Maestría en Economía

Optimal Portfolio Choices and the Fiscal Channel of Monetary Policy

Autoría: Kossacoff, Ramiro V.
Año: 2023

Optimal Portfolio Choices and the Fiscal Channel of Monetary Policy*

Ramiro V. Kossacoff†

June 12, 2023

Abstract

The main objective of this paper is to analyze the impact of countercyclical fiscal rules on monetary policy transmission channels. Using a model with portfolio heterogeneity and aggregate uncertainty as a basis, it is shown that unexpected shocks on nominal interest rate induce effects on the composition of income across the wealth distribution. In this context, a fiscal policy rule aimed at reducing the procyclicality of government spending in recessionary contexts through debt issuance (i.e., a countercyclical fiscal rule) helps to mitigate these distributional effects. This result is associated with the fact that the increase in the supply of bonds generates changes in their expected return –impacting households' consumption and portfolio decisions–, which alters the transmission of monetary shocks on income. On the other hand, the conclusions presented in this paper lay the foundations for future analyses aimed at studying the trade–off between monetary policy stabilization and its distributional consequences.

Keywords: Monetary and Fiscal Policy, Heterogeneous Agents, General Equilibrium

JEL Codes: C63, E21, E63

*I would like to thank Manuel Macera for his advisory and supporting. I am also grateful for helpful initial comments and suggestions by Tomás Caravello and Francisco Ciocchini, as the enriching discussions with Ramiro Sciandro, and the Department of Economics of Torcuato di Tella University.

†Email: ramirokossacoff@gmail.com – Web site: linkedin.com/in/kossacoffr

1 Introduction

This paper studies how countercyclical fiscal rules affect the transmission channels of monetary policy. In a model with heterogeneous households that accumulate assets of different liquidity, monetary shocks alter the composition of income, and the objective here is to show that, in this context, a debt policy aimed at isolating the procyclicality of government spending mitigates the impact of monetary policy shocks on the distribution of wealth.

Recent literature (Luetticke (2021)) indicates that modeling heterogeneity in household portfolios is relevant to explain the transmission channels of monetary shocks. This paper will model an economy with portfolios composed of two assets of different liquidity (government–issued bonds and capital) and income heterogeneity, in a context of aggregate uncertainty. Under this environment, the transmission of shocks to monetary policy is strongly linked to households' marginal propensities to consume and invest, due to their heterogeneity. A contractionary monetary shock affects the evolution of aggregate variables through two main channels: one associated with changes in the composition of portfolios; and the other with the interaction between heterogeneity and the marginal propensities to consume and invest.

In this model, a contractionary monetary shock will be understood as a monetary surprise that causes an increase in the nominal interest rate. This is one of the instruments most commonly used today by central banks when the objective of monetary policy is to stabilize economic activity. Taylor (1993) proposes a rule under which the monetary authority defines the optimal short–term interest rate in response to gaps in different variables of its target values (such as the inflation rate, real income and the federal funds rate). When central banks adopt and follow this Taylor rule, monetary policy has a direct impact on the intertemporal decisions of economic agents. This is because, in principle, changes in the interest rate alter the intertemporal consumption relationship, while motivating a re–optimization in the composition of household portfolios. In this way, the Taylor rule operates as a mechanism that seeks to control fluctuations in the inflation rate and activity, acting through different transmission channels, such as those mentioned above.

Since households can invest in government bonds –which will be considered liquid assets–, the contractionary monetary shock promotes a change in the composition of portfolios, because it increases their real return over capital. And, since household incomes are heterogeneous, the shock will not have the same effect across the wealth distribution: under this structure, there will be a redistribution of resources from the lowest percentiles of the distribution to the highest. This redistributive channel of monetary policy is associated with how total household income changes in the face of the monetary shock.

This is a result that, in essence, arises from the Central Bank's active response to a fluctuation in the economy. When economic policy is tightened (following the Taylor rule defined by the monetary authority), these changes have effects on the rest of the variables and alter agents' decisions. The purpose of this paper is to show that, just as the Central Bank defines a monetary rule to preserve the stability of its target variables, the fiscal rules set by the government alter the transmission channels of monetary policy. And, more precisely, that countercyclical fiscal rules depress the redistributive effects of monetary shocks.

A countercyclical fiscal rule is understood as the expansion of public debt (bond issuance) to finance government spending in the face of temporary drops in revenue in recessionary scenarios. In this model, a temporary tightening of monetary policy implies a fall in production and tax revenues. Under this fiscal rule, debt issuance should increase to smooth the evolution of government spending. Note that this is an analysis focused on the interaction between monetary and fiscal policy.

The relationship between both has already been studied by Sargent and Wallace (1981) in a seminal paper which shows the relevance of coordinating decisions on public debt in the face of monetary policy tightening. Barro (1979) proposes a theory on the evolution of debt which, applied to this context, should be based on fiscal smoothing, and which consists of defining a countercyclical rule of debt in the face of temporary fluctuations that affect household income. The importance of this mechanism of substituting tax revenues for debt is based on the fact that the latter, by operating against the economic cycle, finances the public sector avoiding greater pressure on current households' income.

In an economy with this structure, public debt issuance will determine the aggregate supply of bonds, which will represent the liquid asset of the portfolios, over which there is no friction whatsoever. On the other hand, capital will play the role of an illiquid asset, and there will be restrictions on its trading: each period, a constant fraction of households (the agents in charge of accumulating capital) will have the possibility of re–optimizing their holdings of it, while the remainder will only be able to alter their bond holdings. Aggregate uncertainty and incomplete markets result in the existence of a liquidity premium paid on capital. In the face of a shock, this liquidity premium falls, promoting portfolio re–optimization and affecting the composition of income. But, when the government injects liquidity through the supply of bonds (i.e., defines a countercyclical fiscal policy), it contains the fall in the liquidity premium in the face of a change in the nominal interest rate, because the impulse in the supply of this asset helps to moderate the change in its real return. This weakens portfolio substitution and, in addition, the distributional consequences of the monetary surprise on income, since the transmission of monetary policy will be altered. And this attenuation effect in the redistributive channel will be defined as the fiscal channel of monetary policy.

The order of this paper is as follows: Section 2 will introduce the model and discuss its numerical solution; Section 3 will present the results and Section 4 will summarize the conclusions.

2 Model

The structure of the economy in this paper is that of a neo–Keynesian model with heterogeneous agents, incomplete markets, idiosyncratic income risk and price rigidities, which follows the essence of the work of Bayer and Luetticke (2020) and Luetticke (2021). The set of agents in the economy is composed of three groups: households, firms and the public sector, consisting of the Central Bank and the government.

2.1 Households

Households live infinite periods, and make consumption decisions, offer their labor force, accumulate capital, and trade in the bond market. There is a continuum of households of measure one that are ex–ante identical, indexed by $i \in [0,1]$. These can be either workers or entrepreneurs, depending on their level of human capital, $h_{i,t}$. A working household ($h_{i,t} > 0$) will receive labor income, while an entrepreneurial household ($h_{i,t} = 0$) will receive as income a fair fraction of the firms' profits. However, all households pay the same tax rate to the government, τ. Moreover, each period a fixed fraction ν of households have the possibility to participate in all financial markets, and re–optimize their capital holdings (while the rest of the households can only make decisions about their bond holdings). Each unit of capital in period t costs q_t to a household, and pays a net return (dividend) in the next period defined by r_t. $R\left(b_{i,t}, R_t^b, \overline{R}\right)$ will be the nominal return on bonds received by household i, where $b_{i,t}$ represents its holdings in the current period, R_t^b is the nominal interest rate, and $\overline{R}$ is a financial intermediation cost incurred if the household has a short position in the asset ($b_{i,t} < 0$). [1]

