Why the Eurozone Escaped Fiscal Inflation: Lessons from the U.S. Experience

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August 29, 2025

Master Thesis - M2 Analysis and Policy in Economics (APE)

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Abstract

This study investigates whether fiscal inflation has played a meaningful role in the Euro area's macroeconomic dynamics. The model builds on Galí et al. (2012), which provides the baseline New Keynesian framework. It is extended in two ways, by introducing Ricardian and non-Ricardian households, and by incorporating the fiscal block of Bianchi et al. (2023), thereby embedding the Fiscal Theory of the Price Level through the introduction of unfunded transfers. The resulting Two-Agent New Keynesian (TANK) model allows two policy regimes to coexist. In a monetary-led regime, the central bank actively stabilizes inflation while the fiscal authority passively adjusts taxes and spending to ensure debt sustainability. In a fiscally-led regime, the economy is hit by unfunded transfers—transfers not expected to be offset by future fiscal adjustments—so the fiscal authority behaves actively, disregarding debt sustainability. Debt can then only be stabilized through higher inflation, forcing the central bank to behave passively by accommodating the required price increase—fiscal inflation—rather than countering it. The model is estimated with Bayesian methods on Euro-area data for 2000–2019. Results indicate that fiscal inflation was largely absent, even in the immediate aftermath of the 2008 global financial crisis, when transfers expanded substantially and fiscal coordination peaked within the monetary union. This stands in sharp contrast to the U.S. evidence documented by Bianchi et al. (2023), where unfunded transfers—and the implied fiscal inflation—account for a sizable share of inflation dynamics over recent decades.

JEL codes: E31, E32, E62.

Keywords: Fiscal Inflation, unfunded transfers, monetary and fiscal policy interaction, Eurozone.

*Email: eliot.satta@gmail.com. I am deeply grateful to Julien Matheron for his supervision, constant guidance, and generous advice, not only throughout the completion of this thesis but also over the past year. I owe him sincere thanks for his support. I also wish to thank François Fontaine and Alex Clymo for their insightful remarks and constructive feedback during the macro seminar.

Introduction

In the aftermath of the pandemic, inflation surged to levels not seen in decades, coinciding with rising fiscal deficits and public debt across advanced economies, and growing doubts about governments' capacity to sustain them. This particular context has brought renewed attention to the Fiscal Theory of the Price Level (FTPL), developed by Leeper, Woodford, Cochrane, among others. The FTPL states that if fiscal policy is not expected to adjust future taxes or spending to stabilize debt, monetary policy may be forced to accommodate higher inflation in order to do so. Building on this idea, Bianchi et al. (2023) develop and estimate a quantitative New Keynesian model in which two policy regimes can coexist. A monetary-led regime, where the central bank actively targets price stability, while fiscal policy passively adjusts to ensure debt sustainability. This is the standard active–passive configuration typically associated with policy coordination. In the fiscally-led regime, by contrast, the economy is hit by unfunded transfer shocks—increases in transfers to households that are not backed by credible future fiscal adjustments. In this case, the fiscal authority behaves actively, and debt sustainability can only be restored through an increase in the price level that erodes the nominal value of debt. The central bank, constrained by fiscal dominance, therefore becomes passive and tolerates this rise in inflation. The amount of inflation required to ensure debt sustainability, and accommodated by the central bank, is referred to as fiscal inflation. After estimating their model on U.S. data, the authors find that fiscal inflation explains a substantial share of U.S. inflation over both the 20th and 21st centuries, and that unfunded transfers have played a central role in shaping U.S. macroeconomic dynamics. These findings highlight the FTPL as a powerful framework for interpreting the history of inflation.

While compelling for the U.S., can this approach be extended to Europe? Can the Eurozone's inflation dynamics be explained by the same unfunded-transfers channel? Has fiscal inflation operated in Europe to any meaningful extent, and if not, what has prevented its emergence?

To address these questions, this thesis develops a quantitative DSGE model tailored to the Euro area. The starting point is the New Keynesian framework of Galí et al. (2012), extended in two directions. First, households are made heterogeneous—Ricardian and hand-to-mouth—to allow conventional fiscal policy to directly influence aggregate demand. Second, the fiscal block of Bianchi et al. (2023) is incorporated to distinguish funded from unfunded transfers and to embed the fiscal-theory transmission mechanism. The inclusion of involuntary unemployment à la Galí et al. (2012) makes the model particularly suitable for Euro-area business-cycle analysis. The model is estimated with Bayesian methods on Euro-area data for 2000–2019. The analysis reveals that fiscal inflation was largely absent from Eurozone inflation dynamics. Even in the immediate aftermath of the 2008 global financial crisis, when fiscal coordination was at its peak and transfer spending expanded significantly, unfunded transfers contributed only marginally to movements in inflation and output. This stands in sharp contrast to the U.S. evidence documented by Bianchi et al. (2023).

This study is organised as follows. Section 1 introduces the key ideas of the FTPL and highlights the contribution of Bianchi et al. (2023). Section 2 develops the model. Section 3 describes the Bayesian estimation strategy and prior selection. Section 4 reports the findings, focusing on the contribution of unfunded transfers to Eurozone inflation and output dynamics. Section 5 discusses these results in light of the U.S. benchmark and concludes.

1 Understanding the Fiscal Theory of the Price Level

The Fiscal Theory of the Price Level has recently been restated in detail by Cochrane (2023), in the context of renewed debates over post-pandemic inflation and rising fiscal imbalances. The theory emphasizes how fiscal conditions—rather than monetary policy alone—can be the fundamental driver of the price level, and thus of inflation. At its core lies the debt valuation equation, which states that the real value of outstanding government debt must equal the expected present value of future real primary surpluses, a formulation originally introduced by Cochrane (1999),

$$\frac{B_{t-1}}{P_t} = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j s_{t+j}. \tag{1}$$

Here B_{t-1} denotes the nominal stock of inherited debt, P_t the price level, β the discount factor, and s_t the primary real surplus in period t. This identity implies that if debt increases without a corresponding rise in expected future surpluses, the price level must adjust upward to restore the balance. Similarly, adverse fiscal news—such as a decline in the present value of expected surpluses—will push prices higher. The mechanism can be understood in terms of asset valuation, if bondholders believe that newly issued debt will not be backed by future surpluses, the value of government bonds falls. Investors then attempt to shift out of bonds into goods or other assets, generating excess demand and raising the price level. In this sense, government bonds work as equity claims on future fiscal surpluses. When confidence in those surpluses collapses, their value declines. Crucially, however, the FTPL does not imply a simple mechanical link between current deficits and current inflation. What matters are expectations. Large deficits can coexist with stable prices if agents are confident they will eventually be financed, while inflation may arise even in periods of modest deficits if doubts about long-run fiscal solvency take hold.

The role of monetary policy in this framework can be understood by extending the debt valuation equation (1) to account for debt maturity,

$$\frac{\sum_{j=0}^{\infty} Q_t^{(t+j)} B_{t-1}^{(t+j)}}{P_t} = \mathbb{E}_t \sum_{j=0}^{\infty} \beta^j s_{t+j} \tag{2}$$

where $Q_t^{(t+j)}$ is the price of a bond $B_{t-1}^{(t+j)}$ whose repayment is due j years from now. The central bank affects the left-hand side of the debt valuation equation by setting the path of nominal interest rates, which in turn determines the market value of outstanding debt. When nominal rates rise, the price of existing government bonds falls, since they pay less relative to new bonds. This reduces the nominal value of debt, and if expected future surpluses remain unchanged, the price level must fall to restore the identity. Conversely, a cut in nominal rates raises the value of outstanding debt, requiring a higher price level unless larger surpluses are expected. This mechanism implies that interest rate policy can alter the timing of inflation but cannot eliminate it in the absence of fiscal adjustment. Higher rates may restrain prices today, but if future surpluses fail to materialize, additional inflation will follow when rates normalize. In other words, without fiscal cooperation, monetary policy can smooth inflation across time but cannot determine its long-run level.

Cochrane's conclusion is that the central bank can truly control inflation only in a monetary-led regime. In this configuration, the monetary authority is active—raising interest rates aggressively in response to rising prices, consistent with the Taylor principle—while fiscal policy is passive, adjusting taxes and spending as needed to ensure that deficits can be financed. Here, monetary policy anchors the price level, and fiscal policy maintains debt sustainability. By contrast, when fiscal policy is active—issuing debt without committing to future surpluses—debt sustainability can be restored only through higher inflation. The central bank then loses its ability to target prices and is forced into a passive role, accommodating the inflation necessary to erode the real value of debt, even at the expense of its price-stability mandate. This passive–active configuration defines the fiscally-led regime.

This intuition was first developed by Sargent and Wallace (1981), who argued that monetary policy cannot independently control inflation unless fiscal policy sets its budgets so that deficits can be financed. The first formalization came with Leeper (1991), who showed that equilibrium existence and uniqueness require either an active–passive or a passive–active configuration, a framework that became central to the FTPL. Building on this foundation, subsequent contributions extended the analysis to study regime interactions, with particular emphasis on identifying prevailing regimes—especially in the U.S.—and on understanding the mechanisms through which economies may transition between them. Notable examples include Bianchi (2013), Melosi (2016), and Bianchi and Ilut (2017).

One recent contribution, both empirical and theoretical, is provided by Bianchi et al. (2023), who develop a quantitative model in which fiscally-led and monetary-led regimes can coexist. The model embodies the FTPL by allowing the fiscal authority to implement unfunded transfers—transfers not backed by future fiscal adjustments. When such transfers occur, the central bank is forced to tolerate higher inflation to prevent debt from becoming unsustainable. The policy block features shock-specific rules: government spending and funded transfer shocks are absorbed in a monetary-led regime (active monetary, passive fiscal), while unfunded transfer shocks shift the economy into a fiscally-led regime (active fiscal, passive monetary). In this setting, both authorities adjust relative to two benchmarks: deviations of inflation from fiscal inflation—the level of inflation required to stabilize debt—and deviations of debt from its unfunded component implied by unfunded transfers. Estimating the model on U.S. data, the authors find that unfunded transfers were a central driver of inflation across U.S. history. They sustained the post-2008 recovery by preventing deflation, and they were also at the root of the inflation surge that followed the large fiscal interventions during the pandemic.

Unfunded transfers therefore represent an intriguing policy instrument. They can stimulate economic activity while containing debt accumulation, though at the cost of higher inflation. These characteristics appear particularly appealing in the high-debt, low-growth context of the Euro Area. The goal of this master's thesis is to assess whether unfunded transfers have shaped Eurozone inflation dynamics and, more broadly, to understand the conditions under which such transfers may emerge.

2 The Model

This section presents a quantitative model in which fiscally-led and monetary-led regimes can coexist. The starting point is the framework of Galí et al. (2012), which provides the core New Keynesian structure with price and wage rigidities, intermediate and final goods production, and involuntary unemployment. This baseline is extended in two directions. First, households are divided into Ricardian and non-Ricardian (hand-to-mouth) types, with the former smoothing consumption intertemporally and the latter consuming their entire income each period. Introducing this heterogeneity allows standard fiscal policy to exert direct effects on aggregate demand. Second, the fiscal block of Bianchi et al. (2023) is incorporated, allowing for unfunded transfers and embedding the FTPL spirit into the model. Full notations and the derivation of the system of equations are provided in Sections A and B of the appendix.

2.1 Households

The economy is populated by a unit mass of households. A fraction $\omega \in [0, 1)$ of these are hand-to-mouth households, indexed by H, while the remaining fraction $1 - \omega$ are Ricardian households, indexed by R. Each household consists of a continuum of members identified by a pair $(h, j) \in [0, 1] \times [0, 1]$, where h indexes the type of labor supplied, and j the individual's disutility from supplying such labor. Members within each household pool resources and share risk perfectly, ensuring equal consumption across all individuals within the same household.

Ricardian Agents. Ricardian households derive utility from the consumption of a composite good C_t^{*R}, which aggregates private consumption C_t^R and public consumption G_t as follows,

$$C_t^{*R} = C_t^R + \alpha_G G_t, \tag{3}$$

where α_G governs the degree of substitutability between private and public consumption. Preferences exhibit external habits in consumption, utility depends on current composite (or total) consumption relative to lagged average composite consumption of Ricardian agents $\tilde{C}_{t-1}^{*R}$,

$$C_t^{*R} - \eta \tilde{C}_{t-1}^{*R},$$

where $\eta \in [0, 1]$ measures the strength of habit formation. Agents derive disutility from working. This negative utility is weighted by a scale parameter $\chi > 0$, an endogenous preference shifter Φ_t^R, and varies across individuals according to their j-type work disutility,

$$\chi e^{\zeta_{N,t}} \Phi_t^R j^\nu,$$

where $\nu > 0$ shapes the distribution of disutility from labor across individuals and $\zeta_{N,t}$ is an exogenous labor preference shock. The Ricardian household endogenous preference (or taste) shifter is defined as,

$$\Phi_t^R = \frac{Z_t}{C_t^{*R} - \eta \tilde{C}_{t-1}^{*R}}, \tag{4}$$

where Z_t captures a smooth consumption trend evolving according to,

$$Z_t \equiv (Z_{t-1})^{1-\psi} (C_t^* - \eta C_{t-1}^*)^\psi, \tag{5}$$

where $\psi \in [0, 1]$ controls the strength of a composite wealth effect on labor supply. Aggregate composite consumption is denoted C_t^*, defined as private consumption C_t plus a weighted share of public consumption $\alpha_G G_t$, with private consumption itself split between Ricardian and hand-to-mouth households,

$$C_t^* = C_t + \alpha_G G_t \tag{6}$$

The presence of this taste shifter implies that the disutility from working declines when consumption grows faster than its trend. If aggregate consumption, adjusted for habits, $C_t^* - \eta C_{t-1}^*$, rises above its trend level Z_t, the preference shifter Φ_t^R falls below one, reducing the perceived unpleasantness of work and encouraging individuals to supply labor. It reflects the idea that people are more motivated to work when they feel wealthier relative to the past, making labor supply move in line with consumption changes. The parameter ψ governs the intensity of this wealth effect and, as discussed later in Section 2.2, directly shapes individual labor supply and unemployment dynamics.

