate is described by Teixeira's (2015) own interest rate.

1 This modifications in the canonical Kaleckian growth model are related to critics regarding both its non-convergence to normal utilization rate on the long-rung ~~and the partial solution of Harrodian instability~~ (Dallery and Van Treeck, 2011; Skott, 2012; Hein *et al.*, 2012).

3 A 'bi-capital' Sraffian supermultiplier SFC model

3.1 General equations

Our model is the most parsimonious as possible: a closed capitalist economy without government sector. Output (Y) is determined by a fixed combination of a homogeneous labor (Y_L) input with homogeneous fixed capital (Y_K). For simplicity, we put technological progress, depreciation and goods inflation aside so investment is presented in gross terms and all variables — except for houses — are measured in real terms. Assuming a Leontief production function and that growth is not constrained by labor scarcity, capacity output (Y_{FC}) is determined by firms' capacity creating capital stock (K_f):

$$Y_{FC} = \min(Y_L, Y_K) \tag{1}$$

$$Y_{FC} = \frac{K_{f_{-1}}}{v} \tag{2}$$

$$u = \frac{Y}{Y_{FC}} \tag{3}$$

where v is exogenous capital-output ratio and u is utilization rate.

We further assume a "Kaleckian" economic structure composed by both workers (denoted by hw) and capitalists (denoted by hk) households and only the latter are not not credit constrained. Since we consider a closed without government economy, demand-determined level of output (Y) is the sum of consumption (C) and both households and firms investment (I_h and I_f respectively) and only the latter creates capacity:

$$I_t = I_f + I_h \tag{4}$$

$$Y = \overbrace{[C + I_h]}^{\text{Households}} + \overbrace{[I_f]}^{\text{Firms}} \tag{5}$$

In other words, from institutional sectors perspective, household expenditures have two components (consumption and residential investment) and firms just one (non-residential investment). Only non-residential investment creates productive capacity. So, the novelty of this model is the inclusion of a second investment component all made by household sector and held by capitalists households for simplicity. Therefore, this economy produces two types of real assets: firms productive capital (K_f) and households housing (K_h):

$$K = K_f + K_h \tag{6}$$

Denoting the houses share in total real assets as k, we can rewrite equation 6 as:

$$k = \frac{K_h}{K} \tag{7}$$

$$K = (1-k)\cdot K + k \cdot K$$

Following both Sraffian and Kaleckian strands, we assume exogenous functional income distribution so wage-share (ω) is defined as follows:

$$\omega = \overline{\omega} \tag{8}$$

which allows us to define total wages (W) as:

$$\overline{\omega} = \frac{W}{Y}$$

$$W = \overline{\omega} \cdot Y \tag{9}$$

Table 1 presents the balance sheet matrix for all institutional sectors. Capitalists households hold financial wealth as bank deposits (M) and residential investment is financed by mortgages (MO). Capitalists' total net wealth (NW_{hk}) is the sum of their net financial wealth (V_{hk}) and real assets (*i.e.* housing, K_h). Furthermore, capitalist consumption (C_k) is fully autonomous and financed by loans (L_{hk}) while workers consumption (C_w) is fully induced by their wages. As usual, we assume that workers expend what they earn while capitalists earn what they expend, so workers financial and real wealth are both null. Firms finance their investment primarily by undistributed profits (FU) and the residual by bank loans (L_f) — thus they do not hold deposits. Banks create credit *ex nihilo* and then collect the deposits, paying the same interest rate that they charge.

Table 1. Balance Sheet matrix

	Workers	Capitalists	Firms	Banks	$\sum$
Deposits		$+M$		$-M$	0
Loans		$-L_{hk}$	$-L_f$	$+L$	0
Mortages		$-MO$		$+MO$	0
$\sum$ Net Financial Wealth	—	V_{hk}	V_f	V_b	0
Capital			$+K_f$		$+K_f$
Houses		$+K_{hd}$			$+K_h$
$\sum$ Net Wealth	—	NW_{hk}	NW_f	NW_b	$+K$

Source: Authors' Elaboration

Table 2 presents both transactions flows and the flow of funds matrix. This table shows all economic relations between institutional sectors ensuring that there is no "black holes" so all financial and real transaction are explicit (Macedo e Silva and Dos Santos, 2011).

Table 2. Transactions flow matrix and flow of funds

	Workers	Capitalists		Firms		Banks	Total
		Current	Capital	Current	Capital		Σ
Consumption	$-Cw$	$-C_k$		$+C$			0
Non-residential Investment				$+I_f$	$-I_f$		0
Residential Investment			$-I_h$	$+I_h$			0
[Output]				$[Y]$			$[Y]$
Wages	$+W$			$-W$			0
Profits		$+FD$		$-FT$	$+FU$		0
Deposits interest rate		$+r_m \cdot M_{-1}$				$-r_m \cdot M_{-1}$	0
Loans interest rate		$-r_l \cdot L_{k_{-1}}$		$-r_l \cdot L_{f_{-1}}$		$+r_l \cdot L_{-1}$	0
Mortages interest rates		$-r_{mo} \cdot MO_{-1}$				$+r_{mo} \cdot MO_{-1}$	0
Subtotal	—	$+S_h$	$-I_h$		$+NFW_f$	$+NFW_b$	0
Change in deposits		$-\Delta M$				$+\Delta M$	0
Change in mortgages			$+\Delta MO$			$-\Delta MO$	0
Change in loans		$+\Delta L_{hk}$		$+\Delta L_f$		$-\Delta L$	0
Total		0	0	0	0	0	0