The idiosyncratic shocks to individual productivity will be determined by the autoregressive process that human capital follows, $h_{i,t}$, and a fixed probability of variation between the entrepreneur and worker states ($h_{i,t}$ and $h_{i,t}$). Each household solves the following problem:

$$
\begin{aligned}
\max_{\{c_{i,t}, n_{i,t}, b_{i,t+1}, k_{i,t+1}\}_{t=0}^{\infty}} \quad & \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\frac{c_{i,t}^{1-\xi}}{1-\xi} - \psi \frac{n_{i,t}^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} \right] \right\} \\
\text{s.t.} \quad & c_{i,t} + b_{i,t+1} + q_t \mathcal{I}_\nu k_{i,t+1} = \frac{R\left(b_{i,t}, R_t^b, \overline{R}\right)}{\pi_t} b_{i,t} + \left(q_t \mathcal{I}_\nu + r_t\right) k_{i,t} \\
& \qquad + (1-\tau)\left[w_t h_{i,t} n_{i,t} + \mathcal{I}_{h_{i,t}=0} \Pi_t\right] \\
& h_{i,t} = (1-\zeta)\, e^{\rho_h \log\left(h_{i,t-1} + \epsilon_{i,t}^h\right)} + \iota, \text{ where } \epsilon_{i,t}^h \sim \mathcal{N}(0, \sigma_h) \\
& R\left(b_{i,t}, R_t^b, \overline{R}\right) = R_t^b + \left(1 - \mathcal{I}_{b_{i,t} \geqslant 0}\right) \overline{R} \\
& n_{i,t} \in [0,1] \\
& k_{i,t+1} \geqslant 0 \text{ and } b_{i,t+1} \geqslant \underline{b} \\
& b_0,\ k_0 \text{ given} \\
& \Theta_t\left(b_t, k_t, h_t\right) \text{ and } \Omega \text{ given}
\end{aligned}
$$

[1] Households can borrow up to an exogenously specified limit, $\underline{b} \in (-\infty, 0)$.

Under this notation, Π_t is the firms' profits and π_t is the inflation rate. The consumption basket $c_{i,t}$ is a Dixit–Stiglitz aggregator of differentiated varieties that can be expressed as

$$c_{i,t} = \left(\int_0^1 c_{i,j,t}^{\frac{\eta-1}{\eta}} d_j \right)^{\frac{\eta}{\eta-1}}, \tag{1}$$

where each of these varieties is offered at a price $p_{j,t}$ such that, for a given general price level P_t, the demand for each of them is represented by:

$$c_{i,j,t} = \left(\frac{p_{j,t}}{P_t} \right)^{-\eta} c_{i,t} \tag{2}$$

Θ_t is the joint distribution over the model's idiosyncratic state variables (b_t, k_t and h_t), while Ω represents the aggregate shocks (to total factor productivity on the production side and monetary policy on the public sector side). Θ_t fluctuates in response to these aggregate shocks. It is worth noting that the price level (P_t) and the aggregate real quantity of bonds ($B_{t+1} \equiv \widetilde{B}_{t+1}/P_{t+1}$) are functions of this joint distribution.

The problem for a given household can be written dynamically with Bellman equations, V_a and V_n, where the subindexes refer to the possibility of adjusting –or not– capital holdings in that particular period:

$$\begin{aligned} V_a(b,k,h;\Theta,\Omega) = \max_{k',b'_a,n'_a} u\left(c\left(b,b'_a,k,k',h,n'_a\right)\right) + \beta\nu\mathbb{E}\left\{V_a\left(b'_a,k',h',\Theta',\Omega'\right)\right\} + \\ +\beta(1-\nu)\mathbb{E}\left\{V_n\left(b'_a,k',h',\Theta',\Omega'\right)\right\} \end{aligned} \tag{3}$$

$$\begin{aligned} V_n(b,k,h;\Theta,\Omega) = \max_{b'_n,n'_n} u\left(c\left(b,b'_n,k,h,n'_n\right)\right) + \beta\nu\mathbb{E}\left\{V_a\left(b'_n,k,h',\Theta',\Omega'\right)\right\} + \\ +\beta(1-\nu)\mathbb{E}\left\{V_n\left(b'_n,k,h',\Theta',\Omega'\right)\right\} \end{aligned} \tag{4}$$

The optimal policy functions will be defined by $\{c^*_a, n^*_a, b^*_a, k^*\}$ and $\{c^*_n, n^*_n, b^*_n\}$, depending on whether the household is under a capital adjustment case or not. The following system of equations[2] characterizes the solution of the household problem for an interior solution:

$$\begin{aligned} q(\Theta,\Omega)\frac{\partial u(c(\mathbf{x}_a))}{\partial c(\mathbf{x}_a)} &= \beta\mathbb{E}\left\{\nu\frac{\partial u(c(\mathbf{x}'_a))}{\partial c(\mathbf{x}'_a)}\left(q(\Theta',\Omega')+r(\Theta',\Omega')\right)+(1-\nu)\frac{\partial V_n(\mathbf{x}'_a)}{\partial k'}\right\} \\ \frac{\partial u(c(\mathbf{x}_a))}{\partial c(\mathbf{x}_a)} &= \beta\mathbb{E}\left\{\frac{R^b(\Theta',\Omega')}{\pi(\Theta',\Omega')}\left[\nu\frac{\partial u(c(\mathbf{x}'_a))}{\partial c(\mathbf{x}'_a)}\left(q(\Theta',\Omega')+r(\Theta',\Omega')\right)+(1-\nu)\frac{\partial u(c(\mathbf{x}'_n))}{\partial c(\mathbf{x}'_n)}\right]\right\} \\ \frac{\partial u(c(\mathbf{x}_n))}{\partial c(\mathbf{x}_n)} &= \beta\mathbb{E}\left\{\frac{R^b(\Theta',\Omega')}{\pi(\Theta',\Omega')}\left[\nu\frac{\partial u(c(\mathbf{x}'_a))}{\partial c(\mathbf{x}'_a)}\left(q(\Theta',\Omega')+r(\Theta',\Omega')\right)+(1-\nu)\frac{\partial u(c(\mathbf{x}'_n))}{\partial c(\mathbf{x}'_n)}\right]\right\} \end{aligned}$$

Where $\mathbf{x}$ represents an aggregator of the arguments. The first equation defines the optimal allocation of capital, while the others represent the optimal bond conditions under the adjustment

[2] See Appendix.

and non–adjustment case. Note that, in equilibrium, the marginal benefit and cost of investing in an additional unit of the bond is the same regardless of whether the household is under an adjustment scenario of its capital holdings or not. On the other hand, the return spread between assets (liquidity premium) is given by the following expression:

$$LP_t = \begin{cases} \mathbb{E}\left\{\frac{q(\Theta',\Omega')+r(\Theta',\Omega')}{q(\Theta',\Omega')} - \frac{R^b(\Theta',\Omega')}{\pi(\Theta',\Omega')}\right\} & \text{with probability } \nu \\ \mathbb{E}\left\{\frac{1}{q(\Theta',\Omega')}\frac{\partial V_n(\mathbf{x}'_n)}{\partial k'} - \frac{R^b(\Theta',\Omega')}{\pi(\Theta',\Omega')}\frac{\partial u(c(\mathbf{x}'_n))}{\partial c(\mathbf{x}'_n)}\right\} & \text{with probability } 1-\nu \end{cases}$$

2.2 Production

The supply side is represented by three types of firms. The first problem is that of a producer of intermediate goods whose objective is to maximize its profits in each period:

$$\begin{aligned} \max_{\{K_t,N_t\}} \quad & mc_t Y_t - w_t N_t - (r_t+\delta) K_t \\ \text{s.t.} \quad & Y_t = Z_t N_t^{\alpha} K_t^{1-\alpha} \\ & \log(Z_t) = \rho_Z \log(Z_{t-1}) + \epsilon_t^Z, \text{ where } \epsilon_t^Z \sim \mathcal{N}(0,\sigma_Z) \end{aligned}$$

mc_t is the relative price at which the firm sells its product, while Z_t is total factor productivity, which follows the stochastic process described above. The intermediate firm demands capital (K_t) and labor (N_t) in competitive markets by equating the marginal productivity of both factors to their marginal costs:

$$\alpha mc_t Z_t \left(\frac{K_t}{N_t}\right)^{1-\alpha} = w_t \tag{5}$$

$$(1-\alpha) mc_t Z_t \left(\frac{N_t}{K_t}\right)^{\alpha} = r_t + \delta \tag{6}$$