The lifetime utility of a Ricardian household is therefore given by,

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t e^{\zeta_{U,t}} \left(\log \left(C_t^{*R} - \eta \tilde{C}_{t-1}^{*R} \right) - \int_0^1 \int_0^1 \mathbb{1}_t(h, j)\, \chi e^{\zeta_{N,t}} \Phi_t^R j^\nu \, dj \, dh \right) \right],$$

where $\mathbb{1}_t(h,j)$ is an indicator function taking the value 1 if individual (h,j) is employed at time t, and 0 otherwise, $\beta \in (0,1)$ is the subjective discount factor and $\zeta_{U,t}$ an exogenous discount factor shock. Letting $N_t^R(h)$ denote the mass of employed Ricardian workers specialized in labor type h, and aggregating over individual labor types, the disutility term simplifies allowing the household's lifetime utility to be rewritten as,

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t e^{\zeta_{U,t}} \left(\log \left(C_t^{*R} - \eta \tilde{C}_{t-1}^{*R} \right) - \int_0^1 \chi e^{\zeta_{N,t}} \Phi_t^R \frac{N_t^R(h)^{1+\nu}}{1+\nu} \, dh \right) \right]. \tag{7}$$

What is not consumed by Ricardian agents can be accumulated as wealth in the form of physical capital, denoted K_t^R. Capital depreciates at a constant rate δ and increases with investment I_t^R. The law of motion for physical capital is given by,

$$K_t^R = (1-\delta) K_{t-1}^R + e^{\zeta_{I,t}} \left[1 - S\left(\frac{I_t^R}{I_{t-1}^R} \right) \right] I_t^R, \tag{8}$$

where $\zeta_{I,t}$ is an exogenous investment-specific technology shock, and $S(.)$ is an investment adjustment cost function. This function satisfies the following conditions,

$$S(e^{\varkappa}) = S'(e^{\varkappa}) = 0 \quad \text{and} \quad S''(e^{\varkappa}) \equiv \nu_I > 0,$$

where $\varkappa$ denotes the logarithm of the steady-state growth rate of exogenous technological progress (to be detailed later). The parameter ν_I therefore captures how costly it is for firms to adjust their investment away from its usual path. A higher ν_I means firms face greater costs, making investment decisions less responsive to shocks.

Ricardian agents earn income by renting effective capital $\Upsilon_t K_{t-1}^R$ to intermediate firms, where Υ_t represents the capital utilization rate. Utilizing capital is costly, the cost of utilizing one unit of capital is given by a strictly increasing and convex function $a(\Upsilon_t)$, assumed to be proportional to available capital stock. Letting Υ_*, the steady state value of the utilization rate, being equal to 1, the function $a(.)$ is normalized so that,

$$a(1) = 0 \quad \text{and} \quad \frac{a''(1)}{a'(1)} = \frac{\vartheta}{1-\vartheta} \equiv \nu_\Upsilon > 0.$$

The role played by ν_Υ is similar to that of ν_I, but it applies to how intensively capital is used rather than how much is invested. Specifically, ν_Υ determines how costly it is to operate capital at a level different from what is normally observed in the economy. A higher value of ν_Υ means that even small increases or decreases in capital utilization quickly become expensive, making capital services more stable over time.

In addition to accumulating capital, Ricardian households can use their income to trade both short-term and long-term government bonds, denoted $B_{S,t}$ and $B_{L,t}$ respectively. These bonds are acquired at prices $P_{S,t}$ and $P_{L,t}$. One-period bonds are in zero net supply. Long-term bonds are modeled as perpetuities with geometrically decaying coupons at rate $\rho \in [0,1)$. Implying that a bond purchased at time t pays one euro at $t+1$, ρ euros at $t+2$, ρ^2 euros at $t+3$ and so on. As a result, the price at time t of a bond issued in $t-1$ is simply $\rho P_{L,t}$. The gross holding return on short-term bonds is defined as,

$$R_{S,t} \equiv \frac{e^{-\zeta_{rp,t}}}{P_{S,t}},$$

where $\zeta_{rp,t}$ is an exogenous risk premium shock. The gross holding returns for the long-term bonds is,

$$R_{L,t} \equiv \frac{1+\rho P_{L,t}}{P_{L,t-1}} \quad . \tag{9}$$

In each period t, the representative Ricardian household receives income from labor earnings, government transfers T_t, and dividends from firms D_t. These resources are allocated between consumption, investment in physical capital, and purchases of short- and long-term government bonds. The Ricardian household maximizes his lifetime utility (7) subject to the law of motion for capital (8), and the following period budget constraint,

$$\begin{aligned}(1+\tau_{C,t})P_t C_t^R + P_t I_t^R + P_{S,t}B_{S,t}^R + P_{L,t}B_{L,t}^R \\ = B_{S,t-1}^R + (1+\rho P_{L,t})B_{L,t-1}^R + \int_0^1 (1-\tau_{N,t})W_t(h)N_t^R(h)\,dh \\ + P_t\left[(1-\tau_{K,t})R_{K,t}\Upsilon_t - a(\Upsilon_t)\right]K_{t-1}^R + P_t D_t^R + P_t T_t,\end{aligned} \tag{10}$$

where $W_t(h)$ is the wage paid to labor of type h, P_t the nominal price of the final good, R_K is the real rental rate of capital, and $\tau_{C,t}$, $\tau_{N,t}$, $\tau_{K,t}$ denote tax rates on consumption, labor income, and capital income, respectively. The first-order conditions (FOCs) of the Ricardian household's maximization problem are provided in Section B.1 of the appendix.

Hand-to-mouth Agents. Unlike Ricardians, hand-to-mouth households (or non-Ricardian) do not accumulate physical capital nor participate in bond markets, they consume entirely their current income in each period. Their income consists only of labor earnings and government transfers. Consequently, aggregate capital and investment are entirely determined by Ricardian households,

$$K_t = (1-\omega)\Upsilon_t K_t^R, \quad I_t = (1-\omega)I_t^R.$$

The lifetime utility function of hand-to-mouth households mirrors that of Ricardian agents, sharing identical functional forms for consumption preferences and labor disutility. The representative hand-to-mouth household maximizes its lifetime utility with respect to the following budget constraint,

$$(1+\tau_{C,t})P_t C_t^H = \int_0^1 (1-\tau_{N,t})W_t(h)N_t^H(h)\,dh + P_t T_t, \tag{11}$$

where $N_t^H(h)$ is the mass of agents from non-Ricardian households specialized in labor of type h that actually work at t. Note that public transfers and tax rates do not depend on household type and are identical across hand-to-mouth and Ricardian agents.

2.2 Wage Setting and Unemployment

This subsection describes the wage-setting block of the model. Households of type h are represented by unions that set wages, and supply differentiated labor $N_t(h)$ to labor packers. Labor packers aggregate individual labor into a final labor input N_t, which is then sold to intermediate firms. Unions operate under monopolistic competition over their specific type of labor, granting them wage-setting power. However, they face Calvo-style frictions that prevent them from adjusting wages freely each period. These rigidities generate wage stickiness and give rise to involuntary unemployment.

Labor Packer. The economy features a large number of perfectly competitive labor packers who produce the final labor input according to the following technology,

$$N_t = \left(\int_0^1 N_t(h)^{\frac{\theta_w - 1}{\theta_w}} \, dh \right)^{\frac{\theta_w}{\theta_w - 1}},$$

where $\theta_w > 1$ denotes the constant elasticity of substitution across labor types. The differentiated labor input $N_t(h)$ is defined as,

$$N_t(h) = \omega N_t^H(h) + (1 - \omega) N_t^R(h),$$

where $N_t^H(h)$ and $N_t^R(h)$ denote labor supplied by hand-to-mouth and Ricardian households, respectively.

Labor packer rent differentiated labor $N_t(h)$ at wage $W_t(h)$ from unions, and sell the aggregate labor input to intermediate firms at wage W_t. The cost-minimization problem of the representative labor packer leads to the following demand for each type of differentiated labor,

$$N_t(h) = N_t \left(\frac{W_t(h)}{W_t} \right)^{-\theta_w}.$$

Given that both Ricardian and hand-to-mouth households are specialized in supplying labor of type h, and that they face the same wage $W_t(h)$, there is no distinction in the type of household providing this labor. As a result, the demand for each labor type $N_t(h)$ is met equally across household types, implying,

$$N_t^R(h) = N_t^H(h) = N_t(h).$$

Union. Following the formalism of Calvo (1983), at each period t, every union h faces a constant probability $1 - \alpha_w$ of being allowed to reset its wage. With probability α_w, the union cannot reoptimize and instead mechanically updates its wage following an indexation rule,

$$W_t(h) = e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_{t-1})^{\gamma_w} W_{t-1}(h),$$

where $\gamma_w \in [0, 1]$ captures the degree of indexation to past inflation, $\Pi_{t-1} \equiv P_{t-1}/P_{t-2}$ is the previous period's gross inflation rate, and Π_* denotes the gross steady-state inflation rate. The term $e^{\varkappa}$ accounts for the steady growth trend in the economy. The parameter $\alpha_w \in [0, 1]$ being constant over time, it represents the fraction of wage contracts that remain unchanged from one period to the next, providing a direct measure of wage rigidity in the economy.

Let's define the wage revision factor, $V^w_{t|t+s}$, which captures the mechanical evolution of wages for unions that are unable to reoptimize overtime,

$$V^w_{t|t+s} = \begin{cases} e^{s\varkappa} \prod_{j=t}^{t+s-1} (\Pi_*)^{1-\gamma_w} (\Pi_j)^{\gamma_w} & \text{if } s \geq 1 \\ 1 & \text{if } s = 0 \end{cases}$$

Let $W_t^\star(h)$ denote the wage optimally set by union h upon receiving the opportunity to reoptimize at time t. The effective wage applied by union h in period $t + s$, conditional on the last wage adjustment occurring at time t, is thus given by $V^w_{t|t+s} W_t^\star(h)$. Substituting this expression into the labor demand equation yields,

$$N_{t+s|t}(h) = N_{t+s} \left(\frac{V^w_{t|t+s} W_t^\star(h)}{W_{t+s}} \right)^{-\theta_w},$$

where $N_{t+s|t}(h)$ represents the demand for labor of type h in period $t+s$, under the assumption that the last wage reset occurred in period t.

Upon receiving a reoptimization opportunity, union h sets $W_t^\star(h)$ so as to maximize,

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_w)^s \Bigg[\Lambda_{t+s}(1-\tau_{N,t+s})\bar{W}_{t+s} \left(\frac{V^w_{t|t+s} W_t^\star(h)}{W_{t+s}} \right)^{1-\theta_w} N_{t+s} \\ - \frac{\chi}{1+\nu} e^{\zeta_{U,t+s}+\zeta_{N,t+s}} \Phi^R_{t+s} \left(\frac{V^w_{t|t+s} W_t^\star(h)}{W_{t+s}} \right)^{-\theta_w(1+\nu)} N_{t+s}^{1+\nu} \Bigg]$$

which yields the following first-order condition,

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_w)^s \Bigg[\Lambda_{t+s}(1-\tau_{N,t+s})\bar{W}_{t+s} \left(\frac{V^w_{t|t+s} W_t^\star(h)}{W_{t+s}} \right)^{1-\theta_w} N_{t+s} \\ - \mu_w \, e^{\zeta_{U,t+s}+\zeta_{N,t+s}+\zeta_{W,t+s}} \chi \Phi^R_{t+s} \left(\frac{V^w_{t|t+s} W_t^\star(h)}{W_{t+s}} \right)^{-\theta_w(1+\nu)} N_{t+s}^{1+\nu} \Bigg] = 0$$

where $\bar{W}_t(h) = W_t(h)/P_t$, denotes the real wage, and Λ_t the marginal utility of wealth for Ricardian households in period t. Introducing the shock $\zeta_{W,t}$ in the wage-setting block allows for exogenous variation in the wage markup,

$$\mu_w = \frac{\theta_w}{\theta_w - 1} \quad .$$

The FOC allows for the isolation of $W_t^\star(h)$ and the derivation of a wage dispersion index instrumental in closing the model. Further details are provided in Sections B.2 and B.4 of the appendix.

Unemployment. Once wages are set, firms determine the quantity of labor they wish to hire. Households accommodate this demand as long as the real wage offered exceeds the disutility from supplying labor, as perceived by the marginal worker. Consider the example of a member (h, j) of a Ricardian household. This agent will be willing to work at the prevailing real wage if and only if,

$$\frac{e^{\zeta_{U,t}}}{C_t^{*R} - \eta \tilde{C}_t^{*R}} \left(\frac{1-\tau_{N,t}}{1+\tau_{C,t}} \right) \bar{W}_t(h) \geq \chi e^{\zeta_{U,t}+\zeta_{N,t}} \Phi_t^R j^\nu,$$

where the left-hand side represents the marginal utility of consumption weighted by labor income, and where the right-hand side captures the disutility from working. Let $L_t^R(h)$ denote the marginal supplier of labor of type h. Using the taste shifter expression (4), the condition for the marginal worker becomes,

$$\left(\frac{1-\tau_{N,t}}{1+\tau_{C,t}} \right) \bar{W}_t(h) = \chi e^{\zeta_{N,t}} Z_t \left(L_t^R(h) \right)^\nu ,$$

implying that all household members with a j below $L_t^R(h)$ are willing to supply labor. Therefore, this condition determines the marginal worker, whose willingness to work pins down labor market participation. Importantly, the parameter ψ incorporated in Z_t, controls the intensity of the wealth effect. When $\psi = 0$, Z_t is purely exogenous, and the equation above reduces to a labor-supply condition without wealth effects, where participation depends solely on the net wage. When $\psi = 1$, the wealth effect is complete, and the condition collapses to the canonical labor-supply equation in which the marginal rate of substitution equals the net wage. Intermediate values of ψ therefore capture partial wealth effects. As will be shown empirically in Section 3.3, the posterior estimate of

ψ is relatively small (below 0.3), suggesting that wealth effects play only a limited role in shaping Euro Area labor supply.