Source: Authors' Elaboration

3.2 Firms

In order to produce, firms purchase capital goods ($-I_f$ in capital account) and hire workers, whom total remuneration is the economy wage bill. Their total profits (FT) are a residual between sales (Y) and total wages (W). Firms retain part (γ_F) of profits net of interest payments (FU) — to reinvest — and distribute the rest to capitalists (FD):

$$FT = Y - W \tag{10}$$

$$FU = \gamma_F \cdot (FT - r_l \cdot L_{f_{-1}}) \tag{11}$$

$$FD = (1 - \gamma_F) \cdot (FT - r_l \cdot L_{f_{-1}}) \tag{12}$$

Firms (non-residential) investment is fully induced by the level of effective demand (Freitas and Serrano, 2015), and its growth rate changes accordingly to the capital stock adjustment principle. This implies that firms react to the discrepancies between actual and normal utilization rates. As mentioned above, only firms investment creates productive capital stock.

$$I_f = h \cdot Y \tag{13}$$

$$\Delta h = h_{t-1} \cdot \gamma_u \cdot (u - \overline{u}_N) \tag{14}$$

$$\Delta K_f = I_f \tag{15}$$

where h is (endogenous) marginal propensity to invest and γ_u must be sufficiently small in order to the adjustment be gradual[2].

2 The size of this parameter guards a fundamental relation to the stability of the model, as shown by Freitas and Serrano (2015).

Firms finance part of investment that exceeds undistributed profits by bank loans, charged by r_l interest rate. We assume an elastic supply of credit for investment. Moreover, tables 1 and 2 show firms net wealth (NW_f) and net financial balance (NFW_f) explicitly:

$$\Delta L_f = I_f - FU \tag{16}$$

$$r_g = \frac{\pi \cdot u}{v}$$

$$r_n = r_g - r_l \cdot \frac{L_{f_{-1}}}{K_f}$$

$$NFW_f = FU - I_f \tag{17}$$

$$NW_f = K_f - L_f \tag{18}$$

where r_g and r_n denotes gross and net profit rate respectively.

3.3 Banks

As in most part of SFC literature, banks do not have an active role in our model. They create money as credit is demanded and just after they collect deposits (Le Bourva, 1992). Firms finance part of their investment with credit (L_f) and capitalists households finance all their residential investment by mortgages (MO) and consumption by loans (L_{hk}), as already mentioned. Each operation has its own interest rate defined by a spread over deposits interest rate (r_m) exogenously determined by banks. For simplicity, we assume null bank spreads so interest rate on mortgages and on loans are the same as on deposits. Banks net balances (NFW_b) are defined by interests received net of interests payments. As those interests are the same, banks net wealth is necessarily zero (see table 1) and deposits are residuum:

$$L = L_f + L_{hk} \tag{19}$$

$$r_l = (1 + \sigma_l) \cdot r_m \tag{20}$$

$$r_{mo} = (1 + \sigma_{mo}) \cdot r_m \tag{21}$$

$$r_m = \bar{r}_m \tag{22}$$

$$NFW_b = r_{mo} \cdot MO_{-1} + r_l \cdot L_{-1} - r_m \cdot M_{-1} \tag{23}$$

$$NFW_b = \Delta MO + \Delta L - \Delta M$$

$$NW_b = V_b \equiv 0 \tag{24}$$

$$\Delta M = \Delta L + \Delta MO \tag{25}$$

3.4 Households

Workers As mentioned before, we assume that workers expend (C_w) what they earn (W). For simplicity, we consider that wages are the only source of income workers' disposable income (YD_w) and do not have access to consumption loans, so worker' saving (S_{hw}) are null. Therefore, accordingly to our hypothesis, workers' do not hold both net financial and total wealth.

$$C_w = W \tag{26}$$

$$YD_w = W \tag{27}$$

$$S_{hw} = YD_w - C_w \tag{28}$$

$$S_{hw} = 0$$

$$NFW_{hw} = S_{hw} = 0 \tag{29}$$

$$V_{hw} = 0 \tag{30}$$

Capitalists This is the most complex institutional sector of our model. We assume consumption (C_k) is fully-autonomous and financed by loans (L_{hk}). Disposable income (YD_k) is the sum of distributed profits and received interests on deposits, net of interests payments on both mortgages and loans. Capitalists savings (S_{hk}) are disposable income net of consumption. At odds with SFC literature, savings are not equal to net balance (NFW_{hk}) since we have included residential investment.

$$\Delta L_{hk} = C_w \tag{31}$$

$$YD_k = FD + \overline{r}_m \cdot M_{-1} - r_{mo} \cdot MO_{-1} - r_l \cdot L_{hk_{-1}} \tag{32}$$

$$S_{hk} = YD_k - C_k \tag{33}$$

$$NFW_{hk} = S_{hk} - I_h \tag{34}$$

In order to fulfill our goals, we employ Freitas and Cavalcanti's (2019) procedure in which NCC autonomous expenditure (Z) composition (R) remains unchanged so we express capitalists and total consumption as follows:

$$\Delta MO = I_h \tag{35}$$

$$Z = C_k + I_h \tag{36}$$

$$\frac{C_k}{Z} + \frac{I_h}{Z} = R + (1 - R)$$

$$C_k = R \cdot Z \tag{37}$$

$$C = C_w + C_k \tag{38}$$

$$C = C_w + R \cdot Z$$

As households are the only institutional sector realizing residential investment, its supply (I_{hs}) and demand (I_h) are equal and the same applies to houses stock.

$$I_{hs} = I_h \tag{39}$$

$$K_{hs} = K_{hd} \tag{40}$$

$$\Delta K_{hs} = \Delta K_{hd} = I_{hs} = I_h \tag{41}$$

where S and D denote supply and demand respectively. Accordingly to our hypothesis, nominal (V_{hk}) and real net wealth (V_{hkr}) are defined as follows:

$$V_{hk} = K_{hd} \cdot p_h + M - L_{hk} - MO \tag{42}$$

$$V_{hkr} = K_{hd} + M - L_{hk} - MO \tag{43}$$

Finally, we present residential investment growth rate (g_{I_h}) as determined by houses own interest rate (own, equation 46) as introduced by Teixeira (2015).

$$I_h = (1 + g_{I_h}) \cdot Ih_{-1} \tag{44}$$

$$g_{I_h} = \phi_0 - \phi_1 \cdot own \tag{45}$$

$$\pi = \frac{\Delta p_h}{p_{h_{t-1}}}$$

$$own = \left(\frac{1 + r_{mo}}{1 + \pi}\right) - 1 \tag{46}$$

where π stands for real estate inflation, ϕ_0 represents long-term determinants (*e.g.* demographic factors, housing and credit policies, etc.) while ϕ_1 captures the demand for real estate arising from expectations of capital gains resulting from speculation with the existing dwellings stock.