Another type of reseller firms are in charge of differentiating the intermediate good to sell it in the form of varieties to a producer of final goods, paying costs *à la Rotemberg* for the price adjustment. For this, they delegate the job of setting prices to a group of households with zero mass called *directors*, which do not participate in the financial market and maximize the present value of profits, given the demand for the variety j[3]:

$$\max_{\{p_{j,t}\}_{t=0}^{\infty}} \quad \mathbb{E}_0\left\{\sum_{t=0}^{\infty}\beta^t\left[\left(\frac{p_{j,t}}{P_t} - mc_t\right)\left(\frac{p_{j,t}}{P_t}\right)^{-\eta} - \frac{\eta}{2\kappa}\log\left(\frac{p_{j,t}}{p_{j,t-1}}\right)^2\right] Y_t\right\}$$

The following neo–Keynesian Phillips curve is obtained from the previous problem:

$$\log(\pi_t) = \beta\mathbb{E}_t\left\{\log\left(\pi_{t+1}\frac{Y_{t+1}}{Y_t}\right)\right\} + \kappa\left(mc_t - \frac{\eta-1}{\eta}\right) \tag{7}$$

As this group has measure zero, all profits are distributed among the entrepreneurial house-

[3]Defined by $y_{j,t} = \left(p_{j,t}/P_t\right)^{-\eta} Y_t$.

holds. On the other hand, as these firms (households) obtain profits from adjusting the aggregate capital stock, through the transformation function

$$K_{t+1} = I_t + \left(1 - \frac{\phi}{2}\left(\frac{K_{t+1} - K_t}{K_t}\right)^2\right) K_t, \tag{8}$$

and since this is a competitive market, in equilibrium the following condition on the price of capital must be satisfied:

$$q_t = 1 + \phi\left(\frac{K_{t+1}}{K_t} - 1\right) \tag{9}$$

The producer of final goods –used to consume and invest– acquires these varieties, choosing $y_{j,t}$ taking $p_{j,t}$ as given, by solving the following sequential problem in each period:

$$\begin{aligned} \max_{y_{j,t}\in[0,1]} \quad & P_t Y_t - \textstyle\int_0^1 p_{j,t} y_{j,t} d_j \\ \text{s.t.} \quad & Y_t = \left(\textstyle\int_0^1 y_{j,t}^{\frac{\eta-1}{\eta}} d_j\right)^{\frac{\eta}{\eta-1}} \end{aligned}$$

Because of the zero profits condition, the expression for the general price level is equal to:

$$P_t = \left(\int_0^1 p_{j,t}^{1-\eta} d_j\right)^{\frac{1}{1-\eta}} \tag{10}$$

2.3 Public Sector

The Central Bank, on the one hand, defines monetary policy following a standard Taylor rule, where the nominal interest rate –the return on liquid assets, in this case– is set in response to its own deviations from the steady state value, and to the dynamics of inflation:

$$\log\left(R_{t+1}^{b,ss}\right) = \rho_R \log\left(R_t^{b,ss}\right) + (1-\rho_R)\,\theta_\pi \log\left(\pi_t^{ss}\right) + \log\left(\epsilon_t^R\right) \tag{11}$$

where the variable $x_t^{ss} \equiv {}^{x_t}/_{\overline{x}}$ represents the deviation about its own steady–state value and $\log\left(\epsilon_t^R\right) \sim \mathcal{N}\left(0, \sigma_R\right)$. Note that ρ_R represents the smoothing of the monetary reaction (how strongly the interest rate reacts to deviations from the inflation rate), while θ_R is a coefficient that measures how important it is for the monetary authority to stabilize inflation around its steady–state value.

On its side, the government satisfies its sequential budget constraint in each period, choosing the current expenditure (G_t), the tax revenues ($\mathcal{T}_t$), and the level of public debt to be placed in the market (B_{t+1}), taking the interest rate as given:

$$G_t + \left(\frac{R_t^b}{\pi_t}\right) B_t = \mathcal{T}_t + B_{t+1} \tag{12}$$

$$\mathcal{T}_t = \tau \left(\nu \int_\Theta w_t h_{i,t} n^a_{i,t} d\Theta_t + (1-\nu) \int_\Theta w_t h_{i,t} n^n_{i,t} d\Theta_t + \Pi_t \right) \tag{13}$$

Fiscal policy can be described by the following debt placement function:

$$\log\left(B^{ss}_{t+1}\right) = \rho_B \log\left(\frac{R^{b,ss}_t}{\pi^{ss}_t} B^{ss}_t \right) - \gamma_\pi \log\left(\pi^{ss}_t\right) + \gamma_{\mathcal{T}} \log\left(\mathcal{T}^{ss}_t\right) \tag{14}$$

On the one hand, ρ_B is a coefficient representing how quickly the government repays its obligations (for $\rho_B < 1$, the roll–over of debt is not complete). While $\{\gamma_\pi, \gamma_{\mathcal{T}}\}$ are coefficients that determines the cyclicality of the debt evolution: whether it is procyclical or countercyclical. A policy that moves against the business cycle requires an increase in debt issuance to finance spending if it generates a fall in revenue. In this model, this is satisfied when $\gamma_\pi > 0 > \gamma_{\mathcal{T}}$, since $\Delta\pi^{ss}_t > 0$ in the face of an expansion in activity. On the other hand, if it is satisfied that $\gamma_{\mathcal{T}} > 0 > \gamma_\pi$, the policy is procyclical.

Note that through equation (14) monetary policy interacts with fiscal policy. In the face of a monetary shock, changes in π_t and $\mathcal{T}_t$ affect the aggregate supply of bonds and this, in turn, affects aggregate savings in liquid assets. In the work developed by Luetticke (2021), $\gamma_\pi = \gamma_{\mathcal{T}} = 0$ and changes in the aggregate supply of bonds only depend on the value of prior period debt.

In this model, the rule that determines the issuance of public debt given by the equation (14) depends, in addition to the repayment of interest on government obligations, on how the inflation rate and tax revenue respond to monetary policy shocks. In the face of a monetary shock, the change in fiscal policy can be expressed as follows:

$$\Delta \log\left(B_{t+1}\right) = \begin{cases} \rho_B \Delta \log\left(R^b_t\right) + \rho_B \Delta \log\left(B_t\right) - \rho_B \Delta \log\left(\pi_t\right) & \text{si } \gamma_\pi = \gamma_{\mathcal{T}} = 0 \\ \rho_B \Delta \log\left(R^b_t\right) + \rho_B \Delta \log\left(B_t\right) - \rho_B \Delta \log\left(\pi_t\right) - \Psi\left(\gamma_\pi, \gamma_{\mathcal{T}}\right) & \text{si } \gamma_\pi \neq 0,\ \gamma_{\mathcal{T}} \neq 0 \end{cases}$$

Where $\Psi\left(\gamma_\pi, \gamma_{\mathcal{T}}\right) \equiv \gamma_\pi \Delta \log\left(\pi_t\right) - \gamma_{\mathcal{T}} \Delta \log\left(\mathcal{T}_t\right)$. On the one hand, if the shock to monetary policy is contractionary, $\text{sign}\left(\Delta \log\left(\pi_t\right)\right) = \text{sign}\left(\Delta \log\left(\mathcal{T}_t\right)\right) < 0$. From this it follows that if $\gamma_\pi > 0 > \gamma_{\mathcal{T}}$ fiscal policy is countercyclical, as the fall in the stock of debt dumped on the market subsides: $\Psi\left(\gamma_\pi, \gamma_{\mathcal{T}}\right) < 0$. But if $\gamma_\pi < 0 < \gamma_{\mathcal{T}}$ the effect is the inverse.

When the fiscal rule that defines the level of debt responds to the business cycle, through changes in the supply of bonds this propagation mechanism is triggered (either by increasing or decreasing it relative to the base case, where $\gamma_\pi = \gamma_{\mathcal{T}} = 0$). If the fiscal essence is countercyclical, the supply of bonds is larger and the smoothing of spending (in the face of falling revenue) is stronger.

