Journal of Economic Behavior and Organization 212 (2023) 466–481

Contents lists available at ScienceDirect

Journal of Economic Behavior and Organization

journal homepage: www.elsevier.com/locate/jebo

Interactions of fiscal and monetary policies under waves of optimism and pessimism

Paul De Grauwe[a,b,*], Pasquale Foresti[c,a]

[a] The London School of Economics, United Kingdom
[b] CEPR, United States
[c] University of Roehampton London, United Kingdom

ARTICLE INFO

Article history:
Received 3 October 2022
Revised 17 May 2023
Accepted 20 May 2023

JEL classification:
E52
E61
F33
F36

Keywords:
Monetary policy
Fiscal policy
Beliefs
Heuristics
Animal spirits

ABSTRACT

In this article we study fiscal and monetary policies interaction under the assumption that agents have limited cognitive capabilities. To this aim, we employ a behavioral New Keynesian model in which agents' beliefs generate endogenous waves of optimism and pessimism. The role of such waves is studied under three alternative policy setups: fiscal dominance, monetary dominance and no dominance. Output, inflation, government spending and public debt result to be strongly linked to the agents' beliefs irrespectively of the policy regime. However, under fiscal dominance the system is characterized by more persistent waves of optimism and pessimism. The consequent higher volatility of the system under fiscal dominance also undermines the central bank's credibility. We show that in order to minimize these negative effects of fiscal dominance, under such a regime governments should focus on public debt stabilization and leave the stabilization of output and inflation to the monetary authority.

1. Introduction

Following the renewed interest in the joint role that fiscal and monetary policies can play in stabilizing the economy, a growing body of literature has focused on the design of the right policy-mix. This has involved both dynamic (Schmitt-Grohé and Uribe, 2007; Kirsanova et al., 2009; Engwerda et al., 2013; Saltari et al., 2021) and static (Dixit and Lambertini, 2003a; 2003b; Foresti, 2018; Di Bartolomeo and Giuli, 2011) analyses of the interactions between fiscal and monetary policies.

A large part of this literature has modeled the interaction between fiscal and monetary authorities in a strategic way and has looked at how different assumptions about the interaction can affect the outcome of the policy-mix. The relevance of this kind of analysis is supported by a substantial amount of recent empirical studies showing how different countries are characterized by different dominance regimes. For instance, Fragetta and Kirsanova (2010) show that a regime of fiscal dominance applies to the UK and Sweden, while in the US authorities seem to interact without any dominance so that their interaction can be better approximated by a Nash game.

Clearly, a different structure in the fiscal-monetary policy interaction has different implications for both the outcome and the institutional design of the policy-mix. For instance, existing contributions highlight that, when compared to a Nash game,

* Corresponding author.
E-mail addresses: p.c.de-grauwe@lse.ac.uk (P. De Grauwe), pasquale.foresti@roehampton.ac.uk, p.foresti@lse.ac.uk (P. Foresti).

https://doi.org/10.1016/j.jebo.2023.05.024

fiscal dominance can improve the outcome of the policy-mix if the central bank is hard-nosed (Dixit and Lambertini, 2003a). At the same time, the potential harm generated by the absence of leadership increases if the fiscal authority discounts the future too much, and/or aims for excess output (Kirsanova et al., 2005).

The contribution of the present article is to study the impact of different policy regimes assuming that agents follow simple heuristics when forming their expectations. To this aim, the research methodology adopted in his paper is closely related to the work of Peter Flaschel in many respects. First, we depart from the rational expectations assumption and present a behavioural New Keynesian model with heterogeneous expectations formation for output, inflation and government spending (Flaschel et al., 2015; 2018). Second, similar to Flaschel et al. (2015), we assume that agents can be either fundamentalists or extrapolators when forming their expectations. We introduce rationality by allowing agents to revise their forecasting rules. The adopted learning mechanism creates a further point of contact with the work of Flaschel as it generates endogenous waves of optimism and pessimism (Flaschel et al., 2018). Finally, we study how, given the presence of these destabilizing waves, the economy can be stabilized under different fiscal-monetary policies arrangements (Asada et al., 2010; Charpe et al., 2011; Chiarella et al., 2005; 2012). Overall, this approach allows us to focus on aspects that are largely ignored in the existing literature but that were also central in Peter Flaschel's truly inspiring research agenda.

First, we analyze the basic properties of the model by assuming that the interaction between fiscal and monetary policy takes place without any leading role by one of the two authorities. Then, we look at the different implications from fiscal or monetary dominance. Specifically, we study how the policy-mix can be used to reduce the impact of booms and busts.

The analysis of the regime in which no authority has a dominant position provides the following basic results. Output and government spending are strongly linked to agents' beliefs. Furthermore, we show that the capability of the central bank to keep inflation close to its target affects monetary policy credibility via the learning mechanism. All these results occur irrespectively of the policy regime. We also show that the government faces a trade-off between the stabilization of public debt and of the animal spirits.

Based on these basic results of our model, we analyze the main differences between the alternative policy regimes.

Under fiscal dominance the system is exposed to more persistent waves of optimism and pessimism when compared to monetary dominance. In a broader perspective, under fiscal dominance the model shows higher volatility in all its crucial variables, except for public debt.

We show that, under our specification of fiscal dominance, the government forces the central bank to contribute to public debt stabilization. As a result, the government is able to avoid the policy trade-off between the stabilization of output and public debt. However, this also reduces the central bank's ability to stabilize output and inflation, causing the higher volatility and the more persistent waves of optimism and pessimism under fiscal dominance.

We also show that under fiscal dominance, monetary conservatism is negatively affected due to the higher inflation volatility around the central bank's target. By looking at the impact of this on agents' beliefs, we then demonstrate that fiscal dominance also undermines the central bank's credibility.

Finally, the model allows us to show that the unattractive features of fiscal dominance become less pronounced when the government focuses on debt stabilization. We conclude from this that under fiscal dominance the policy-mix is most effective when the government focuses exclusively on public debt stabilization while the stabilization of the output is left to the central bank.

The paper is organized as follows. In Section 2, we derive the equations of the model and discuss its calibration. In Section 3, we present the basic properties of the model. In Section 4, we compare the results of the model under the alternative settings of fiscal and monetary dominance. Section 5 concludes the paper.

2. The model

Our analysis is based on a micro founded heterogeneous-agent New Keynesian model. The economy is characterized by an aggregate demand, a Phillips curve and a public debt equation. The forecasts of output, inflation and government spending are based on simple heuristics. Thanks to a learning mechanism, the model generates endogenous waves of optimism and pessimism that we summarize in two variables: animal spirits and fiscal beliefs. The policy block is then specified with simple linear monetary and fiscal rules allowing for three alternative policy setups: fiscal dominance, monetary dominance and no dominance.

2.1. The economy

The characterization of the equations representing the economy includes a unit mass of households and firms. By aggregating and linearizing the optimal choices of representative household and firm, we retrieve the equations of the aggregate demand and of the Phillips curve. Households are allowed to invest in government bonds, so the model considers also the evolution of public debt.

Households

Each household $i \in [0,1]$ maximizes a utility function defined over consumption (C_t^i) and labor (N_t^i)

$$\tilde{\mathbb{E}}_t^i \sum_{s=t}^{\infty} \beta^s \left[\frac{(C_s^i)^{1-\sigma}}{1-\sigma} - \frac{(N_s^i)^{1+\eta}}{1+\eta} \right] \tag{1}$$

Where C_t^i is an index defined, over the good variety $j \in [0,1]$, by the following CES function, $C_t^i = (\int_0^1 C_t^i(j)^{\frac{\theta-1}{\theta}} dj)^{\frac{\theta}{\theta-1}}$. Furthermore, the parameters σ and η represent the inverses of the inter-temporal elasticity of consumption and of the Frisch elasticity of labor supply, respectively.

The utility function is maximized subject to the following budget constraint

$$P_t C_t^i + \frac{D_{t+1}^i}{1+r_t} \leq D_t^i + (1-\tau)\Big[W_t N_t^i + P_t \Xi_t(j)\Big] \tag{2}$$

In which, W_t is the nominal wage rate, D_{t+1}^i is the nominal payoff of the one period risk-free government bonds held, r_t is the nominal interest rate, τ is the constant income tax rate, while $\Xi_t(j)$ represents firm j's real profits. The aggregate price index in equation (2) is defined as $P_t = (\int_0^1 P_t(j)^{1-\theta} dj)^{\frac{1}{1-\theta}}$.

By optimizing, we can retrieve the following standard Euler (in which $\Pi_{t+1} = \frac{P_{t+1}}{P_t}$) and real wage ($w_t = \frac{W_t}{P_t}$) equations[1]

$$\frac{(C_t^i)^{-\sigma}}{1+r_t} = \beta \tilde{\mathbb{E}}_t^i \left[\frac{(C_{t+1}^i)^{-\sigma}}{\Pi_{t+1}} \right] \tag{3}$$

$$w_t = \frac{(N_t^i)^{\eta} (C_t^i)^{\sigma}}{1-\tau} \tag{4}$$

Equations (3) and (4) must hold in the equilibrium together with the budget constraint.