This particular real interest rate is the most relevant for households since the holders of an asset take their price into account in the decision-making process since its variation can generate capital gains/losses (Teixeira, 2015, p. 114). In other words, the mortgage interest rate (numerator) captures debt service for investors — in this case, households — while the real estate inflation (denominator) incorporates changes in equity. Therefore, this own interest rate stands for the real cost in real estate from buying real estate (Teixeira, 2015, p. 53). It worth noting that during a houses' bubble periods, it is real estate inflation that governs own interest rate dynamics. In other words, the lower this real interest rate is, the greater the capital gains (in real estate) for speculating with real estate will be.

4 Analytical solution

In this Section, we present the analytical solution of our model in order to analyze both stability condition and obtain fully-adjusted position relationships (deonetd by *). To do so, some equations will be turned into their continuous time equivalent to express it in terms of partial derivatives[3]. In our no-government closed economic system, real output (equation 5) is the sum of household consumption (equation 38) and both types of investment (equation 4). If we substitute equations 9 and 13 into 5 and considering equation 36 we get the short-run GDP level:

$$Y = \left(\frac{1}{1 - \omega - h}\right) \cdot Z \tag{47}$$

Then, we present our model in growth rate terms as follows (Freitas and Serrano, 2015):

$$g = g \cdot \omega + \dot{h} + g \cdot h + g_z \cdot \frac{Z}{Y}$$

$$g = \frac{\dot{h}}{1 - \omega - h} + g_z \tag{48}$$

As mentioned before, endogenous firms' marginal propensity to invest reacts to discrepancies between the utilization rate (u) and the normal one (u_N). During the adjustment process ($u \rightarrow u_N$), GDP growth rate moves towards NCC autonomous expenditure growth rate (in this case, residential investment and capitalist consumption):

$$u \rightarrow u_N \Leftrightarrow g \rightarrow g_z \tag{49}$$

and (endogenous) fully-adjusted position marginal propensity to invest will be:

$$h^* = g_z \frac{\overline{v}}{\overline{u}_N} \tag{50}$$

Next, replacing equation 48 in 50 and 3 in order to build a bi-dimensional system of equation

$$\begin{cases} \dot{u} = \left(\frac{\dot{h}}{1-\omega-h} + g_z - \frac{h_t u_t}{v}\right) u_t \\ \dot{h} = \gamma_u \left(-u_N + u_t\right) h_t \end{cases}$$

3 Script is available under request. The experiments in Section 5 are simulated in discrete time.

and assess its stability condition (evaluated at the equilibrium point):

$$J = \begin{bmatrix} \frac{\partial \dot{h}}{\partial h} & \frac{\partial \dot{h}}{\partial u} \\ \frac{\partial \dot{u}}{\partial h} & \frac{\partial \dot{u}}{\partial u} \end{bmatrix}$$

$$J = \begin{bmatrix} 0 & \frac{g_Z \gamma_u v}{u_N} \\ -\frac{u_N^2}{v} & -g_Z \end{bmatrix} \tag{51}$$

As Gandolfo (2010) demonstrates, a positive determinant and a negative trace are both necessary and sufficient stability condition for a bi-dimensional system of differential equation:

$$Det(J) = g_Z \gamma_u u_N > 0$$

$$Tr(J) = -g_Z < 0$$

As both γ_u and u_N are strictly positive values, we just need to check positive trace condition. Differently from Freitas and Serrano (2015), we do not assume this condition initially. Thus, our system is stable (near the fully-adjusted position) only if houses' own interest rate (equation 45) meets the following inequality:

$$g_{I_h} = g_Z = \phi_0 - \phi_1 \cdot own > 0$$

$$own < \frac{\phi_0}{\phi_1} \tag{52}$$

Since the relations between economic growth and income distribution are well established in the Sraffian super-multiplier literature, we move towards the analysis of the particularities of our model: one of the NCC autonomous expenditures also contributes to capital stock accumulation. Equation 53 bellow describes the ratio between houses and total capital stock at the fully-adjusted position (defined as k^*). It worth noting that the second term of RHS of equation 53 is equal to the so-called "fraction" (f) introduced by Serrano (1995) and also closes the model.

$$k^* = 1 - \frac{h^*}{(1-\omega)} \tag{53}$$

$$k^* = 1 - f \qquad\qquad f = 1 - k^* \tag{54}$$

From equation's 53 complete version (see equation 60 in Appendix A) we can show that houses share on total capital stock depends positively on deposits interest rate (Eq. 55) and negatively both on autonomous component of residential investment growth rate (equation 56), real estate inflation (equation 57) and wage-share (equation 58):

$$\frac{\partial k}{\partial rm} = -\frac{\phi_1 v (\sigma_{mo} + 1)}{u_N (\pi + 1)(\omega - 1)} > 0 \tag{55}$$

$$\frac{\partial k}{\partial \phi_0} = \frac{v}{u_N (\omega - 1)} < 0 \tag{56}$$

$$\frac{\partial k}{\partial \pi} = \frac{\phi_1 v (rm \cdot (1 + \sigma_{mo}) + 1)}{u_N (\pi + 1)^2 (\omega - 1)} < 0 \tag{57}$$

$$\frac{\partial k}{\partial \omega} = -\frac{v (\phi_0 (\pi + 1) - \phi_1 (-\pi + rm \cdot (1 + \sigma_{mo})))}{u_N (\pi + 1)(\omega - 1)^2} < 0 \tag{58}$$

Before moving on to the numerical simulations, it worth noting that — besides its counterintuitivity — the decrease of k^* as a result of the increase of residential investment growth rate (reported in equations 56 and 57 above) is in line with the SSM. Since firms' investment grows (temporally) at a higher pace than NCC autonomous expenditures, it has only a level effect on capital stock. As usual, changes in income distribution affects GDP temporally. However, it has permanent effects over capital stock composition as a result of this level effect reported before (equation 58).

