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Are fiscal multipliers state dependent? Insights from an agent-based model

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Are fiscal multipliers state dependent?
Insights from an agent-based model

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Abstract

The paper examines the macroeconomic effects of fiscal policy under varying economic conditions. The analysis is conducted using a closed-economy agent-based model, where macroeconomic outcomes of fiscal intervention emerge from the bottom up as the result of interactions between heterogeneous agents in different markets, with feedback loops between demand, supply, and the financial sector. The model simulation results indicate that expansionary fiscal policies generate significant positive effects on aggregate output, with a public consumption multiplier of 1.6 on average, and an income tax multiplier of approximately 1.0. Notably, the effectiveness of a public direct consumption stimulus exhibits significant non-linearities, with multipliers reaching up to 3.5 during periods of economic slack and 2.5 during times of high financial fragility. In contrast, income tax rate multiplier appears largely acyclical. Overall, this analysis contributes to the growing and unsettled debate on the state-dependent effects of fiscal policy, providing model-based insights into this crucial topic.

Keywords: Fiscal policy; State-dependent fiscal multipliers; Agent-based models; Non-linear dynamics

JEL codes: C63; E62; H30

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1 Introduction

The present study develops a macroeconomic agent-based model (ABM) to assess the effects of expansionary fiscal policy. We aim at estimating fiscal multipliers for various fiscal instruments, and at exploring whether these multipliers vary under different economic conditions. By doing so, the analysis adds to the growing literature on the potential state-dependent effects of fiscal policy, offering theoretical, model-based insights on this critical topic.

Since the influential work of Auerbach and Gorodnichenko (2012), increasing attention has been given to understanding whether the magnitude of fiscal multipliers depends on the specific economic context in which fiscal policies are implemented (cf. Ramey, 2019; Castelnuovo and Lim, 2019). Fiscal policy effectiveness may indeed be state-dependent, as the strength of several transmission channels can vary according to prevailing economic conditions. Key factors influencing fiscal multipliers include the level of idle resources (DeLong et al., 2012; Michillat et al., 2014), financial frictions and borrowing constraints (Gali et al., 2007; Canzonieri et al., 2016), congestion in goods markets (Ghassibe and Zanetti, 2022), private sector confidence (Bachmann and Sims, 2012), and the responsiveness of monetary policy (Christiano et al., 2011).

Recent empirical studies have examined fiscal policy non-linear effects by considering factors such as the level of slack in the economy (e.g., Auerbach and Gorodnichenko, 2012, 2013; Ramey and Zubairy, 2018; Amendola, 2023), the presence of the zero lower bound on nominal interest rates (Miyamoto et al., 2018; Amendola et al., 2020; Bonam et al., 2022), financial distress (Corsetti et al., 2012; Ferraresi et al., 2015), the public debt-to-GDP ratio (Perotti, 1999; Ilzetzki et al., 2013), and private sector indebtedness (Klein, 2017; Bernardini and Peersman, 2018; Bernardini et al., 2020; Kim, 2023).

However, empirical evidence on fiscal multipliers remains mixed, and consensus has yet to emerge. For instance, while many studies find that fiscal multipliers are larger during economic downturns (e.g., Auerbach and Gorodnichenko, 2012, 2013, 2017; Batini et al., 2012; Jordà and Taylor, 2016; Amendola, 2023), others do not support this conclusion (Alloza, 2017; Ramey and Zubairy, 2018; Banerjee and Zampolli, 2019; Gomes et al., 2020). This uncertainty extends to other forms of state dependency and even to linear analyses, leading to significant disagreement regarding the size of multipliers for different fiscal instruments (cf. Gechert and Rannenberg, 2018).

This paper contributes to the existing literature by conducting a theoretic-driven, model-based exploration of the macroeconomic impacts of fiscal policies. Specifically, our analysis delves into the macroeconomic consequences of public expenditure and income tax rate stimuli, focusing on determining whether the efficacy of these policies varies depending on the prevailing economic conditions. Our targeted selection of fiscal instruments enables a thorough examination of two broad categories of fiscal interventions: direct demand-stimulation policies, such as public consumption, and indirect measures, like income tax reduction. The latter, notably, has been underexplored in the empirical state-dependency literature, which has predominantly focused on public expenditure.

The analysis is conducted through the well-established Schumpeter Meeting Keynes (K+S) agent-based model (Dosi et al., 2010). Many versions of the model have been used so far as a laboratory to evaluate policies in a large number of areas: innovation policies (Dosi et al., 2010; Dosi et al., 2023), fiscal, redistributive and monetary policies (Dosi et al., 2013, 2015, 2016; Guerini et al., 2022; Amendola and Pereira, 2025), labour-market policies (Dosi et al., 2017, 2018b, 2021), and low-carbon transition policies (Lamperti et al., 2021; Lamperti and Roventini, 2022; Amendola et al., 2024). We extend the decentralized labour-augmented version of the K+S model (Dosi et al., 2017, 2018, 2020), refining consumer behaviour and incorporating a more detailed array of fiscal instruments available to the government. The model is rich enough to study fiscal policy, creating a complex environment where fiscal shocks propagate through interactions among heterogeneous agents across various markets, traditionally considered potential sources of non-linearity in fiscal policy. These include the financial sector (Canzoneri et al., 2016), the labour market (Michaillat, 2014; Shen and Yang, 2018), and consumption-goods market (Ghassibe and Zanetti, 2020). It also captures critical feedback loops between demand, supply, and the financial components of the economy.

From a methodological standpoint, we build on the framework proposed by Amendola and Pereira (2025) to estimate both linear and non-linear impulse response functions from an agent-based model output data. Fiscal multipliers are then calculated cumulatively, following the approach advocated by Ramey (2019) and others. This represents a key innovation of the paper, as despite the extensive use of agent-based models to analyze fiscal policy (e.g., Dosi et al., 2015, 2016, 2017; Harting, 2015; Teglio et al., 2019), attempts to investigate fiscal policy via impulse response functions and fiscal multipliers are still lacking within this context.[1]

This gap is somewhat surprising as several attractive features of the ABM approach, such as the possibility of building economic models which accommodate agent-level heterogeneity, direct local interactions, and bounded-rational behavioural rules. In those models, macro-outcomes emerge from the bottom up in an *evolving complex system* characterized by true, nonlinear, irreversible, and potentially path-dependence dynamics (Tesfatsion, 2006; LeBaron and Tesfatsion, 2008; Delli Gatti et al., 2011; Fagiolo and Roventini, 2017). These features make agent-based modelling an appealing resource to analyse policy interventions (Fagiolo and Roventini, 2017; Dosi and Roventini, 2019). Furthermore, as argued by Amendola and Pereira (2025), they render the methodology particularly well-suited for investigating the non-linear propagation of policy feedbacks or, more broadly, shocks. This allows for state dependency eventually manifesting as a truly *emergent property* of the (complex) system. This paper addresses the gap in the literature by conducting a thorough examination, and rigorous quantification, of fiscal multipliers within a well-established agent-based model.

A key insight from our analysis is the emergence of state-dependent effects of fiscal policy within a *complex and evolving* environment. Our findings reveal that, on average, expansionary fiscal policies positively impact aggregate output, consistent with the Keynesian perspective of the model. Specifically, linear multipliers are in average 1.6 for public direct expenditure in consumption goods, and 1.0 for income tax reductions. However, we also observe significant non-linearities in the effectiveness of public consumption stimuli. Multipliers are higher during

[1] To our knowledge, the only works that provide some basic insights on fiscal multipliers in the ABM literature are Palagi et al. (2017) and Reissl (2020).

periods of economic slack, reaching up to 3.5, and during times of increased financial fragility, at 2.5. This suggests that direct demand stimulation policies may be particularly beneficial in periods of weak economic performance. In contrast, income tax rate multipliers appear largely acyclical. These distinctive findings are truly emergent, non-trivial properties of the model. They do not arise from a straightforward isomorphism between aggregate outcomes and specific micro-level behavioural rules, but rather from the bottom-up interactions, feedback mechanisms, and heterogeneity (Dosi and Roventini, 2019). Also, those findings align with a large share of the empirical literature (e.g., Auerbach and Gorodnichenko, 2012, 2013; Corsetti et al., 2012; Batini et al., 2012; Ferraresi et al., 2015; Jordà and Taylor, 2016; Gechert and Rannenberg, 2018; Amendola, 2023). However, the ABM methodology allows not only reproducing established stylized facts but, more importantly, to uncover the mechanisms and transmission channels behind them, to experiment with counterfactual scenarios, and to assess and compare potential policies.

The rest of the paper is organized as follows. The model is presented in section 2. In section 3, we empirically validate it by showing its ability to reproduce a large set of relevant stylized facts. Section 4 focuses on methodological aspects, while results are presented in Section 5. Section 6 concludes.

2 The model

The model is rooted in the Schumpeterian and Keynesian traditions, established by the seminal work of Dosi et al. (2010). It is a general disequilibrium, stock-flow consistent, agent-based model populated by heterogeneous sectors, firms, banks, and households which behave according to bounded-rational behavioural rules in a closed-economy set-up. More specifically, we extend the Labour-augmented Schumpeter Meeting Keynes (K+S) model (Dosi et al., 2017, 2018, 2020) by introducing a more refined behaviour of consumers and a more detailed set of fiscal instruments available to the government.

In terms of household behaviour, we relax the assumption that a worker-consumer (try to) fully expend income by incorporating savings and wealth-accumulation rules into the model. This upgrade is crucial for our research questions, as the responsiveness of private consumption to changes in income is in principle a key transmission channel of fiscal policy. Therefore, an empirically-plausible representation of consumer behaviour is essential for our analysis. On the government side, significant extensions include the introduction of public expenditure in the form of public procurement of goods, and the incorporation of (potentially) differentiated tax rates on income and profits.

In the following, after a brief description of the main structure of the model, we present in detail the main novelties of the present version of the model. A comprehensive description of the existing components of the model, including the most relevant behavioural rules for other agent categories, is provided in Appendix A.[2]

[2] The model code is available in the LSD platform, available at https://github.com/santannaks/lsd, in the examples section, under "Labor- and Finance-augmented K+S Model", version 5.3.

2.1 Model structure

The model is composed of four populations of heterogeneous, micro-level agents, F_t^1 capital-good firms, F_t^2 consumption-good firms, B commercial banks, L_S workers, plus two institutional agents, the government and the central bank.

The basic skeleton of the model is depicted in Figure 1. Capital-good firms produce heterogeneous machines and invest in R&D trying to produce cheaper and more productive machines. Consumption-good firms combine machines, bought from capital-good firms, and labour in order to produce a substitutable, quality- and price-differentiated consumption good. Banks provide credit to firms, according to their individual requirements and the macroprudential regulatory framework, collect accumulated wealth of firms and workers, and buy government bonds. Workers submit job applications to a subset of firms, accept (or not) employment offers, and decide how much to consume and save, as bank deposits, out of income (*cf.* section 2.2.). Government levies taxes from profits of firms and banks and from workers' income, pays unemployment benefits, bails out failing banks, executes public consumption expenditure, and sets a minimum wage (*cf.* section 2.3). Finally, the central bank sets the prime interest rate, and buys outstanding government bonds.