Firms

The model includes a continuum of monopolistically competitive firms.[2] Each firm $j \in [0,1]$ produces a differentiated good using a technology that can be represented by the following production function

$$Y_t(j) = AN_t(j) \tag{5}$$

Where A is the aggregate productivity parameter that, without loss of generality, we set equal to 1.

Each firm j maximizes its profit that we write as

$$P_t \Xi_t(j) = P_t(j) Y_t(j) - mc_t Y_t(j) P_t - \frac{\phi}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 Y_t P_t \tag{6}$$

Where we have assumed that firms face a quadratic cost of adjusting nominal prices, that measured in terms of the final good is written as $\frac{\phi}{2}(\frac{P_t(j)}{P_{t-1}(j)} - 1)^2 Y_t$ (see Rotemberg, 1982). Furthermore, mc_t represents the firm's marginal cost of production. Equation (6) can be written, by using the price index, as

$$P_t \Xi_t(j) = P_t(j)^{1-\theta} P_t^{\theta} Y_t - mc_t P_t(j)^{-\theta} P_t^{1+\theta} Y_t - \frac{\phi}{2}\left(\frac{P_t(j)}{P_{t-1}(j)} - 1 \right)^2 Y_t P_t \tag{7}$$

Then, by optimizing with respect to $P_t(j)$, we obtain the following equation[3]

$$\begin{aligned}(\theta-1)\frac{P_t(j)Y_t(j)}{P_t Y_t} &+ \phi \Pi_t(j)(\Pi_t(j)-1) \\ &= \theta mc_t \frac{Y_t(j)}{Y_t} + \phi\beta \tilde{\mathbb{E}}_t^j \left[\left(\frac{C_{t+1}^j}{C_t^j} \right)^{-\sigma} \frac{Y_{t+1}}{Y_t} \Pi_{t+1}(j)(\Pi_{t+1}(j)-1) \right]\end{aligned} \tag{8}$$

[1] See Appendix I for further details.

[2] Note that, in line with our specification of Eq. (2), we assume that each firm is run by a household. Therefore, firms' heuristics for predicting future variables correspond to the ones of their respective household.

[3] See Appendix I for further details.

Aggregation and Log-linearization

Based on the assumption of the adjustment costs á la Rotemberg, the resource constraint of the economy is the following

$$Y_t = C_t + G_t + \frac{\phi}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 Y_t = C_t + g_t Y_t + \frac{\phi}{2}\left(\frac{P_t}{P_{t-1}} - 1\right)^2 Y_t \tag{9}$$

Where G_t is total public spending and g_t represents spending as a percentage of GDP.

The representation of the economy requires the specification of an equation identifying the evolution of the total public debt. With debt (D) measured at the beginning of the period, its law of motion can be represented as (see Kirsanova et al., 2007; Blake and Kirsanova, 2012; Kirsanova and Wren-Lewis, 2012)

$$D_{t+1} = (1 + r_t)(D_t + P_t G_t - \tau P_t Y_t) \tag{10}$$

As a final step, we aggregate the relevant equations and represent them in their log-linear form. To this aim, the model is log-linearized around a zero inflation steady state (the rest point of the model in absence of shocks).

First, we derive the aggregate demand that, by using Eqs. (3) and (9), can be written as[4]

$$\hat{Y}_t = \tilde{\mathbb{E}}_t \hat{Y}_{t+1} - \frac{\bar{g}}{1-\bar{g}}(\tilde{\mathbb{E}}_t \hat{g}_{t+1} - \hat{g}_t) - \frac{1}{\sigma}(\hat{r}_t - \tilde{\mathbb{E}}_t \pi_{t+1}) + \epsilon_t \tag{11}$$

Where $\bar{g}$ is the public spending to income ratio in the steady state.[5]

Similarly, Eq. (8) implies the following Phillips curve equation

$$\pi_t = \beta \tilde{\mathbb{E}}_t \pi_{t+1} + k(\sigma + \eta)\hat{Y}_t - k\sigma \frac{\bar{g}}{1-\bar{g}} \hat{g}_t + \xi_t \tag{12}$$

Where $k = \frac{\theta - 1}{\phi}$.

Finally, defining a measure of real debt as $d_{t+1} = \frac{D_{t+1}}{P_t}$, the log-linearized version of the government budget constraint (10) is the following

$$\hat{d}_{t+1} = \hat{r}_t + (1 + \bar{r})\left[\hat{d}_t - \pi_t + \frac{\bar{g}}{\chi}\hat{g}_t + \left(\frac{\bar{g} - \tau}{\chi}\right)\hat{Y}_t\right] + \phi_t \tag{13}$$

Where $\bar{r}$ and χ are the interest rate and the ratio of public debt to output in the steady state, respectively.

We have added demand (ϵ_t), supply (ξ_t) and public debt (ϕ_t) shocks to their respective equations. These shocks are all assumed to be normally distributed with constant standard deviation.

Equations (11), (12) and (13) represent the evolution of the economy that needs to be completed by specifying the setting of the monetary and fiscal policy variables.

2.2. Policy setup

In the specification of the policy setup, we assume that policy makers interact non-cooperatively by using simple linear monetary and fiscal rules with feedback coefficients on variables of interest. We specify the policy rules in a non-optimizing framework in a way similar to Fragetta and Kirsanova (2010). A non-optimizing framework can easily mimic a linear-quadratic optimization problem because the solution to the latter can be written as a pair of linear policy rules. This can then be modeled in a simplified and tractable way as follows. Depending on the policy regime, the specification of the related rules changes and can include additional terms with contemporaneous policy variables. In our model, the central bank's instrument is the interest rate[6], while the government is assumed to perform fiscal policy by modifying public spending. We consider three alternative interaction regimes: Fiscal dominance (FD), Monetary dominance (MD) and No dominance (ND). We follow Fragetta and Kirsanova (2010) and define these policy setups as follows[7]:

- Under ND, the authorities make decisions simultaneously without taking into account each other's reaction, meaning that the contemporary fiscal instrument does not directly affect monetary decisions and the contemporary monetary instrument does not directly affect fiscal policy. However, as we assume instrument smoothing, each policy rule is affected by the other authority's policy instrument with one lag. This is due to the fact that past policy variables (in our case interest rate and spending) become predetermined state variables when the authorities smooth their respective policy instruments.

[4] Where the symbol ˆ indicates that variables are measured in log-deviations from their steady-state values. Further details on the aggregation and linearization are provided in Appendix III.

[5] See Appendix II for the characterization of the steady state.

[6] In the specification of the monetary rule we assume that the central bank targets a zero inflation rate. In this way, the inflation target corresponds to its steady state value.

[7] It is worth noting that in the published version the authors consider only two setups (corresponding to our FD and ND), while the setup representing MD is considered only in the working paper version.

- Under FD, the fiscal authority leads and is able to affect monetary policy. This implies that the contemporaneous fiscal variable (public spending) enters the monetary rule. At the same time, the contemporaneous interest rate does not enter the fiscal rule because, due to its dominant position, the government sets spending independently from the central bank's decisions.
- Under MD, the central bank leads and influences fiscal decisions. This implies that the contemporaneous monetary policy variable (interest rate) affects fiscal decisions and therefore it enters the fiscal policy rule. At the same time, the contemporaneous fiscal policy variable does not affect monetary policy because in this case it's the central bank that takes policy decisions independently from the government's ones.

In order to allow the setup to consider these three alternative regimes, the monetary and fiscal rules are written as

$$\hat{r}_t = c_1\pi_t + c_2\hat{Y}_t + c_3\hat{r}_{t-1} + c_4\hat{g}_{t-1} + c_5\hat{g}_t + \mu_t \tag{14}$$

$$\hat{g}_t = f_1\hat{g}_{t-1} - f_2\hat{Y}_{t-1} - f_3\hat{d}_{t-1} + f_4\hat{r}_{t-1} + f_5\hat{r}_t + \nu_t \tag{15}$$

Equation (14) is an augmented Taylor rule, where the central bank reacts to changes in inflation and output via parameters c_1 and c_2, respectively. The parameter c_3 measures the degree of interest rate smoothing, while μ_t represents a monetary shock.

The fiscal rule (15) follows the same logic but we assume that the government reacts to the variables of interest (output via f_2 and public debt via f_3) with one lag as it needs one period to process and implement fiscal adjustments (see for instance, Muscatelli and Tirelli, 2005). This reflects the fact that fiscal decisions are normally taken at a lower frequency and are the result of a longer decisional process when compared to monetary policies. The parameter f_1 measures the degree of policy instrument smoothing faced by the fiscal authority and ν_t indicates a fiscal policy shock.