2.4 Competitive Equilibrium

Market clearing conditions are the following ones:

- Labor market empties for equilibrium wage w_t^*:

$$w_t^* = \alpha mc_t Z_t \left(\frac{K_t^*}{N_t^*}\right)^{1-\alpha}$$

- The capital services market empties for an equilibrium real return r_t^*, and the aggregate capital stock market empties for an equilibrium price q_t^*:

$$r_t^* + \delta = (1-\alpha)\, mc_t \left(\frac{N_t^*}{K_t^*}\right)^{\alpha}$$

$$q_t^* = 1 + \frac{\phi}{K_t^*}\left(K_{t+1}^* - K_t^*\right)$$

$$K_{t+1}^* = \int_{\Theta} \left[\nu k_a^*(b,k,h) + (1-\nu)\, k_n^*(b,k,h)\right] \Theta_t(b,k,h)\, d_b d_k d_h$$

- For an equilibrium interest rate $R_t^{b,*}$, the bond market empties whenever the following equality is satisfied:

$$B_{t+1}^* = \int_{\Theta} \left[\nu b_a^*(b,k,h) + (1-\nu)\, b_n^*(b,k,h)\right] \Theta_t(b,k,h)\, d_b d_k d_h$$

- The goods market empties by Walras' law, given the equilibrium in the rest of the markets.

In this economy a recursive competitive equilibrium is defined by a set of value functions $\{V_a, V_n\}$, a set of policy functions $\{c_i^*, n_i^*, b_i^*, k^*\}_{i\in\{a,n\}}$ and an aggregate allocation $\{B, K, N\}$ such that, given price functions $\left\{r, R^b, w, \pi, q\right\}$, idiosyncratic state variables distributions Θ_t, and a law of motion Γ perceived by the agents for such distributions it is satisfied that:

1. The policy functions solve the household problem and the value functions are solutions for the equations (3) and (4).

2. The markets for labor, intermediate and final goods, bonds and capital are emptied.

3. The law of motion perceived by the agents (Γ) coincides with the true joint distribution of the idiosyncratic state variables (Θ): $\Theta' = \Gamma(\Theta, \Omega')$.

2.5 Numerical Solution

To simulate the model, the methods applied in Bayer and Luetticke (2020) and Luetticke (2021) are used. The calibration of the parameters is drawn primarily from the two previously mentioned papers, and various sources cited therein, and described in Section 3 and the Appendix.

Since the joint distribution of the state variables Θ_t is an infinite–dimensional object, it must be discretized and represented by its histogram.

The solution to the household problem is obtained by applying the extended endogenous grid method of Hintermaier and Koeniger (2010), iterating over the first–order conditions. The stochastic process of idiosyncratic productivity is approximated through a Markov chain with four states using the method proposed in Tauchen (1986). To compute the solution to the household problem, the policy functions are solved for 30 points on a logarithmic grid for both bonds and capital.

Then, the first–order perturbation method around the stationary equilibrium without shocks is applied to solve the aggregate dynamics, as in Reiter (2009). To reduce the dimension of the problem and compute more efficiently the solution, the fixed copula method defined in Bayer and Luetticke (2020) is used.

3 Results

To show how countercyclical fiscal rules affect the redistributive channel of monetary policy, two models are calibrated: one under which debt issuance responds only to the value of the previous period's obligations, and another in which changes in inflation and tax revenues are also accounted for. Under the first model it is satisfied that $\gamma_\pi = \gamma_\mathcal{T} = 0$, and the fiscal rule is called acyclical; and, under the second specification, the fiscal rule is countercyclical: $\gamma_\pi > 0 > \gamma_\mathcal{T}$.

Table 1 presents the calibrations of these parameters, while Table 3 (Appendix) presents more extensively the calibration of all model parameters.

Table 1: Fiscal policy parameters calibration

Parameter	Value	Description	Target
Acyclical fiscal policy			
τ	0.3	Tax rate	Luetticke (2021)
ρ_B	0.86	Debt persistence	Luetticke (2021)
γ_π	0	Reaction to inflation	Luetticke (2021)
$\gamma_\mathcal{T}$	0	Reaction to tax revenues	Luetticke (2021)
Countercyclical fiscal policy			
τ	0.3	Tax rate	Luetticke (2021)
ρ_B	0.86	Debt persistence	Luetticke (2021)
γ_π	1.5	Reaction to inflation	Luetticke et al. (2019)
$-\gamma_\mathcal{T}$	0.5075	Reaction to tax revenues	Luetticke et al. (2019)

A contractionary shock to monetary policy will be understood as a surprise that increases the nominal interest rate paid by liquid assets (bonds) by one standard deviation, $\sqrt{\sigma_R}$. This increase in the interest rate motivates a substitution in the composition of portfolios. In the base case (under which the fiscal rule is acyclical), debt placement increases because –only– the value of government obligations increases. The real interest rate rises because of the rise in the nominal interest rate, making the government's liabilities more expensive, and then it places more debt in the market to meet debt repayments, and investment in physical capital falls. When the parameters of the debt function are calibrated such that $\gamma_\pi > 0 > \gamma_T$, the government places more debt in the market than it would under the base case ($\gamma_\pi = 0 = \gamma_T$), responding to changes in inflation and tax revenues. In other words, it finances its obligations with more debt. This accentuates the initial drop in capital investment, due to the deepening of the substitution effect within portfolios, as shown in Figure 1.

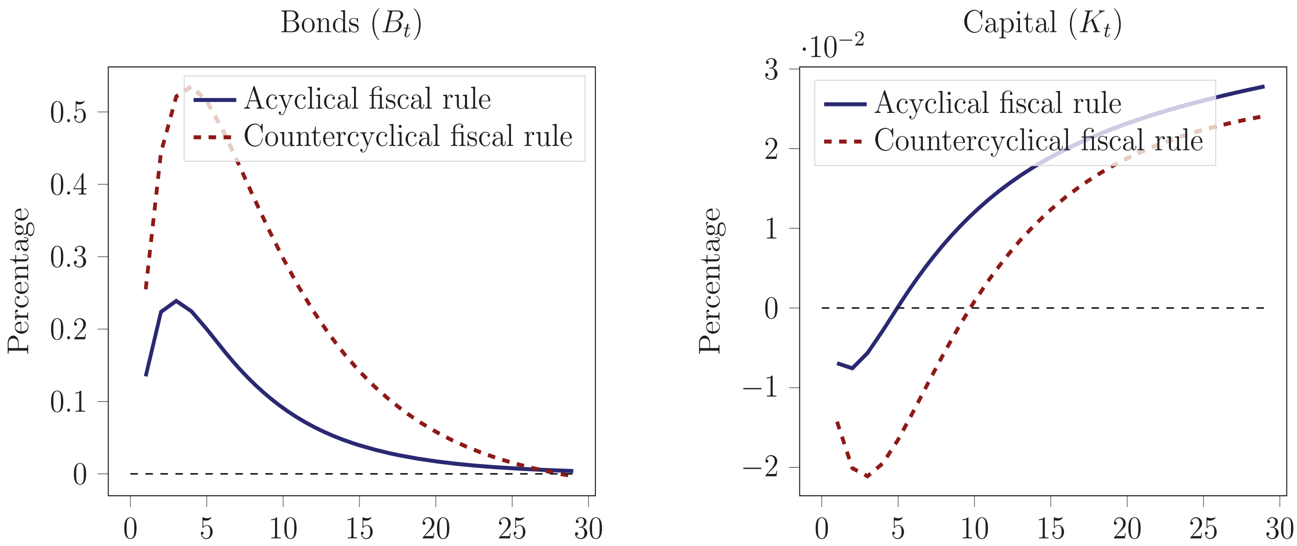

Figure 1: Assets impulse–response functions

The intertemporal substitution effect depresses consumption and thus activity, causing output and the inflation rate to fall. Marginal factor productivity falls and with it the marginal cost of firms (in equilibrium, wages and dividends must fall). This lowers the mark–up of the reseller firms, increasing profits. It is at this point that the redistributive effect of monetary policy between wage–earning and entrepreneurial households is generated: households that benefit from changes in monetary policy are those that enjoy an appreciation of their wealth, and have a very high marginal propensity to invest relative to households whose incomes are negatively affected by the shock. Entrepreneurial households –motivated by their enrichment– substitute consumption intertemporally through higher asset absorption, and working households, which are hurt by the fall in their incomes, are much more exposed to volatility in their consumption.