In each model period, roughly equivalent to a quarter, the following timeline of events takes place:

1. Policy variables, like tax rates, unemployment benefits rate, minimum wage, interest rate, are fixed by the government and the central bank;
2. Workers update their (learning-by-doing) skills;
3. Machines ordered in the previous period are delivered to consumption-good firms;
4. Capital-good firms perform R&D and signal their machines to a set of consumption-good firms;
5. Consumption-good firms determine desired investment, production, workforce size, and credit demand;
6. Subject to credit constraints, firms send/receive machine-tool orders for the next period;
7. Job-seekers send applications to firms in both sectors;
8. The labour market closes, and job vacancies are partly or totally filled;
9. Firms pay wages and bonuses, and produce machines and final goods;
10. Government pays unemployment benefits, levies taxes on income and profits, and decide public consumption expenditure;
11. Based on disposable income, workers decide about consumption demand and savings;
12. Consumption-good market opens and shares evolve driven by relative competitiveness;
13. Firms and banks compute profits, and repay debts;
14. Firms with near-zero market share or negative net worth exit the market;
15. Aggregate variables are computed;
16. New firms enter the two sectors and the next period starts.

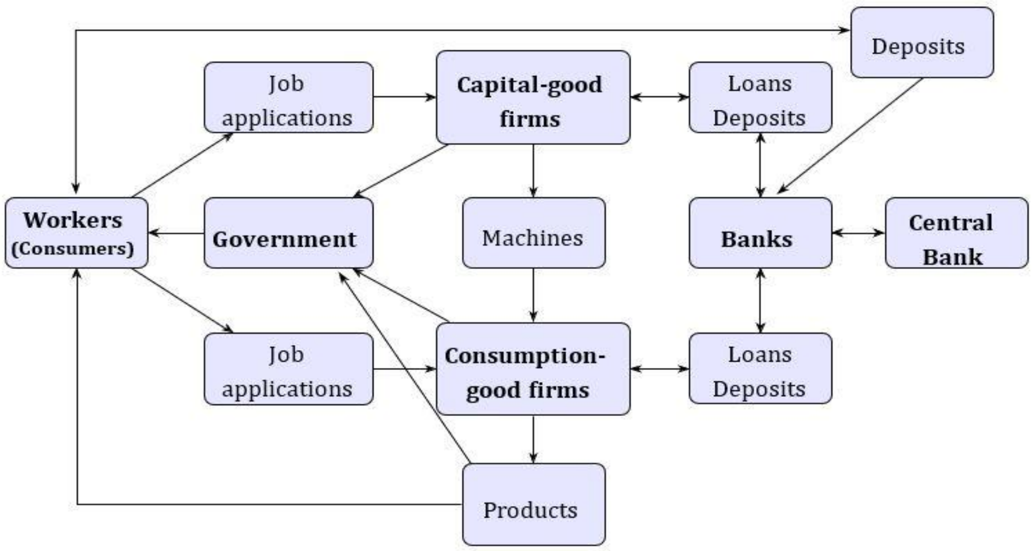

Figure 1: Overall structure of the model.

2.2 Consumers

Employed worker ℓ receives, at period t, a pay from the employer firm equal to the sum of the wage $w_{\ell,t}$ and the bonus $Bon_{\ell,t}$, if any. The wage is determined by direct interaction between workers and firms (*cf.* Appendix A). The bonus, instead, is a variable component that depends on the performance of the firm.[3] Unemployed individuals receive a subsidy w_t^u from the Government, which is equal to a share $\varphi_u \in [0,1]$ of the average country wage. Additionally, individuals may earn financial income from interest accrued on bank deposits (savings). Consequently, the gross nominal income of consumer ℓ is:

$$In_{\ell,t} = \begin{cases} w_{\ell,t} + Bon_{\ell,t-1} + Sav_{\ell,t-1}^{\text{acc}} r_{t-1}^D & \textit{if empolyed at time t} \\ w_t^u + Sav_{\ell,t-1}^{\text{acc}} r_{t-1}^D & \textit{if unempoyed at time t} \end{cases}, \tag{1}$$

where $Sav_{\ell,t}^{acc}$ and r_t^D represent the accumulated savings and the current interest rate on deposits, respectively. Gross income is subject to a flat tax rate $tr_{in} \in [0,1]$, possibly affected by a temporary, exogenous policy shock $s_t^{in} \geq 0$. Disposable income is thus:

$$\tilde{I}n_{\ell,t} = (1 - tr_{in} + s_t^{in}) In_{\ell,t} \tag{2}$$

Given the nominal disposable income $\tilde{I}n_{\ell,t}$, we assume that desired real consumption expenditure is, in principle, a linear combination of the expected real disposable income and the past consumption reference levels (Ciarli et al., 2019):

$$\begin{aligned} &\alpha_c \hat{I}n_{\ell,t}^{exp} + \beta_c \hat{C}_{\ell,t}^{ref}, && \alpha_c + \beta_c \leq 1, \\ &\hat{I}n_{\ell,t} = \frac{\tilde{I}n_{\ell,t}}{CPI_t^{exp}}, && CPI_t^{exp} = \frac{1}{T_{exp}} \sum_{v=1}^{T_{exp}} CPI_{t-v}, \end{aligned} \tag{3}$$

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[3] Only firms with a profit rate above the average pay bonuses to workers. The total bonus paid by firm j at time t is $Bon_{j,t} = \Pi_{j,t}(1 - tr_t^{\pi})\varphi_b$, where $\Pi_{j,t}(1 - tr_t^{\pi})$ is the net profit and $\varphi_b \in [0,1]$ is a parameter governing the share of net profit distributed to workers. The bonus is allocated to workers proportionally to the wages.

$$\hat{C}^{ref}_{\ell,t} = \frac{\sum_{v=1}^{T_{exp}} (\omega_c)^{v-1} \, \hat{C}^{d}_{\ell,t-v}}{\sum_{v=1}^{T_{exp}} (\omega_c)^{v-1}},$$

where $\hat{In}^{exp}_{\ell,t}$ is the expected real disposable income, and $\hat{C}^{ref}_{\ell,t}$ is a *reference consumption* level equal to an exponential moving average of the last $T_{exp} \in \mathbb{N}$ periods of the real desired consumption levels, $\omega_c \in]0, 1]$ is a decay parameter.[4] α_c and β_c are the parameters that regulate the importance of current real disposable income and past consumption levels in the definition of the desired consumption.

This formulation implies that consumption follows income dynamics but in a sluggish way: individuals slowly adjust consumption to income changes (Morley, 2007). The inclusion of current income is justified on the grounds of the empirical evidence on the relevance of this variable for consumption demand of individuals (cf. for example Jappelli and Pistaferri, 2010). Accordingly, the parameters α_c and β_c are calibrated based on the empirical evidence on the (mean) marginal propensity to consume of individuals (Jappelli and Pistaferri, 2014; Carrol et al., 2017). The inclusion of (fading-out) past consumption levels, on the other hand, is motivated by the idea of *internal habits* in consumption, which explains why consumption reacts slowly to income changes (Pollak, 1970; Morley, 2007; Carrol, 2011).[5]

A *ratchet effect* is finally introduced to capture intuition of Duesenberry (1948) that "it is harder for a family to reduce its expenditure from a higher level than for a family to refrain from making high expenditures in the first place". In line with Caiani et al. (2019), we model this asymmetric behaviour by imposing a lower bound on the consumption reduction that individuals accept in a single period, leading to the final specification of the real desired consumption specification of consumer ℓ at period t:

$$\hat{C}^{d}_{\ell.t} = \max\left(\alpha_c \hat{In}^{exp}_{\ell,t} + \beta_c \hat{C}^{ref}_{\ell,t}, \quad \gamma_c \hat{C}^{ref}_{\ell,t} \right), \qquad \beta_c < \gamma_c < 1, \qquad (4)$$

where γ_c determines the stickiness of individuals to consumption standards, being $(1-\gamma_c)$ the maximum percentage reduction accepted by the workers in a single period. The ratchet effect becomes binding in the event of significant decreases in current income of a consumer.

Individuals do not have access to credit and rely on accumulated wealth to smooth consumption over time, whenever their desired consumption exceeds current income. Consequently, individuals can finance their desired consumption level only if they possess sufficient resources (current disposable income plus savings), and (nominal) desired consumption in money terms is given by:

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[4] The real disposable income is an expected value since, in the model, workers must decide about consumption expenditure before prices are set by the firms. The expected consumption price level CPI^{exp}_{t} is modelled as the T_{exp} period moving average of the consumer price index CPI_t.

[5] This consumption function is similar to the ones used in many macro-ABMs grounded on the idea of *backward looking permanent income* (cf. Dawid and Delli Gatti, 2018). Indeed, our consumption function can be rewritten as a weighted average of the current and all past real disposable incomes, with decreasing weights as we go back into the past. Here, the reference consumption summarizes the information of the past real disposable income of individuals, and α_c and β_c are the weights of current and past incomes in the computation of the *permanent income*. The slow reaction of consumption to income changes is due to the sluggish response of permanent income to income changes.

$$C^d_{\ell,t} = \min\left(\frac{\hat{C}^d_{\ell,t}}{CPI^{exp}_t}, \quad \tilde{I}n_{\ell,t} + Sav^{acc}_{\ell,t-1} \right). \tag{5}$$

Those without adequate resources cannot fully satisfy their desired consumption, resulting in constrained effective consumption demand, and no savings. Otherwise, the unspent share of disposable income of consumer ℓ is saved:

$$Sav^{acc}_{\ell,t} = Sav^{acc}_{\ell,t-1} + \tilde{I}n_{\ell,t} - C^d_{\ell,t}. \tag{6}$$

2.3 Government

As in the standard K+S model, the government levies taxes (Tax_t), pays unemployment direct transfers (G^{trf}_t) and interest rate (r^{bonds}_t) on the bond stock ($Bonds_t$), absorbs central bank net results (Π^{cb}_t), and bails-out failing banks (G^{bail}_t). We extend the policy instruments by introducing the possibility of discretionary public consumption expenditure (G^c_t), and time-varying shocks on both the income ($s^{in}_t \geq 0$) and the profit ($s^{\pi}_t \geq 0$) tax rate parameters $(tr_{in}, tr) \in \mathbb{R}^2_+$, respectively. Given revenues and expenditures, tax proceeds and public deficit read:

$$\begin{aligned} Tax_t &= (tr - s^{\pi}_t)(\Pi^1_t + \Pi^2_t + \Pi^b_t) + (tr_{in} - s^{in}_t)\, In_t, \\ Def_t &= G^{trf}_t + G^c_t - Tax_t - \Pi^{cb}_t + r^{bonds}_{t-1} Bonds_{t-1} + G^{bail}_{t-1}, \end{aligned} \tag{7}$$

where $\Pi^k_t, k = 1, 2, b$, represents the gross profits of capital, consumption, and financial sectors, respectively In_t is the total income of workers. In case of (positive) deficit, the government issues new bonds, which are bought by banks. The central bank intervenes and buys the bonds only when the banks are not able to buy the total amount.

Public desired consumption is modelled as a public procurement process in which the Government buys goods directly from the consumption-good sector (Assenza et al., 2018). This amount of goods is "consumed" by the Government, without any further transformation.[6] To determine the level of public consumption in each period, we base our approach on empirical evidence. Specifically, in advanced economies over recent decades, we observe that: i) the public consumption-to-GDP ratio shows no clear long-term trend; ii) this ratio fluctuates in the short term; iii) public consumption tends to be slightly procyclical in most countries, though the public consumption-to-GDP ratio displays countercyclical dynamics (Lane, 2003; Lamo et al., 2013). In line with this empirical evidence, we assume the following simple and flexible rule:

$$G^{c,d}_t = g_0\, Y^{mt}_t + s^g_t, \qquad G^c_t \leq G^{c,d}_t \tag{8}$$

where $g_0 \in [0, 1]$ is a parameter that determines the target public consumption-to-GDP ratio, Y^{mt}_t represents the *medium-term GDP*, calculated by a linear regression on a fixed number $T_{mt} \in \mathbb{N}$ of GDP periods, and $s^g_t \geq 0$ represents a possible discretionary but temporary policy shock. This

[6] We do not assume any feedback between public and private consumption demand. Yet, public consumption may partially crowds-out private consumption in situations of excess of demand.

formulation allows us to replicate a public consumption-to-GDP ratio that fluctuates around the target value (g_0) in a countercyclical manner. Desired public consumption demand $G_t^{c,d}$ is then allocated among consumption-good firms based on their market share. As firm individual supply may be smaller than the allocated government share, and there is no inter-firm compensation in this case, effective public consumption G_t^c may be (slightly) lower than desired.