The identification of the three alternative policy regimes is obtained by setting the values of the remaining parameters $c_4,\ c_5,\ f_4$ and f_5 accordingly. As in Fragetta and Kirsanova (2010), we set the parameters as follows. In the ND scenario, both authorities act without taking into account each other's reaction. This implies that the contemporaneous interest rate and public spending do not directly affect each other. However, as we assume that authorities smooth their respective policy instruments, the interaction still occurs via their lagged observations.[8] This is formalized by setting $c_4 \neq 0,\ c_5 = 0,\ f_4 \neq 0$ and $f_5 = 0$ in Eqs. (14) and (15). Under FD, the fiscal authority is able to contemporaneously affect the interest rate rule. Formally, this implies $c_4 \neq 0,\ c_5 \neq 0,\ f_4 \neq 0$ and $f_5 = 0$. The opposite occurs in case of MD, that is formalized as $c_4 \neq 0,\ c_5 = 0,\ f_4 \neq 0$ and $f_5 \neq 0$.

2.3. Expectations

In our model, we depart from the assumption of rational expectations and assume that agents use simple rules, heuristics, in order to forecast output, inflation and public spending. Specifically, we follow Brock and Hommes (1997) and De Grauwe and Foresti (2020) by assuming that agents can use two alternative forecasting rules

$$Fundamentalist\quad rules:\quad \tilde{\mathbb{E}}^f_t\hat{Y}_{t+1} = 0;\ \tilde{\mathbb{E}}^f_t\pi_{t+1} = 0;\ \tilde{\mathbb{E}}^f_t\hat{g}_{t+1} = 0 \tag{16}$$

$$Extrapolative\quad rules:\quad \tilde{\mathbb{E}}^e_t\hat{Y}_{t+1} = \hat{Y}_{t-1};\ \tilde{\mathbb{E}}^e_t\pi_{t+1} = \pi_{t-1};\ \tilde{\mathbb{E}}^e_t\hat{g}_{t+1} = \hat{g}_{t-1} \tag{17}$$

According to equation (17), extrapolators forecast the variable by using its most recent observation, while equation (16) means that fundamentalists forecast it by using the steady state value of the variable. Note that given the assumption that the central bank targets a zero inflation rate, inflation fundamentalists can also be interpreted as the agents using the central bank's target as a reference value for their expectations.

The aggregate output forecast is given by the weighted average between the two rules

$$\tilde{\mathbb{E}}_t\hat{Y}_{t+1} = \alpha^y_{f,t}\tilde{\mathbb{E}}^f_t\hat{Y}_{t+1} + \alpha^y_{e,t}\tilde{\mathbb{E}}^e_t\hat{Y}_{t+1} \tag{18}$$

Where $\alpha^y_{f,t}$ and $\alpha^y_{e,t}$ are the probabilities that agents use the fundamentalist and extrapolative rule when forecasting $\hat{Y}_{t+1}$ (then $\alpha^y_{f,t} + \alpha^y_{e,t} = 1$). The same applies to inflation and government spending. Note that these probabilities also represent the fractions of agents using the two rules. However, these fractions are not constant as agents are able to revise their expectations and move from one rule to another. To this aim, they use the mean squared forecasting errors of the two rules in order to measure their performance (L) as follows

$$L^y_{f,t} = -\sum_{k=0}^{\infty}\omega_k[\hat{Y}_{t-k-1} - \tilde{\mathbb{E}}^f_{t-k-2}\hat{Y}_{t-k-1}]^2 \tag{19}$$

[8] As clarified also in Fragetta and Kirsanova (2010), under the assumption that the two policy rules are persistent, the two policy instruments become state variables. This implies that $f_4 \neq 0$ and $c_4 \neq 0$ in Eqs. (14) and (15) irrespective of the interaction regime.

$$L^y_{e,t} = -\sum_{k=0}^{\infty}\omega_k[\hat{Y}_{t-k-1} - \tilde{\mathbb{E}}^e_{t-k-2}\hat{Y}_{t-k-1}]^2 \tag{20}$$

We assume the weights assigned to each error in time (ω_k) as declining and define them as $\omega_k = (1-\rho)\rho^k$, with $0 \leq \rho \leq 1$. Then, following Anderson et al. (1992), we obtain the probabilities of choosing the two rules as

$$\alpha^y_{f,t} = \frac{exp(\gamma L^y_{f,t})}{exp(\gamma L^y_{f,t}) + exp(\gamma L^y_{e,t})} \tag{21}$$

$$\alpha^y_{e,t} = \frac{exp(\gamma L^y_{e,t})}{exp(\gamma L^y_{f,t}) + exp(\gamma L^y_{e,t})} = 1 - \alpha^y_{f,t} \tag{22}$$

These equations show how the fractions of agents using each rule are not constant and change according to their performance. According to equations (21) and (22), the distribution of agents in the two rules is also determined by γ. This parameter measures the agents' willingness to learn (see De Grauwe, 2012). Thus, the selection mechanism that we employ should be interpreted as a learning mechanism based on trial and error. When agents observe that the rule they use performs less well than the alternative one, they are willing to switch to the more performing rule.

The same learning mechanism applies to the expectations formation of inflation and government spending.

2.4. Animal spirits and fiscal beliefs

The model specification of expectations allows us to define indices measuring agents' beliefs.

First, we use the fractions of output fundamentalists and extrapolators to define a variable measuring the animal spirits (De Grauwe and Ji, 2019)

$$AS_t = \begin{cases} \alpha^y_{e,t} - \alpha^y_{f,t} & if \quad \hat{Y}_{t-1} > 0, \\ -\alpha^y_{e,t} + \alpha^y_{f,t} & if \quad \hat{Y}_{t-1} < 0. \end{cases} \tag{23}$$

AS_t ranges between -1 (indicating the maximum level of pessimism) and $+1$ (indicating maximum level of optimism). When $\hat{Y}_{t-1} > 0$, a fraction $\alpha^y_{e,t}$ (extrapolators) of agents forecast a positive output gap. These agents are then defined as optimist. At the same time, the other fraction $\alpha^y_{f,t}$ (fundamentalists) makes a pessimistic forecast as these agents expect the positive gap to go back to zero. These agents are then defined as pessimist. When $\alpha^y_{e,t} = \alpha^y_{f,t}$, market sentiments are neutral and optimism and pessimism cancel out, $AS_t = 0$, and animal spirits do not affect the dynamics of the model. Following the same logic, when $\alpha^y_{e,t} > \alpha^y_{f,t}$ the economy is characterized by waves of optimism ($AS_t > 0$), while if $\alpha^y_{e,t} < \alpha^y_{f,t}$ the economy goes through a phase of pessimism ($AS_t < 0$). Clearly, the opposite reasoning applies when $\hat{Y}_{t-1} < 0$. In such a case, optimism is measured by $\alpha^y_{f,t}$ while pessimism by $\alpha^y_{e,t}$, and the magnitude of the waves of optimism and pessimism is measured by the difference between the two fractions.

A similar approach can be followed to define fiscal beliefs as

$$FB_t = \begin{cases} \alpha^g_{e,t} - \alpha^g_{f,t} & if \quad \hat{g}_{t-1} > 0, \\ -\alpha^g_{e,t} + \alpha^g_{f,t} & if \quad \hat{g}_{t-1} < 0. \end{cases} \tag{24}$$

Also $-1 \leq FB_t \leq +1$ but its interpretation is slightly different. When $\hat{g}_{t-1} > 0$, extrapolators ($\alpha^g_{e,t}$) expect a fiscal expansion, while fundamentalists ($\alpha^g_{f,t}$) expect a restrictive fiscal policy. The opposite occurs when $\hat{g}_{t-1} < 0$. Fiscal beliefs in the economy are then generated by the difference between the fractions of the two agent types. When $FB_t > 0$, fiscal beliefs are characterized by an increase in government spending, while the opposite occurs when $FB_t < 0$. Again, the magnitude of such beliefs depends on the difference between $\alpha^g_{f,t}$ and $\alpha^g_{e,t}$. In the extreme cases, if $FB_t = 1$ all agents expect an increase in public spending, while when $FB_t = -1$ every agent expects a reduction in spending.

2.5. Summary of the model and calibration

The complete model can be summarized as follows. It includes the aggregate demand (11), the Phillips curve (12), the monetary and fiscal policy rules (14) and (15), and the equation representing the evolution of public debt (13). The expectations evolve according to the principles enunciated in Eqs. (16)-(22). The model is then completed by measuring animal spirits and fiscal beliefs with equations (23) and (24).