5 Numerical simulations

In this Section, we present the results of the following experiments[4]: (i) wage-share decrease; (ii) real estate inflation and; (iii) deposits interest rate increase. Since we use a SFC framework — similar to Brochier and Macedo e Silva (2019) and Mandarino (2018) — first shock assess whether or not income distribution affects fully-adjusted position growth rates. Real estate increase shock is motivated by recent US experience while the last one aims to evaluate indebtedness stability. Table 4 in Appendix B presents the parameters of simulation and Table 3 compare each result to baseline. Figure 1 reports all shocks in a single plot while particular results of each experiment are available in Appendix C.

5.1 Wage-share decrease

A wage-share decrease has a negative impact both in growth rate and utilization rate (see Figure 2). As a consequence GDP level decrease, firms' investment growth rate and marginal propensity to invest decline as well. Since autonomous expenditure growth rate remains unchanged, this negative effect is followed by a increase in productive investment growth rate because firms react to the discrepancies between actual and normal utilization rates. Additionally, wage-share decrease also changes supermultiplier so autonomous expenditures share on GDP increases. In summary, we report standards SSM model results: (i) marginal propensity to invest decrease is temporally and returns to baseline level; (ii) utilization rate moves towards normal one; (iii) supermultiplier decreases and autonomous expenditure share increases due to GDP decline and; (iv) since autonomous expenditure growth rate does not change, distribution effects are temporally.

Despite temporary effects in growth rate, wage-share decrease has a permanent effect in house share on total capital stock (see Equation 53 and Figure 3). This result stems from the initial lower accumulation rate as residential investment growth rate remains constant. Another persistent effect is the higher capitalists' indebtedness despite the profit-share increase. This result stems from the decline in profit level as a consequence of the negative effect on GDP and subsequent decrease in capitalists' disposable income. In other words, we report a paradox in capitalists attempt to increase their profits — due to markup changes and subsequent increase in profit-share — since it generates a negative effect on net profits.

Finally, we also report a persistent effect on firms' balance sheet due to wage-share decrease. The negative level effect on GDP implies an already mentioned temporally decrease in marginal propensity to invest. As a consequence, firms require less external funding — as profits distribution policy remains the same — so its indebtedness decreases. Therefore, gross and net profit rate remains persistently close to each other (see Figure 3)

5.2 Real estate inflation increase

Real estate inflation implies a higher residential investment growth due to houses own interest rate increase. As a result, both GDP growth rate and capacity interest rate increase as well. Since firms react to discrepancies between actual and normal utilization rates, capacity creating investment growth rate is temporally higher than GDP growth rate (positive overshooting) due to marginal propensity to invest adjustment. Furthermore, capitalists' disposable income also increases as a result of the already mentioned higher GDP growth rate. Since loans interest remains unchanged, capitalists' indebtedness ratio decreases. During the traverse, gross and net profit rate are temporally close to each other as a result of profits level increase, so firms' indebtedness decreases as well. Therefore, similar to Hein (2018)

4 Simulation scripts are available under request. It worth noting that our experiments are simulated using *pysolve3* package available at https://github.com/gpetrini/pysolve3. Implementation and improvement requests are all welcome.

and Mandarino (2018), we also report paradox of debt.

In summary, we report standard fully-adjusted position results: (i) GDP growth rate converges to NCC autonomous expenditure growth rate; (ii) Marginal propensity to invest remains persistently higher compared to baseline and; (iii) utilization rate moves gradually towards the normal one. As mentioned before, our model distinctiveness is the existence of two types of capital stocks since households invest as well. Besides the usual SSM results, we report some particularities regarding real assets composition. The most distinct result is real houses share **decreases** on total capital stock as a result of residential investment growth rate **increase**.

Although counterintuitive, this result is in line with SSM literature. Firms investment follows capital stock adjustment principle, so a higher firms investment growth rate implies that GDP grows faster than residential investment, reducing both the latter share on GDP and also the utilization rate. In other words, both autonomous expenditures share on GDP — higher supermultiplier — and Houses share on real assets (see Equation 57) decline as a result of the already described firms' positive overshooting reaction. Finally, it worth noting that real estate increase also has permanent effects over stock/flow ratios due to capital gains. Figure 5 in Appendix C shows that capitalists' nominal net wealth grows faster than disposable income, so the ratio between both converges to zero.

5.3 Interest rate increase

A increase in deposits interest rate — increasing the other interest rate respectively — has a persistent effect on long-run growth rate since houses own interest rate increases as well. Firms' investment growth rate decreases (negative overshooting) as a result of residential investment growth rate permanent decline, so houses share on real assets increases. In summary, this shock has opposite effects on long-run growth rates, NCC autonomous expenditure share on GDP, utilization rate and marginal propensity to invest than the previous one (compare Figures 6 and 4).