3 Empirical validation

The proposed K+S model extension model was simulated, and results were obtained from a comprehensive Monte Carlo (MC) experiment.[7] The model successfully replicates a broad range of both macroeconomic and microeconomic stylized facts. Specifically, it reproduces all the key stylized facts captured by previous versions of the K+S model (summarized in Table C.1 in Appendix C), while also offering new insights into consumption, income, and wealth dynamics at both individual and aggregate levels.

At the macroeconomic level, consistent with the K+S tradition, the model generates endogenous growth dynamics alongside business cycle fluctuations and deep crises (see Figure C.1 in Appendix C).[8] Moreover, the model produces relatively realistic utilization rates for productive inputs (labour and capital) and sustainable public finance conditions (Table C.2).

At the business-cycle frequencies, the model predicts that investment is significantly more volatile than GDP, whereas private consumption is less volatile than GDP (Figure C.2). Analysing the business-cycle co-movements between macroeconomic variables, we find that, in line with the empirical evidence (e.g., Stock and Watson, 1999; Napoletano et al., 2006). The model predicts that private consumption, net investment, changes in inventories, productivity, and nominal wages are pro-cyclical, while unemployment rate, mark-up and bankruptcy rate of firms are countercyclical (Table 1). Public consumption is slightly pro-cyclical and lagging, following existing evidence (Stock and Watson, 1999; Lane, 2003; Lamo et al., 2013).

With respect to consumption, the model generates empirically consistent aggregate propensities to consume, with a marginal value around one third and an average of about 90% (Jappelli and Pistaferri, 2010; Carroll et al., 2017). At the individual level, interesting patterns emerge. First, in line with most empirical literature (e.g., Jappelli and Pistaferri, 2014; Fagereng et al., 2018; Johnson et al., 2006), the model predicts that consumers with low income or wealth tend to have a higher marginal propensity to consume compared to those in better conditions (Figure 2). Specifically, as found by Jappelli and Pistaferri (2014), this propensity for low-income/wealth individuals is approximately twice that of wealthier people. A similar pattern holds for the average: wealthier individuals exhibit lower propensities (Figure C.3) (Dynan et al., 2004; Bozio et al., 2011; Fisher et al., 2018). Additionally, the model predicts that consumers experiencing

[7] The presented K+S model extension was coded and simulated using the LSD framework (Valente and Pereira, 2023), and the results were analysed using the R platform (R Core Team, 2024). The MC experiment was based on 200 realizations of 500 discrete time periods ($t = 1, \dots, 500$) each. The model is loosely calibrated so one time period roughly corresponds to on quarter. The parametrization of the model is reported in Appendix B.

[8] Time-series plots present the MC time series excluding a "warm-up" period of 100 time steps. Calibration of initial conditions are kept to a minimum: all firms in each sector, and workers start equal at $t = 1$, departing from balanced supply and demand, under planned utilization, in all markets. The objective is to have the model structure endogenously determining appropriate initial conditions after the warm-up period.

rising incomes tend to show a lower average propensity to consume when compared to those with declining incomes (Figure C.4), as noted by Carrol and Weil (1994).

Series (Bpf)	GDP (Bpf)								
	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
GDP	-0.239	0.025	0.444	0.837	1.000	0.837	0.444	0.025	-0.239
	(0.013)	*(0.011)*	*(0.007)*	*(0.002)*	*(0.000)*	*(0.002)*	*(0.007)*	*(0.011)*	*(0.013)*
Private cons.	-0.168	0.057	0.411	0.761	0.939	0.841	0.520	0.129	-0.164
	(0.020)	*(0.014)*	*(0.007)*	*(0.006)*	*(0.005)*	*(0.003)*	*(0.011)*	*(0.017)*	*(0.017)*
Net investment	-0.255	-0.157	0.023	0.205	0.301	0.266	0.143	0.021	-0.026
	(0.010)	*(0.011)*	*(0.015)*	*(0.017)*	*(0.015)*	*(0.012)*	*(0.011)*	*(0.012)*	*(0.011)*
Chg. inventories	-0.199	-0.067	0.150	0.327	0.353	0.208	-0.006	-0.160	-0.183
	(0.009)	*(0.008)*	*(0.010)*	*(0.012)*	*(0.010)*	*(0.009)*	*(0.013)*	*(0.014)*	*(0.010)*
Public cons.	0.218	0.285	0.345	0.346	0.260	0.103	-0.062	-0.178	-0.219
	(0.015)	*(0.011)*	*(0.010)*	*(0.015)*	*(0.016)*	*(0.012)*	*(0.008)*	*(0.011)*	*(0.014)*
Unempl. rate	0.298	0.226	0.054	-0.132	-0.245	-0.246	-0.172	-0.092	-0.049
	(0.014)	*(0.019)*	*(0.023)*	*(0.022)*	*(0.018)*	*(0.014)*	*(0.014)*	*(0.015)*	*(0.015)*
Productivity	0.101	0.222	0.341	0.418	0.413	0.307	0.139	-0.030	-0.133
	(0.016)	*(0.016)*	*(0.016)*	*(0.017)*	*(0.018)*	*(0.018)*	*(0.018)*	*(0.019)*	*(0.019)*
Wage	0.032	0.146	0.265	0.353	0.374	0.304	0.165	0.011	-0.096
	(0.014)	*(0.016)*	*(0.017)*	*(0.017)*	*(0.020)*	*(0.023)*	*(0.022)*	*(0.018)*	*(0.014)*
Bankruptcy rate	0.071	0.052	-0.020	-0.126	-0.216	-0.239	-0.180	-0.068	0.044
	(0.012)	*(0.012)*	*(0.015)*	*(0.018)*	*(0.018)*	*(0.017)*	*(0.015)*	*(0.015)*	*(0.014)*
Mark-up	0.126	0.125	0.098	0.050	-0.006	-0.051	-0.077	-0.080	-0.068
	(0.013)	*(0.015)*	*(0.016)*	*(0.016)*	*(0.015)*	*(0.013)*	*(0.012)*	*(0.013)*	*(0.014)*
Hand-to-mouth	0.071	0.003	-0.039	-0.162	-0.295	-0.313	-0.341	-0.304	-0.259
	(0.016)	*(0.016)*	*(0.020)*	*(0.019)*	*(0.018)*	*(0.017)*	*(0.014)*	*(0.015)*	*(0.015)*

Table 1: Correlation structure. Bpf: Baxter-King bandpass-filtered (6,32,12) series. Monte Carlo standard errors in parentheses. 200 MC runs.

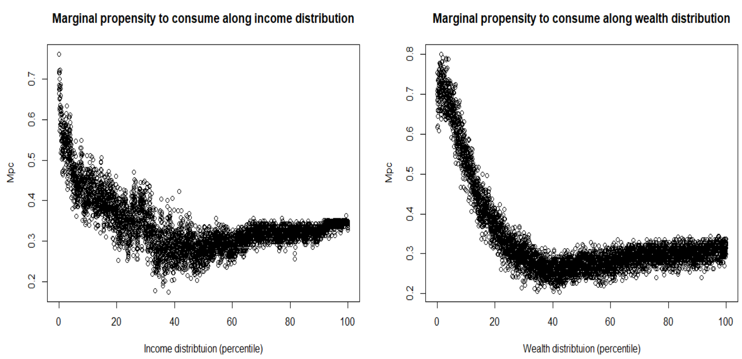

Figure 2: Marginal propensity to consume along income and wealth distributions. Every dot represents the average marginal propensity to consume in a specific percentile of a specific run. Results for 50 MC runs.

The heterogeneity among individuals has important implications for our analysis. The response of private consumption to fiscal policy interventions depends significantly on the profile of the individuals directly or indirectly affected by the policy. Consumer heterogeneity, in reality, plays a key role in shaping the macroeconomic impact of fiscal policies (Carrol, 2012; Jappelli and Pistaferri, 2014).

But what drives household heterogeneity in our model? The explanation lies in the endogenous generation of "*hand-to-mouth*" consumers. Specifically, individuals become hand-to-mouth when own resources are insufficient to cover the desired consumption level, making one's consumption entirely dependent on current income, with a marginal propensity to consume close to one (Mankwin, 2000).[9] This process is fully endogenous within the model, as it stems from the consumption, income, and wealth dynamics of each individual. As a result, the share of hand-to-mouth consumers fluctuates over time (Figure 3), moving with the business cycle and showing a countercyclical pattern (Table 1). This is particularly important because it establishes a possible link between the state of the economy and the effectiveness of fiscal policy.[10] In the model, the aggregate relationship between propensity to consume and income-wealth distribution emerge because the fraction of hand-to-mouth consumers progressively increases as the analyzed percentiles of income and wealth distributions decrease.

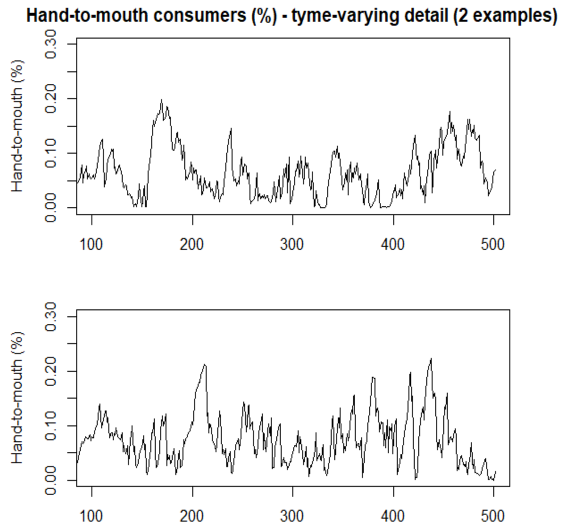

Figure 3: Time-varying fraction of hand-to-mouth consumers. Detail of two sample simulation runs selected for example purpose.

The model yields several noteworthy additional insights into consumption, income, and wealth dynamics. First, it generates aggregate wealth/income ratio compatible with empirical data (Figure C.5, left). Second, the model predicts an interesting positive relationship between individual income and wealth/income ratio (Figure C.5, right). Lastly, the model captures clear

[9] A somewhat similar dynamic, at least in the vein, is present in some recent Heterogeneous Agent New Keynesian (HANK) models (Galì, 2018).

[10] In a DSGE-context, for example, Galì et al. (2007) show that public spending multiplier increase as the fraction of hand-to-mouth *(non-ricardian)* households increases. In that model, however, different fractions of hand-to-mouth consumers are imposed ex ante. In our model, instead, the share of hand-to-mouth consumers is endogenously determined.

inequality patterns among individuals, showing that inequality in consumption is lower than inequality in income, which in turn is lower than inequality in wealth (Table C.2) (Fisher et al., 2018).

4 Policy experiments

The paper delves into the examination of expansionary fiscal policies in the form of public consumption or income tax rate stimuli. These policies are modelled as follows. Assuming the policies begin in period t, the public consumption stimulus is modelled by adding a positive shock (s_t^{Gg}) to the equation (8) above, while the income tax rate stimulus is modelled adding a positive shock (s_t^{in}) to equation (2).