The model is simulated according to the parameters calibration over quarterly observations, meaning that β=0.99 and therefore $\bar{r} = 0.01$. For the aggregate demand, Phillips curve and public debt equations, we calibrate the parameters to match standard macroeconomic simulation results. This ensures any potential comparability with the baseline macroeconomic model. In the demand function, we set $\sigma = 2$ and $\bar{g} = 0.21$ (Hommes et al., 2018). For the supply function we set $\eta = 2$, as well as $\phi = 100$ and $\theta = 6$, which imply $k = \frac{\theta-1}{\phi} = 0.05$ (Hommes et al., 2018). Finally, we assume that debt to output ratio in the equilibrium is 60%, so we set $\chi = 0.6$ (Kirsanova et al., 2007; Kirsanova and Wren-Lewis, 2012). Then, $\tau = 0.216$ has been retrieved from the debt to output equation in the steady state, $\tau = (1 - \beta)\chi + \bar{g}$.[9] Also for the calibration of the policy block, we tried to be as consistent as possible with the intervening literature. We apply the Taylor principle and set $c_1 = 1.5$ in the monetary policy function. In the calibration of the fiscal policy rule, we set $f_2 = 0.6$ and $f_3 = 0.05$ (De Grauwe and Foresti, 2020). Furthermore, we assume policy instruments smoothing and set $c_3 = 0.5$ and $f_1 = 0.5$ (Woodford, 2003; De Grauwe, 2012). For the interaction parameters, established values are not available with precision in the literature. For the FD setup, we rely on estimations in Fragetta and Kirsanova (2010) where both c_4 and c_5 have positive sign, so we set $c_4 = 0.025$ and $c_5 = 0.15$. Then, based on this, we also set $f_4 = 0.025$ and $f_5 = 0.15$ in MD.[10] Finally, regarding the expectations equations, we set the parameter of the agents' willingness to learn as $\gamma = 2$ and the memory parameter as $\rho = 0.5$ (De Grauwe, 2012).

3. Expectations and basic properties of the model

We first highlight the main features of the model by simulating it under ND. These characteristics are in line with the literature using this type of models (see Calvert Jump and Levine, 2019; De Grauwe and Ji, 2019; De Grauwe and Foresti, 2020).

Fig. 1 provides information on animal spirits and output from the simulation of the model over 2000 periods. Panel (a) reports the simulated output and animal spirits in the time domain. It shows strong cyclical movements in output that are closely linked to the waves of optimism and pessimism in the market as measured by animal spirits. Firstly, we focus on the waves of optimism and pessimism, whose presence is also documented by representing the animal spirits in the frequency domain (panel (b)). These waves of optimism and pessimism are essentially unpredictable and are grounded in the expectations formation and the learning mechanism of the model. A series of random shocks creates the possibility that one of the two forecasting rules, say the optimistic one, performs better (higher L) than the other. This induces some agents that were using the pessimistic rule to switch to the more performing one. This contagion effect leads to an increasing use of the optimistic rule to forecast output, resulting in a self-fulfilling wave of optimism. Then, following negative stochastic shocks (that can also be the result of fiscal and/or monetary policy decisions) a dent in the performance of the optimistic forecasts is created. The pessimistic belief becomes attractive again. This feature of the model is reflected in the changes in animal spirits as evidenced in both panels (a) and (b). Thus, these waves of optimism and pessimism can be understood as resulting from the learning mechanisms of agents who do not fully understand the underlying model but are continuously searching for the truth. An essential characteristic of this searching mechanism is that it leads to systematic correlation in beliefs (either optimistic or pessimistic ones).

Another relevant insight of Fig. 1 is that such swings in the animal spirits are highly correlated to the output. The link between animal spirits and output is then highlighted in both the time domain in panel (a) and in a scatter diagram in panel (c). There, we can verify that when pessimism dominates, output growth is below average, while in periods of optimism, output growth is above average. The final confirmation of such link is given by the fact that in our simulation the correlation between animal spirits and output is 0.83. In other words, periods of optimism are characterized by booms in economic activity, while periods of pessimism correspond to busts. This link can be easily explained as follows. In a phase of intense optimism in animal spirits, agents forecast positive output growth and behave accordingly. This generates a boom in output via the aggregate demand. The opposite occurs when pessimism dominates. Hence, this systematic correlation is at the core of the booms and busts created in the output. Note also that the frequency distribution of the output is non-Gaussian. It is characterized by excess kurtosis and fat tails. The latter are driven by the extreme values of the animal spirits.

Similar evidence is provided regarding the link between fiscal beliefs and government spending in Fig. 2.

Again, the figures show a strong link between the behavior of fiscal beliefs and public spending. Both panels (a) and (c) highlight that they are closely linked and, according to our simulation, this results in a correlation of 0.89 between the two variables. Government spending reflects the cycles in output, as government stabilizes output by changing its spending with one lag. This is then reflected in the fiscal beliefs that follow the same self-fulfilling mechanism of animal spirits. Thus, also the swings in fiscal beliefs documented in panels (a) and (b) are the result of the expectations formation and learning mechanisms of the model. In periods of optimistic (expansionary) fiscal beliefs, the latter will have a negative impact on output via the aggregate demand. This would allow governments to increase spending and the optimistic beliefs are then vindicated. Thanks to the learning mechanism, the increased performance of optimism will attract other agents from the pessimistic pool. The opposite occurs when pessimism (contractionary) fiscal beliefs dominate. As a result, also fiscal beliefs are self-fulfilling.

In Fig. 3, we also report the time path of inflation together with the fraction of agents using the extrapolative rule. The figure suggests the following link between inflation and agents' heuristics. The fraction of inflation extrapolators fluctuates around 50% (so the same can be said about the inflation fundamentalists) when the inflation rate is around the central bank's target. When the inflation rate moves away from the target declared by the monetary authority, the fraction of

[9] See Appendix II for further details.

[10] Note that $c_5 = 0$ in MD and ND, while $f_5 = 0$ in FD and ND. Furthermore, note that we also present the results of the simulations based on negative signs for the interaction parameters in Appendix IV.