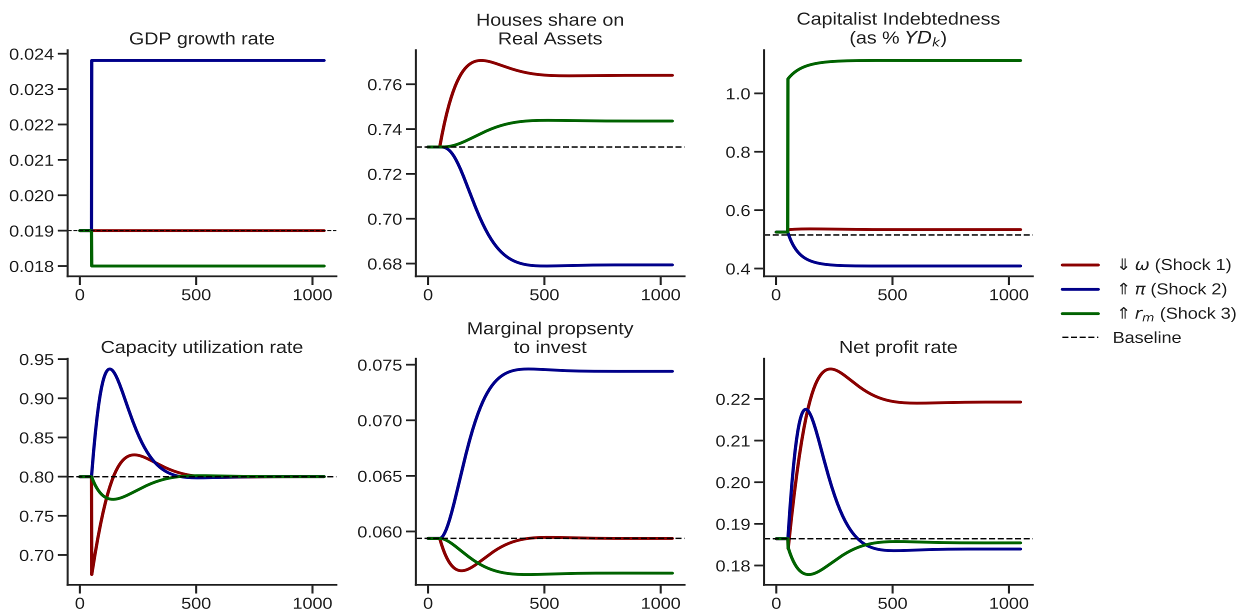
In particular, we report a stronger negative effect over both capitalists' and firms' balance sheet than wage-share decrease (compare figures 3 and 5). This result stems from the stronger (and temporary) decline of GDP growth rate compare to NCC autonomous expenditure growth rate ~~($\downarrow g > \downarrow g_Z$)~~. Thus, capitalists' disposable income decrease — as a result of profits level decrease due to lower GDP growth rate — is higher than debt-financed consumption growth rate decrease. This mechanisms alone is enough to capitalists' indebtedness level to increase, however its followed by loans interest rate increase, so the overall effect is stronger than wage-share decrease shock. Regarding firms' balance sheet, we report a decrease in both gross and net profit rate and a permanent increase in the gap between them due to increase in external funding and decrease in profits level. Therefore, we find a stable debt dynamics for both capitalists and firms (other parameters remaining unchanged).

Table 3. Shocks summary (compared to baseline)

	Medium-run ($h \neq h^*$)				**Long-run** ($h = h^*$)			
	$\Uparrow \phi_0$	$\Uparrow \pi$	$\Downarrow \omega$	$\Uparrow rm$	$\Uparrow \phi_0$	$\Uparrow \pi$	$\Downarrow \omega$	$\Uparrow rm$
g	+	+	-	-	+	+	0	-
g_Z	+	+	0	-	+	+	0	-
u	+	+	-	-	0	0	0	0
h	+	+	-	-	+	+	0	-
k	-	-	+	+	-	-	+	+
$\frac{Z}{Y}$	-	-	+	+	-	-	+	+
$\frac{(r_{mo}\cdot MO_{-1}+r_l\cdot L_{k_{-1}})}{YD_k}$	-	-	+	+	-	-	+	+

Source: Authors' Elaboration

Figure 1. Experiments simulations



Source: Authors' Elaboration

6 Concluding Remarks

This paper contributes to demand-led growth agenda, taking in consideration recent efforts of embedding it in a SFC framework. Our novelty is twofold: (i) inclusion of residential investment and (ii) determination of its growth rate by houses' own interest rate. Residential investment was included due to recent empirical works showing its relevance for macroeconomic dynamics. Houses' own interest rate allowed us to include asset bubbles in a Sraffian strand. As far as we know, none works have described this expenditure with this particular real interest rate.

Our model reports standard results of Sraffian supermultiplier: (i) utilization rate converges to the normal one through changes on firms' marginal propensity to invest; (ii) GDP growth rate converges to NCC autonomous expenditure growth rate and; (iii) income distribution affects growth rate only during the traverse. A particular feature of our model is the dual composition of capital stock: firms' capacity creating and real estate. The most distinct result is the decrease of houses share on capital stock due to the increase of residential investment growth rate. Although counterintuitive, this occurs because firms react to the discrepancies between actual and desired utilization rates. In other words, for capacity utilization converges to the normal one, firms' investment needs to grow temporarily faster than residential investment, changing the ratio between houses and total capital stock at the fully adjusted position.

Finally, it worth noting that this is a first step of a wider research agenda on the role of residential investment for economic growth and business cycles. Future research should increase the complexity of this model in order to understand some recent dynamics (such as increases of mortgages share on banks' balance sheet). In regarding residential investment, some extensions are: exploring other determinants of its growth rate and its effects on banks' net financial wealth. This emerging "housing agenda" should also moves towards empirical grounds. For example, future research could assess whether or not houses' own interest rate describes residential investment growth rate econometrically.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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A Mathematical appendix