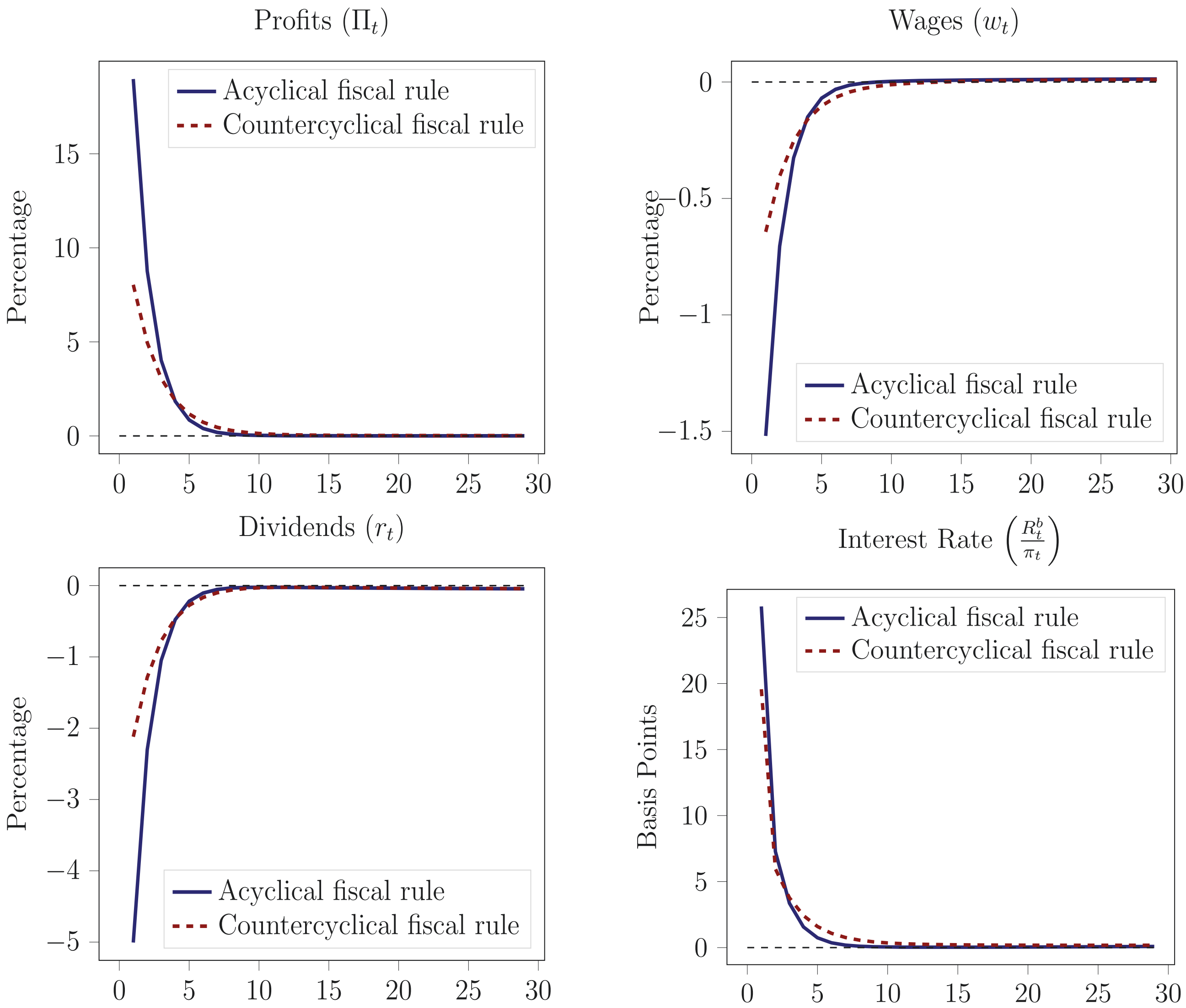

Figure 2: Income impulse–response functions

When the fiscal rule is countercyclical, higher debt issuance means that the real return on bonds does not increase as much in the face of the shock (relative to the base case). This weakens the intertemporal substitution effect, which contains the fall in consumption. Because of the previously mentioned dynamics, both the fall in wages and the increase in profits are dampened, which weakens the redistributive channel of monetary policy, also explaining the more controlled fall in output, as can be seen in Figures 2 and 3.

The weakening in the response of profits and wages to the shock shows how the effects of the redistributive channel of monetary policy are attenuated when the fiscal rule is countercyclical. In this model, when the government seeks to isolate the procyclicality of spending that manifests itself in the face of the shock through debt issuance, it also affects changes in the composition of income.