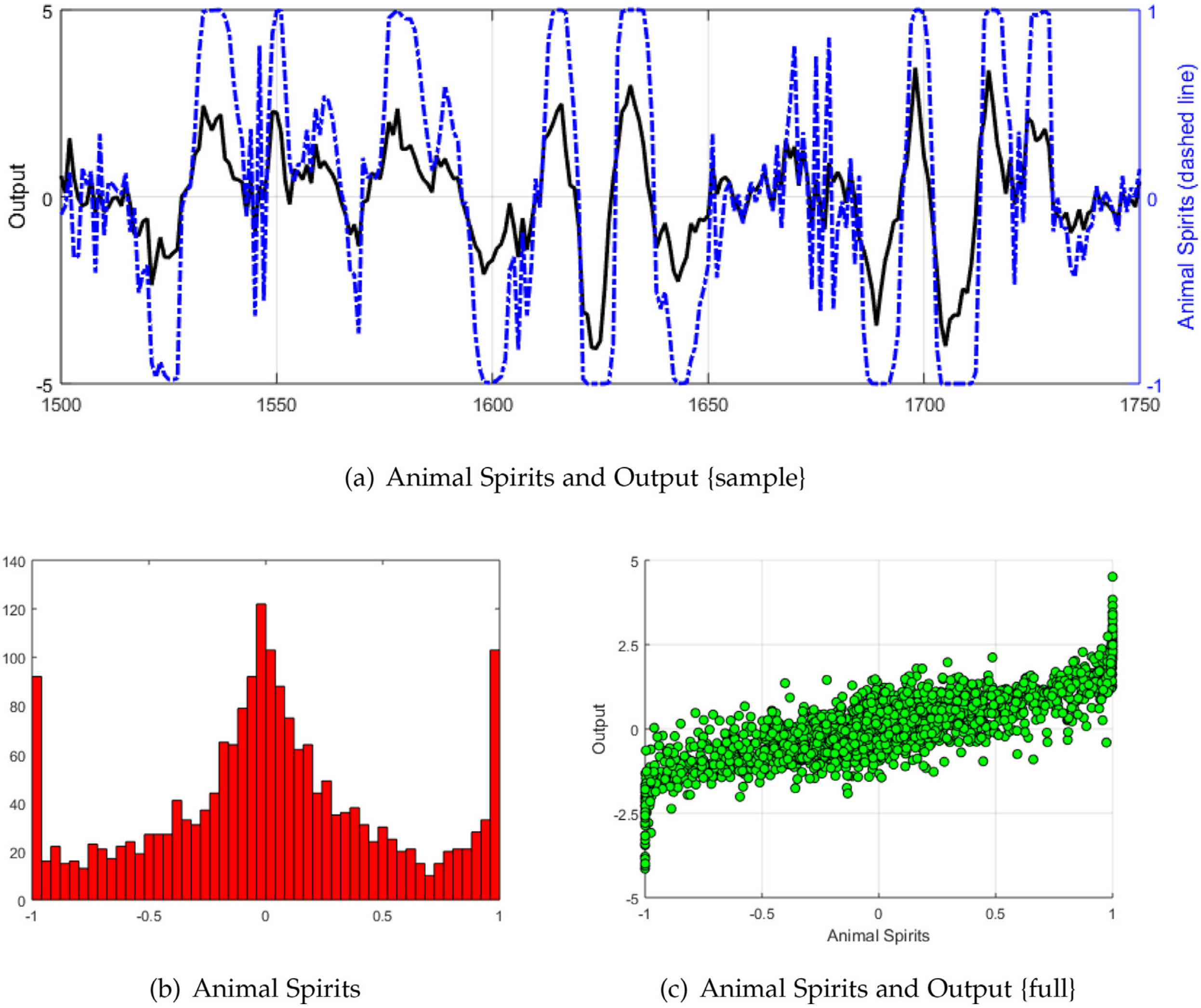


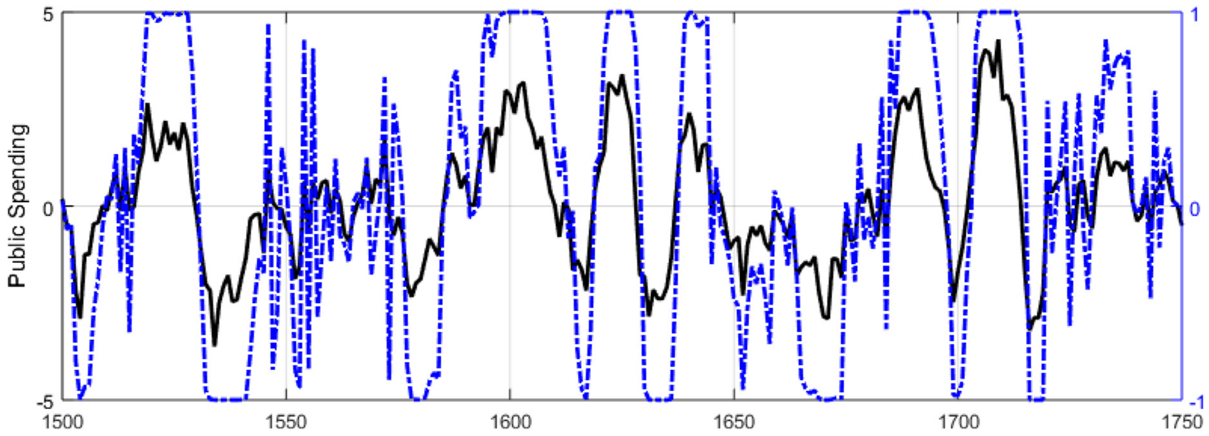
Fig. 1. Animal spirits and output.

fundamentalists sharply declines and more and more agents rely on the extrapolative rule. Therefore, when the central bank is able to keep inflation around the target, a substantial fraction of agents use this target as a reference point when forecasting inflation because they perceive it as a reliable benchmark. On the contrary, in periods when inflation deviates more (both positive and negative deviations) from the target, agents interpret this as a sign of weakness in the central bank's inflation targeting and extrapolators dominate.

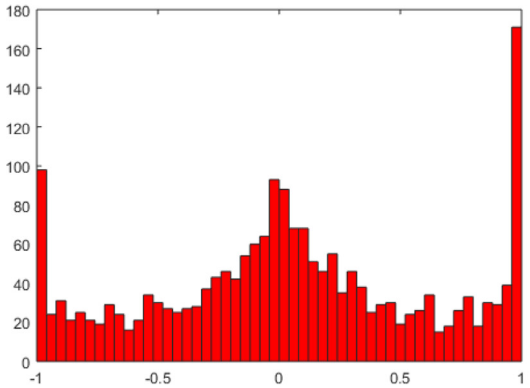
Given that the share of inflation fundamentalists can be considered as a measure of the central bank's policy credibility, Fig. 3 also suggests that the more the monetary authority is able to keep the inflation around its declared target, the higher its credibility.

Another interesting result of the model is the negative relation between animal spirits and public debt. According to our simulations, the correlation between these two variables under ND is -0.35. The existence of such negative link is confirmed by the results reported in Fig. 4. Panel (a) shows how the two variables tend to move in opposite directions. Periods of high public debt are characterized by pessimism, while optimism characterizes the economy when public debt is low.

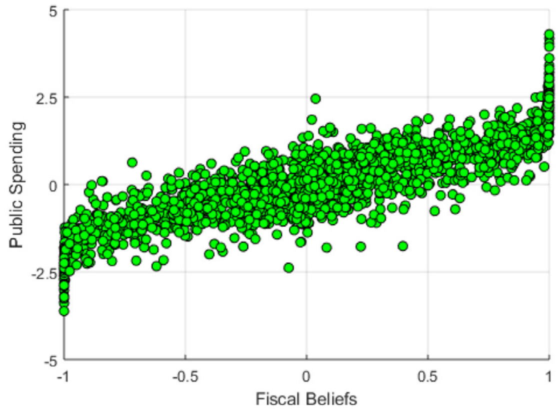
The underlying mechanism is the following. Suppose that an economy is hit by a strong wave of pessimism. Given the high correlation between animal spirits and output, the wave of pessimism translates into a phase of recession. The recession will lead to an automatic increase in the budget deficit and to an increasing public debt. This link suggests the potential existence of a trade-off for the fiscal authorities: attempts at stabilizing output (and then the animal spirits) by fiscal stimulus will increase the budget deficit and raise public debt. The same holds when the economy experiences a boom produced by strong optimism. Therefore, if the government follows a fiscal rule like in equation (15), it will have to choose between the stabilization of the output/animal spirits and the stabilization of public debt. We provide evidence of this trade-off in panels (b) and (c). In panel (b) we report the combinations of the volatility of output and of public debt for



(a) Fiscal Beliefs and Spending {sample}



(b) Fiscal Beliefs



(c) Fiscal Beliefs and Spending {full}

Fig. 2. Fiscal beliefs and government spending.

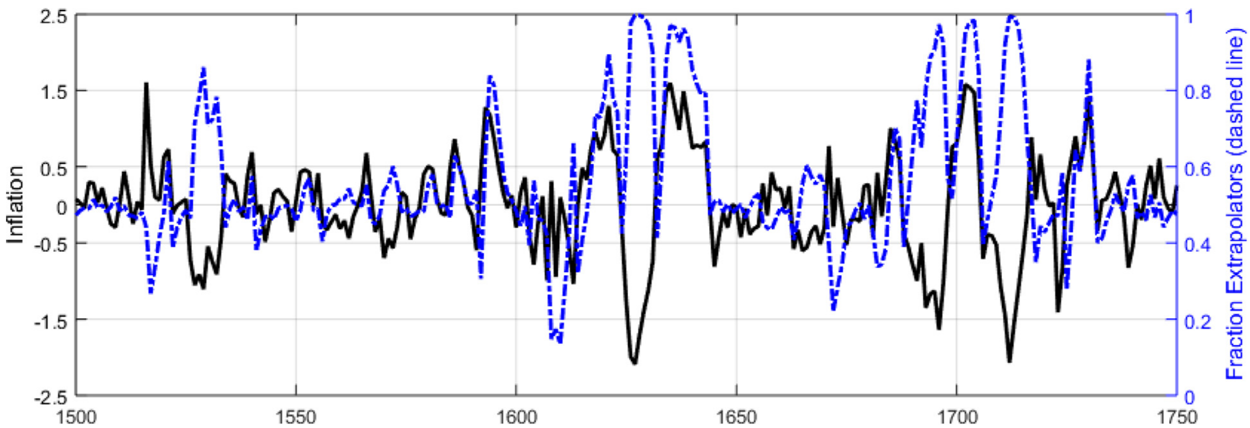
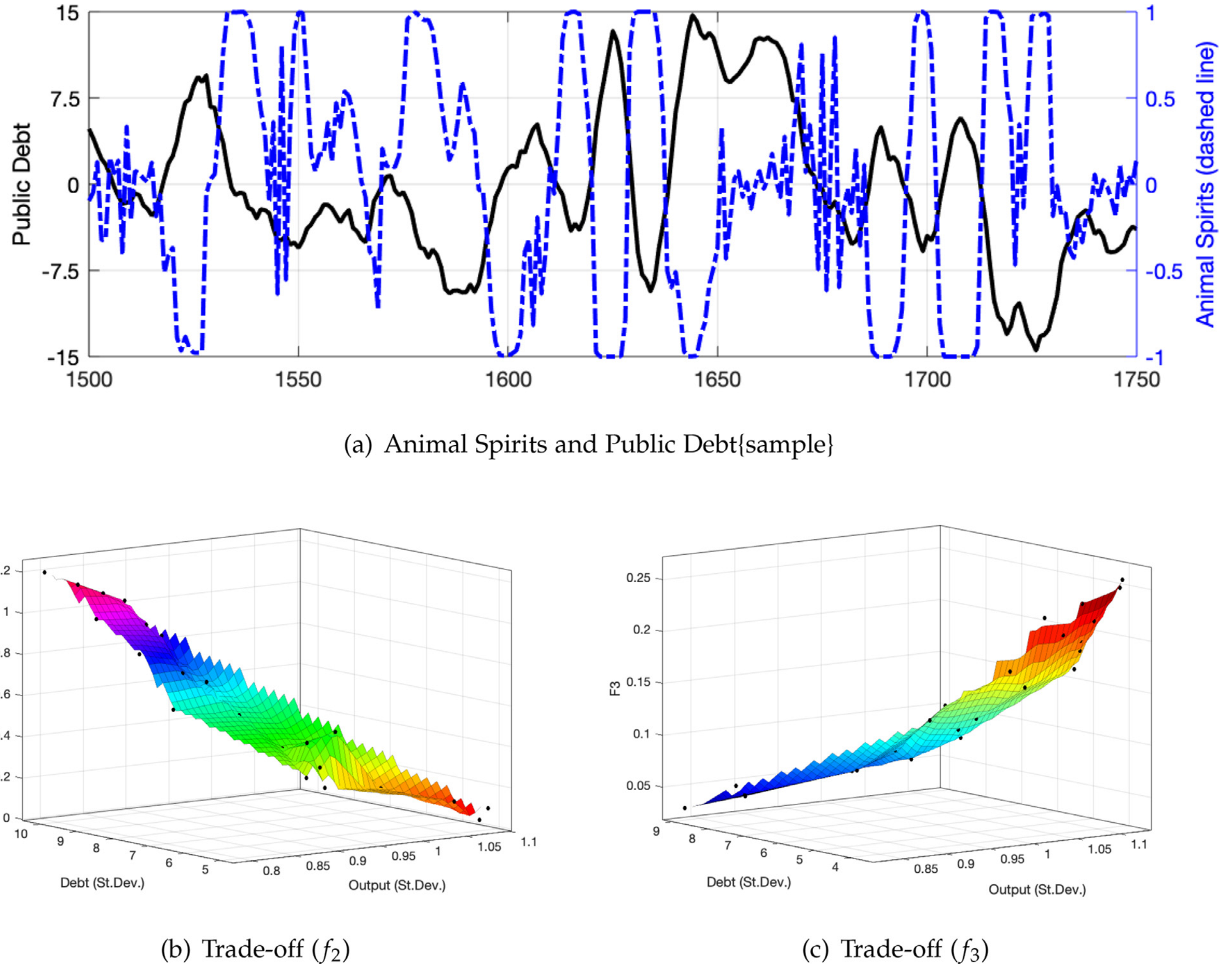