Since all households face the same preferences and risks, each type of household behaves in the same way when it comes to supplying labor. As a result, the marginal willingness to work is identical across Ricardian and hand-to-mouth agents,

$$L_t(h) = L_t(h)^R = L_t(h)^H.$$

Letting $L_t \equiv \int_0^1 L_t(h)\, dh$ denote the aggregate labor force, the labor supply condition can be rewritten as,

$$\Delta_t \left(\frac{1 - \tau_{N,t}}{1 + \tau_{C,t}} \right) \bar{W}_t = \chi e^{\zeta_{N,t}} Z_t \left(L_t \right)^{\nu} \tag{12}$$

where the term $\Delta_t \equiv \int_0^1 \left(\frac{W_t(h)}{W_t} \right)^{\frac{1}{\nu}} dh \Big)^{\nu}$ captures wage dispersion generated by nominal rigidities.

In this model, unions have market power over their specific type of labor and set wages under monopolistic competition. Due to Calvo-style frictions, only a fraction of unions can reset wages optimally in any given period. As a result, wages may not adjust flexibly to shocks and can become misaligned with current labor market conditions. In particular, real wages may remain too high for firms to hire additional workers even though households are willing to work as those wages. This mismatch gives rise to involuntary unemployment, defined as the gap between the total labor force L_t and actual employment N_t, normalized by the labor force,

$$U_t \equiv \frac{L_t - N_t}{L_t}. \tag{13}$$

Adding unemployment to the model improves its ability to replicate the dynamics of Eurozone business cycles. The structure of the model implies that labor market fluctuations occur entirely through the extensive margin i.e., through changes in employment status, unlike in models such as Bianchi et al. (2023), which focus on the intensive margin by modeling hours worked. While the intensive margin may be more appropriate for highly flexible labor markets like that of the U.S., the Eurozone is characterized by lower labor mobility and stronger rigidities. Another advantage of introducing an explicit measure of unemployment is the ability to disentangle labor supply shocks from wage markup shocks (which appear in the same place in the wage-setting FOC), a key identification challenge highlighted by Chari et al. (2009) and addressed by Galí et al. (2012).

2.3 Production and Price Setting

The production sector consists of firms that produce both intermediate and final goods. This subsection outlines the structure of production and details the price-setting process, which follows a Calvo framework to capture nominal rigidities in price adjustment.

Final Good Sector. The final good Q_t is produced by a perfectly competitive sector that aggregates a continuum of intermediate goods $Q_t(f)$, indexed by $f \in [0, 1]$, according to the following technology,

$$Q_t = \left(\int_0^1 Q_t(f)^{\frac{\theta_p - 1}{\theta_p}} df \right)^{\frac{\theta_p}{\theta_p - 1}},$$

where $\theta_p > 1$ denotes the constant elasticity of substitution across intermediate goods. With P_t the price of the final good, and $P_t(f)$ the price of intermediate good f, the representative final goods producer chooses $Q_t(f)$, taking Q_t as given, so as to maximize its profits. This optimization problem yields the demand for intermediate inputs,

$$Q_t(f) = Q_t \left(\frac{P_t(f)}{P_t} \right)^{-\theta_p}.$$

The final good Q_t can be allocated to private consumption C_t, investment I_t, public consumption G_t, paying for capital utilization $a(\Upsilon_t)K_{t-1}$, or used as a material input M_t into the production of intermediate goods. Substituting the expressions for C_t, I_t, and K_t from Section 2.1, the aggregate resource constraint can be written as,

$$Q_t = \omega C_t^H + (1-\omega)C_t^R + (1-\omega)I_t^R + G_t + a(\Upsilon_t)(1-\omega)K_{t-1}^R + M_t. \tag{14}$$

Intermediate Good Sector. Regarding the intermediate goods sector, the model assumes that each differentiated input f is produced by a monopolist. The production technology for intermediate good f is given by,

$$Q_t(f) = \min\left\{ \frac{Y_t(f)}{1-s_M}, \quad \frac{M_t(f)}{s_M} \right\},$$

where $s_M \in (0,1)$ denotes the share of material inputs in total production costs. The value-added component $Y_t(f)$ is produced using a Cobb–Douglas production function,

$$Y_t(f) = K_t(f)^\theta \left(A_t N_t(f)\right)^{1-\theta} - \kappa A_t, \tag{15}$$

where $\theta \in [0,1]$ denotes the elasticity of output with respect to capital, and $\kappa \geq 0$ captures a fixed production cost, scaled by the level of technology A_t. The inputs $K_t(f)$, $N_t(f)$, and $M_t(f)$ represent capital, labor, and materials used by firm f. The scaling of κ by A_t ensures that the fixed cost grows proportionally with the economy, ensuring it does not vanish with time. The labor-augmenting technology A_t evolves according to,

$$\log A_t = \varkappa + \log A_{t-1} + \zeta_{A,t}, \tag{16}$$

where $\varkappa > 0$, and $\zeta_{A,t}$ is an exogenous shock to productivity. The fixed cost parameter κ is calibrated such that aggregate real profits are zero in the initial steady state. The real marginal cost of production S_t reflects both the cost of material inputs and the cost of value-added inputs (capital and labor). It is given by,

$$S_t = s_M + (1-s_M)S_t^{VA}, \tag{17}$$

where S_t^{VA} is the marginal cost of producing one unit of value added $Y_t(f)$. To derive S_t^{VA}, consider the cost-minimization problem of a representative intermediate firm f, which chooses capital $K_t(f)$ and labor $N_t(f)$ to minimize the cost of producing a given quantity of value added. The associated Lagrangian of this program is,

$$\mathbb{L}_t(f) = \bar{W}_t N_t(f) + R_{K,t}K_t(f) - S_t^{VA}\Big(K_t(f)^\theta (A_t N_t(f))^{1-\theta} - \kappa A_t - Y_t(f)\Big).$$

The two FOCs yield the real wage $\bar{W}_t$ and, the real rental rate of capital $R_{K,t}$,

$$\bar{W}_t = A_t S_t^{VA}(1-\theta)\left(\frac{K_t(f)}{A_t N_t(f)}\right)^\theta, \quad R_{K,t} = S_t^{VA}\theta\left(\frac{K_t(f)}{A_t N_t(f)}\right)^{\theta-1}.$$

These equations characterize the optimal capital–labor ratio and the marginal cost of producing one unit of value added. The full real marginal cost S_t then combines the cost share of materials s_M and that of value-added inputs $1-s_M$.

Aggregate Production. The Leontief combination of value-added $Y_t(f)$ and materials $M_t(f)$ in the production of intermediate good $Q_t(f)$ implies the following accounting conditions for each firm f,

$$s_M Q_t(f) = M_t(f), \quad \text{and} \quad (1 - s_M)Q_t(f) = Y_t(f),$$

which simply state that a constant share s_M of output must be allocated to materials, and the remaining share to value added. Integrating both expressions over all firms using the demand for intermediate inputs, yields the following aggregate relationships,

$$s_M Q_t \int_0^1 \left(\frac{P_t(f)}{P_t}\right)^{-\theta_p} df = \int_0^1 M_t(f)df,$$

and,

$$(1 - s_M)Q_t \int_0^1 \left(\frac{P_t(f)}{P_t}\right)^{-\theta_p} df = \int_0^1 Y_t(f)df,$$

where aggregate value-added output is defined as $Y_t \equiv (1 - s_M)Q_t$. Therefore, the second condition can be rewritten as,

$$Y_t \int_0^1 \left(\frac{P_t(f)}{P_t}\right)^{-\theta_p} df = \int_0^1 \left[K_t(f)^\theta (A_t N_t(f))^{1-\theta} - \kappa A_t\right] df,$$

linking aggregate output with the sum of firm-level production functions. The presence of,

$$\Xi_t \equiv \int_0^1 \left(\frac{P_t(f)}{P_t}\right)^{-\theta_p} df,$$

reflects the impact of price dispersion across intermediate goods, which distorts the aggregation and implies inefficiencies relative to a perfectly competitive economy with identical prices. The product $\Xi_t Y_t$ thus captures effective aggregate value-added after accounting for these distortions and the fixed cost of production.

From the FOCs of the cost-minimization problem describing $\bar{W}$ and $R_{K,t}$ it follows that the optimal capital-labor ratio $\frac{A_t N_t(f)}{K_t(f)}$ is constant across all intermediate producers. Applying the market-clearing conditions on materials, labor, and capital,

$$\int_0^1 M_t(f)\, df = M_t, \qquad \int_0^1 N_t(f)\, df = N_t, \qquad \int_0^1 K_t(f)\, df = (1 - \omega)\Upsilon_t K^R_{t-1},$$

allows to conclude that for any $f \in [0, 1]$,

$$\frac{K_t(f)}{A_t N_t(f)} = \frac{(1 - \omega)\Upsilon_t K^R_{t-1}}{A_t N_t} \quad .$$

Plugging this ratio into the expressions of the real wage $\bar{W}_t$, the real rental rate of capital $R_{K,t}$, the effective value added $\Xi_t Y_t$, and using the market clearing condition for materials yields the following set of aggregagte quantities,

$$M_t = s_M Q_t \Xi_t, \tag{18}$$

$$Y_t \Xi_t = \left((1 - \omega)\Upsilon_t K^R_{t-1}\right)^\theta (A_t N_t)^{1-\theta} - \kappa A_t, \tag{19}$$

$$\bar{W}_t = A_t S^{VA}_t (1 - \theta) \left[\frac{(1 - \omega)Y_t K^R_{t-1}}{A_t N_t}\right]^\theta, \tag{20}$$

$$R_{K,t} = S^{VA}_t \theta \left[\frac{(1 - \omega)Y_t K^R_{t-1}}{A_t N_t}\right]^{\theta-1}. \tag{21}$$

Price Setting. Applying the same Calvo style rigidities as in the wage setting block, it is assumed that in each period, a firm f can reset its price with probability $1-\alpha_p$. With probability α_p, it must instead follow a mechanical indexation rule,

$$P_t(f) = (\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p} P_{t-1}(f),$$

where $\gamma_p \in [0,1]$ determines the degree of indexation to past inflation. The parameter $\alpha_p \in [0,1]$, being constant over time, can be interpreted as the fraction of prices that remain unchanged from one period to the next, and thus serves as a natural index of price rigidity. This staggered price-setting framework mirrors the wage-setting mechanism described earlier, introducing nominal frictions into firms' pricing decisions.

Let $P_t^\star(f)$ denote the optimal reset price chosen by firm f at time t, and $V^p_{t|t+s}$ the price revision factor. If the last price adjustment occurred in period t, then the price in period $t+s$ evolves according to,

$$V^p_{t|t+s} = \begin{cases} \prod_{j=t}^{t+s-1} (\Pi_*)^{1-\gamma_p}(\Pi_j)^{\gamma_p} & \text{if } s \geq 1 \\ 1 & \text{if } s = 0 \end{cases}$$

Given this evolution, the demand faced by firm f in period $t+s$ is now equal to,

$$Q_{t|t+s}(f) = Q_{t+s}\left(\frac{V^p_{t|t+s} P_t^\star(f)}{P_{t+s}}\right)^{-\theta_p}.$$

Each intermediate firm f is owned by the representative Ricardian household, which acts to maximize the firm's value on its behalf. When choosing its pricing strategy, the firm accounts for the intertemporal valuation of profits by Ricardian households. This is captured by the stochastic discount factor between periods t and $t+s$, defined as,

$$\beta^s \frac{\Lambda_{t+s}}{\Lambda_t} \quad .$$

If firm f is selected to reoptimize its price in period t, it chooses the reset price $P_t^\star(f)$ to maximize the expected discounted stream of real profits while its price remains in effect,

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_p)^s \frac{\Lambda_{t+s}}{\Lambda_t}\left[\frac{V^p_{t|t+s} P_t^\star(f)}{P_{t+s}} Q_{t|t+s}(f) - S_{t+s} Q_{t|t+s}(f)\right].$$

Differentiating this expression with respect to $P_t^\star(f)$ yields the first-order condition,

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_p)^s \frac{\Lambda_{t+s}}{\Lambda_t}\left[\left(\frac{V^p_{t|t+s} P_t^\star(f)}{P_{t+s}}\right)^{1-\theta_p} Q_{t+s} - \mu_p S_{t+s} e^{\zeta_{P,t+s}} \left(\frac{V^p_{t|t+s} P_t^\star(f)}{P_{t+s}}\right)^{-\theta_p} Q_{t+s}\right] = 0,$$

where $\zeta_{P,t}$ is an exogenous shock that allows for time variation in the price markup,

$$\mu_p \equiv \frac{\theta_p}{\theta_p - 1},$$

enabling the model to capture fluctuations in firms' pricing power.

The procedure for deriving the price dispersion index, instrumental for closing the model, is detailed in Sections B.3 and B.4 of the appendix.

2.4 Government

The government must balance its expenditures, including public transfers, public consumption, and servicing existing debt with available resources, coming from taxes on households and firms and from new long-term borrowing. As mentioned in Section 2.1, short-term government bonds are in zero net supply, implying that all government debt is issued as long-term bonds. The nominal government budget constraint can thus be written as,

$$\begin{aligned} P_{L,t}B_{L,t} + \tau_{N,t}W_tN_t + \tau_{K,t}P_tR_{K,t}\Upsilon_t(1-\omega)K^R_{t-1} + \tau_{C,t}P_tC_t \\ = (1+\rho P_{L,t})B_{L,t-1} + P_t(G_t+T_t), \end{aligned} \tag{22}$$

where $B_{L,t} \equiv (1-\omega)B^R_{L,t}$ denotes the stock of long-term government bonds held by Ricardian households.

Regarding public debt, the government debt-to-output ratio is initially defined as the ratio of the nominal stock of debt to quarterly nominal GDP,

$$S'_{B,t} \equiv \frac{P_{L,t}B_{L,t}}{P_tY_t} \quad .$$

However, this definition is not directly comparable to the measure employed in euro area statistics. According to the European Central Bank's Statistical Data Warehouse (ECB SDW), the official debt-to-GDP ratio is computed as the nominal stock of government debt divided by the four-quarter moving average of nominal GDP. In terms of the model's variables, this corresponds to,

$$S_{B,t} \equiv \frac{P_{L,t}B_{L,t}}{P_tY_t + P_{t-1}Y_{t-1} + P_{t-2}Y_{t-2} + P_{t-3}Y_{t-3}} \quad . \tag{23}$$

Since the model is intended to be estimated using euro area data, the second specification, defined in equation (23), will be used when referring to the debt-to-GDP ratio.