In this Appendix, we present the procedures to obtain the equation 53 mentioned on the text. To do so, we redefine utilization rate as follows:

$$u = \frac{Y \cdot v}{K \cdot (1-k)}$$

So, we can see that dividing GDP by houses stock is equivalent to

$$\frac{Y}{k \cdot K}$$

multiplying by capital-full capacity output ratio (v)

$$\frac{Y}{k \cdot K} \cdot v = \frac{Y \cdot v}{K} \cdot \left(\frac{1}{k}\right)$$

then, multiplying both numerator and denominator by $1-k$, we find the following connection with capacity utilization:

$$\frac{Y \cdot v}{K \cdot (1-k)} \cdot \left(\frac{1-k}{k}\right) = u \cdot \left(\frac{1-k}{k}\right)$$

Thus,

$$Y \frac{v}{K_h} = u \cdot \left(\frac{1-k}{k}\right)$$

$$u = Y \frac{v}{K_h} \cdot \left(\frac{k}{1-k}\right)$$

$$u = \left(\frac{1}{1-R}\right) \cdot \left(\frac{g_Z \cdot v}{1-\omega-h}\right) \cdot \left(\frac{k}{1-k}\right) \tag{59}$$

Replacing endogenous variables into equation 59, we find k at the fully-adjusted position:

$$k^* = 1 - \frac{v\left(\phi_0 - \phi_1\left(-1 + \frac{rm \cdot (1+\sigma_{mo})}{\pi+1}\right)\right)}{u_N\left(-\omega+1\right)} \tag{60}$$

which the simplified version (as shown on text) is:

$$k^* = 1 - \frac{h^*}{(1-\omega)} \tag{61}$$

B Numerical Appendix

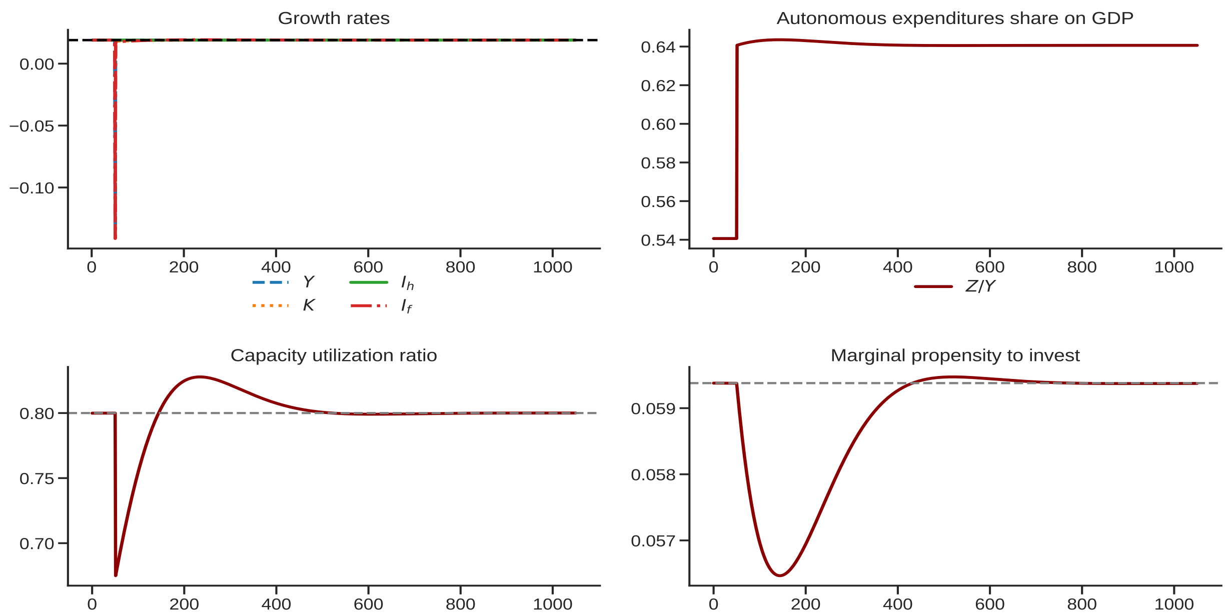
Table 4. Parameters of variables

	Base scenario	$\Delta\phi_0$	$\Delta\omega$	Δrm	π
α	1.0000	1.0000	1.0000	1.0000	1.0000
γ_F	0.0800	0.0800	0.0800	0.0800	0.0800
γ_u	0.0100	0.0100	0.0100	0.0100	0.0100
ω	0.4000	0.4000	0.3000	0.4000	0.4000
rm	0.0100	0.0100	0.0100	0.0200	0.0100
σ_l	0.0000	0.0000	0.0000	0.0000	0.0000
σ_{mo}	0.0000	0.0000	0.0000	0.0000	0.0000
u_N	0.8000	0.8000	0.8000	0.8000	0.8000
v	2.5000	2.5000	2.5000	2.5000	2.5000
ϕ_0	0.0200	0.0250	0.0200	0.0200	0.0200
ϕ_1	0.1000	0.1000	0.1000	0.1000	0.1000
R	0.7000	0.7000	0.7000	0.7000	0.7000
π	0.0000	0.0000	0.0000	0.0000	0.0500