Fig. 3. Extrapolators and inflation.



(a) Animal Spirits and Public Debt{sample}

(b) Trade-off (f_2)

(c) Trade-off (f_3)

Fig. 4. Animal spirits, public debt and output.

different values of the output stabilization parameter in the fiscal rule (f_2). The fitted surface clearly shows the existence of the trade-off. Stronger focus on output stabilization (increasing f_2), implies a reduction in output volatility but an increase in the volatility of public debt. Similar conclusions can be drawn from panel (c). Here, we report the results of a similar experiment in which we have allowed for changes in the parameter of debt stabilization in the fiscal rule (f_3). Also in this case, the fitted surface highlights the existence of the trade-off. More focus on public debt stabilization (increasing f_3) helps increasing debt stability but it implies a higher output volatility. Hence, the two fitted surfaces in panels (b) and (c) can be interpreted as two representations of the trade-off faced by the fiscal authority.

4. Policy regimes and agents' beliefs

After having established the basic properties of the model, we can now compare its functioning under the three alternative policy setups.

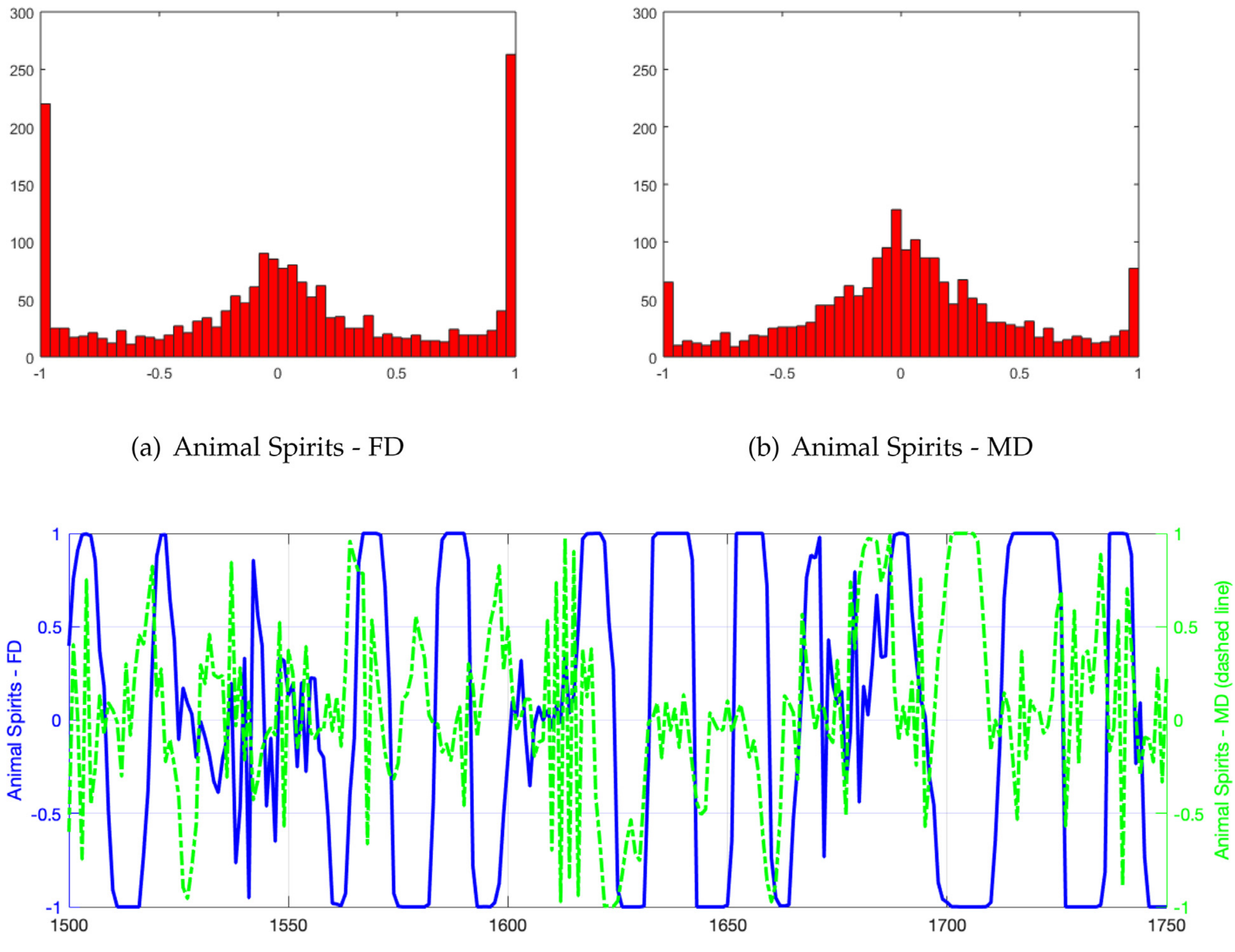
As a first step, we report some data regarding the simulated variables under the three alternative regimes. Table 1 shows how under MD all the variables, except for public debt, experience more stability when compared to FD. Furthermore, FD shows higher volatility in all the variables when compared to the ND case. Specifically, under FD the volatility of inflation, interest rate and output increases.

A very interesting result reported in Table 1 is that the volatility of animal spirits is substantially lower under MD. Hence, in Fig. 5 we complement this result by showing that the main difference between MD and FD is that under the latter the system is exposed to stronger and more persistent waves of optimism and pessimism. This is clearly shown in panel (c) that compares the animal spirits in the time domain under the two alternative regimes. There is clear evidence of more persistent waves under FD. This result is even more evident if we look at panels (a) and (b), where the animal spirits in the two regimes are reported in the frequency domain. We observe that under FD there is a higher concentration of extreme

Table 1
Volatility in different policy setups.

Simulated Variables Standard Deviation*	Policy Setup *ND*	*FD*	*MD*
$StDev_{AS}$	0.51	0.63	0.46
$StDev_{Y}$	1.01	1.52	0.88
$StDev_{\pi}$	0.60	0.87	0.55
$StDev_{r}$	1.36	2.05	1.19
$StDev_{FB}$	0.57	0.63	0.59
$StDev_{g}$	1.15	1.65	1.15
$StDev_{d}$	6.27	7.28	8.36

*Standard deviations of variables computed from simulated series over 2000 periods.