2.5 Monetary and Fiscal policy

The true novelty of this model lies in the structure of its policy block, adapted from Bianchi et al. (2023). This framework accommodates the coexistence of two distinct policy regimes: a monetary-led regime and a fiscally-led regime. The former corresponds to the conventional approach in DSGE models, where the central bank follows a Taylor-type rule and responds more than one-for-one to deviations of inflation from target, while fiscal policy ensures public debt sustainability. In this setting, the central bank actively combats inflation, and the fiscal authority passively adjusts spending to maintain a stable debt path.

By contrast, the fiscally dominant regime describes a scenario in which fiscal policy constrains the central bank. Here, the government is no longer willing to adjust spending, transfers, or taxes in response to rising debt, and public finances may evolve along an unsustainable path. As a result, debt stabilization can only occur through rising inflation, which erodes the real value of outstanding debt. Recognizing this fiscal constraint, the central bank refrains from tightening policy in response to inflation and becomes passive.

Note that in this section, all policy rules are reported in their log-linear form. Lower-case variables denote log-deviations from steady state of the corresponding variables introduced earlier.

Monetary-led Regime. Variables under the monetary-led regime are indexed by M. In this regime, the central bank sets the short-term nominal interest rate $r^M_{S,t}$ in response to inflation π^M_t and output y^M_t according to a standard Taylor rule,

$$r^M_{S,t} = \rho_r r^M_{S,t-1} + (1-\rho_r)\left[\phi_\pi \pi^M_t + \phi_y y^M_t\right] + \zeta_{m,t},$$

where $\zeta_{m,t}$ denotes an exogenous monetary policy shock. The coefficients ϕ_π and ϕ_y govern the policy response to inflation and output, respectively, with ϕ_π satisfying the Taylor principle and assumed to be large enough to guarantee equilibrium determinacy. While the ECB's primary mandate is price stability—unlike the U.S. Federal Reserve, which has an explicit dual mandate—it is reasonable to allow for some responsiveness to output or unemployment fluctuations in the interest rate rule, reflecting practical considerations in the ECB's decision-making.

Fiscal policy in this regime also behaves according to standard assumptions. Taxes $\hat{\tau}^M_{j,t}$, public consumption g^M_t, and public transfers τ^M_t, are adjusted in response to macroeconomic conditions and public debt. A high debt-to-GDP ratio prompts fiscal tightening, while economic downturns trigger stimulus measures through higher transfers. These fiscal feedback rules are expressed as,

$$g^M_t = \rho_g g^M_{t-1} - (1-\rho_g)\gamma_g s^M_{B,t-1} + \zeta_{G,t}$$

$$\tau^M_t = \rho_\tau \tau^M_{t-1} - (1-\rho_\tau)\left[\phi_{\tau y} y^M_t + \gamma_\tau s^M_{B,t-1}\right] + \zeta_{T,t}$$

$$\hat{\tau}^M_{j,t} = \rho_j \hat{\tau}^M_{j,t-1} + (1-\rho_j)\gamma_{\tau_j} s^M_{B,t-1}$$

where $j \in \{C, K, N\}$ stands for consumption, capital and labor, and $\zeta_{G,t}, \zeta_{T,t}$ are exogenous shocks to government consumption and funded transfers, respectively. The ρ's denote fiscal rule persistence, while the γ's coefficients represent the strength of the fiscal response to debt, and are assumed to be positive.

Fiscally-led Regime. Variables under the fiscally-led regime are indexed by F. Under fiscal dominance, the government no longer ensures debt sustainability. Inflation rises as a means to reduce the real value of debt, and the central bank refrains from tightening its policy in order to accommodate fiscal pressures. The central bank is constrained to let inflation go by the active fiscal authority. Compare to the monetary-led regime, all feedback coefficients related to inflation and debt are now set to zero. The policy rules reduce to,

$$r^F_{S,t} = \rho_r r^F_{S,t-1} + (1-\rho_r)\phi_y y^F_t$$

$$g^F_t = \rho_g g^F_{t-1}$$

$$\tau^F_t = \rho_\tau \tau^F_{t-1} + (1-\rho_\tau)\phi_{\tau y} y^F_t + \zeta_{F,t}$$

$$\hat{\tau}_{j,t} = \rho_j \hat{\tau}_{j,t-1}$$

where $\zeta_{F,t}$ is an exogenous shock to unfunded transfers.

In this fiscally-led regime, public debt does not trigger fiscal consolidation and therefore becomes unfunded. An unfunded transfer shock generates a substantial increase in consumption, investment, and output, as agents do not anticipate future fiscal offsetting. Since debt accumulation is not counteracted by higher taxes or reduced spending, inflation serves as the sole adjustment mechanism. Consequently, inflation rises and erodes the real value of public debt. The amount of inflation required to stabilize nominal debt is referred to as fiscal inflation, denoted π^F_t. The monetary authority remains passive, further reinforcing the expansionary effects by refraining from raising interest rates.

The Full Economy. The full economy is obtained by aggregating the two sub-economies. Given the model's linear structure, each variable can be expressed as the sum of its monetary-led and fiscally-led components. For a generic variable x_t (e.g., consumption or output) expressed in log deviation, the aggregation is,

$$x_t = x_t^M + x_t^F.$$

Leading to the following set of policy rules for the full economy,

Monetary rule:

$$r_{S,t} = \rho_r r_{S,t-1} + (1-\rho_r)\left[\phi_\pi(\pi_t - \pi_t^F) + \phi_y y_t\right] + \zeta_{m,t} \tag{24}$$

Public consumption:

$$g_t = \rho_g g_{t-1} - (1-\rho_g)\gamma_g(s_{B,t-1} - s_{B,t-1}^F) + \zeta_{G,t} \tag{25}$$

Public transfers:

$$\tau_t = \rho_\tau \tau_{t-1} - (1-\rho_\tau)\left[\phi_{\tau y} y_t + \gamma_\tau(s_{B,t-1} - s_{B,t-1}^F)\right] + \zeta_{T,t} + \zeta_{F,t} \tag{26}$$

Consumption tax rule:

$$\hat{\tau}_{C,t} = \rho_C \hat{\tau}_{C,t-1} + (1-\rho_C)(s_{B,t-1} - s_{B,t-1}^F) \tag{27}$$

Capital tax rule:

$$\hat{\tau}_{K,t} = \rho_K \hat{\tau}_{K,t-1} + (1-\rho_K)(s_{B,t-1} - s_{B,t-1}^F) \tag{28}$$

Labor tax rule:

$$\hat{\tau}_{N,t} = \rho_N \hat{\tau}_{N,t-1} + (1-\rho_N)(s_{B,t-1} - s_{B,t-1}^F) \tag{29}$$

where the central bank responds to deviations of inflation from fiscal inflation π_t^F, and the government reacts to deviations of total debt from its unfunded component $s_{B,t}^F$.

2.6 Solving the Model

All equations comprising the core system, along with the derivation steps, and the steady-states expressions, are presented in Sections B and C of the appendix. The model is solved using a first-order perturbation method. Accordingly, all variables are detrended to account for the labor-augmenting technological trend. The resulting system is then log-linearized around a deterministic steady state. The full set of log-linear equations is provided in Section D of the appendix.

The structure of the policy block necessitates solving two distinct sub-economies, one under a fiscally-led regime and the other under a monetary-led regime. This decomposition is required to track the dynamics of fiscal inflation and the unfunded component of public debt. Owing to the linearity of the model, and using the same type of argument as in Bianchi et al. (2023), the aggregate economy is constructed by summing the dynamics of these two sub-economies. The `MATLAB` codes used to solve the model are available at: `https://github.com/EliotSatta/Master-Thesis---Replication`.

3 Estimation

The model is estimated using Bayesian techniques. The dataset comprises nine macroeconomic variables for the Euro Area, spanning 2000Q2 to 2019Q4. The post-COVID period is deliberately excluded to avoid the extreme volatility induced by the confinement shock. Because the estimation assumes shocks are drawn from the same processes across the entire sample, including COVID quarters would require assigning implausibly large variances to some disturbances (e.g. demand and labor supply) in order to match the extreme fluctuations. These inflated variances would then spill over to normal periods, distorting parameter estimates. Excluding the COVID period ensures that the analysis focuses on fiscal–monetary interactions under regular business-cycle conditions rather than extraordinary, one-off disruptions.

This section details the data sources and explains the transformations applied to align the data with the model. It then describes the estimation procedure, including the choice and justification of prior distributions, and concludes with the presentation of the resulting posterior estimates.

3.1 Estimation Procedure

3.1.1 Collecting the Data

All macroeconomic data were sourced from the ECB SDW, which provides quarterly, harmonized time series for the Euro Area. Since the model is expressed in terms of real, per capita, and stationary variables, the raw data series were transformed accordingly to ensure consistency between the empirical data and the model's structure. The dataset used for the estimation includes nine observed variables:

- Real per capita GDP growth: dy_t^{obs}
- Real per capita private consumption growth: dc_t^{obs}
- Real per capita investment growth: di_t^{obs}
- Real per capita transfers growth: $d\tau_t^{\text{obs}}$
- Real wage inflation: dw_t^{obs}
- Inflation: π_t^{obs}
- Unemployment rate: u_t^{obs}
- 3-month Euribor: $r_{S,t}^{\text{obs}}$
- Debt-to-GDP ratio: $s_{B,t}^{\text{obs}}$

To construct the real per capita GDP growth, the nominal GDP (expressed in billions of euros) was first divided by the total population and then deflated using the GDP deflator, yielding the real GDP per capita. To ensure stationarity, a first-difference log transformation was applied, resulting in the real per capita GDP growth rate. The same methodology was employed for private consumption, public consumption, public transfers, and investment. Note that public transfers are defined as the sum of cash transfers and social transfers in kind. The wage inflation measure was derived from the Compensation per Employee Index, which reflects total labor costs, including employer social contributions. This series was deflated using the GDP deflator, and a first-difference log filter was applied to obtain real per capita wage inflation. The inflation rate was constructed by applying a first-difference log transformation to the GDP deflator. The unemployment rate corresponds directly to the model's definition and thus required no further transformation. Similarly, the three-month Euribor is used for the short-term nominal interest rate and is used in levels without transformation. The debt-to-GDP ratio, defined in accordance with ECB statistics, requires an adjustment of the model-based measure of debt in order to ensure consistency between theory and data as discussed in Section 2.4.

3.1.2 Constructing the Observable Equation

To estimate the model, it is necessary to link the observable variables described above to the model's theoretical variables by defining the observable equation. Recall that the model is solved using a first-order perturbation method, implying that the solution takes the following form,

$$S_t = \Omega S_{t-1} + \Sigma \varepsilon_t,$$

where S_t denotes the vector of state variables and ε_t the vector of structural innovations. The observables are then linked to the model's state variables via the following observable equation,

$$O_t = C + HS_t,$$

where O_t is the vector of observable variables, C is a vector of constants, and H is a matrix mapping the model's theoretical variables to the observed data. The main challenge lies in the appropriate identification of C and H. The full specification of the observable equation used in this study is given by,

$$\underbrace{\begin{pmatrix} dy_t^{obs} \\ dc_t^{obs} \\ di_t^{obs} \\ dg_t^{obs} \\ d\tau_t^{obs} \\ dw_t^{obs} \\ \pi_t^{obs} \\ u_t^{obs} \\ r_{S,t}^{obs} \\ s_{B,t}^{obs} \end{pmatrix}}_{O_t} = \underbrace{\begin{pmatrix} \varkappa \\ \varkappa \\ \varkappa \\ \bar{g} \\ \bar{\tau} \\ \varkappa \\ \bar{\pi} \\ U_* \\ \bar{r}_S \\ S_{B_*} \end{pmatrix}}_{C} + \underbrace{\begin{pmatrix} y_t - y_{t-1} + \zeta_{A,t} \\ c_t - c_{t-1} + \zeta_{A,t} \\ i_t^R - i_{t-1}^R + \zeta_{A,t} \\ g_t - g_{t-1} \\ \tau_t - \tau_{t-1} \\ w_t - w_{t-1} + \zeta_{A,t} \\ \pi_t \\ u_t \\ r_{S,t} \\ s_{B,t} \end{pmatrix}}_{HS_t}.$$

In this specification, some constants in C are set to the empirical averages of the corresponding observed variables, inflation and the short-term interest rate. While this approach is somewhat imprecise, it offers a simple and practical shortcut. A more rigorous approach would involve filling C with the model-implied steady-state values or long-term trends. This is the case for output, consumption, investment, public consumption, transfers, wage, unemployment and debt-to-GDP ratio. For example, in the case of real per capita GDP growth, the observable equation takes the form,

$$dy_t^{obs} = \varkappa + y_t - y_{t-1} + \zeta_{A,t},$$

where $\varkappa$ denotes the model-implied trend growth rate of output per capita, and $\zeta_{A,t}$ accounts for shocks to productivity that may affect output growth.

The observable equation makes it possible to write the model in state-space form,

$$\begin{cases} S_t = PS_{t-1} + Q\varepsilon_t & \text{(state equation)} \\ O_t = C + HS_t & \text{(observable equation)} \end{cases}$$

where the state equation describes how the economy's hidden states evolve, while the observable equation describes how these states relate to observed data. This formulation enables the use of the Kalman filter to estimate latent states and construct the likelihood function $\mathcal{L}(y^T|\Gamma)$, where y^T is the complete history of observables and Γ the vector of parameters.

3.1.3 Becoming Bayesian

The large size and complexity of the model make it impractical to estimate the parameter set using frequentist methods such as Maximum Likelihood Estimation (MLE). This motivates a Bayesian approach. The key difference between Bayesian and frequentist econometrics lies in how uncertainty is treated. In the frequentist view, data are random because they depend on the sampling process, while parameters are fixed but unknown, with inference based on the likelihood function $\mathcal{L}(y^T|\Gamma)$. By contrast, the Bayesian perspective treats the observed data as fixed and parameters as random variables. Prior beliefs about parameters, represented by $P(\Gamma)$, are updated in light of the data to form the posterior distribution $P(\Gamma|y^T)$.