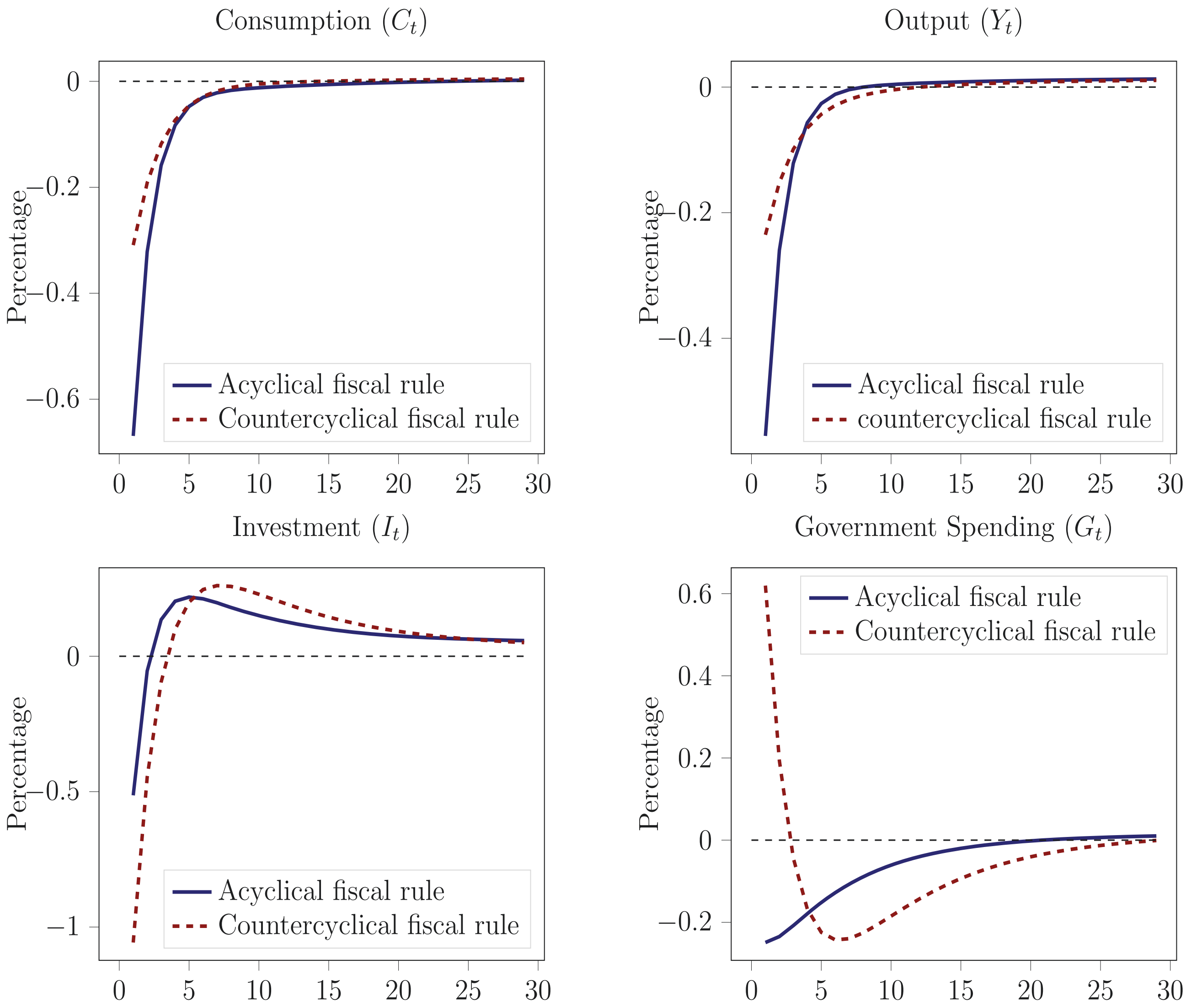

Figure 3: Aggregate variables impulse–response functions

But the effect of the cyclical essence of the fiscal rule makes sense thanks to the partial liquidity in the economy. This is because if the capital market were frictionless, there would be no excess return between assets that varies with the monetary shock, promoting the effects of the redistributive channel. A countercyclical debt policy reduces the impact of the shock on the liquidity premium (as can be seen in Figure 4), while in a fully liquid scenario, asset returns should move together to equalize in equilibrium. Monetary surprise increases the expected return on bonds (defined as $\mathbb{E}_t\left\{R^b_{t+1}/\pi_{t+1}\right\}$). In a model without portfolio heterogeneity, the positions on both assets are indeterminate in equilibrium, since both the expected return of the liquid and illiquid assets should equalize and thus leave households indifferent to holding positive amounts of either asset. This condition would be given by the following equality: $\mathbb{E}_t\left\{r^k_{t+1}/q_t\right\} = \mathbb{E}_t\left\{R^b_{t+1}/\pi_{t+1}\right\}$, where $r^k_{t+1} \equiv q_{t+1} + r_{t+1}$. However, in this model, the liquidity premium falls in the face of the monetary shock, since it redistributes resources through changes in the wealth composition (from the lowest to the highest percentiles).

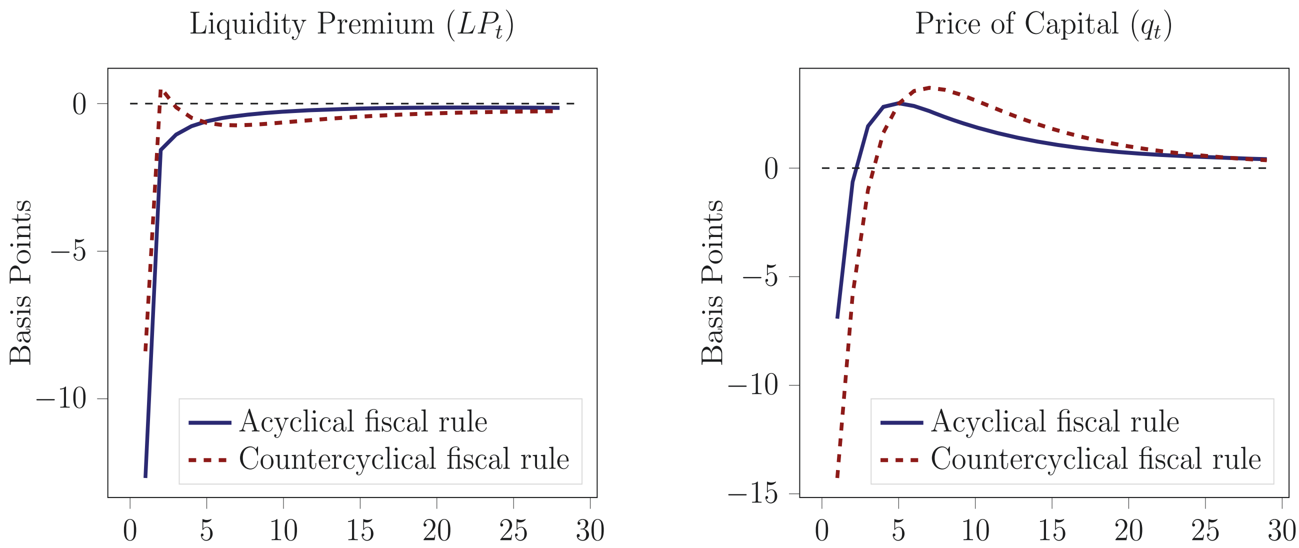

Figure 4: Liquidity impulse–response functions

Under the countercyclical fiscal rule, the increase in liquidity through the supply of bonds further depresses the price of capital relative to the base case. Since households in the highest percentiles of the wealth distribution hold the largest share of illiquid assets, the more pronounced is the depreciation of their resources, which deepens the erosion of the redistributive channel.

In summary, the fiscal channel of monetary policy is a liquidity rule that acts through asset prices and income. The expansion in the supply of bonds has a direct effect on the current price of capital that intensifies the wealth depreciation of households with a higher marginal propensity to invest (those who own the largest share of these assets). The real interest rate falls less with respect to the base case, which discourages intertemporal substitution of consumption and, in addition, relaxes the cost of borrowing for households with a higher marginal propensity to consume (as can be seen in Figure 5). The latter implies a smaller fall in the marginal productivities of firms and in mark–ups, which dampens the fall in wages and limits the increase in profits.

The more subdued inflation response helps contain the increase in the cost of borrowing, which is helpful for households that have a very high marginal propensity to consume, explaining the moderation in the consumption response. Therefore, this liquidity policy helps to reverse the effects of the redistributive channel operating through prices.

Table 2 summarizes the exposure of household income to the monetary shock, sorted by wealth percentile. The values reported are the percentage changes in income by type within each percentile, expressed in terms of steady–state consumption, in the face of a one standard deviation monetary policy shock.[4] The responses of different sources of household income are

[4]Results are averaged using frequency weights from the steady-state wealth distribution.

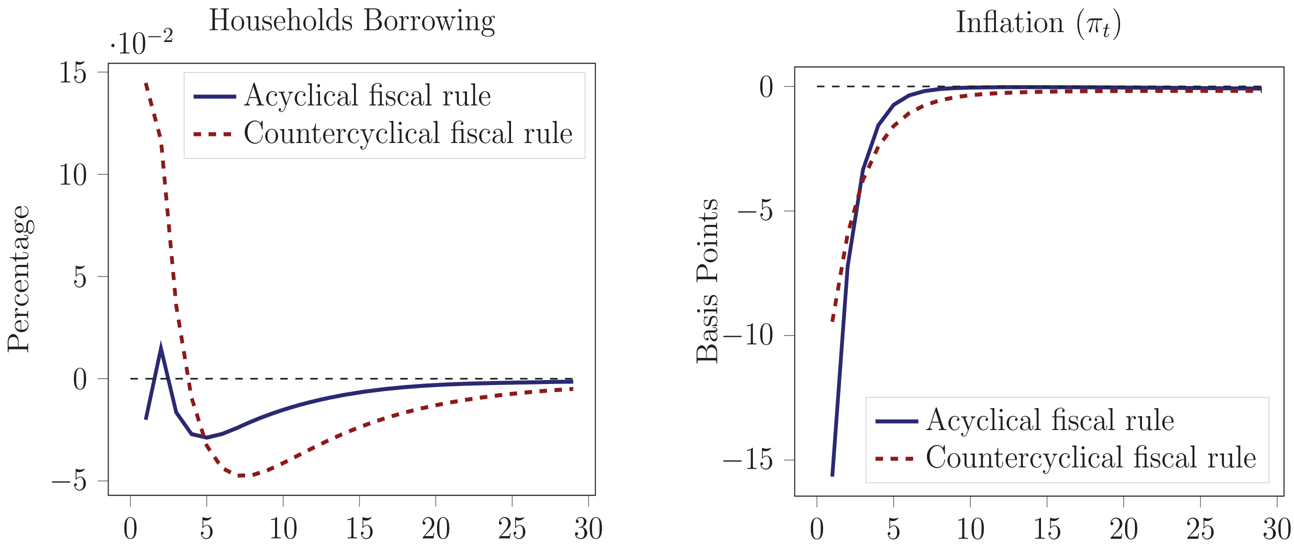

Figure 5: Households borrowing impulse–response functions

decomposed and compared under the two fiscal rules to highlight how the redistributive channel of monetary policy is weakened when the fiscal transmission channel is introduced.