Source: Authors' elaboration

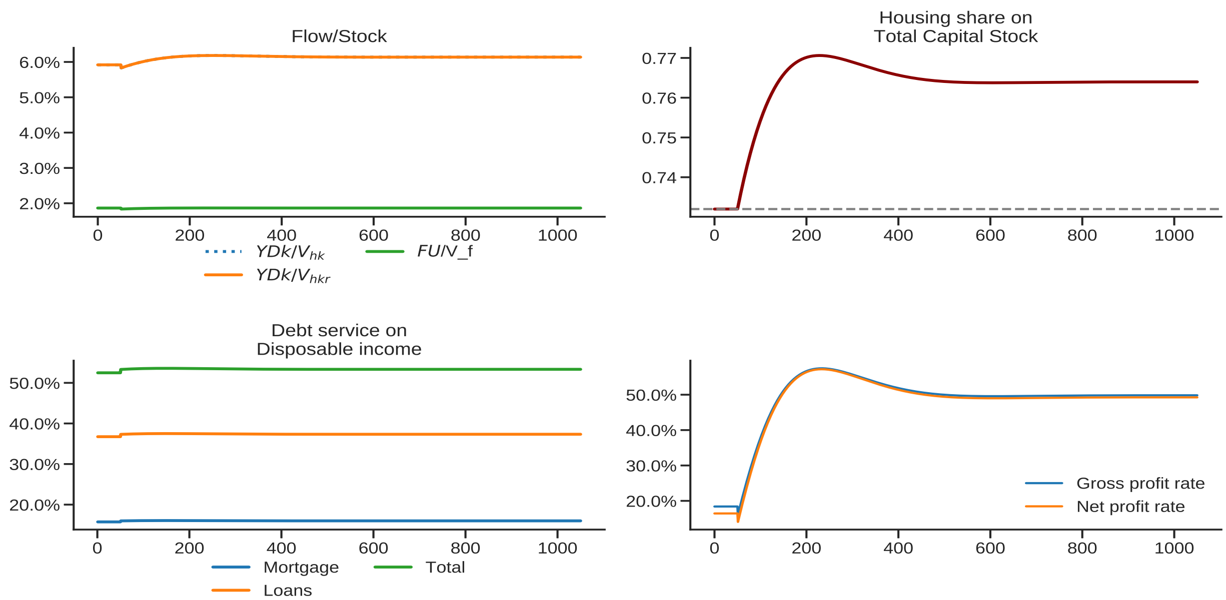
C Simulation appendix

Figure 2. Wage-share decrease



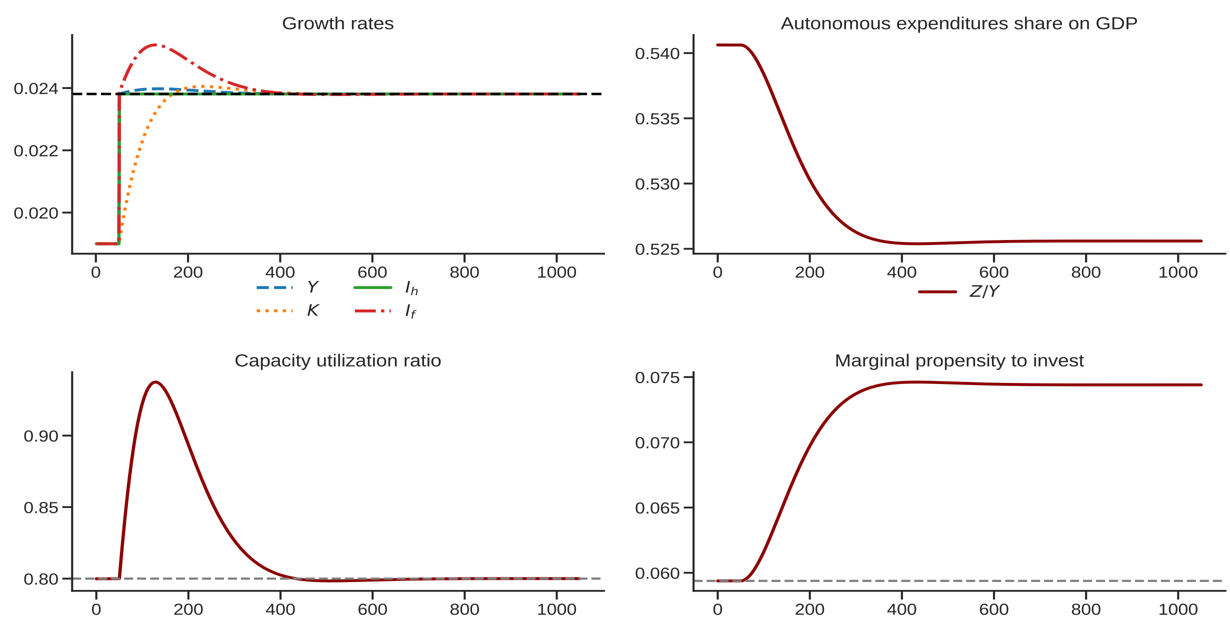
Source: Authors Elaboration

Figure 3. Wage-share decrease



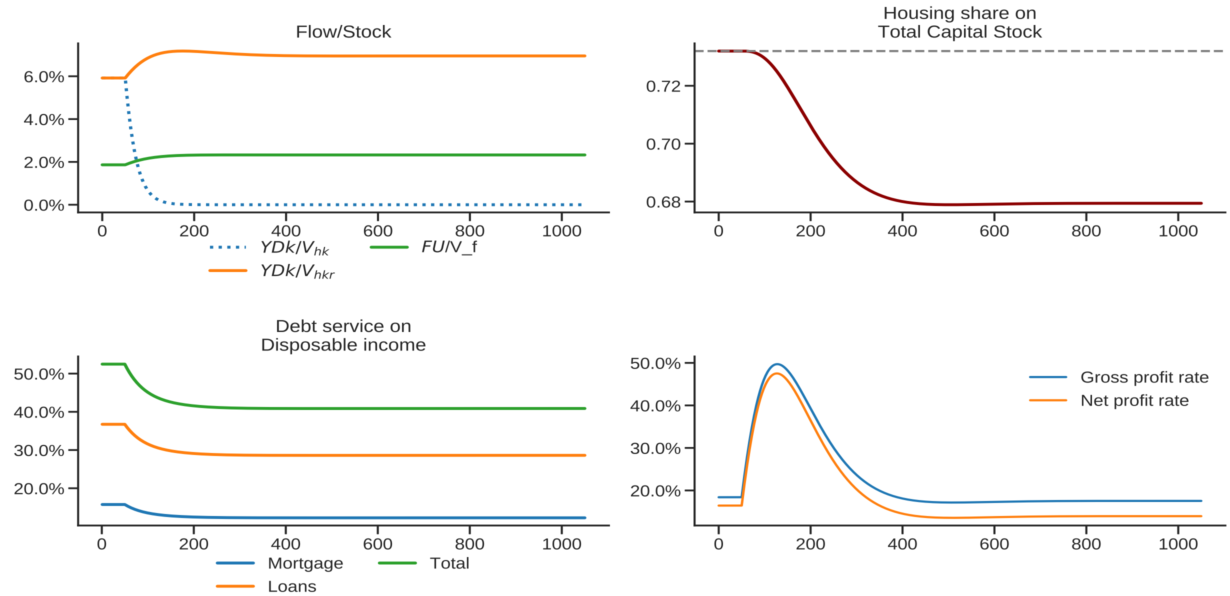
Source: Authors Elaboration

Figure 4. Real estate inflation increase