Both shocks are calibrated to be equivalent to a $y_{sh} = 1\%$, of the GDP on impact and are fully financed by deficit. Moreover, building on empirical evidence suggesting that fiscal policy shocks tend to be very persistent over time (e.g., Blanchard and Perotti, 2002; Caldara and Kamps, 2008; Ramey and Zubairy, 2018), we treat them as extremely persistent, assuming they remain in levels.[11] In principle, the timing of the shock is set at period 300 to avoid occurrences close to the warm-up phase of the model. In addition, as noticed by Amendola and Pereira (2025), adopting such a straightforward rule for shock timing is the simplest way to avoid any *selection into treatment* bias, which could distort linear estimates in the presence of state-dependent effects.

To gauge the linear effects of fiscal shocks, we compare Monte Carlo sets in which each observation is composed by two simulation runs with identical parameter values, initial conditions, and pseudorandom number generator (PRNG) seeds.[12] The fiscal shock is introduced in only one of the quasi-twin simulations, with the non-shocked simulation serving as a direct counterfactual scenario. Differences in time series between the shocked and non-shocked scenarios can be then attributed to the fiscal shock and causal effects directly identified. Yet, as typical in ABM, a Monte Carlo approach need to be adopted to wash away across simulation variability and extrapolate a robust signal (Delli Gatti and Grazzini, 2020). A Monte Carlo experiment of size 500 is adopted to robustly identify the impacts of our policies. Further details on the so-called Counterfactual Monte Carlo (CMC) methodology applied here is presented in Amendola and Pereira (2025).

Fiscal multipliers, in line with the recent empirical literature, are computed as cumulative multipliers. This measure has the advantage of taking into consideration the GDP-gain and cost of the policy, an appropriate way to compute fiscal multipliers in a dynamical environment (Mountford and Uhlig, 2009; Ramey, 2019). Multipliers are calculated individually for each observation of the Monte Carlo experiment. For instance, the (cumulative) public consumption multiplier for the h-th period after the shock in the i-th CMC run are computed as:

[11] For instance, in the case of a public consumption shock, we assume that $s_t^{Gg} = 0$ for $t < t_e$ and $s_t^{Gg} = 0.01 * GDP_{t_e - 1}$ for $t \geq t_e$, where t_e is the time of the shock.

[12] The seed of the PRNG entirely determines the stochastic realizations of the model, allowing introducing *controlled stochasticity* in the analysis.

$$Mult_{i,h} = \frac{\sum_{j=0}^{h}\left[\left(Y_{i,t+j}|s_t^g \neq 0\right) - \left(Y_{i,t+j}|s_t^g = 0\right)\right]}{\sum_{j=0}^{h} s_{t+j}^g}, \qquad h = 0, \dots, H, \tag{9}$$

where $H \in \mathbb{N}$ is the chosen time horizon for policy evaluation, and $Y_{i,t+j}|s_t^g \neq 0$ and $Y_{i,t+j}|s_t^g = 0$ are the values of GDP in shocked and non-shocked periods, respectively. CMC-sample mean and median multipliers are then computed to assess the effects of fiscal policy in the model.

The policies are evaluated for a maximum time horizon H of 16 periods. This corresponds to a time window equivalent to four years after the introduction of the policy ($h = 0$). This time window, largely used in the empirical analyses on fiscal multipliers (e.g., Ramey and Zubairy, 2018; Amendola, 2023), appears long enough to capture short- and medium-term effects of fiscal policy.

4.1 In search of state-dependency

Amendola and Pereira (2025) propose an intuitive, yet robust, framework for constructing state-dependent impulse response functions within an agent-based context. Drawing inspiration from empirical analyses which employ a threshold local projection model to explore state-dependency (e.g., Owyang et al., 2013; Ramey and Zubairy, 2018) - and building on the broader foundation of threshold nonlinear time series models (Teräsvirta et al., 2010) - the authors propose assessing state-dependency by comparing impulse response functions across sub-samples of a Counterfactual Monte Carlo (CMC) experiment. These sub-samples are representative of alternative states of the economy, which were equal until the policy shock is applied in just one of them, at $h = 0$, and then branch in two now-divergent realizations. Therefore, the CMC experiment can be characterized, for instance, by comparing the values of one or more *state variables* against appropriate thresholds. The authors propose two approaches for selecting the relevant state variables and the corresponding threshold values. The first, grounded in theory, involves testing candidate state variables, and usual thresholds, deemed potentially relevant in the literature. Alternatively, the authors proposed a data-driven algorithm (Random Forest State Identification Algorithm – RFSIA), based on the machine-learning random forests, to discover interesting economic states – combining state variables and thresholds – from the CMC data.

In the following, we adopt the CMC-RFSIA methodology of Amendola and Pereira (2025) to investigate the possible state-dependent effects of fiscal policy. Firstly, we explicitly test whether fiscal multipliers are higher in slack situations than in expansionary periods, relying on performance indicators largely adopted in the literature. Subsequently, we adopt a data-driven perspective by supplying RFSIA with an extensive array of potential state variables. These variables encompass diverse metrics, ranging from indicators of economic slack to measures of financial distress, allowing us to uncover other possible sources of state-dependency within our model.

5 Results

5.1 Linear analysis

Figure 4 (left) presents the GDP response to a public consumption stimulus. The stimulus delivers a substantial boost to the economy, resulting in approximately a 1% increase in GDP in the short term, and a 2% increase in the medium term. This effect remains statistically significant throughout the entire analysis window, as shown by the 90% confidence interval of the CMC GDP-irf.

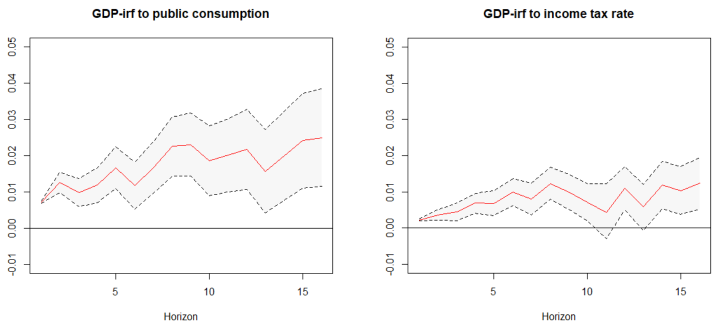

Figure 4: Impulse response function of GDP to public consumption and income tax rate stimuli. Results are relative to GDP one period before the shock at $h = 0$. Red line: average effect; black dashed lines: 90% confidence intervals. 500 CMC runs.

Transmission channels, illustrated in Figure 5, reveal a clear crowding-in effect on private consumption, consistent with empirical analysis (Blanchard and Perotti, 2002; Caldara and Kamps, 2008; Amendola, 2023). This effect is propelled by the positive impact of the public consumption stimulus on the average real disposable income of individuals, which, in conjunction with the contemporaneous rise in public consumption demand, explains the rise in industrial production. Regarding private investment, the model predicts a general tendency towards a positive response, although its impulse response function exhibits greater volatility compared to private consumption. This volatility underscores the inherent challenge in predicting the reaction of investment to fiscal shocks. However, a statistically significant crowding-in effect on private investment is observed in the short term. Other interesting results include: (i) a persistent decline in the unemployment rate, with nominal wages largely unaffected by the public consumption stimulus, implying that the rise in disposable income is primarily driven by reduced unemployment rather than wage growth; (ii) positive effects on private firms, reflected by increased profits following the policy implementation; and (iii) some inflationary pressure resulting from the public consumption stimulus, as indicated by the response of the consumer price index.

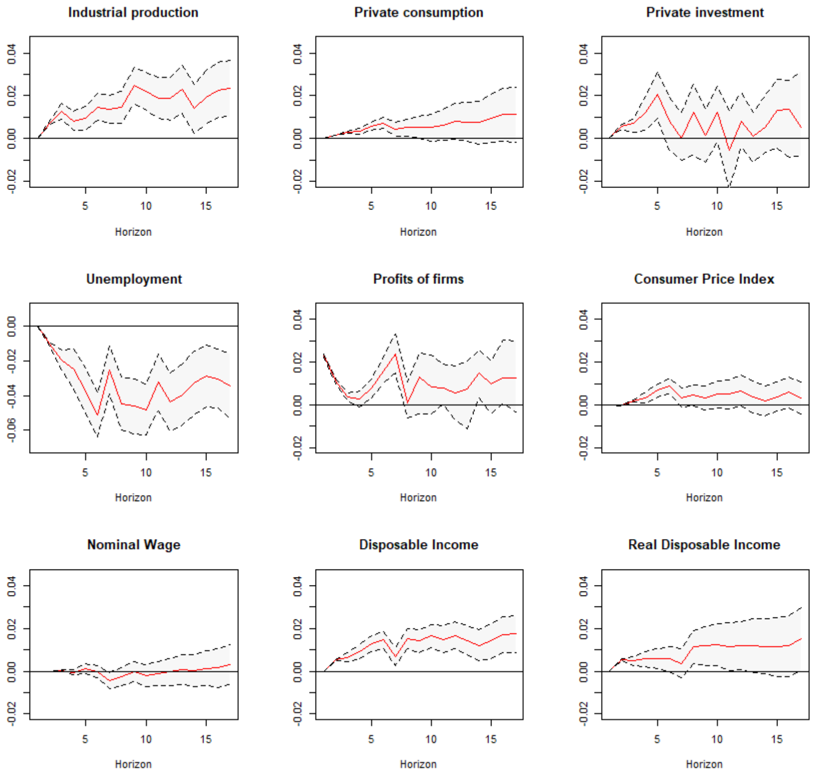

Figure 5: Impulse responses to public consumption stimulus. Results are relative to the value of the variable one period before the shock at $h = 0$. Red lines: average effects; black dashed lines: 90% confidence intervals. 500 CMC runs.

The income tax rate stimulus produces a significantly positive effect on aggregate output, with a persistent and statistically significant impact across most time horizons considered (Figure 6, right). However, compared to the public consumption stimulus, the GDP response is weaker, especially in the short term. As shown in Figure 6, the primary driver of output expansion is the strong and persistent increase in private consumption, which responds positively to the income tax rate reduction. This consumption response is attributed to the positive effect on the average real disposable income of individuals resulting from the reduction in the income tax. Unlike the public consumption scenario, private investment does not show a clear short-term reaction, though some positive response emerges in the medium term. Similar to the public consumption stimulus, the income tax rate cut leads to a decrease in the unemployment rate, increased firm profits, and mild pressure on the consumer price index.

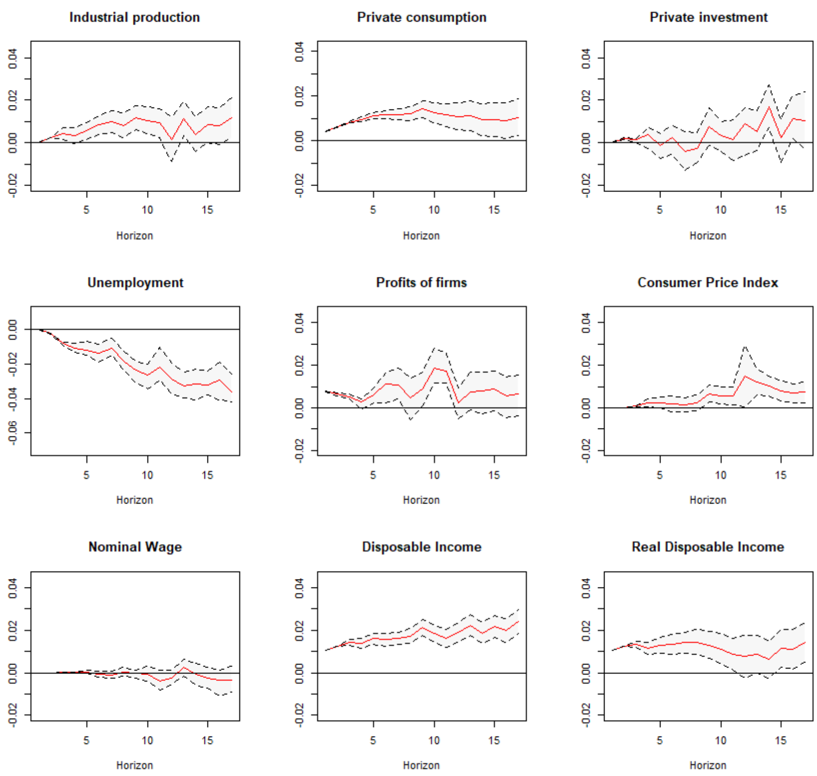

Figure 6: Impulse responses of several variables to income tax stimulus. Results are relative to one period before the shock at $h = 0$. Red lines: average effects; black dashed lines: 90% confidence intervals. 500 CMC runs.