Formally, Bayes' rule combines the likelihood with the prior according to,

$$P(\Gamma|y^T) = \frac{\mathcal{L}(y^T|\Gamma)P(\Gamma)}{P(y^T)} \propto \mathcal{L}(y^T|\Gamma)P(\Gamma), \tag{30}$$

where $P(y^T)$ is the marginal likelihood (data density), acting as a normalizing constant.

Unlike point estimates, the posterior distribution provides a full probability distribution over parameter values. This makes inference richer but also more challenging, as computing posterior moments such as the mean and variance, defined as,

$$\mathbb{E}(\Gamma \mid y^T) = \int \Gamma \, P(\Gamma \mid y^T) \, d\Gamma$$

$$\mathbb{V}(\Gamma \mid y^T) = \mathbb{E}(\Gamma^2 \mid y^T) - [\mathbb{E}(\Gamma \mid y^T)]^2 = \int \Gamma^2 \, P(\Gamma \mid y^T) \, d\Gamma - [\mathbb{E}(\Gamma \mid y^T)]^2,$$

requires evaluating integrals that are rarely tractable.

To overcome this difficulty, the posterior distribution is approximated through Markov Chain Monte Carlo (MCMC) methods, which generate simulated draws from the posterior and allow the computation of any desired moment. In this study, estimation relies on the Random-Walk Metropolis–Hastings (RW-MH) algorithm, a widely used variant of MCMC.

3.2 Priors

In a Bayesian estimation framework, priors represent beliefs about the values of parameters before observing the data. Their role is to incorporate non-data information into the estimation process, providing additional curvature to the likelihood function. In this context, prior distributions are selected based on established economic reasoning and previous empirical studies. In this study, the specification of the fiscal block draws heavily on Bianchi et al. (2023), while the priors for the structural parameters are guided by Smets and Wouters (2003), given the focus on the Euro area.

Calibrated parameters. Some parameters remain fixed throughout the estimation. These can be viewed as dogmatic priors, meaning priors with all probability mass concentrated on a single value, a distribution known in statistics as a Dirac distribution. In practice, this implies that the parameter is not estimated from the data but imposed directly, reflecting either standard values used in the literature or identification constraints. Among the standard parameters, the discount factor β is set to 0.99, the capital depreciation rate δ to 0.025, and the output elasticity with respect to capital θ to 0.33. Other parameters are held fixed due to identification issues during preliminary estimation. This is the case for θ_w and θ_p, which govern the wage and price markups, respectively. Both are set to 7, corresponding to a steady-state markup of approximately 15%. The rate of decay ρ is set to 0.9593, following Bianchi et al. (2023), implying an average maturity of approximately

6 years for outstanding government debt. Steady-state inflation Π_* is normalized to 1. The labor disutility scale parameter χ is set to 1, and the share of material inputs in total production costs s_M is set to 0.25. The steady-state ratio of public consumption to output S_{G_*} is set to its empirical mean, 0.21. The steady-state tax rates on labor, capital, and consumption, denoted by τ_{N_*}, τ_{K_*}, and τ_{C_*}, respectively, are set to 0.41, 0.33, and 0.17, following the calibration provided in Trabandt and Uhlig (2011) for the Euro area. The consumption-tax rate is kept constant and thus does not react to deviations in the debt-to-GDP ratio, accordingly, both its response coefficient γ_C and persistence parameter ρ_C are fixed at zero. Table 1 presents the parameters that are calibrated rather than estimated, along with their respective values.

Table 1: Calibration

Parameter	**Value**	**Definition**
Preferences, labor and Production		
β	0.99	Discount factor
δ	0.025	Depreciation rate
θ	0.33	Output elasticity to capital
χ	1.0	Labor disutility scale parameter
s_M	0.25	Materials cost share
θ_p	7.0	Elasticity of substitution across goods
θ_w	7.0	Elasticity of substitution across labor types
ρ	0.9593	Rate of decay
Steady-states and Fiscal Policy		
Π_*	1.00	Steady-state inflation
S_{G_*}	0.21	Steady-state public consumption-output ratio
τ_{C_*}	0.17	Steady-state tax rate on consumption
τ_{K_*}	0.33	Steady-state tax rate on capital
τ_{N_*}	0.41	Steady-state tax rate on labor
γ_C	0.00	Consumption tax response to public debt
ρ_C	0.00	Consumption tax persistence

Estimated parameters. Priors for the structural shocks are assigned to both their standard deviations and persistence parameters. The standard deviations follow inverse gamma (IG) distributions with shape and scale parameters reflecting relatively uninformative beliefs while ensuring positivity. The autoregressive (AR) coefficients are modeled using beta (B) distributions with a mean of 0.5 and a standard deviation of 0.1, capturing the belief that shocks are moderately persistent without imposing excessive rigidity. This approach differs from that of Bianchi et al. (2023), who specify highly persistent priors for certain shocks. For instance, the AR coefficients for the price markup and transfers shocks are centered around 0.995 in their framework. The present specification allows for more flexibility and avoids strongly pre-imposing near-unit-root behavior. This structure is applied uniformly across all shocks in the model. Regarding the structural parameters, the prior for the share of hand-to-mouth consumers follows Leeper et al. (2022) and is centered around 0.30. The prior of the logarithm of the steady-state growth rate of the economy $\varkappa$ is centered around 0.0030 which corresponds to a 1.2% annual growth rate. The prior for the strength of the composite wealth effect on labor supply ψ is centered around 0.5 and follows the specification of Galí et al. (2012). The priors for the price and wage-setting block parameters, and the one for the monetary policy rule, are based on Smets and Wouters (2003), whose estimation is conducted using euro area data. This choice reflects the view that production structures and labor market institutions differ substantially between the United States and the Eurozone, warranting region-specific priors. Finally, the priors associated with the fiscal block parameters are drawn from Bianchi et al. (2023). Same thing for parameters that are not explicitly mentioned.

3.3 Posteriors

The posterior distributions for the exogenous shock parameters and structural parameters are reported in Tables 2 and 3, respectively. In Bayesian estimation, a key indication of identification is that posterior distributions differ meaningfully from their priors, reflecting the information provided by the data.

Table 2: Prior and Posterior Distributions - Shocks

Param.	**Description**	**Posterior**			**Prior**		
		Mean	5%	95%	Type	Mean	Std.
σ_A	St.dev. Technology	1.6800	1.4361	1.9159	IG	1.0000	2.0000
σ_U	St.dev. Discount factor	2.8022	1.4705	4.1809	IG	1.0000	2.0000
σ_N	St.dev. Labor preference	0.9052	0.7397	1.0694	IG	1.0000	2.0000
σ_I	St.dev. Investment	4.5765	3.5308	5.6433	IG	1.0000	2.0000
σ_G	St.dev. Public consumption	0.5183	0.4415	0.5914	IG	1.0000	2.0000
σ_T	St.dev. Funded transfers	0.3087	0.2362	0.3788	IG	1.0000	2.0000
σ_F	St.dev. Unfunded transfers	0.2858	0.2114	0.3543	IG	1.0000	2.0000
σ_m	St.dev. Monetary policy	0.1420	0.1290	0.1553	IG	1.0000	2.0000
σ_W	St.dev. Wage markup	0.6383	0.5330	0.7386	IG	1.0000	2.0000
σ_P	St.dev. Price markup	0.1456	0.1290	0.1610	IG	1.0000	2.0000
σ_{rp}	St.dev. Risk premium	0.1825	0.1475	0.2190	IG	1.0000	2.0000
ρ_A	AR coeff. Technology	0.1811	0.0953	0.2634	B	0.5000	0.1000
ρ_U	AR coeff. Discount factor	0.6987	0.5783	0.8265	B	0.5000	0.1000
ρ_N	AR coeff. Labor preference	0.8744	0.8362	0.9133	B	0.5000	0.1000
ρ_I	AR coeff. Investment	0.5404	0.4424	0.6385	B	0.5000	0.1000
ρ_G	AR coeff. Public consumption	0.4293	0.2330	0.6365	B	0.5000	0.1000
ρ_T	AR coeff. Funded transfers	0.5587	0.3854	0.7306	B	0.5000	0.1000
ρ_F	AR coeff. Unfunded transfers	0.4777	0.3147	0.6384	B	0.5000	0.1000
ρ_m	AR coeff. Monetary policy	0.5600	0.3427	0.7796	B	0.5000	0.1000
ρ_W	AR coeff. Wage markup	0.3276	0.2014	0.4514	B	0.5000	0.1000
ρ_P	AR coeff. Price markup	0.2071	0.1209	0.2907	B	0.5000	0.1000
ρ_{rp}	AR coeff. Risk premium	0.6703	0.5954	0.7496	B	0.5000	0.1000

Table 3: Prior and Posterior Distributions - Structural Parameters

Param.	**Description**	**Posterior**			**Prior**		
		Mean	5%	95%	Type	Mean	Std.
$\bar{g}$	Const. public cons. growth	0.0033	0.0029	0.0038	N	0.0030	0.0010

Param.	Description	Posterior			Prior		
		Mean	5%	95%	Type	Mean	Std.
$\bar{\tau}$	Const. transfers growth	0.0041	0.0037	0.0046	N	0.0040	0.0010
$\bar{\pi}$	Const. inflation	0.0041	0.0030	0.0052	N	0.0040	0.0010
$\bar{r}_S$	Const. short-term rate	0.0045	0.0033	0.0057	N	0.0040	0.0010
U_*	Steady-state unemployment	0.0958	0.0942	0.0976	N	0.0950	0.0010
S_{B_*}	Steady-state debt ratio	0.7973	0.7957	0.7990	N	0.7970	0.0010
$\varkappa$	Steady-state growth rate	0.0023	0.0014	0.0032	N	0.0030	0.0010
ν	Inverse Frisch elasticity	2.4720	2.1212	2.8426	N	2.0000	0.2500
α_G	Public vs. private cons.	0.0274	-0.1321	0.1832	N	0.0000	0.1000
ν_I	Investment adjustment cost	6.5334	5.7556	7.2834	N	6.0000	0.5000
ϑ	Capital utilization cost	0.1880	0.1114	0.2575	B	0.5000	0.1000
η	Strength of habit formation	0.8356	0.7626	0.9193	B	0.5000	0.2000
ω	Share of hand-to-mouth	0.3917	0.3696	0.4149	B	0.3000	0.1000
ψ	Short-term wealth effect	0.2798	0.1386	0.4070	B	0.5000	0.2000
γ_p	Degree of price indexation	0.6090	0.3682	0.8690	B	0.5000	0.2000
γ_w	Degree of wage indexation	0.5080	0.1831	0.8326	B	0.5000	0.2000
α_p	Degree of price rigidity	0.8231	0.7846	0.8657	B	0.7500	0.0500
α_w	Degree of wage rigidity	0.5333	0.4292	0.6427	B	0.7500	0.0500
ϕ_π	Monetary response to infl.	1.9607	1.7940	2.1287	N	2.0000	0.1000
ϕ_y	Monetary response to output	0.0373	-0.0116	0.0895	N	0.1250	0.0500
ρ_r	AR coeff. monetary	0.6989	0.6192	0.7797	B	0.5000	0.1000
$\phi_{\tau y}$	Transfers response to output	0.0878	0.0221	0.1533	G	0.1000	0.0500
ρ_τ	AR coeff. gov. transfers	0.7619	0.6762	0.8509	B	0.5000	0.1000
γ_τ	Transfers response to debt	0.2778	0.1681	0.3826	N	0.2500	0.1000
γ_g	Gov. cons. response to debt	0.2547	0.1430	0.3612	N	0.2500	0.1000
ρ_g	AR coeff. Gov. cons.	0.7369	0.6025	0.8656	B	0.5000	0.1000
γ_K	Capital tax response to debt	0.0711	-0.1011	0.2391	N	0.1000	0.1000
γ_N	Labor tax response to debt	0.2842	0.1485	0.4132	N	0.2500	0.1000
ρ_K	AR coeff. capital tax	0.5018	0.3343	0.6683	B	0.5000	0.1000
ρ_N	AR coeff. labor tax	0.5022	0.3239	0.6764	B	0.5000	0.1000

Most posterior distributions display reasonable shapes (see Appendix E.2), though in several cases the means remain close to the priors and the credible intervals are wide. This suggests that the data are only weakly informative about some structural parameters, so the corresponding estimates should be interpreted with caution.

The posterior mean estimate for the share of hand-to-mouth households, ω, is approximately 38%, with a relatively narrow 90% credible interval. This sizable proportion suggests that a significant fraction of households in the model hold little or no wealth, in line with empirical evidence indicating that the bottom 50% of European households own less than 5% of total wealth [1]. As a result, the model features pronounced non-Ricardian effects in response to changes in public consumption or transfers. This finding stands in marked contrast to the results of Bianchi et al. (2023),

[1]The World Inequality Database (WID), managed by an international network of researchers led by T. Piketty, E. Saez, and G. Zucman, provides systematic data on the distribution of income and wealth across countries. See `https://wid.world/`, which documents that the bottom 50% of households in Europe own less than 5% of total wealth.

who estimate the share of hand-to-mouth households at only 7%, with non-Ricardian dynamics in their framework arising mainly through unfunded transfers rather than direct liquidity constraints.

The posterior distribution for the inverse Frisch elasticity, ν, points to a moderate responsiveness of labor supply to wage changes. The estimate for the substituability between public and private consumption, α_G, remains centered near zero, indicating limited substituability between the two categories. The strength of habit formation, with a posterior mean of approximately 0.84, closely matches the value found by Bianchi et al. (2023). In addition, the estimated short-term wealth effect parameter, ψ, is around 0.28, about ten times larger than the estimate of Galí et al. (2012), implying that household consumption in this model is highly responsive to wealth fluctuations.