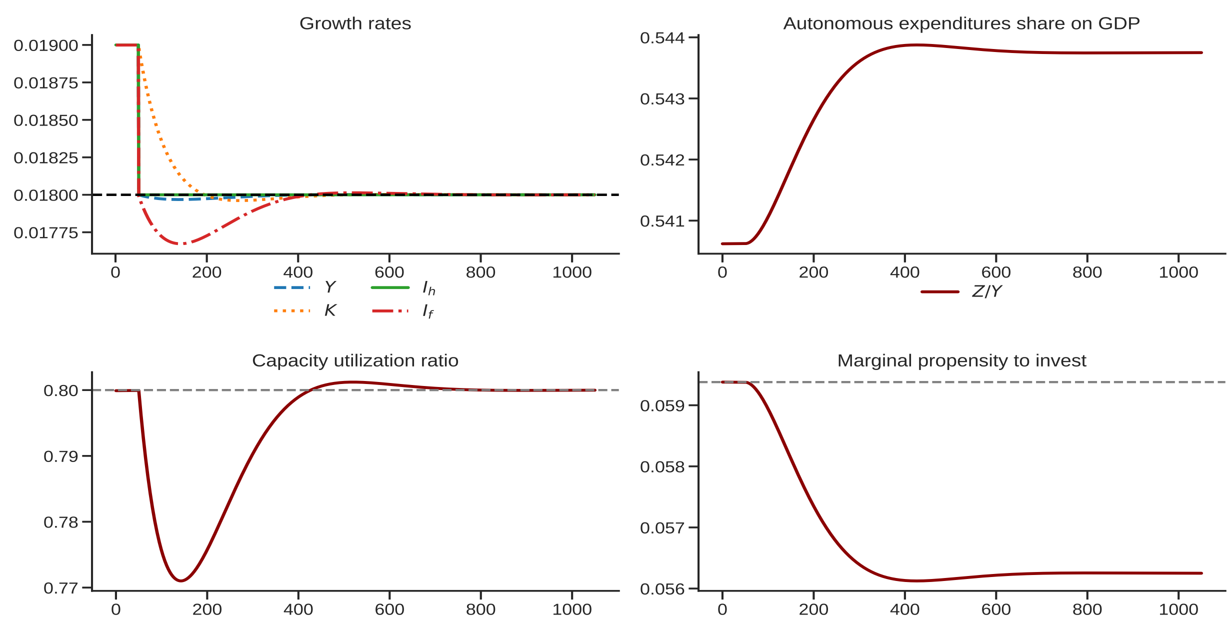
Source: Authors Elaboration

Figure 5. Real estate inflation increase



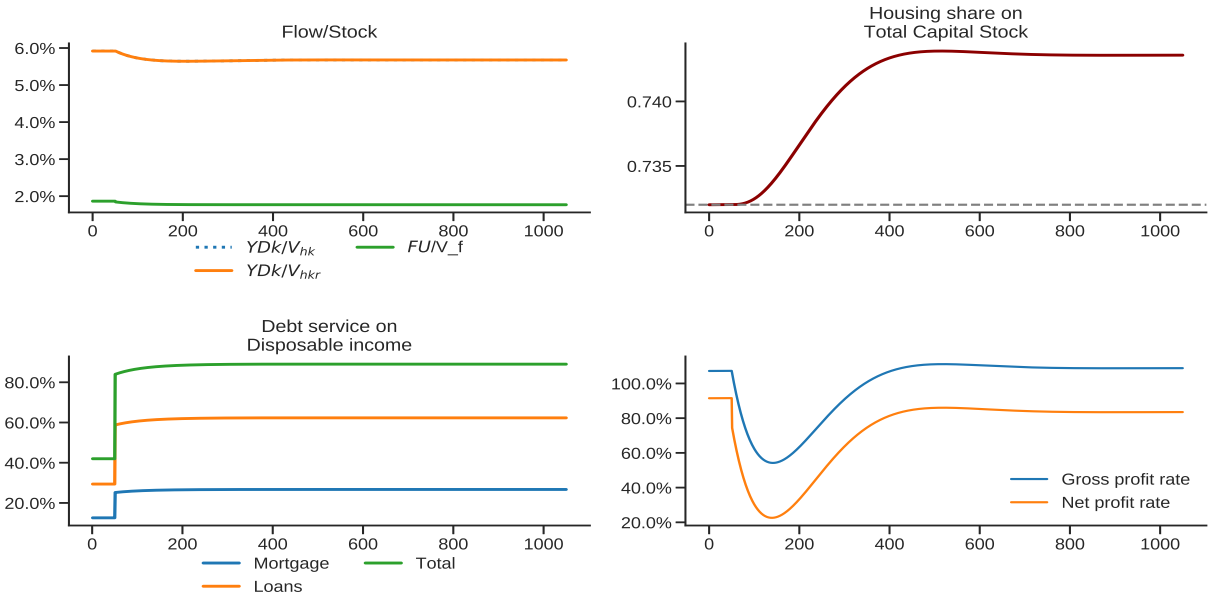
Source: Authors Elaboration

Figure 6. Interest rate increase



Source: Authors Elaboration

Figure 7. Interest rate increase



Source: Authors Elaboration