(a) Animal Spirits - FD

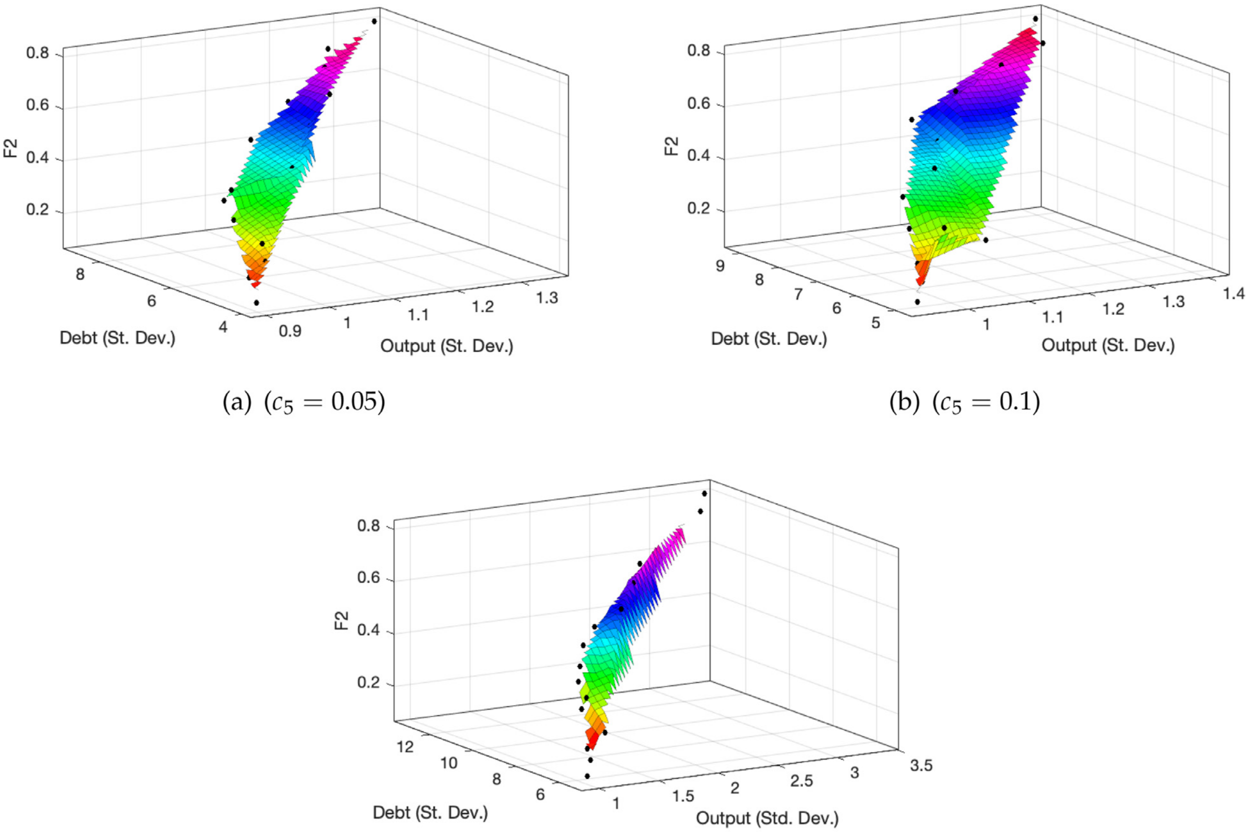
(b) Animal Spirits - MD

(c) MD vs FD{sample}

Fig. 5. Animal spirits under MD and FD.

values (positive or negative) of animal spirits than under MD. At the same time, under MD, we observe the presence of more periods in which animal spirits are neutral.

The broad picture that emerges from these results is that under FD the policy-mix is less capable of stabilizing the macroeconomic variables and agents' sentiments, while a regime of MD allows the policy-mix to guarantee more stability. As a result, under FD the system experiences more volatility and longer waves of optimism/pessimism. Where do these results come from? To understand the mechanism underlying these results, we replicate the sensitivity exercise of Fig. 4 panels (b) and (c) under FD. In Fig. 6, we report the combinations of the volatility of output and of public debt for different values of



(a) $(c_5 = 0.05)$

(b) $(c_5 = 0.1)$

(c) $(c_5 = 0.15)$

Fig. 6. f_2 and the stabilization of output and public debt under FD.

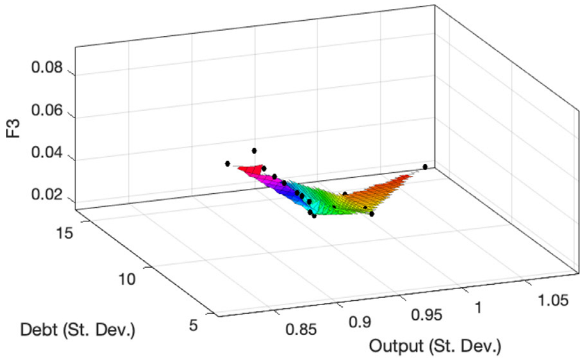
the output stabilization parameter in the fiscal rule (f_2) under different degrees of FD (c_5). In Fig. 7, we perform a similar exercise but there we link the volatility of output and public debt to the debt stabilization parameter in the fiscal rule (f_3). The first thing to note is that the two figures show how under FD the fiscal authority does not face the trade-off between output and debt stabilization anymore. However, for any given value of f_2 and f_3, the stronger the influence of the fiscal authority on monetary policy (higher c_5), the higher the volatility in both output and public debt. These results are rooted in the characterization of the monetary policy rule under FD. The latter can be rewritten, by substituting the fiscal rule (15) in the monetary rule (14) in order to rewrite the latter, as follows

$$\hat{r}_t = c_1\pi_t + c_2\hat{Y}_t + (c_3 + c_5 f_4)\hat{r}_{t-1} + (c_4 + c_5 f_1)\hat{g}_{t-1} - c_5 f_2 \hat{Y}_{t-1} - c_5 f_3 \hat{d}_{t-1} + (c_5 \nu_t + \mu_t) \tag{25}$$

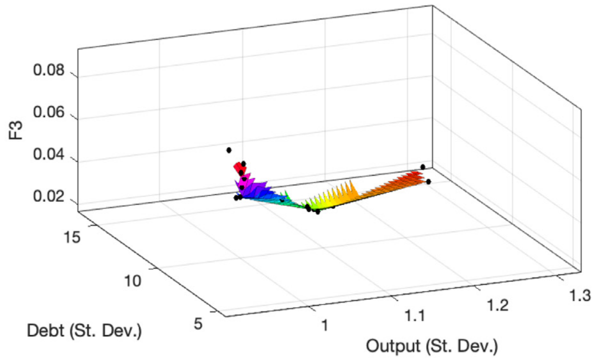
Equation (25) shows how the government's dominating position forces the central bank to contribute to the stabilization of public debt. This releases fiscal policy from the policy trade-off that it would face under ND or MD. However, the downside of this is that the central bank's capability to stabilize the economy is undermined. This is evident in equation (25) showing how the central bank's reaction to changes in output is weakened. This also provides an explanation for the fact that under FD the system shows lower volatility in public debt but more volatility in all the other variables.

However, due to the absence of the policy trade-off between the stabilization of output and debt under FD, the fitted surfaces represented in Fig. 6 and 7 suggest a possible solution to this problem.

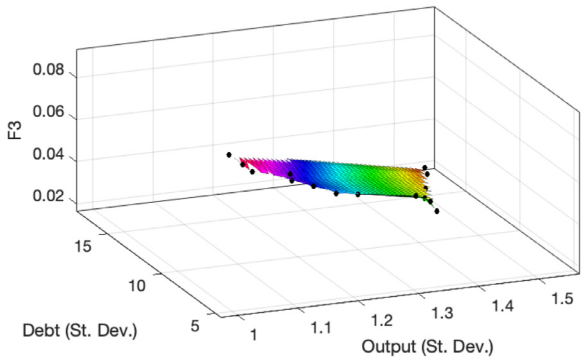
In Fig. 6, we can see how decreasing f_2 implies lower volatility for both variables under FD. At the same time, Fig. 7 shows how increasing f_3 generates a reduction in the volatility of both output and public debt. Hence, by increasing f_3 and reducing f_2, the government should be able to reduce the volatility of both public debt and output. By reducing f_2, the government reduces the negative effects on the central bank's capacity of stabilizing output. At the same time, by increasing f_3 the government focuses more on debt stabilization and forces the central bank to adjust the interest rate to public debt variations. Hence, one can argue that under FD, the stabilization capability of the policy-mix can be improved if the government focuses exclusively on public debt stabilization and leaves output stabilization to the central bank. In order to verify this, we remove the output from the fiscal rule ($f_2 = 0$) and re-simulate the model. We also address the potential relevance of the lagged reaction of the government as we further simulate the model assuming contemporary reaction of government spending in the fiscal rule (15). In Table 2, we report the results of these attempts.