Table 2 presents fiscal multipliers estimates. Our results indicate that public consumption multipliers are approximately 1.0 in the short term, with an impact multiplier around 0.7, rising to above 1.0 in the medium term and peaking at 1.6.[13] Median multipliers closely align with average values, indicating widespread positive effects across simulations. In contrast, income tax multipliers are notably below 1.0 in the short term and around 1.0 in the medium term (see Table 3). The initial effect of income tax rate cuts on GDP is approximately three times weaker than that of an equivalent public consumption stimulus, with an impact multiplier around 0.25. This gap narrows in the medium term, with income tax multipliers reaching about 60% of those for public consumption policy.

	Public consumption stimulus			Income tax stimulus		
Time horizon	Average multiplier	*90% CI*	Median multiplier	Average multiplier	*90% CI*	Median multiplier
1	0.67***	(0.63,0.70)	0.75	0.24***	(0.22,0.26)	0.23
4	1.02***	(0.85,1.18)	1.17	0.41***	(0.28,0.53)	0.53
8	1.34***	(1.04,1.63)	1.37	0.76***	(0.53,0.99)	0.90
16	1.64***	(1.08,2.19)	1.65	0.96***	(0.55,1.35)	1.19

Table 2: Cumulative GDP multipliers for public consumption and income tax rate stimuli. (***): p-value < 0.001; (**): p-value < 0.01; (*): p-value<0.05. 500 CMC runs.

[13] Multipliers are below 1.0, in the short-term, as part of the additional demand is satisfied through reductions in inventories.

Do these multipliers align with the empirical evidence? Answering this question is complex due to significant variability in estimates across the literature. However, a comparison with recent meta-analyses, such as those by Gechert and Rannenberg (2018) and Hlaváček and Ismayilov (2022), suggests that our estimates fall within the empirical range, albeit slightly leaning toward the right side of the distribution. Yet, the model is expected to partially overestimate fiscal multipliers compared to most of these empirical studies, given its closed-feature nature, which does not account for potential leakages related to imports and price competitiveness (cf. Spilimbergo, 2009; Iltezki, 2013). Overall, we contend that the model yields reasonable results, providing a valuable framework for exploring the effects of fiscal policy.

5.2 Slack vs good periods

Let us now analyse whether fiscal multipliers vary according to economic conditions. We begin by comparing recessionary vs. expansionary economic conditions, using recognized indicators from the literature to objectively assess these states. Recessionary periods are identified based on the following criteria, evaluated at the time fiscal policy is implemented: i) a capacity utilization rate below the sample mean (Fazzari, 2015); ii) an unemployment rate above the sample mean (Ramey and Zubairy, 2018; Amendola, 2023); and iii) two consecutive quarters of negative GDP growth (Batini et al., 2012). Conversely, good periods are characterized by a capacity utilization rate above the sample mean, an unemployment rate below the sample mean, and two consecutive quarters of above-average GDP growth.

Figure 7 illustrates the state-dependent impulse response functions (IRF) of GDP to public consumption shocks during periods of differentiated conditions. In the left are presented the IRFs associated with a weak economy, and in the right, the ones of a strong state. From the top, in Figure 7 we compare the effect of a public consumption policy under (i) low and high utilization in the installed productive capacity, (ii) high and low unemployment, and (iii) recessionary or expansionary period. The results clearly demonstrate that our model predicts distinct GDP responses in the two states, regardless of the criterion used for classification. Specifically, the impact on GDP is strong and lasting in downturn periods, with medium-term multipliers nearly double those observed in the linear analysis above. In contrast, the response during good economic conditions is relatively weak and not statistically significant in the medium term. When evaluating multipliers over the entire time horizon, our findings suggest that multipliers are approximately 2.5 times higher during slack periods compared to good conditions (0.8). This aligns with prior empirical analyses, such as those by Auerbach and Gorodnichenko (2012) and Amendola (2023), which found that multipliers during economic slack are 50-60% higher than linear estimates. Moreover, the difference is highly significant, confirmed at the 1% significance level by the application of two-means *t*-tests, and also by the analysis of the interquartile distributions (boxplots) for the bootstrapped mean (left) and median (right) multipliers in Figure 8.

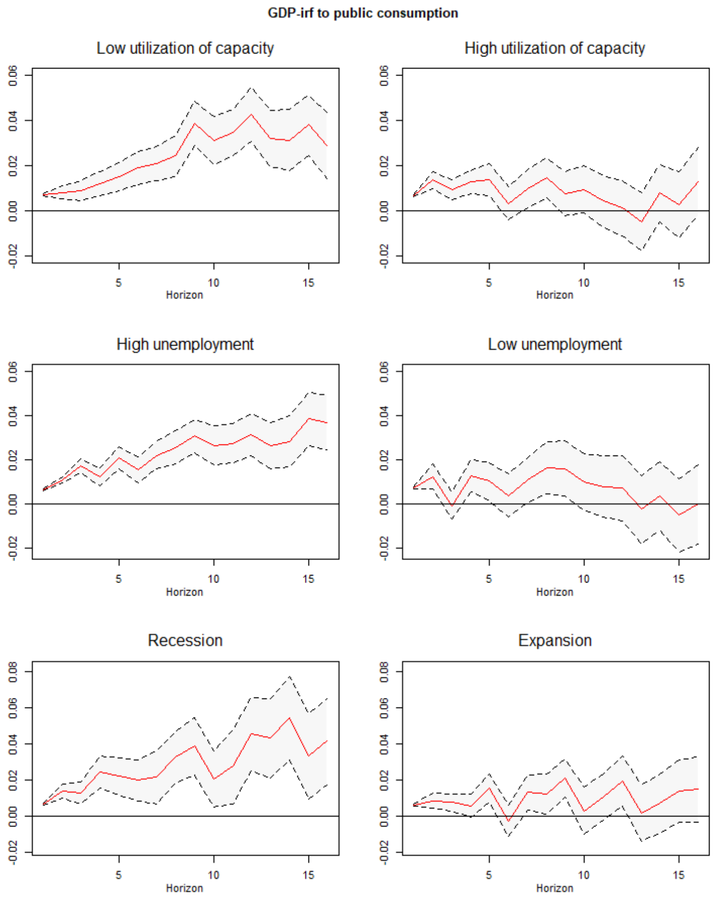

Figure 7: State-dependent impulse responses of GDP to public consumption stimulus applied in specific economic conditions. Red line: average effect; black dashed lines: 90% confidence intervals. Top panel: low (left) or high (right) utilization of capacity (sample sizes: 242/258); Middle panel: high (left) or low (right) unemployment (sample size: 298/202); Bottom panel: recession (left) or expansion (right) (sample size: 63/148).

Several mechanisms contribute to these state-dependent effects. Consistent with Auerbach and Gorodnichenko (2013), and Amendola (2023), among others, we observe a marked difference in private consumption responses across the two economic states (Figure C.6 in Appendix C). In contraction periods, the public consumption stimulus generates a strong and lasting crowding-in effect on private consumption, nearly doubling the one observed in the linear analysis. Conversely, when the stimuli are implemented in good conditions, the crowding-in effect is weak and limited to the short term, with evidence of a crowding-out effect emerging in the medium term.

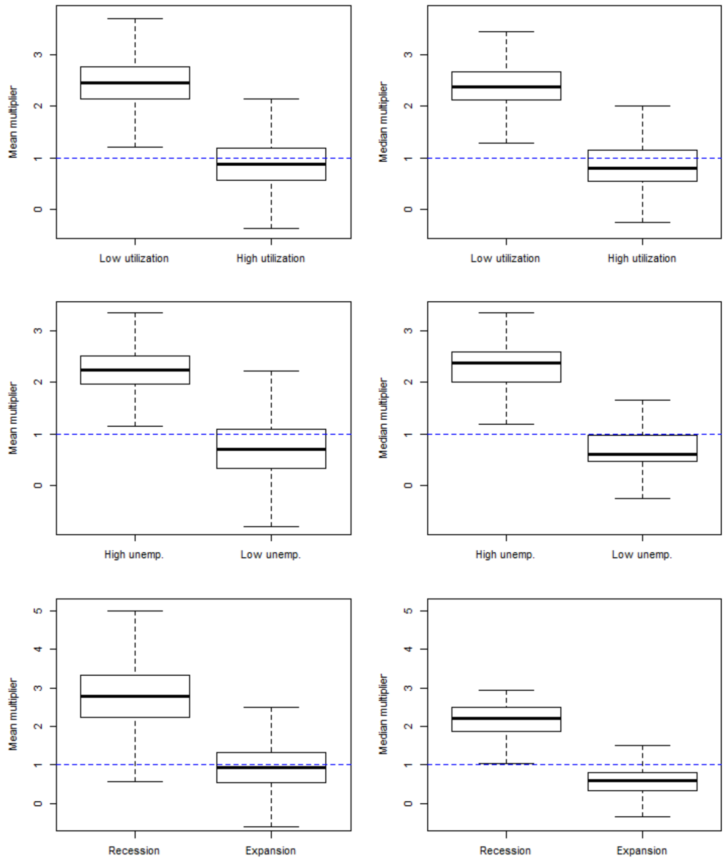

Figure 8: Interquartile distributions for the state-dependent, public consumption, medium-term cumulative fiscal multipliers. Left column: mean multipliers; Right column: median multipliers. Top panel: low or high utilization of capacity (sample sizes: 242/258); Middle panel: high or low unemployment (sample size: 298/202); Bottom panel: recession or expansion (sample size: 63/148). Bootstrap replications: 10000.

The state-dependent response of private consumption can be attributed to three primary mechanisms. The first is linked to the average real income of individuals, which experiences a substantial increase in slack scenarios but remains relatively stable in good conditions (Figure C.7, left). This phenomenon is partially explained by the more significant impact of the policy on nominal disposable income in recessionary periods (Figure C.7, middle). Additionally, a different reaction of prices plays a crucial role: inflation is substantially zero in weak-economy periods, while it is pronounced otherwise, offsetting the rise in nominal income (Figure C.7, right). This state-dependent inflation response to public consumption policy is an interesting emerging property of the model, corroborated by empirical analysis (e.g., Riera-Crichton et al., 2015).

The second reason that could explain the state-dependent reaction of private consumption is related to the higher presence of *hand-to-mouth* consumers in underperforming conditions (Galì et al., 2007). The percentage of these consumers is approximately 10% higher during slack periods, leading to a greater aggregate marginal propensity to consume in worse conditions and, consequently, a stronger consumption response.

Finally, the third mechanism involves the physical productive capacity of consumption-good firms to meet the increased demand from public consumption. In scenarios characterized by *supply bottlenecks*, public consumption policy may directly crowd out private consumption. This effect is less likely in slack situations, as these are typically associated with higher levels of inventories and underutilized production inputs.