Table 2: Variation in household income by type and percentile of the wealth distribution in the face of the monetary shock. All variables are expressed in terms of steady state consumption. Household income is differentiated between "financial" (which includes both returns on bonds and accumulated capital, and the market value of capital holdings) and "non–financial" (composed of labor income and profit sharing).

	Income variation by type				
Percentile	$\Delta\left(\frac{R^b_{t-1}}{\pi_t}\right) b_t$	$\Delta r_t k_t$	$\Delta w_t N_t + \Delta\Pi_t$	$\Delta q_t k_t$	Total variation
Under acyclical fiscal rule					
0.00 – 0.20	0.07	0.07	-2.27	-0.32	-2.45
0.20 – 0.40	0.07	-0.49	-1.79	-0.91	-2.49
0.40 – 0.60	0.11	-0.75	-1.33	-1.40	-3.37
0.60 – 0.80	0.26	-0.99	-1.41	-1.85	-3.99
0.80 – 1.00	0.84	-1.24	3.29	-2.30	0.59
Under countercyclical fiscal rule					
0.00 – 0.20	0.04	-0.07	-0.96	-0.65	-1.64
0.20 – 0.40	0.04	-0.21	-0.76	-1.87	-2.80
0.40 – 0.60	0.07	-0.32	-0.56	-2.87	-3.68
0.60 – 0.80	0.16	-0.42	-0.60	-3.80	-4.66
0.80 – 1.00	0.51	-0.52	1.39	-4.74	-3.36

Households in the bottom percentile of the wealth distribution (> 80%) are those that accumulate more assets and the magnitude of changes in their consumption due to changes in the returns on their portfolios are larger; however, it is the only group whose non–financial income is positively affected by the shock. The latter is due to the proportion of entrepreneurial households that receive a fraction of the benefits –rather than a wage– which increase with the monetary contraction. In particular, when the fiscal rule is acyclical, it is the only group whose total change in income is positive after the monetary shock. The appreciation of their liquid assets and income exceeds the depreciation of their illiquid assets and returns. The rest of the households –on average– located in the lower percentiles experience a reduction in their total income. These results help to explain more precisely how the redistributive channel of monetary policy acts, and replicate the findings reported in Luetticke (2021).

But, when the fiscal rule is countercyclical, this channel is markedly weakened for the following reasons: first, the appreciation of liquid assets is reduced for all percentiles. On the other hand, although the fall in capital return is lower, the depreciation of its value is much deeper and affects to a greater extent those households that own most of it, which are concentrated in the last percentile of the wealth distribution. In turn, it should be noted that, in this case, the last percentile is the one that is most adversely affected by the variation in its non–financial income, due to the fall in profits, while the first percentile is the one that benefits the most from the response of wages. In the aggregate, even though all groups experience a drop in income, households at the bottom of the distribution end up benefiting more than any other group relative to the base case, and those at the top end up hurting.

All of the above explains why defining a countercyclical debt rule reduces the redistributive effects of the contractionary monetary shock. The greatest activity is concentrated in the peaks of the distribution, since when comparing the results under the two fiscal regimes, the redistributive effects of monetary policy show the largest changes at the bottom and at the top of the distribution. When fiscal policy is countercyclical in nature, the effect of monetary policy on non–financial income in the top and bottom groups is dampened, benefiting those with a higher marginal propensity to consume and hurting those with a lower one. The depreciation of the value of illiquid assets is also very relevant in explaining the depression of the redistributive channel.

4 Conclusion

Countercyclical fiscal rules play a key role in the intertemporal smoothing of monetary shocks. This paper delves into the relationship between monetary and fiscal policy, and emphasizes how countercyclical debt rules alter the transmission channels of monetary surprises.

When the rule defining the evolution of public debt is countercyclical in nature, the government can isolate the cyclicality of spending by financing it with higher bond issuance and alter the transmission of the monetary shock through asset prices and income. This is referred to as the fiscal channel of monetary policy.

Quantitative results show a reversal of the redistributive effects of the monetary shock along the wealth distribution: compared to a base case where the rule that determines the evolution of debt is acyclical, in this model we observe a weakening in the transmission of the shock on income and a greater depreciation in the financial wealth of households that accumulate the highest percentage of illiquid assets.

Finally, the results of this paper may motivate a deeper future analysis, related to the problem of a benevolent planner interested in the trade–off between monetary policy stabilization and its distributional consequences. In this sense, the conclusions presented so far present the basis for extending the quantitative scope of this model to one that focuses on optimal policy decisions.

References

[1] Barro, R. J. (1979). "On the Determination of the Public Debt". *Journal of Political Economy*, 87(5): 940–971.

[2] Bayer, C., Luetticke, R., Pham-Dao, L., and Tjaden, V. (2019). "Precautionary Savings, Illiquid Assets, and the Aggregate consequences of Shocks to Household Income Risk". *Econometrica*, 87(1):255–290.

[3] Bayer, C., Luetticke, R. (2020). "Solving Heterogeneous Agent Models in Discrete Time with Many Idiosyncratic States by Perturbation Methods". *Quantitative Economics*, 11, pp. 1253–1288.

[4] Carroll, C. (2006). "The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems". *Economics Letters*, 91(3):312– 320.

[5] Chetty, R., Guren, A., Manoli, D., and Weber, A. (2011). "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins". *The American Economic Review*, 101(3):471–475.

[6] Guvenen, F., Kaplan, G., and Song, J. (2014). "The Glass Ceiling and the Paper Floor: Gender Differences among Top Earners, 1981–2012". *NBER Working Paper Series, 20560.*

[7] Hintermaier, T., Koeniger, W. (2010). "The Method of Endogenous Gridpoints with Occasionally Binding Constraints among Endogenous Variables". *Journal of Economic Dynamics and Control*, 34(10):2074–208.

[8] Kaplan, G., Violante, G. L. (2014). "A Model of the Consumption Response to Fiscal Stimulus Payments". *Econometrica*, 82:1199–1239.

[9] Luetticke, R. (2021). "Transmission of Monetary Policy with Heterogeneity in Household Portfolios". *American Economic Journal: Macroeconomics*, 13 (2): 1–25.

[10] Reiter, M. (2009). "Solving Heterogeneous–Agent Models by Projection and Perturbation". *Journal of Economic Dynamics and Control*, 33(3):649–665.

[11] Rotemberg, J. J. (1982). "Sticky Prices in the United States". *Journal of Political Economy*, pp. 1187–1211.

[12] Sargent, T., Wallace, N. (1981). "Some Unpleasant Monetarist Arithmetic". *Federal Reserve Bank of Minneapolis Quarterly Review*, 5(3), 1–17.

[13] Storesletten, K., Telmer, C. I., and Yaron, A. (2004). "Cyclical Dynamics in Idiosyncratic Labor Market Risk". *Journal of Political Economy*, 112(3):695–717.

[14] Tauchen, G. (1986). "Finite State Markov-Chain Approximations to Univariate and Vector Autoregressions". *Economics Letters*, 20(2):177–181.

[15] Taylor, J. (1993). "Discretion versus Policy Rules in Practice". *Carnegie–Rochester Conference Series on Public Policy*, vol. 39, issue 1, 195–214.

[16] Woodford, M. (1995). "Price–Level Determinacy Without Control of a Monetary Aggregate". *Carnegie–Rochester Conference Series on Public Policy*, 43:1–46.