(a) ($c_5 = 0.05$)



(b) ($c_5 = 0.1$)



(c) ($c_5 = 0.15$)

Fig. 7. f_3 and the stabilization of output and public debt under FD.

Table 2
Different fiscal rule specifications under FD.

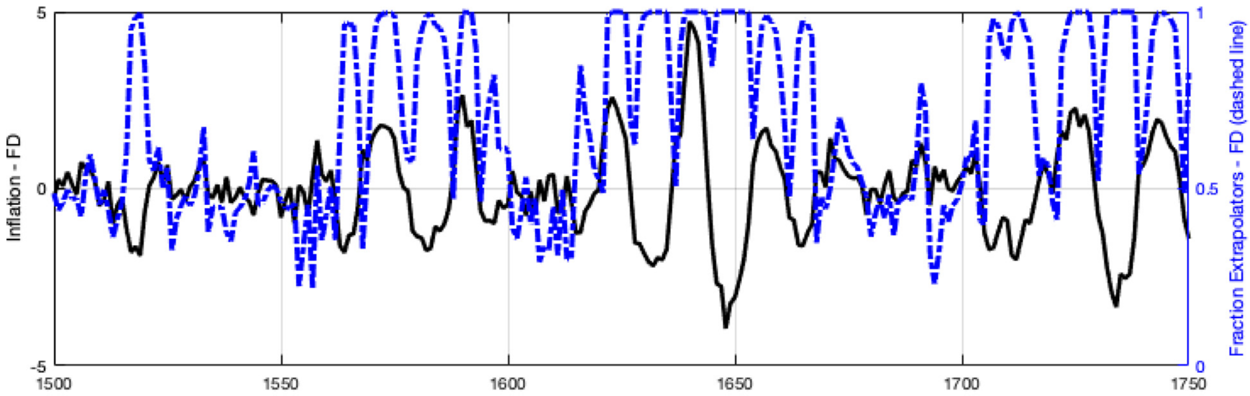
	Fiscal Rule Specification	
Simulated Variables St.Dev.*	(1) *No − Lag* $f_2 = 0$	(2) *Lag* $f_2 = 0$
$StDev_{AS}$	0.51	0.51
$StDev_Y$	1.04	1.02
$StDev_\pi$	0.54	0.56
$StDev_r$	1.25	1.28
$StDev_{FB}$	0.36	0.37
$StDev_g$	0.69	0.72
$StDev_d$	4.31	4.50

*Standard deviations of variables computed from simulated series over 2000 periods.

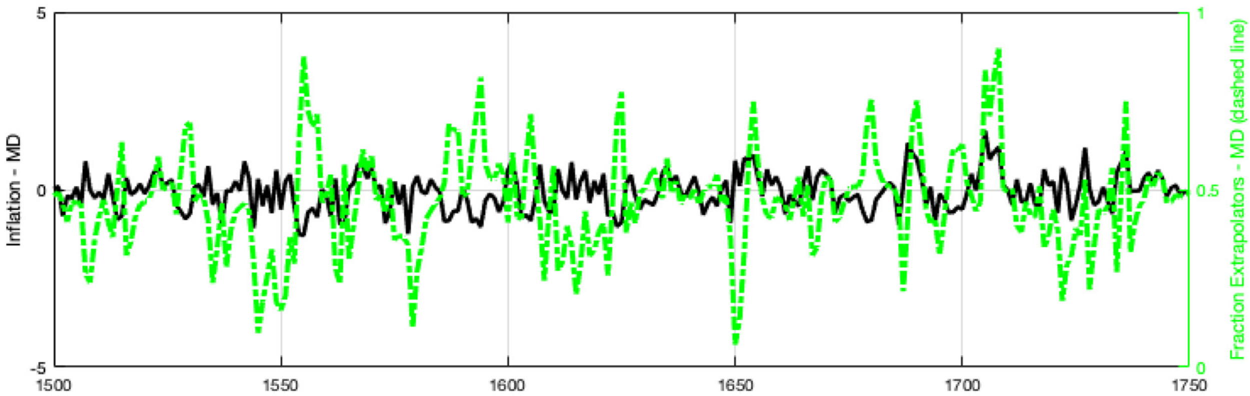
First, by comparing the results in column (1) with (2), we can rule out any relevant role played by the lagged reaction of the government. Most importantly, the results reported in Table 2 show how allowing the government to focus on the stabilization of debt brings the volatility of all variables closer to the MD case[11] and allows for further stabilization of public debt. Hence, other than arguing that MD is more desirable than FD due to the stronger stabilization capacity of the policy-mix, we can also say that if the system is characterized by FD, it is preferable that the government focuses only on public debt stabilization and leaves the stabilization of output to the monetary authority.

As a final step of our analysis, we provide a closer look at the higher degree of inflation stability under MD and its implications. In Fig. 8, we look at the inflation rate in the time domain. We also represent the fraction of inflation extrapo-

[11] In order to see this, one should compare the results in Table 2 column 2 with the ones in columns 2–3 of Table 1.



(a) Inflation and Extrapolators - FD



(b) Inflation and Extrapolators - MD

Fig. 8. Inflation and fraction of extrapolators under MD and FD.

lators under FD (panel (a)) and MD (panel (b)). Once again, the higher inflation volatility under FD is confirmed. This derives from the fact that the government is not directly concerned about inflation stabilization and, as a result, in a regime of FD monetary policy is loose. On the contrary, under MD the inflation seems to be strongly under control as the result of the dominance of the central bank's objectives.

Thanks to its expectations and learning mechanisms, the model is capable of providing additional insights. As shown in Fig. 8, the higher volatility of inflation under FD undermines also the central bank's credibility. As it can be seen by comparing panels (a) and (b), there is a stronger presence of inflation extrapolators under FD. This comes from the fact that under FD agents observe that inflation is more volatile and oscillates more around the central bank's target. As a result, the performance of the fundamentalist rule decreases, pushing more agents into being extrapolators. In contrast, we can conclude from panel (b) that the presence of fundamentalist agents in the forecast of inflation is much stronger under MD. Thus, we can also conclude that FD undermines monetary policy credibility. This is the result of the fact that the central bank can keep inflation much closer to its target under MD as it forces the government to keep into account also inflation when implementing fiscal policy. According to our model, the mechanism is the following. An increase in inflation triggers the reaction of the central bank that increases the interest rate. Under MD, the increase in the interest rate generates also a direct reaction in government spending that provides further support to the central bank in containing inflation.

5. Conclusion

In this article we have presented a New Keynesian behavioral model to study the interaction between fiscal and monetary policies under the assumption that agents have limited cognitive capabilities that generate endogenous waves of optimism and pessimism (animal spirits).

First, we analyzed the links between the animal spirits and the macroeconomic variables of our model. Then, we used these peculiar features of our model to discuss how the presence of animal spirits can affect the impact of the policy-mix on the economy under three alternative police regimes. Our main results are the following.

When no authority has a dominant position, we obtained the following relations. Output and government spending are strongly linked to animal spirits and fiscal beliefs, respectively. Furthermore, the capability of the central bank to keep inflation close to its target affects monetary policy credibility via the learning mechanism. Another important result suggested by our model is that public debt and animal spirits are negatively correlated and that the fiscal authority faces a policy trade-off between the stabilization of these two variables. Given the strong positive correlation between animal spirits and output, there is a similar trade-off between the stabilization of output and public debt.

On the basis of these results, we have then analyzed the main differences between the alternative policy setups.

Under fiscal dominance the volatility in output, inflation and interest rate increases relative to monetary dominance. Furthermore, under fiscal dominance the system is exposed to more persistent waves of optimism and pessimism when compared to monetary dominance.

The higher inflation volatility around the central bank's target under fiscal dominance has shown how monetary conservatism is negatively affected under this policy regime. Given the consequent reaction in agents' beliefs, we have then shown that fiscal dominance also undermines monetary policy credibility.

These results are due to the leading position of the government under fiscal dominance. Thanks to its dominant position, the government is able to avoid the policy trade-off between the stabilization of output and public debt by forcing the central bank to contribute to public debt stabilization. However, this implies reduced stabilization capabilities of monetary policy which in turn tend to increase volatility and the persistence of waves of optimism and pessimism.

Finally, the model has allowed us to show that the negative effects of fiscal dominance diminish the more (less) the government focuses on debt (output) stabilization. Based on this result, we demonstrated that under fiscal dominance the most effective policy-mix occurs when the government focuses exclusively on public debt stabilization and the stabilization of the output is left to the central bank.

Declaration of Competing Interest

We hereby confirm that we have no personal interest that could have influenced the research reported in our paper.

Data availability

Data will be made available on request.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jebo.2023.05.024.

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