Do these findings also apply to income-tax reduction policy? Interestingly, our model does not yield robust evidence in support of this conclusion. While there is weak evidence suggesting anticyclical tax multipliers during periods of high unemployment or recession, this evidence is considerably less compelling than in the case of public consumption. Furthermore, we find no indication of higher multipliers during periods of low-capacity utilization (Figure C.8). Overall, it seems reasonable to conclude that income-tax policy multipliers are acyclical, or only weakly anticyclical in our model. Remarkably, although empirical literature on the state-dependent effects of income-tax fiscal policy is limited, this finding aligns with the conclusions of Gechert and Rannenberg (2018), who argue that tax multipliers are not particularly sensitive to economic conditions. One possible explanation for this result lies in the nature of income-tax policies, whose effects unfold gradually through adjustments in disposable income and individual consumption decisions. The slow dynamic creates a significant lag between policy implementation and the full impact on the economy, ultimately turning the effectiveness of such policies less dependent on the economic conditions at the time of introduction.

5.3 In search of others state-dependent effects

To conclude our analysis, we adopt the RFSIA data-driven approach to identify state-dependency in a systematic way. This method requires the choice of a metric, which serves as the dependent variable for a random forest regression model. For our analysis, we select the medium-term cumulative multiplier for a time horizon $H = 16$, as it effectively captures the tested policies' medium-term effects. The algorithm is then configured with a broad set of potential explanatory variables, including indicators of economic performance (e.g., capacity utilization, unemployment, GDP growth), measures of financial fragility (e.g., share of non-performing loans, number of bank failures, banks' net wealth), public finance indexes (e.g., debt-to-GDP, deficit-to-GDP), and inequality metrics (e.g., Gini coefficient).[14]

The RFSIA algorithm reveals some compelling patterns. First, the capacity utilization rate is identified as the most frequent splitting variable. However, the findings suggest that the ad hoc rules applied above for differentiating between good and bad conditions were overly simplistic. According to the results, the best split is not the average utilization rate, close to the 5th decile of the distribution, but by the second decile. This indicates a significant gap in public-consumption policy multipliers when the utilization rate is particularly low, specifically under the second decile of the distribution, reflecting a substantial recession. Under these conditions, public consumption multipliers reach values around 3.5. This result is particularly consistent with the ones of Caggiano et al. (2015), who reported large fiscal multipliers during periods of deep recessions.

[14] Constrained by the RFSIA parameters, the algorithm generates a series of "candidate" decision trees, each characterized by adequate stratifications for the dependent variable. It then assesses whether the outcomes in each terminal node differ statistically from the rest of the data. Finally, the algorithm aggregates the most frequent splitting paths, replacing specific threshold values with the corresponding quantiles (discretization). See Amendola and Pereira (2025) for details.

Second, the analysis identifies financial fragility as a key factor influencing the effectiveness of public consumption policy. Specifically, the share of non-performing loans, and the level of bank net wealth relative to GDP emerge as prominent state variables. The results indicate that fiscal multipliers are particularly high in scenarios characterized by a high share of non-performing loans (2.5) or when bank assets are distressed (2.1). This aligns with literature suggesting that fiscal policy is especially impactful during pronounced financial fragility (e.g., Almunia et al., 2010; Corsetti et al., 2012; Blanchard and Leigh, 2013; Ferraresi et al., 2015; Canzonieri et al., 2016; Glocker et al., 2019). Bank lending plays a critical role in this context, as it is substantially boosted by increase in public consumption expenditure. This suggests a process like a financial accelerator mechanism based on quantitative borrowing constraints which are alleviated by the fiscal stimulus (Challe and Ragot, 2011; Turrini et al., 2012; Ferraresi et al., 2015; Hebous and Zimmermann, 2021).

6 Concluding remarks

In this study, we analyze the short- and medium-term effects of expansionary fiscal policies by means of a theoretical macroeconomic agent-based model. Specifically, we propose an extended version of the labour-augmented K+S model (Dosi et al., 2017, 2018, 2020) to investigate the macroeconomic impacts of public consumption and income-tax reduction policies under various economic conditions. These effects are rigorously quantified, allowing us to estimate both linear and state-dependent fiscal multipliers under multiple economic scenarios. To the best of our knowledge, this study is one of the pioneering efforts in this area within the agent-based modelling literature.

Our findings show that (deficit-financed) expansionary fiscal policies, whether through increased public spending or income-tax cuts, have significant positive effects on aggregate output. Public consumption (linear) multiplier is approximately 1.6, while tax multiplier is around 1.0. In the very short term, the difference between policies is even more pronounced, with expenditure multipliers being two to three times higher than those associated with tax reductions. Although some model features, such as its closed-economy structure, may lead to overestimation of fiscal multipliers, our results underscore the critical role of fiscal policy as a powerful tool for policymakers.

However, the analysis suggests that fiscal policy linear effects should be considered with caution, as non-linearities can significantly affect policy effectiveness. Specifically, we find pronounced non-linearities in the propagation of public consumption policy, with multipliers (up to 3.5) higher during periods of economic slack, and high financial fragility (2.5). We identify inflationary pressures, supply bottlenecks, and borrowing constraints as potential sources of these non-linearities. Importantly, these findings emerge as genuine properties of the model rather than aggregate outcomes derived from micro-level decision rule specification. Interestingly, this pattern is not observed for policy based on income-tax cuts. Our results suggest that tax policy multipliers remain largely acyclical (around 1.0).

Our findings indicate that expansion in public consumption expenditure is significantly more powerful than cuts in income tax rates, particularly in situations of economic downturn, and heightened financial fragility – precisely when fiscal stimulus is most needed. In a distinctly Keynesian manner, direct demand stimulation emerges as the more adequate policy choice to restore economic growth. Conversely, the state-dependent superiority of public consumption is partially reversed under favourable economic conditions. The model analysis attributes this dependency to the relative speed at which each policy instrument generates the relevant macroeconomic impacts. Indirect demand-stimulation policies, such as tax cuts, tend to act more gradually, often producing most effects after the economic environment has already changed.

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Appendices

Appendix A – model's details

Capital sector

Capital-good firms produce machines, on order of consumption-good firms, using labour only. The technology of the *i-th* capital-good firms is represented by a couple of values (A_i^τ, B_i^τ), where A_i^τ is the productivity of the machine produced and B_i^τ is the labour productivity in the production process of the machine itself. The index τ is the vintage/technology produced. The capital-good industry is the place where innovations are endogenously generated, in the economy, in a Schumpeterian competition framework driven by technological innovation. Capital-good firms, indeed, trying to increase their market share and their profits, perform innovation and imitation activity. Specifically, firms invest in R&D according to the following rule:

$$RD_{i,t} = v * S_{i,t-1} \qquad (i)$$

where $RD_{i,t}$ is the monetary expenditure on R&D activity, $S_{i,t-1}$ is the past period revenue from sales and $v \in (0,1]$ is a parameter that determine how much of the past sales is reinvested in R&D. Firms on the technological frontier invest all their R&D expenditure in the innovation activity while other firms split their R&D expenditure between innovation (IN_i) and imitation (IM_i) according to the parameter $\xi \in [0,1]$:

$$IN_{i,t} = \xi * RD_{i,t} \qquad (ii)$$

$$IM_{i,t} = (1 - \xi) * RD_{i,t} \qquad (iii)$$

Innovation and imitation are uncertain activities and are modelled as a two-step stochastic process. The first step determines whether a firm has access to innovation or imitation and is modelled as draws from Bernoulli distributions whose parameters are:

$$\theta_{i,t}^{in} = 1 - e^{-\zeta 1 * IN_{i,t}} \qquad (iv)$$

$$\theta_{i,t}^{im} = 1 - e^{-\zeta 2 * IM_{i,t}} \qquad (v)$$

where ζ_1 and ζ_2 are the parameters that regulate the probability of accessing to the second step. The probability of accessing the second step depends on the resources putted into the two R&D activities. Firms that access the second step of the innovative process may draw a new machine whose productivities are determined as:

$$A_{i,t}^{in} = A_{i,t} * \left(1 + x_{i,t}^A\right) \qquad (vi)$$

$$B_{i,t}^{in} = B_{i,t} * \left(1 + x_{i,t}^B\right) \qquad (vii)$$

where $x_{i,t}^A$ and $x_{i,t}^B$ are independent realizations from a Beta (α_1, β_1) distribution over the support$[\underline{x_1}, \overline{x^1}]$. $\underline{x_1}$ is assumed to be lower than zero allowing for the possibility of failure innovations.

Firms that access the second step of the imitative process have the possibility to imitate the technology of one competitor, with an imitation probability inversely related to the technological distance to other firms. Imitation process and innovative process can lead to a potential failure and, therefore, firms switch to the new potential technology only if this technology outperforms the current one. Particularly, firms select the machine to produce according to the following rule:

$$min\left[p_{i,t}^{h} + b * c_{A_i^h,t}^{h}\right], \qquad h = \tau, in, im \qquad (viii)$$

where b is the payback parameter for the investment decisions of the consumption-good firms and $c_{A_i^h,t}^{h}$ is the unit cost of production of the machine. The produced machine is advertised sending brochures with price and productivity of the machine to the consumption-good firms. Capital-good market is characterized by imperfect information and, therefore, capital-goods firms can signal the productivity and the price of their machines only to their existing customers plus a subset of potential new customers. With regards to price, they are fixed adding a constant mark-up (μ_1) over the unit cost of production (c_i):

$$p_{i,t} = (1 + \mu_1) * c_{i,t} \qquad (ix)$$

Consumption-good sector

Firms in the consumption-good sector produce an homogenous consumption good using labour and machines as inputs, under constant return to scale. Production decisions are based on the expected demand level (D_j^e), equal to a weighted average of the past demand received by the firm:

$$D_{j,t}^{e} = g\left(D_{j,t-1}, D_{j,t-1}, \dots, D_{j,t-h}\right), \qquad 0 < h < t \qquad (x)$$

Firms try to maintain a buffer of inventories over this expected demand, trying to fulfil unexpected demand peaks (Steindl, 1952). Their desired production (Q_j^d), therefore, is equal to:

$$Q_{j,t}^{d} = (1 + \iota) * D_{j,t}^{e} - N_{j,t-1} \qquad (xi)$$

where ι is the parameter that define the desired level of inventories and $N_{j,t-1}$ are the accumulated inventories from the previous period. Given the desired production level, consumption-good firms calculate their desired capital stock (K_j^d) as a linear function of the desired production. If the actual capital stock is lower than the desired level firms invest to expand their capital stock. Desired expansionary investment (EI_j^d) are then equal to:

$$EI_{j,t}^{d} = K_{j,t}^{d} - K_{j,t-1} \qquad (xii)$$

where $K_{j,t-1}$ is the actual capital stock of the firm *j*. Firms invest not only to increase the stock of capital but also to increase the productivity of their capital stock. These technological replacement investments are based on a payback rule in which firms consider the price and the productivity of the new machines and the productivity of the machines they own. Specifically, defining $\Xi_{j,t}$ as the set of all vintages of machines held by the firm j at time t, firm *j* decides to scrap the machine $A_i^\tau \in \Xi_{j,t}$ if:

$$\frac{p_{j,t}^*}{c_{j,t}^{A_i^\tau} - c_{j,t}^*} \leq b \qquad (xiii)$$

where $p_{j,t}^*$ is the price of the new machine and the denominator represents the difference between the unit cost of production of the machine A_i^τ and the new machine. b is the payback parameter. Desired replacement investment (SI_j^d) is then calculated as the sum of all the machines scrapped following the payback rule. Total investment is the sum of expansionary and replacement investment.