Appendix

First Order Conditions of the Household Problem

The aggregators of the arguments of the household utility function are defined as:

$$
\begin{aligned}
\mathbf{x}_a &= \left(b, b'_a, k, k', h, n'_a\right) \\
\mathbf{x}_n &= \left(b, b'_n, k, h, n'_n\right) \\
\mathbf{x}'_a &= \left(b'_a, k', h'; \Theta', \Omega'\right) \\
\mathbf{x}'_n &= \left(b'_n, k, h'; \Theta', \Omega'\right)
\end{aligned}
$$

First order conditions from each household problem are:

$$
\begin{aligned}
(k^*):&\quad \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\frac{\partial c\left(\mathbf{x}_a\right)}{\partial k'} + \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_a\right)}{\partial k'} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_a\right)}{\partial k'}\right\} = 0 \\
(b_a^*):&\quad \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\frac{\partial c\left(\mathbf{x}_a\right)}{\partial b'_a} + \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_a\right)}{\partial b'_a} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_a\right)}{\partial b'_a}\right\} = 0 \\
(b_n^*):&\quad \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}\frac{\partial c\left(\mathbf{x}_n\right)}{\partial b'_n} + \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_n\right)}{\partial b'_n} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_n\right)}{\partial b'_n}\right\} = 0 \\
(n_a^*):&\quad \frac{\partial u\left(n_a\right)}{\partial n'_a} + \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\frac{\partial c\left(\mathbf{x}_a\right)}{\partial n'_a} = 0 \\
(n_n^*):&\quad \frac{\partial u\left(n_n\right)}{\partial n'_n} + \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}\frac{\partial c\left(\mathbf{x}_n\right)}{\partial n'_n} = 0
\end{aligned}
$$

Using the sequential budget constraint[5] the following expressions can be found,

$$
\begin{aligned}
\frac{\partial c\left(\mathbf{x}_a\right)}{\partial k'} &= -q \\
\frac{\partial c\left(\mathbf{x}'_i\right)}{\partial b'_i} &= -1 \quad \text{where } i = \{a, n\} \\
\frac{\partial c\left(\mathbf{x}'_i\right)}{\partial n'_i} &= (1-\tau)\, wh \quad \text{where } i = \{a, n\}
\end{aligned}
$$

[5] $c = \left(\frac{R^b}{\pi}\right) b + (q+r)\, k + (1-\tau)\left[whn + \mathcal{I}_{h=0}\Pi\right]$.

which are then used to replace in the previous system, obtaining:

$$
\begin{aligned}
(k^*): &\quad q\frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)} = \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_a\right)}{\partial k'} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_a\right)}{\partial k'}\right\} \\
(b^*_a): &\quad \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)} = \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_a\right)}{\partial b'_a} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_a\right)}{\partial b'_a}\right\} \\
(b^*_n): &\quad \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)} = \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_n\right)}{\partial b'_n} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_n\right)}{\partial b'_n}\right\} \\
(n^*_a): &\quad \frac{\partial u\left(n_a\right)}{\partial n'_a} = -whn\frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)} \\
(n^*_n): &\quad \frac{\partial u\left(n_n\right)}{\partial n'_n} = -whn\frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}
\end{aligned}
$$

Since the value functions V_a and V_n are an unknown of the problem, they must be differentiated with respect to b and k to obtain the final equations that describes the solution.

$$
\begin{aligned}
\frac{\partial V_a\left(b,k;\Theta,\Omega\right)}{\partial k} &= \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\frac{\partial c\left(\mathbf{x}_a\right)}{\partial k} = \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\left(q\left(\Theta,\Omega\right)+r\left(\Theta,\Omega\right)\right) \\
\frac{\partial V_a\left(b,k;\Theta,\Omega\right)}{\partial b} &= \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\frac{\partial c\left(\mathbf{x}_a\right)}{\partial b} = \frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\frac{R^b\left(\Theta,\Omega\right)}{\pi\left(\Theta,\Omega\right)} \\
\frac{\partial V_n\left(b,k;\Theta,\Omega\right)}{\partial b} &= \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}\frac{\partial c\left(\mathbf{x}_n\right)}{\partial b} = \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}\frac{R^b\left(\Theta,\Omega\right)}{\pi\left(\Theta,\Omega\right)} \\
\frac{\partial V_n\left(b,k;\Theta,\Omega\right)}{\partial k} &= \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}\frac{\partial c\left(\mathbf{x}_n\right)}{\partial k} + \beta\mathbb{E}\left\{\nu\frac{\partial V_a\left(\mathbf{x}'_n\right)}{\partial k} + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_n\right)}{\partial k}\right\} \\
&= \frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)}r\left(\Theta,\Omega\right) \\
&\quad + \beta\nu\mathbb{E}\left\{\frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)}\left(q\left(\Theta,\Omega\right)+r\left(\Theta,\Omega\right)\right)\right\} + (1-\nu)\beta\mathbb{E}\left\{\frac{\partial V_n\left(\mathbf{x}'_n\right)}{\partial k}\right\}
\end{aligned}
$$

Replacing these new expressions in the system of equations that characterize the agent's solution, the final Euler equations are obtained:

$$
\begin{aligned}
q\left(\Theta,\Omega\right)\frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)} &= \beta\mathbb{E}\left\{\nu\frac{\partial u\left(c\left(\mathbf{x}'_a\right)\right)}{\partial c\left(\mathbf{x}'_a\right)}\left(q\left(\Theta',\Omega'\right)+r\left(\Theta',\Omega'\right)\right) + (1-\nu)\frac{\partial V_n\left(\mathbf{x}'_a\right)}{\partial k'}\right\} \\
\frac{\partial u\left(c\left(\mathbf{x}_a\right)\right)}{\partial c\left(\mathbf{x}_a\right)} &= \beta\mathbb{E}\left\{\frac{R^b\left(\Theta',\Omega'\right)}{\pi\left(\Theta',\Omega'\right)}\left[\nu\frac{\partial u\left(c\left(\mathbf{x}'_a\right)\right)}{\partial c\left(\mathbf{x}'_a\right)}\left(q\left(\Theta',\Omega'\right)+r\left(\Theta',\Omega'\right)\right) + (1-\nu)\frac{\partial u\left(c\left(\mathbf{x}'_n\right)\right)}{\partial c\left(\mathbf{x}'_n\right)}\right]\right\} \\
\frac{\partial u\left(c\left(\mathbf{x}_n\right)\right)}{\partial c\left(\mathbf{x}_n\right)} &= \beta\mathbb{E}\left\{\frac{R^b\left(\Theta',\Omega'\right)}{\pi\left(\Theta',\Omega'\right)}\left[\nu\frac{\partial u\left(c\left(\mathbf{x}'_a\right)\right)}{\partial c\left(\mathbf{x}'_a\right)}\left(q\left(\Theta',\Omega'\right)+r\left(\Theta',\Omega'\right)\right) + (1-\nu)\frac{\partial u\left(c\left(\mathbf{x}'_n\right)\right)}{\partial c\left(\mathbf{x}'_n\right)}\right]\right\}
\end{aligned}
$$

Calibration

Table 3 summarizes the parameters calibration for both models.

Table 3: Parameters calibration under both acyclical and contracyclical fiscal rule

Parameter	Value	Description	Target
Households			
β	0.983	Discount factor	Luetticke (2021)
ν	0.125	Participation frequency	Luetticke (2021)
ξ	4	Relative risk aversion	Kaplan y Violante (2014)
γ	1	Frisch elasticity	Chetty et al. (2011)
ψ	1	Labor disutility	Luetticke (2021)
ζ	0.00065	$\Pr\left(h_t = 0 \mid h_{t-1} \neq 0\right)$	Luetticke (2021)
ι	0.0625	$\Pr\left(h_t = 1 \mid h_{t-1} = 0\right)$	Guvenen, Kaplan y Song (2014)
$\overline{R}$	0.16	Borrowing penalty	Luetticke (2021)
ρ_H	0.98	h_t persistence	Storesletten, Telmer y Yaron (2004)
σ_H	0.06	h_t standard deviation	Storesletten, Telmer y Yaron (2004)
Production			
α	0.67	Labor participation	Standard value
δ	0.0135	Depretiation rate	Luetticke (2021)
ρ_Z	0.95	Z_t persistence	Standard value
σ_Z	0.01	Z_t standard deviation	Output standard deviation
κ	0.09	Price rigidity	Luetticke (2021)
η	20	Substitution elasticity	$\frac{\eta-1}{\eta} = 0.95$
ϕ	10	Capital adjustments cost	Luetticke (2021)
Monetary Policy			
Π	1	Infaltion	0% p.a.
R^B	1.005	Nominal interest rate	2% p.a.
θ_π	1.5	Reaction to inflation	Standard value
ρ_R	0.8	Interest rate smoothing	Standard value
σ_R	0.001	Standard deviation of shock $\left(\epsilon_t^R\right)$	Standard value