The estimated degrees of price and wage indexation, γ_p and γ_w, are moderately high, with posterior means around 0.60 and 0.53, respectively. However, the wide credible intervals for these parameters indicate limited precision and weak identification from the data. By contrast, the posterior distributions for the price and wage rigidity parameters, α_p and α_w, are tightly estimated, with means of approximately 0.82 for prices and 0.53 for wages. The estimate for price rigidity is in line with common values found in the literature, whereas the relatively low value for wage rigidity diverges from previous studies, such as Bianchi et al. (2023) and Smets and Wouters (2003), which typically report values for α_w in the range of 0.74 to 0.82.

Turning to the fiscal block, the debt response parameters $(\gamma_\tau, \gamma_g, \gamma_K, \gamma_N)$ display substantial uncertainty, as reflected by their wide credible intervals. The posterior means suggest that fiscal adjustments in response to deviations from the debt-to-output ratio are distributed relatively evenly across transfers, public consumption, and taxes. This pattern differs from the findings of Bianchi et al. (2023), who observe a predominant adjustment through transfers, with minimal responses from taxes. Finally, the estimated Taylor rule parameters indicate a robust monetary policy reaction to deviation fiscal inflation, with ϕ_π estimated close to 2.0, broadly consistent with previous results. The response to output, as measured by ϕ_y, is positive but remains moderate and only weakly identified.

All figures and the complete set of codes used for model estimation and data processing are available in Appendix E.

4 Results

This section aims to identify the role played by unfunded transfers in shaping inflation dynamics within the Eurozone. The model described in Section 2, is estimated as detailed in Section 3, and is employed to isolate and quantify their impact on inflation. This approach closely mirrors the analysis conducted by Bianchi et al. (2023) for the United States.

4.1 Identification of Unfunded Transfers

To isolate the specific effect of unfunded transfers, the analysis focuses on three shocks among the full set present in the model. The first is a cost-push, or price markup shock $\zeta_{P,t}$, which captures supply-side disturbances such as a sharp increase in energy prices. The second is a funded transfers shock $\zeta_{T,t}$, representing changes in public transfers that are explicitly expected to be offset by future fiscal adjustments. The third, the unfunded transfers shock $\zeta_{F,t}$, captures variations in transfers that are not backed by future fiscal consolidation. The impulse response functions (IRFs) for these shocks are reported in Figure 1.

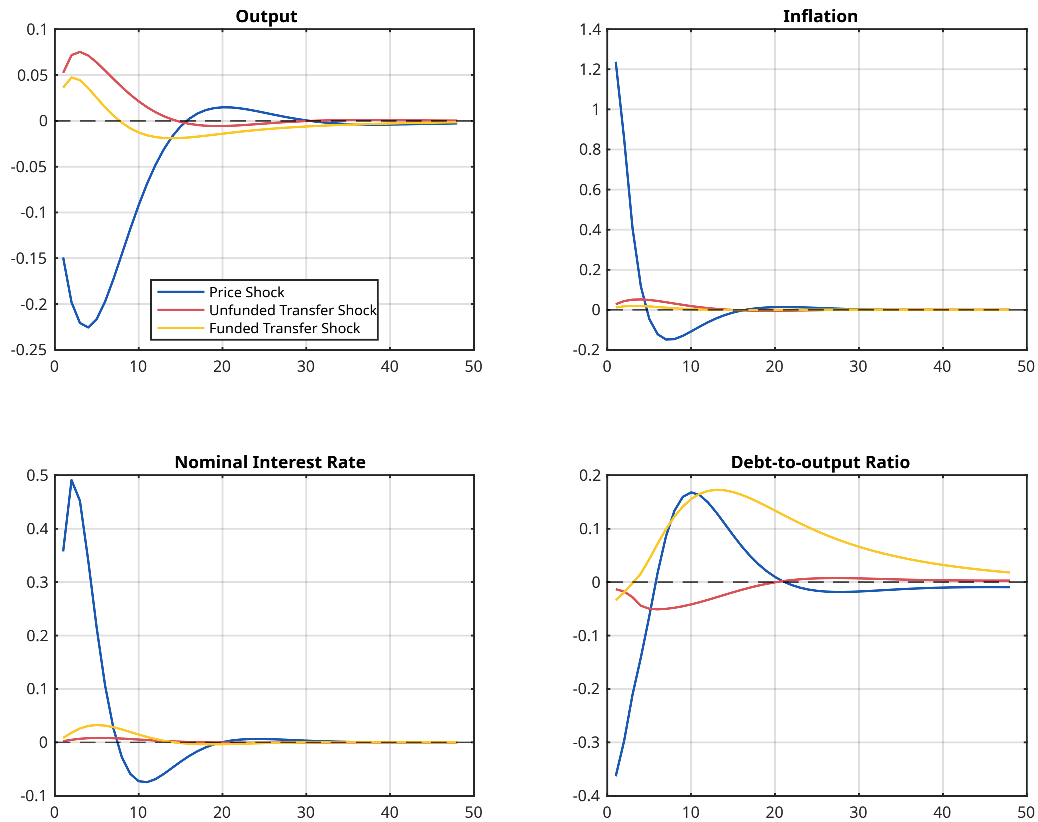

Figure 1: IRFs for output, inflation, interest rate and debt. Each panel shows the effect of a one-standard-deviation structural shock over 48 quarters. Output is shown as percent deviations from steady state. Inflation and the short-term interest rate are presented as annualized percentage-point (p.p.) deviations from their initial values, while the debt-to-GDP ratio is also in percentage points. For example, following a price markup shock, inflation rises by roughly 1.2 p.p., if initial inflation is 2%, this implies a temporary rate of 3.2%.

Because the model features a large share of hand-to-mouth consumers, a funded transfer shock generates a noticeable expansion in output, despite the fact that these transfers are backed by future fiscal surpluses. Here, the two-agent specification embedded in the model breaks down the Ricardian equivalence. The resulting increase in aggregate demand and inflation prompts the central bank to raise the nominal interest rate, which partially offsets the fiscal stimulus and dampens both output and inflation after about 10 quarters. Following a funded transfer shock, the debt-to-GDP ratio begins to rise and remains above its initial level for several years. This persistent rise in the public debt level stems from the monetary tightening, which restrains both output growth and inflation, thereby limiting the nominal growth needed to erode the real value of debt. Since these transfers are expected to be offset by future consolidation, the central bank is able to behave actively by tightening its policy in response to overheating economic activity, without concern for the sustainability of public finances, as central banks normally do.

While funded transfer shocks generate an expansion in output through the hand-to-mouth channel, this mechanism is further amplified when the transfers are unfunded. In the case of an unfunded transfer shock, the absence of anticipated fiscal consolidation leads agents to perceive the transfers as a net increase in resources. As a result, both the magnitude and persistence of the responses in output and inflation are greater. By implementing unfunded transfers, the fiscal authority adopts an active stance, disregarding concerns over debt sustainability. In this setting, stabilizing the debt-to-GDP ratio requires allowing inflation to rise, thereby eroding the real value of outstanding nominal debt. The central bank, constrained by the fiscal authority's active behavior, adopts a passive stance, refraining from raising interest rates in response to rising inflation in order to preserve public finances. As a result, with output and inflation both increasing and the interest rate remaining unresponsive, the debt-to-GDP ratio declines. Nominal growth being sufficiently strong to offset the initial increase in transfers.

Turning to price markup shocks, the model produces a sharp but short-lived contraction in output and a spike in inflation of up to 1.2 percentage points. In this setting, the central bank once again behaves actively, it is unconstrained by fiscal considerations and can respond aggressively to rising inflation by raising its nominal interest rate. This policy response deepens the output contraction but facilitates the return of inflation to target. The initial surge in inflation reduces the debt-to-GDP ratio by around 0.30 percentage points. However, as inflation declines while output remains weak, the debt ratio gradually rises again.

These IRFs illustrate the coexistence of monetary-led and fiscally-led regimes within the model. Unfunded transfers generate a distinct macroeconomic pattern, characterized by a persistent increase in both output and inflation, accompanied by a decline in the public debt-to-GDP ratio. This combination of responses reflects the coordination of an active fiscal authority with a passive monetary authority, setting unfunded transfer shocks apart from all other policy or price disturbances considered in the model. It acts as an empirical signature, enabling the model to identify and quantify the unfunded transfers' effects on the Eurozone economy.

These results are broadly consistent with the findings of Bianchi et al. (2023). However, two important distinctions emerge. First, the hand-to-mouth transmission channel plays a substantial role in the Eurozone model, whereas it is virtually absent in the U.S. setting analyzed by Bianchi, Faccini, and Melosi. Funded transfers thus produce a strong impact on the macroeconomy. Second, the magnitude of price markup shocks overwhelmingly exceeds that of transfer shocks in shaping inflation dynamics. Specifically, fiscal inflation induced by unfunded transfer shocks leads to an increase in inflation only around 0.050 percentage points, while price markup shocks can raise inflation by as much as 1.2 percentage points. This suggests that, even when unfunded transfers are present, their contribution to overall inflation remains limited compared to other price shocks.

4.2 Dynamic Effects of Funded vs. Unfunded Transfers

In practice, a rise in government transfers is rarely, if ever, fully unfunded. A more plausible scenario is that a transfer expansion is financed through a mix of funded and unfunded components. To assess the macroeconomic consequences of such policies, the analysis considers a transfer shock that is only partially unfunded. Figure 2 reports the impulse responses of output, inflation, and the debt-to-GDP ratio to a one percent increase in transfers, under three alternative assumptions for the share of unfundedness—0 percent, 30 percent, and 50 percent. The columns correspond to the degree of unfundedness, while the rows display the responses of the three variables of interest. This arrangement highlights how the fiscal financing mix shapes the magnitude and persistence of macroeconomic adjustments.

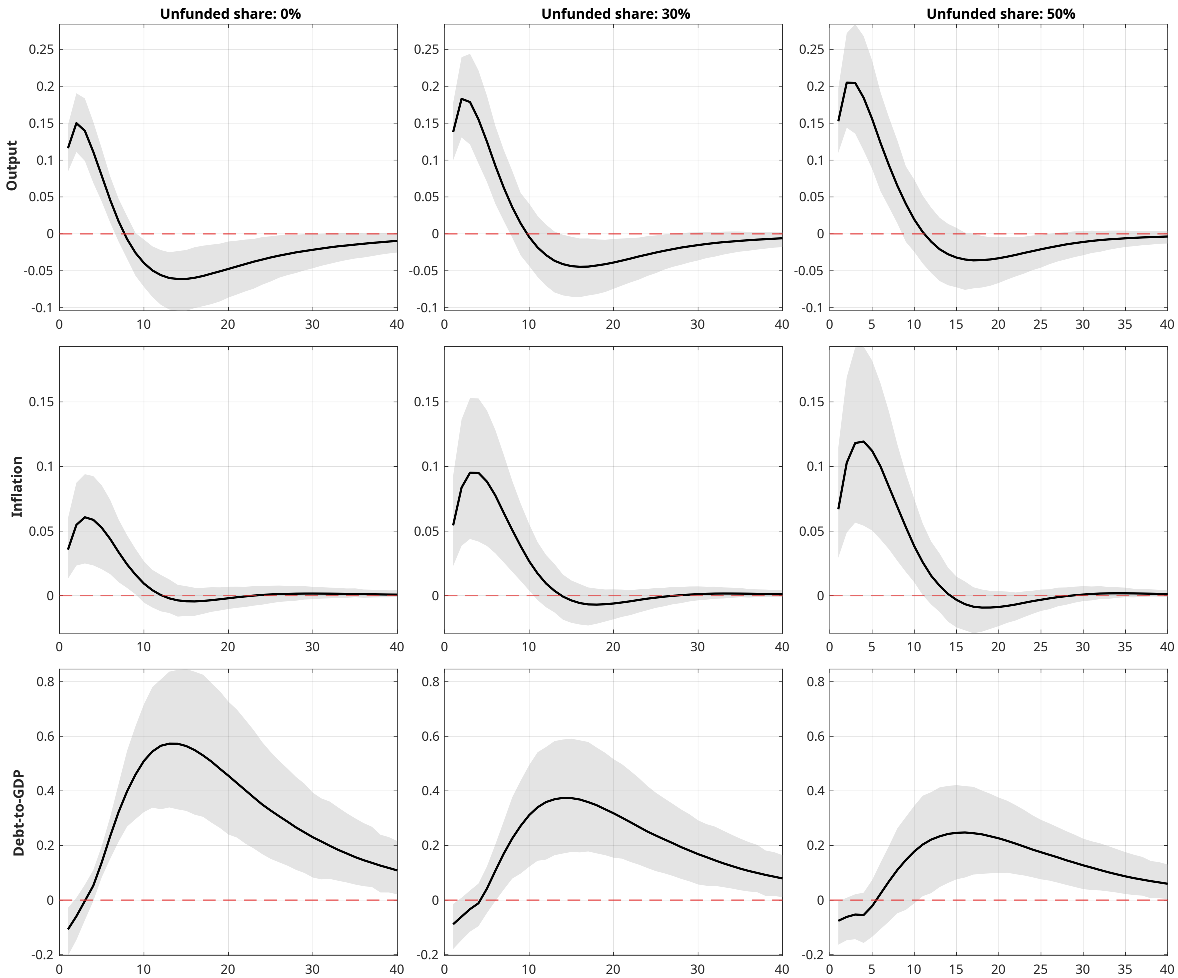

Figure 2: Output, Inflation, and Debt IRFs to a 1% Transfer Increase under Varying Unfunded Shares. Each column shows the response of output, inflation, and the debt-to-GDP ratio to a permanent 1% increase in transfers under three alternative shares of unfunded transfers: 0%, 30%, and 50%. Responses are reported over 40 quarters. Output and debt-to-GDP are expressed in percentage-point deviations. Inflation is shown as annualized percentage-point deviations from its initial value. The grey shaded areas represent the 90% posterior credible intervals from the Bayesian estimation, reflecting parameter and shock uncertainty.

The first row of Figure 2 shows that the larger the unfunded share of the transfer increase, the stronger and more persistent is the expansion in output. With a 30 percent unfunded share, a permanent 1 percent rise in total transfers generates an output increase of about 0.10 to 0.20 percent on impact, which dissipates after roughly ten quarters. The subsequent decline into negative territory reflects the contractionary stance adopted by the monetary authority in response to the funded portion of the transfer increase, which raises the real interest rate once the initial fiscal impulse fades.