Capital-good supplier are chosen comparing price and productivity of the machines for which consumption good firms have received brochures. Machines production is a time-consuming process and, therefore, machines enter in the capital stock of consumption firms one period after their demand. In every period, therefore, the stock of machines held by consumption-good firms is given. Given the stock of machine held ($\Xi_{j,t}$), firms calculate their unit cost of production (c_j) and fix the price applying a variable mark-up over the average unit cost of production:

$$p_{i,t} = (1 + \mu_{j,t}) * c_{j,t} \qquad (xiv)$$

The mark-up decision is done trying to balance the effects of mark-up on profits and on competitiveness. Firms increase their mark-up whenever their market share (f_j) is expanding and decrease it when is contracting:

$$\mu_{j,t} = \mu_{j,t-1} * \left(1 + v * \frac{f_{j,t-1} - f_{j,t-2}}{f_{j,t-1}}\right), \quad 0 < v < 1 \qquad (xv)$$

Imperfect information is also present in the consumption market and consumers do not instantaneously switch to the most competitive producer. Market shares, indeed, evolve according to a (quasi) replicator dynamics where more competitive firms expand their market share while firms with relatively lower competitive firm reduce their market share, or exit the market;

$$f_{j,t} = f_{j,t-1} * \left(1 + \chi * \frac{E_{j,t} - \bar{E}_t}{\bar{E}_t}\right), \qquad \chi > 0 \qquad (xvi)$$

$E_{j,t}$ is the competitiveness of firm j in period t and $\bar{E}_t$ is the average competitiveness in consumption-good sector in the same period. Competitiveness of firms, in turn, depends on the price that they charge on consumers and on their ability to avoid situations of unfilled demand:

$$E_{j,t} = -\omega_1 * p'_{j,t-1} - \omega_2 * l'_{j,t-1} \qquad (xvii)$$

where $p'_{j,t-1}$ and $l'_{j,t-1}$ are the individual normalized prices and unfilled demands.

Entry-exit process

In both sectors there is an endogenous entry-exit process with no imposition of zero net entry. The number of firms, therefore, is free to vary over time. Firms leave the market whenever their market shares get close to zero or their net assets turn negative (bankruptcy). The numbers of new entrants, instead, depends on the number of existing firms in the sector, on the financial situation prevailing in the sector and on a stochastic component (Dosi et al., 1995):

$$b_t^z = max([(1-o) * MA_t^z + o * \pi_t^z] * F_{t-1}^z, 0) \qquad (xviii)$$

where b_t^z is the number of entrants in the sector z ∈ {1,2}, F_{t-1}^z is the number of incumbent firms in the sector and MA_t^z is the entry attractiveness of the sector that is related to the financial conditions of the sector. The entry process depends also on a stochastic component (π^z) modelled as a draw from uniform distribution over a fixed support $[\underline{x}_2, \overline{x}_2]$. The parameter o regulates the relative importance of the stochastic component in the entry process. The entry attractiveness of a sector (MA^z) is defined as:

$$MA_t^z = MC_t^z - MC_{t-1}^z \qquad (xix)$$

where MC_t^z is the financial situation of sector z in time t, represented by the aggregate firms' balance sheet situation that, in turn, is equal to the sum of the assets of the firms (NW_y) minus the sum of the debts of the firms (Deb_y):

$$MC_t^z = \log\left(\sum_y NW_{y,t-1}\right) - \log\left(\sum_y Deb_{y,t-1}\right) \qquad (xx)$$

MA_t^z, therefore, is an indication of the changes in the tightness of the credit market with positive values indicating deleveraged markets and negative values leveraged markets.

The entrant firms get credit from banks to pay for machines and have some seed money. This process, therefore, is completely stock-and-flow consistent.

The financial sector

Firms finance production in advance using accumulated internal founds and demanding credit whenever their internal resources are not enough to finance desired production and investment plans. Credit is provided by a fixed number of banks, up to certain limits fixed by the macroprudential framework (Central Bank). Firms, therefore, may be credit rationed.

The supply of credit of banks is constrained by capital adequacy requirements inspired by Basel-framework rules. Besides the regulatory limit, we assume that banks want to maintain a buffer over the regulatory capital level, in line with the empirical evidence (BIS, 1999). The size of this buffer is not constant over-time since it evolves strategically in order to offset bank financial fragility (proxied by the ratio bad debt/ bank assets). Maximum credit available from bank k a time t therefore is:

$$TC_{k,t} = \frac{NW_{k,t-1}^{b}}{\tau^{b} * \left(1 + \beta * Bda_{k,t-1}\right)} \quad , \quad \tau^{b}, \beta > 0 \qquad (xxi)$$

where $NW_{k,t-1}^{b}$ is the previous period bank's wealth, τ^{b} is the macroprudential regulatory parameter, $Bda_{k,t-1}$ is the ratio between accumulated bad debt and bank assets and β is a parameter which measures the banks' speed of adjustment to its financial fragility.

There is a fixed relationship between banks and firms where the former allocate credit to firms following a pecking order whereby demanding clients are ranked by their creditworthiness proxied by the liquidity-to-sales ratio. Low creditworthiness firms have higher probability to be credit-rationed. In any case, there is a maximum amount of credit that a bank provides to a specific firm and this amount is a function of the past sales of the firm ($S_{j,t.1}$):

$$Deb_{j,t} \leq \lambda * S_{j,t.1}\,, \qquad \lambda \leq 0 \qquad (xxii)$$

Other than provide credit to firms, banks collect firms and workers accumulated wealth and buy Government bonds. Earnings of the banks are the sum of the interests on performing loans, on Government bonds held and on deposits held at the Central Bank. The interest rate on loans is not unique as it depends on the creditworthiness of the client. Banks, indeed, consider idiosyncratic credit risks when they lend money to firms. The costs for the banks, on the other side, are the sum of the interests paid on deposits of firms and workers plus the losses due to non-performing loans. A bank goes bankrupts if it makes negative profits bigger than the net worth of the bank. In those cases, the Government inject capital into the bank to restore the macroprudential capital requirements.

The labour market and the skills dynamics

The labour market is based on a decentralized search and hiring process between workers and firms. Labour demand comes from firms that want expand their labour force while labour supply comes from unemployed and workers in search of better job. This process takes place in a labour market characterized by imperfect information. In every period, workers can submit job applications only to a subset of firms and workers and firms possess information only on the counterparties with whom they come into contact. Hiring firms define a wage offer for the applicant workers and workers select the best offer they get from the firms to which they submitted applications, if any. There are no further rounds of bargaining between firms and workers in the same period. This implies that firms have no guarantee of fulfilling all the open positions and that workers may not find a job.[15]

More in detail, firms in the consumption-good sector[16] decide their desired labour force (L_{j}^{d}) according to the desired production (Q_{j}^{d}) and the average productivity of the capital stock (A_{j}):

$$L_{j,t}^{d} = \frac{Q_{j,t}^{d}}{A_{j,t}} \qquad (xxiii)$$

[15] Given this skeleton, the model is extremely flexible in the determination of the institutional framework that governs this sketched labour market process. For more details see Dosi et al. (2017b, 2018, 2020).

[16] To avoid repetitions, only the consumption-good sector labour market dynamics is sketched.

If the desired labour force is higher than the current labour force, firms open a numbers of job positions (JP_j) equal to:

$$JP_{j,t} = \max\left((1+\theta) * (L^d_{j,t} - L_{j,t-1}), 0\right), \quad \theta \geq 0 \qquad (xxiv)$$

where $L_{j,t-1}$ is the previous period labour force of the firm j and θ is a parameter that is equal or greater than zero.[17] On the supply side, firms receive a numbers of job applications (L^s_j), from unemployed (U) and employed (1-U) searching better work, proportional, in probability, to their market share (f_j):

$$E\left(L^s_{j,t}\right) = (\omega_u * U_{t-1} + \omega_e * (1 - U_{t-1})) * f_{j,t-1}, \qquad \omega_u \geq \omega_e \qquad (xxv)$$

ω_u and ω_e are parameters that determines the number of job-applications that an unemployed and employed make in a single period.

Workers request a wage (w^r_ℓ) equal to:

$$w^r_{\ell,t} = \begin{cases} w_{\ell,t-1} * (1+\varepsilon) & if\ employed\ in\ t-1 \\ max\left\{w^u_t; \frac{1}{T_s}\sum_{h=1}^{T_s} w_{\ell,t-h}\right\} & if\ unemployed\ in\ t-1 \end{cases} \qquad (xxvi)$$

where ε and T_s are parameters and w^u_t is the unemployment subsidy paid by the Government in the period t. Employed workers, therefore, have an increasing requested wage while unemployed individuals present a gradually shrinking satisfying wage, which is equal to a weighted average of the lasts T_s periods salaries received by the worker. In any case, no workers will accept wage lower than the unemployment subsidy.

Workers are heterogenous in terms of skills. Skills acquisition is an endogenous process, inspired to the idea of learning by doing (Arrow, 1962). Specifically, the skills of a worker (s_ℓ) evolves as a multiplicative process, increasing when workers are employed and decreasing during periods of unemployment:

$$s_{\ell,t} = \begin{cases} (1+\tau) * s_{\ell,t-1} & if\ employed\ in\ t-1 \\ \frac{1}{(1+\tau)} * s_{\ell,t-1} & if\ unemployed\ in\ t-1 \end{cases} \qquad (xxvii)$$

Workers' skills define the individual productivity (A_ℓ), for a given vintage A^τ_i, in the following way:

$$A_{\ell,t} = \frac{s_{\ell,t}}{\bar{s}_t} * A^\tau_i \qquad (xxviii)$$

[17] The possibility that firms open more positions than the simple difference between desired and past labour force is justified by the willingness of the firms to reduce the risk of unfilled job positions.

where $\overline{s}_t$ is the average skills level. The ratio ${s_{\ell,t}}/{\overline{s}_t}$ is the normalized worker skills level and higher is that ratio more productive is the worker.

Firms collect received job-applications in their candidates' queue $\{\ell^s_{j,t}\}$ and make a job offer just to a subset of it, if the number of applicants is higher than the opened positions. The subset of workers is decided looking at the skills/requested wage ratio giving preference to workers with the highest ratio.[18] The wage offered by the firms, then, is the minimum wage able to fulfil all the opened positions. On the other hand, workers compare all the offers received and choose the best one, if any.

The Government establishes a minimum wage level, creating a lower bound in the decentralized workers-firms bargaining process. The minimum wage (w^{min}) is linked to average productivity of the economy (A):

$$w_t^{min} = w_{t-1}^{min} * \left(1 + \psi_1 * \frac{\Delta A_t}{A_{t-1}}\right), \qquad \psi_1 > 0 \qquad (xxix)$$

[18] In a specular way, firms fire first the workers with the lowest skills/wage ratio.

Appendix B – parametrization

Parameters	Description	Value
	Technology	
υ	R&D propensity	0.04
ξ	Share of R&D expenditure in innovation	0.5
ζ_1	Search capabilities (innovation)	0.3
ζ_2	Search capabilities (imitation)	0.3
(α_1, β_1)	Beta distribution parameters (innovation process)	(3,3)
(α_2, β_2)	Beta distribution parameters (imitation process)	(2,4)
$[\underline{x}_1, \overline{x}_1]$	Beta distribution support (innovation process)	[−0.15,0.15]
b	Payback	6
	Industrial dynamics	
μ_1	Mark-up in sector 1	0.15
γ	Share of new customers for capital-good firm	0.5
μ_2	Initial mark-up in sector 2	0.20
h	Periods to define expected demand	4
υ	Mark-up sensitiveness (sector 2)	0.04
ι	Desired inventories	0.1
χ	Replicator dynamics	1
ω_1	Competitiveness (price)	1
ω_2	Competitiveness (unfilled demand)	1
o	Stochastic weight in the entry decision	0.5
$[\underline{x}_2, \overline{x}_2]$	Entry distribution support	[−0.15,0.15]
	Government	
g_0	Desired public consumption/GDP ratio (medium term)	0.1
$\overline{tr}^{\pi}$	Tax-rate on profits	0.1
$\overline{tr}^{in}$	Tax-rate on income	0.15
φ_u	Unemployment subsidy rate	0.3
p	Periods to evaluate Medium-term GDP	16
	Credit	
λ	Prudential limit on loans as sales multiple	2
τ^b	Minimum bank capital adequacy rate	0.08
β	Bank sensitivity to financial fragility	1
r	Reference interest rate	0.01
r^d	Interest rate on deposits	0.003
	Labour market	
ω_u, ω_e	Job applications (unemployed, employed)	5,1
ε	Requested wage increase	0.02
T_s	Number of wage memory periods	4
τ	Skills acquisition/deterioration	0.01
θ	Extra job positions	0.01
ψ_1	Minimum wage reaction to productivity	1
φ_b	Bonus rate	0.2
	Number of agents	
F_0^1	Initial number of capital-good firms	20
F_0^2	Initial number of consumption-good firms	200
B	Number of banks	10
L^S	Number of workers	250000

Table B.1 Model parametrization.

Appendix C - Additional figures and tables

Microeconomic Stylized Facts	Aggregate-level Stylized Facts
Skewed firm size distributions	Endogenous self-sustained growth with persistent fluctuations
Fat-tailed firm growth rates distributions	Fat-tailed GDP growth rate distribution
Heterogeneous productivity across firms	Endogenous volatility of GDP, consumption and investment
Persistent productivity differentials	Cross-correlation of macro variables
Lumpy investment rates of firms	Pro-cyclical aggregate R&D investment and net entry of firms in the market
Heterogeneous skills distribution	Persistent and counter-cyclical unemployment
Fat-tailed unemployment time distribution	Endogenous volatility of productivity,
	unemployment, vacancy, separation and hiring rates
	Unemployment and inequality correlation
	Pro-cyclical workers skills accumulation
	Beveridge curve
	Okun curve
	Wage curve
	Matching function

Table C.1 Main stylized facts matched by the K+S labour market model. Source: Dosi et al. (2017b).

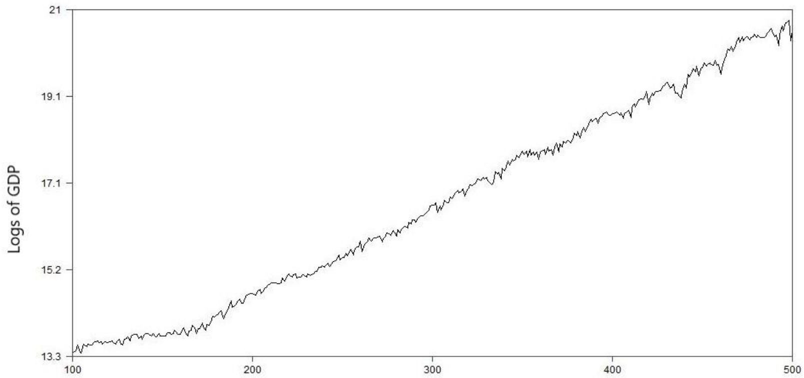

Figure C.1: GDP path (logs). Single simulation selected for example purposes. Simulation periods [100-500].

	Average statistics
GDP growth rate (%)	1.49 (0.27)
Employment rate (%)	79.5 (6.3)
Capacity utilization (%)	82.6 (2.7)
Deficit (% of GDP)	2.07 (1.12)
Debt (% of GDP)	120.8 (95.6)

Table C.2: Time series averages in periods [201,500]. Debt/GDP ratio is evaluated in periods [490,500]. Standard deviations in parentheses. 200 MC runs.

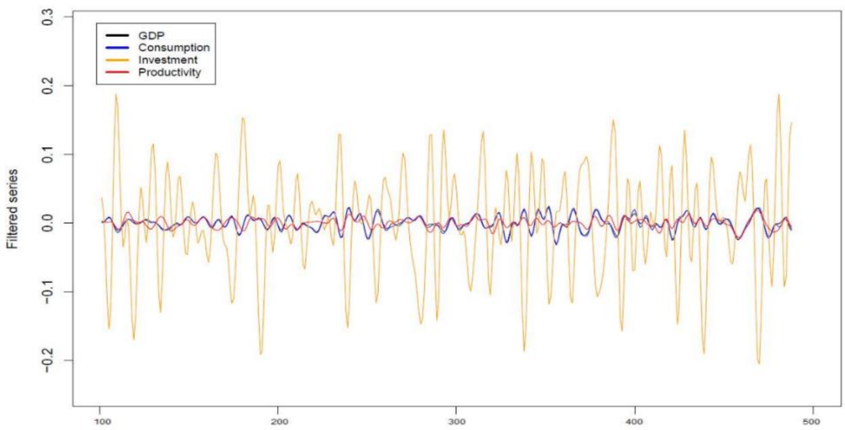

Figure C.2: Band-pass filtered (6,32,12) for GDP, private consumption, investment and productivity series. Simulation periods [100-500]. 200 MC runs.

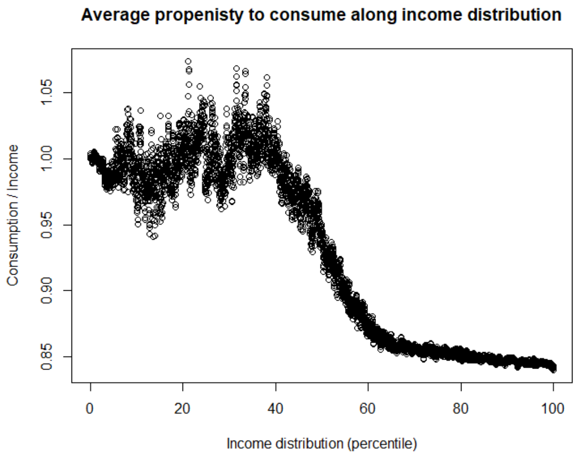

Figure C.3: Average propensity to consume along income distribution. Every dot represents the average marginal propensity to consume in a specific percentile of a specific run. 50 MC runs.

Gini index		
	Value	sd
Consumption	0.182	0.076
Income	0.224	0.061
Wealth	0.408	0.089

Table C.3: Consumption, income and wealth inequality: Gini index. 200 MC runs.

	Dependent variable:
	Apc
Income growth	-0.299***
	(0.008)
Constant	0.917***
	(0.003)
Observations	26,387
R2	0.056
Adjusted R2	0.056
F Statistic	1,578.968*** (df = 1; 26385)
Note:	*p<0.1; **p<0.05; ***p<0.01

Figure C.4: Results of OLS regression between individual average propensity to consume and individual income growth.

Figure C.5: Average wealth/income ratio. Left: over time; right: along income distribution. 50 MC runs.

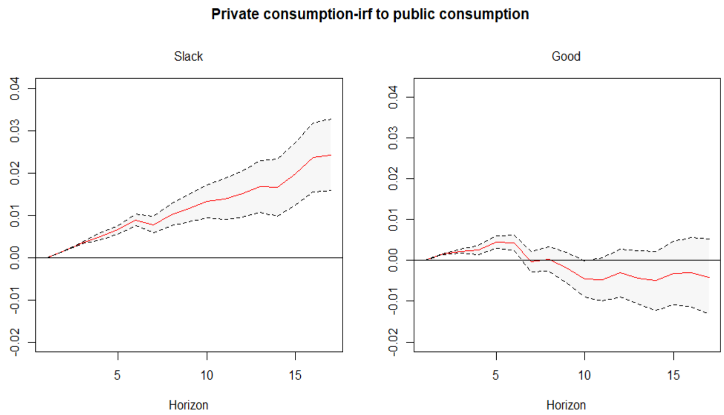

Figure C.6: State-dependent impulse responses of private consumption to public consumption stimulus in deficit. Red line: average effect; black dashed lines: 90% confidence intervals. Results are in terms of one period before the shock values. Slack sample (sample size: 603) is obtained by merging low utilization, high unemployment and recession samples. Good sample (sample size: 622) is obtained by merging high utilization, low unemployment and expansion samples.

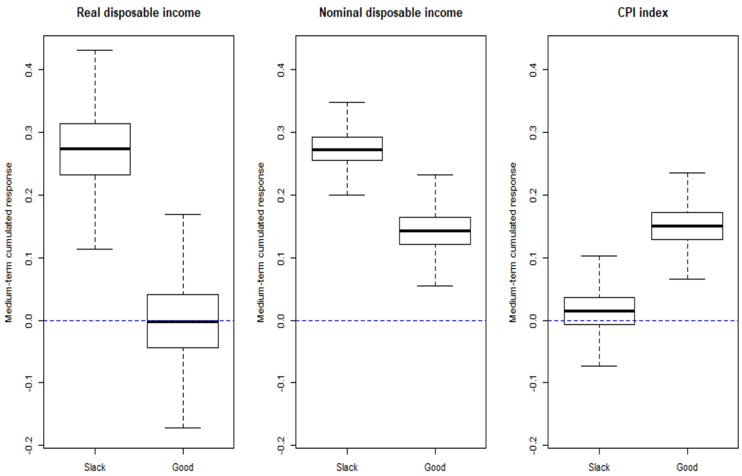

Figure C.7: State-dependent cumulated medium-term reaction of real disposable income (left), nominal disposable income (middle) and CPI index (right) to public consumption stimulus in deficit. Bootstrap replications: 10.000. Slack sample (sample size: 603) is obtained by merging low utilization, high unemployment and recession samples. Good sample (sample size: 622) is obtained by merging high utilization, low unemployment and expansion samples.

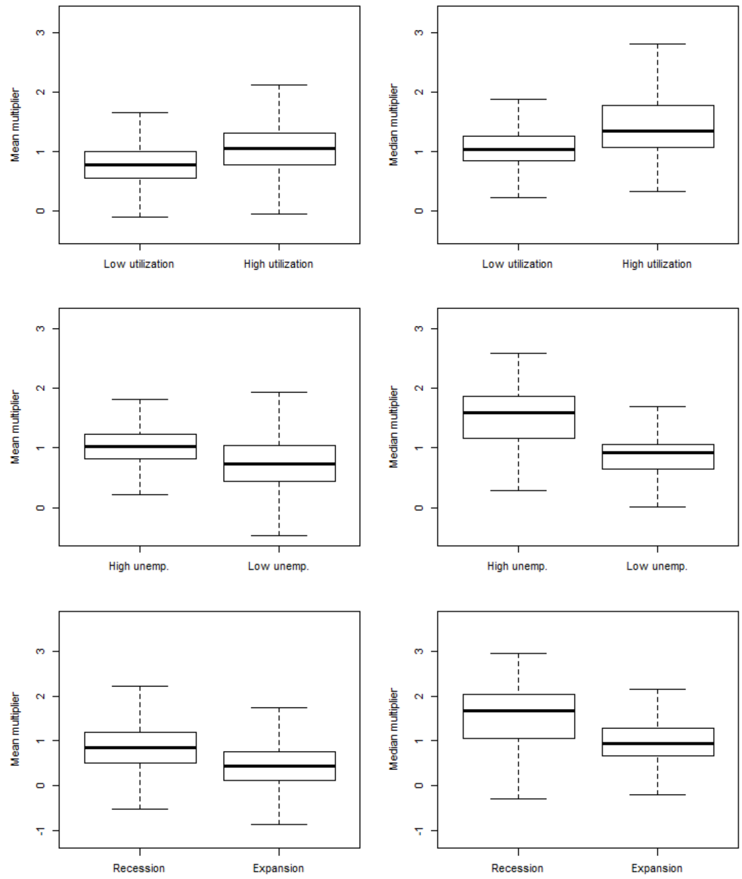

Figure C.8: Boxplots for state-dependent income tax rate medium-term cumulative multipliers. Left column: mean multipliers; Right column: median multipliers. Bootstrap replications: 10.000. Sample size: low utilization = 242; high utilization = 258; high unemployment = 298; low unemployment = 202; recession = 63; expansion = 148.