The second row documents a similar pattern for inflation: higher unfundedness produces not only a larger but also a more persistent price response. In the 30 percent unfunded case, inflation rises by approximately 0.10 percentage point after one year and remains above baseline for close to three years. If the transfer increase is fully funded, the inflationary impact is roughly halved and short-lived. This asymmetry illustrates the core mechanism of fiscal inflation, when transfers are not backed by future fiscal adjustments, monetary policy accommodates higher prices for longer to preserve debt sustainability.

The third row reveals the countervailing response of the debt-to-GDP ratio. Greater unfundedness mitigates and shortens the debt accumulation that follows the transfer increase. This attenuation is a direct consequence of the stronger nominal growth—through both higher inflation and higher output—that erodes the real value of debt. In the medium case of 30 percent unfunded transfers, the debt ratio rises by less than 0.40 percent, compared with about 0.60 percent when the transfer increase is fully funded. The figure thus highlights the fundamental trade-off: unfunded transfers reduce debt pressures and strengthen the economic recovery, but at the cost of more pronounced and persistent inflation.

Unfunded transfers thus emerge as a potentially powerful policy instrument. They stimulate output, ease debt pressures, and support economic recovery without imposing immediate fiscal costs. The trade-off lies in the inflationary consequences, which are more pronounced and persistent when the share of unfundedness increases. Whether such measures have played a significant role in the Eurozone is an empirical question. The next step is therefore to examine how often they occurred and whether they were confined to specific episodes or persisted over time. This can be done through historical decompositions.

4.3 Historical Decomposition

The contribution of unfunded transfers to Eurozone macroeconomic dynamics is assessed through historical decompositions, which allocate fluctuations in observed macroeconomic series—specifically output growth and inflation—to the structural shocks identified in the model. Each component of the decomposition shows the counterfactual path that the variable would have followed if only that shock had occurred, with all others held constant.

To implement this analysis, the estimated shocks are grouped into four categories for the decomposition. The demand group includes the household discount factor $\zeta_{U,t}$ and the risk premium shocks $\zeta_{rp,t}$. The supply group comprises price markup $\zeta_{P,t}$, wage markup $\zeta_{W,t}$, investment adjustment cost $\zeta_{I,t}$, labor supply $\zeta_{N,t}$, and technology $\zeta_{A,t}$ shocks. The policy group contains all shocks directly associated with macroeconomic policy, including monetary policy $\zeta_{m,t}$, government spending $\zeta_{G,t}$, and funded transfers $\zeta_{T,t}$. Unfunded transfer shocks $\zeta_{F,t}$ are treated as a separate category to isolate their specific contribution to output and inflation, allowing a direct comparison with the patterns observed in the impulse responses. Figure 3 presents the resulting historical decomposition.

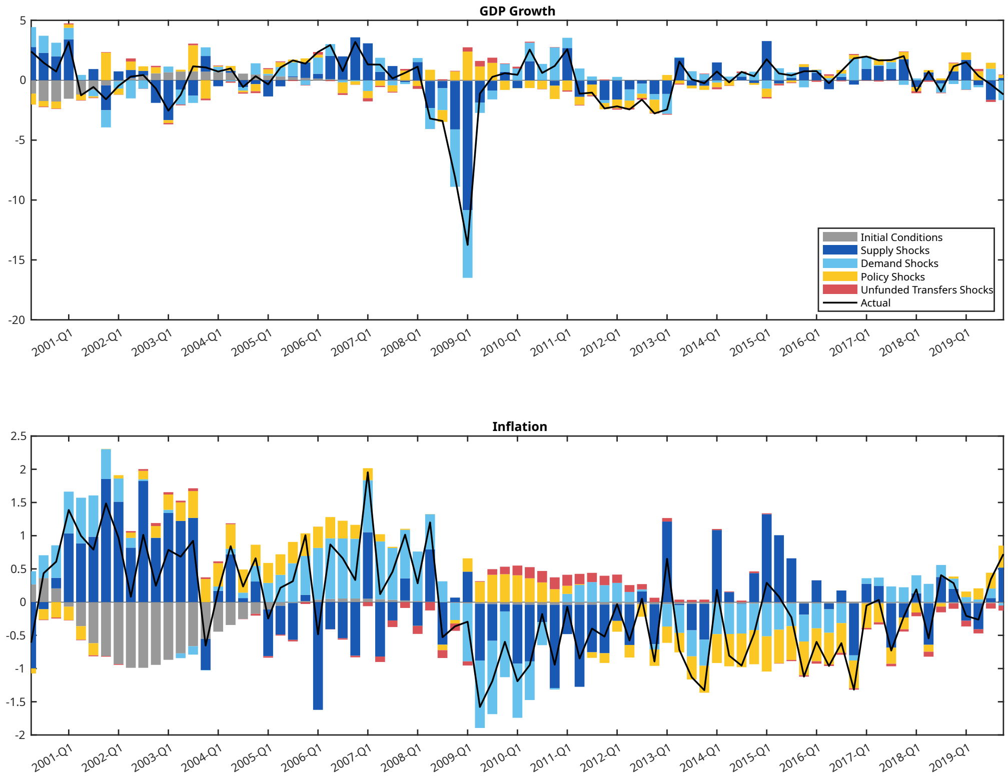

Figure 3: Historical Decomposition for GDP growth and Inflation. The inflation rate and GDP growth are expressed as annualized percentage deviations. Because the series are centered at zero, they do not correspond exactly to the observed data.

The historical decomposition of output growth and inflation shows that unfunded transfers played virtually no role in shaping Eurozone macroeconomic fluctuations during most of the sample. Their influence became visible only in the immediate aftermath of the 2008 global financial crisis. In 2009, they are estimated to have mitigated the contraction in output growth by about 0.50 percentage points, coinciding with the coordinated fiscal expansion—and the associated rise in transfers—implemented by Eurozone member states to support the recovery. On the inflation side, fiscal inflation from unfunded transfers contributed roughly 0.10 percentage point between 2009Q3 and 2012Q4, partly offsetting the deflationary forces of the financial crisis and the early sovereign debt crisis. This longer-lasting price effect, compared with the short-lived boost to output, suggests that the inflationary impulse from the post-2008 fiscal expansion persisted well beyond its initial impact.

This expansionary stance proved short-lived. By 2010, mounting concerns over sovereign debt sustainability prompted a rapid shift toward fiscal consolidation. Several member states—most notably Greece, Portugal, Ireland, Spain, and Italy—enacted substantial austerity packages, combining deep expenditure cuts with tax increases. These measures were often undertaken in response to market pressures or imposed as conditions for external financial assistance from the IMF or other Eurozone members. As a result, the contribution of unfunded transfers to output growth disappears from the historical decomposition, while other policy shocks turn contractionary, reflecting both the withdrawal of stimulus and the Eurozone's reversion to a rules-based, austerity-oriented fiscal framework.

The implementation of fiscal austerity, coupled with the ECB's decision to raise interest rates in 2010 and 2011, signaled a decisive return to a monetary-led regime. This shift effectively marked the end of transfers that could be interpreted as unfunded. Figure 3 supports this interpretation, the historical decomposition of transfer growth shows that unfunded transfers accounted for roughly one-third of total transfer expansion in the immediate aftermath of the subprime crisis. However, their contribution turned negative following the onset of coordinated fiscal consolidation in 2010. This reversal helps explain why unfunded transfers ceased to play a meaningful role for the remainder of the sample period.

Notably, the 2009 expansion in transfers corresponds closely to the "medium" scenario described in Section 4.2, with a substantial positive shock to transfers of which approximately 30% were unfunded.

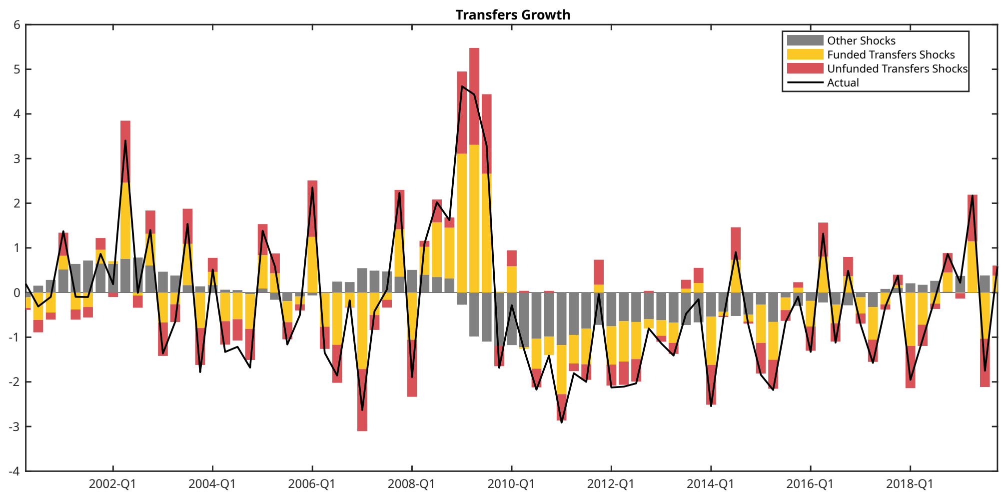

Figure 4: Historical Decomposition for Transfers Growth. Transfers growth is expressed in annualized percentage terms, consistent with the convention used in Figure 2. Here, unfunded transfer shocks are depicted in red, funded transfer shocks in yellow, and all remaining shocks, including initial conditions, are combined and displayed in gray as "other shocks."

Beyond this brief expansionary episode, unfunded transfer shocks played no significant role in shaping macroeconomic fluctuations in the Eurozone. This sharply contrasts with the United States, where Bianchi et al. (2023) show that fiscal inflation accounts for much of the observed inflation dynamics over the same period. In their analysis, unfunded transfers constitute a substantial and persistent share of total transfers, playing a central role in sustaining the post-crisis recovery. Understanding why these mechanisms operated so differently on the two sides of the Atlantic requires a closer look at the institutional and policy environments that either fostered or hindered the emergence of unfunded transfers.

5 Why Fiscal Inflation Failed to Materialize in the Eurozone: Insights from the U.S. Benchmark

5.1 Contrasting Institutional Frameworks

Why did the two regions yield such contrasting results? An important caveat is that the Eurozone and the United States operate in fundamentally different institutional settings. The United States is a federal state with full monetary and fiscal integration, enabling unified policy responses and a single budgetary authority. By contrast, the Eurozone, while functioning as a monetary union and a free trade area, remains far from fiscally integrated. Although a common fiscal framework exists—most notably the 3% deficit and 60% debt thresholds—its enforcement powers have historically been limited, making these rules largely formal. Member states thus retain effective control over their national budgets, allowing them to pursue distinct—sometimes even contradictory—fiscal strategies and limiting the scope for sustained, coordinated fiscal expansions.

This institutional difference is crucial because the emergence of unfunded transfers presupposes coordination between a passive central bank and an active fiscal authority. In the absence of fiscal integration, it is difficult to imagine one or two member states compelling the ECB to tolerate higher inflation at the union level to safeguard debt sustainability. The Greek sovereign debt crisis of 2010–2012 might seem to contradict this claim, yet ECB support during that period was explicitly conditional on deep fiscal retrenchment. Acting as part of the so-called "Troika" [2] alongside the European Commission and the IMF, the ECB tied its interventions—most notably the Securities Markets Programme purchases of Greek bonds—to severe austerity measures, including sharp cuts in public sector wages and pensions, increases in VAT and other taxes, and large-scale privatizations. Far from accommodating an active fiscal stance, this approach forced Greece into rapid consolidation. The episode culminated in the 2012 restructuring of Greek sovereign debt, a clear instance of the central bank refusing to act as a passive backstop to preserve debt sustainability at all costs. Moreover, transfers implemented by a single member state are unlikely to generate a sufficiently large aggregate demand impulse to produce noticeable inflation across the entire monetary union. The emergence of unfunded transfers in the Eurozone would thus require a broad-based, coordinated fiscal expansion across multiple member states, of sufficient magnitude to leave the ECB with no alternative but to accommodate higher inflation.

By contrast, the U.S. federal government has both the institutional capacity and the political mandate to deploy large-scale, centrally coordinated transfers with immediate nationwide impact. In such a setting, the passive-active policy configuration that gives rise to fiscal inflation is far easier to sustain. The Eurozone's structural fragmentation, in contrast, makes such coordination institutionally improbable.

A meaningful comparison with the United States therefore requires focusing on a period when the Eurozone acted—at least temporarily—as a fiscally coordinated bloc, with most member states pursuing similar fiscal strategies. The aftermath of the 2008 global financial crisis stands out as the only clear instance. The severity of the shock compelled member states to adopt simultaneous fiscal expansions under the European Economic Recovery Plan (EERP), narrowing the institutional gap with the U.S. federal system. If unfunded transfers were ever to play a macroeconomic role in the Eurozone comparable to that in the United States, this was the moment. The episode provides a rare opportunity to examine why, even under unusually high coordination and stimulus magnitude, their effects remained far smaller than those observed in the U.S.

5.2 2008 Crisis: Temporary Fiscal Integration

In both economies, fiscal packages were deployed to counter the downturn. In the United States, the American Recovery and Reinvestment Act (ARRA), enacted in February 2009, totaled approximately $787 billion—about 5% of GDP—and devoted a substantial share, roughly 1.5% of GDP, to direct transfers to households, including extended unemployment benefits and Medicaid expansions.[3] Crucially, the package was not accompanied by binding medium-term consolidation

[2] For an overview of the policy conditionality attached to financial assistance during the Greek sovereign debt crisis, see European Commission (2010), *The Economic Adjustment Programme for Greece*, available at: https://ec.europa.eu/economy_finance/publications/occasional_paper/2010/pdf/ocp61_en.pdf.

[3] American Recovery and Reinvestment Act of 2009, Pub. L. 111–5, 123 Stat. 115 (2009). Full text available at: https://www.congress.gov/111/plaws/publ5/PLAW-111publ5.pdf.

commitments, allowing a large portion of these transfers to be perceived as unfunded. This design amplified their expansionary effect, boosting both nominal and real GDP growth and contributing to the fiscal inflation documented by Bianchi et al. (2023).

The EERP in Europe, launched almost simultaneously, was far smaller, about 1.5% of EU GDP, and combined public investment, temporary tax cuts, and social transfers. While detailed compositional data are scarce, the institutional framing was unambiguous: all measures had to comply with the Stability and Growth Pact, and the European Commission emphasized that the stimulus would be strictly temporary and embedded in credible medium-term consolidation plans.[4] Such commitments made it unlikely for transfers to be perceived as unfunded, aligning their expected macroeconomic effects with those of a monetary-led regime. In addition, the absence of a centralized fiscal authority meant the plan was implemented through a patchwork of national measures, limiting both its coherence and aggregate force relative to the unified U.S. program.

The contrast is therefore twofold. First, the U.S. response was both larger in scale and more heavily weighted toward transfers. Second, it unfolded within an institutional setting in which fiscal and monetary authorities could sustain an expansion without immediate pressure to stabilize debt. By contrast, the Eurozone's stimulus was constrained by decentralized fiscal governance and an early pivot to austerity, leaving little scope for a durable passive-active coordination. At the height of post-crisis stimulus, unfunded transfers yet appeared, but their influence on Eurozone inflation dynamics were marginal and short-lived. This near absence of unfunded-transfer effects reflects an institutional framework deeply anchored in debt-sustainability norms. Commitments under the Stability and Growth Pact, the dispersion of fiscal authority across member states, and the ECB's reluctance to accommodate country-specific fiscal slippages make passive-active configuration exceptionally rare, even during episodes of temporary fiscal cooperation between member states such as in 2009. As a result, transfers are typically perceived as funded, sharply limiting their potential inflationary impact.

A potential extension of this analysis is to examine the pandemic episode, which differed in several important respects from the post-2008 environment. First, the fiscal response was both larger in scale and more sustained, supported by EU-level initiatives such as the Next Generation EU recovery fund, the SURE program for employment protection, and expanded common backstops for sovereign financing. Second, the Stability and Growth Pact rules were formally suspended, removing the immediate pressure for consolidation that had constrained the post-2008 stimulus. Third, the early reversion to austerity that characterized the aftermath of the global financial crisis was largely absent. Instead, fiscal support was maintained for several years, often in coordination with highly accommodative monetary policy. These institutional and policy shifts created a setting far more conducive to the emergence of unfunded transfers at the union level. The combination of deepened fiscal integration, relaxed fiscal rules, and centralized EU financing mechanisms could plausibly have altered expectations about the permanence of transfers and the willingness of the ECB to tolerate higher inflation to preserve debt sustainability.

However, post-pandemic macroeconomic outcomes suggest that the Eurozone did not become "unfunded friendly". GDP growth lagged behind that of the United States, and the inflation that did materialize was driven primarily by the energy price shock following the Russian invasion of Ukraine, rather than by sustained demand-side pressures from the fiscal expansion. The resulting spike in headline inflation was sharp and short-lived, reinforcing the view that it was largely an energy price phenomenon rather than the product of a lasting shift in fiscal–monetary coordination. Eurozone inflation returned below the 2% target in September 2024, whereas U.S. inflation remained

[4] European Commission (2008), A European Economic Recovery Plan. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52008DC0800&from=EN.

above target well into 2025, a persistence consistent with the role played by unfunded transfers in sustaining price pressures. This combination of a short-lived inflation spike and relatively weak growth points to a policy environment in which fiscal expansions were still perceived as temporary or funded, limiting the scope for the kind of fiscal-inflation dynamics observed in the U.S. In the Eurozone.

Conclusion

Taken together, the evidence leaves little doubt that unfunded transfers have played no meaningful role in Eurozone inflation dynamics, neither during the post-2008 stimulus nor in normal times. Even when fiscal coordination was temporarily strengthened and the scale of intervention increased, transfers were either explicitly framed as temporary or quickly offset by consolidation measures, preventing the emergence of a sustained passive-active regime. Refining the model to match exactly the one presented by Bianchi et al. (2023) or extending it to the post-covid period would therefore be unlikely to alter the main conclusion: in the Eurozone's institutional and policy setting, unfunded transfers have remained marginal, and their macroeconomic footprint negligible.

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Appendix

A Notation, Variables, and Parameters

A.1 Notation Conventions

Let X_t be a generic *real* variable and X_* its steady state value. If X_t is stationary, x_t denotes the log-deviation of X_t with respect to X_* which can be defined as,

$$x_t = \log\left(\frac{X_t}{X_*}\right)$$

If X_t is non-stationary, i.e trending, let

$$\hat{X}_t = \frac{X_t}{A_t},$$

with A_t a trend, be its normalized value and $\hat{X}_*$ the associated steady-state. In this case, x_t refers to the log-deviation of $\hat{X}_t$ from $\hat{X}_*$,

$$x_t = \log\left(\frac{\hat{X}_t}{\hat{X}_*}\right)$$

Regarding nominal variables, we need to add a step to get their real counterpart. Let Q_t be a generic *nominal* variable, and P_t the aggregate price level. The real counterpart of Q_t is defined as,

$$\bar{Q}_t \equiv \frac{Q_t}{P_t}$$

and $\bar{Q}_*$ denotes its associated steady state value. Using the same convention as before, if $\bar{Q}_t$ is stationary, let q_t denotes the log-deviation of $\bar{Q}_t$ with respect to $\bar{Q}_*$,

$$q_t = \log\left(\frac{\bar{Q}_t}{\bar{Q}_*}\right)$$

If $\bar{Q}_t$ is trending, let $\hat{Q}_t$ be its normalized value and $\hat{Q}_*$ its associated steady-state. In this case, q_t refers to the log-deviation of $\hat{Q}_t$ from $\hat{Q}_*$,

$$q_t = \log\left(\frac{\hat{Q}_t}{\hat{Q}_*}\right)$$

A small caveat concerns the notation of tax variables, which are denoted $\tau_{X,t}$, with $X \in \{C, K, N\}$. For these variables, log-deviations are written $\hat{\tau}_{X,t}$. Since tax variables are not trending, this convention does not introduces any ambiguity.

A.2 Endogenous Variables

Table 4 lists all the model's endogenous variables, along with their corresponding log-deviation symbols and MATLAB codes used for implementation. The definitions provided clarify each variable's economic interpretation.

Table 4: Model Variables

Variable	**Log-dev.**	`MATLAB Code`	**Definition**
Households and Consumption			
C_t	c_t	`c`	Aggregate private consumption
C_t^R	c_t^R	`c_R`	Ricardian private consumption
C_t^H	c_t^H	`c_H`	Non-Ricardian private consumption
C_t^*	c_t^*	`cstar`	Aggregate total consumption
C_t^{*R}	c_t^{*R}	`c_Rstar`	Ricardian total consumption
Λ_t	λ_t	`lambda`	Marginal utility of wealth
Capital, Investment, and Bonds			
I_t^R	i_t^R	`invest`	Investment
K_t^R	k_t^R	`k`	Capital
Υ_t	υ_t	`ups`	Capital utilization rate
$R_{K,t}$	$r_{K,t}$	`rK`	Rental rate of capital
$P_{K,t}$	$p_{K,t}$	`pK`	Shadow price of capital
$B_{S,t}$	—	—	Short-term bond
$B_{L,t}$	$b_{L,t}$	`bL`	Long-term bond
$P_{S,t}$	—	—	Short-term bond price
$P_{L,t}$	$p_{L,t}$	`pL`	Long-term bond price
$R_{S,t}$	$r_{S,t}$	`rS`	Short-term interest rate
$R_{L,t}$	$r_{L,t}$	`rL`	Long-term interest rate
Wage Setting and Labor			
N_t	n_t	`n`	Aggregate labor
L_t	l_t	`l`	Aggregate labor force
U_t	u_t	`u`	Unemployment rate
Φ_t^R	φ_t^R	`varphi_R`	Ricardian taste shifter
$\bar{W}_t$	w_t	`w`	Real wage
Π_t^w	π_t^w	`pi_w`	Wage inflation
Δ_t	—	—	Wage dispersion
$V_{t\|t+s}^w$	—	—	Wage revision factor
Price Setting and Production			
P_t	—	—	Price level
Π_t	π_t	`pi_p`	Gross inflation
$V_{t\|t+s}^p$	—	—	Price revision factor
Ξ_t	—	—	Price dispersion
Y_t	y_t	`y`	Aggregate output
A_t	—	—	Technology
M_t	—	—	Materials
Q_t	—	—	Final good
S_t	s_t	`s`	Real marginal cost
S_t^{VA}	s_t^{VA}	`sVA`	Value-added marginal cost
Z_t	z_t	`z`	Consumption trend
D_t	—	—	Dividends

Fiscal Policy			
G_t	g_t	`g`	Public consumption
T_t	τ_t	`tau`	Public transfers
$\tau_{C,t}$	$\hat{\tau}_{C,t}$	`tauC`	Tax rate on consumption
$\tau_{K,t}$	$\hat{\tau}_{K,t}$	`tauK`	Tax rate on capital
$\tau_{N,t}$	$\hat{\tau}_{N,t}$	`tauN`	Tax rate on labor
$S_{B,t}$	$s_{B,t}$	`sB`	Debt-to-GDP ratio

A.3 Shocks

The model includes 11 exogenous shocks, each following an AR(1) process. Using a generic shock X as an example, the process takes the form,

$$\zeta_{X,t} = \rho_X \zeta_{X,t-1} + \sigma_X \varepsilon_{X,t},$$

where $\rho \in [0, 1)$ denotes the persistence parameter, σ_X is the standard deviation, and $\varepsilon_{X,t} \sim \mathcal{N}(0, 1)$ the innovation. The full list of shocks and their associated parameters is provided in table 5.

Table 5: Shock Processes

Shock / Param.	`MATLAB Code`	**Definition**
Shocks		
$\zeta_{A,t}$	`zeta_A`	Technology shock
$\zeta_{U,t}$	`zeta_U`	Discount factor shock
$\zeta_{N,t}$	`zeta_N`	Labor preference shock
$\zeta_{I,t}$	`zeta_I`	Investment shock
$\zeta_{rp,t}$	`zeta_rp`	Risk premium shock
$\zeta_{W,t}$	`zeta_W`	Wage markup shock
$\zeta_{P,t}$	`zeta_P`	Price markup shock
$\zeta_{m,t}$	`zeta_m`	Monetary policy shock
$\zeta_{G,t}$	`zeta_G`	Public consumption shock
$\zeta_{T,t}$	`zeta_T`	Funded transfers shock
$\zeta_{F,t}$	`zeta_F`	Unfunded transfers shock
Persistence Parameters		
ρ_A	`rho_A`	AR coeff. technology
ρ_U	`rho_U`	AR coeff. discount factor
ρ_N	`rho_N`	AR coeff. labor preference
ρ_I	`rho_I`	AR coeff. investment
ρ_{rp}	`rho_rp`	AR coeff. risk premium
ρ_W	`rho_W`	AR coeff. wage markup
ρ_P	`rho_P`	AR coeff. price markup
ρ_m	`rho_m`	AR coeff. monetary policy
ρ_G	`rho_G`	AR coeff. public consumption
ρ_T	`rho_T`	AR coeff. funded transfers
ρ_F	`rho_F`	AR coeff. unfunded transfers

Standard Deviation Parameters		
σ_A	se_A	St.dev. technology
σ_U	se_U	St.dev. discount factor
σ_N	se_N	St.dev. labor preference
σ_I	se_I	St.dev. investment
σ_{rp}	se_rp	St.dev. risk premium
σ_W	se_W	St.dev. wage markup
σ_P	se_P	St.dev. price markup
σ_m	se_m	St.dev. monetary policy
σ_G	se_G	St.dev. public consumption
σ_T	se_T	St.dev. funded transfers
σ_F	se_F	St.dev. unfunded transfers

A.4 Structural Parameters

Table 6 reports the full list of structural parameters used in the model, along with their associated `MATLAB` codes and economic interpretations.

Table 6: Structural Parameters

Parameter	`MATLAB Code`	**Definition**
Preferences and Households		
β	bbeta	Discount factor
α_G	alpha_G	Public vs. private consumption elasticity
η	eta	Strength of habit formation
χ	chi	Labor disutility scale factor
ν	nu	Inverse Frisch elasticity
ω	omega	Share of hand-to-mouth agents
ψ	psi	Strength of the short-term wealth effect
$\varkappa$	varkappa	Log. of the steady-state growth rate
Capital, Investment, and Bonds		
δ	delta	Capital depreciation rate
ν_I	nu_I	Investment adjustment cost
ϑ	vartheta	Capital utilization cost
ν_Υ	nu_ups	Capital utilization cost constant
ρ	rho	Long-term bonds decay factor
Wage Setting and Labor		
θ_w	thetaw	Constant wage elasticity of substitution
α_w	alpha_w	Degree of wage rigidity
γ_w	gamma_w	Degree of wage indexation
μ_w	mu_w	Steady-state wage markup
Price Setting and Production		
θ_p	thetap	Constant price elasticity of substitution

α_p	`alpha_p`	Degree of price rigidity
γ_p	`gamma_p`	Degree of price indexation
μ_p	`mu_p`	Steady-state price markup
s_M	`sM`	Cost share of intermediate inputs
θ	`theta`	Capital share in production
κ	—	Fixed production cost
Fiscal Policy		
γ_g	`gamma_g`	Gov. consumption response to debt
γ_τ	`gamma_tau`	Gov. transfers response to debt
γ_C	`gamma_C`	Tax on consumption response to debt
γ_K	`gamma_K`	Tax on capital response to debt
γ_N	`gamma_N`	Tax on labor response to debt
$\phi_{\tau y}$	`phi_tau_y`	Gov. transfers response to output
ρ_g	`rho_g`	AR coeff. gov. consumption rule
ρ_τ	`rho_tau`	AR coeff. gov. transfers rule
ρ_{τ_C}	`rho_tauC`	AR coeff. tax on consumption rule
ρ_{τ_K}	`rho_tauK`	AR coeff. tax on capital rule
ρ_{τ_N}	`rho_tauN`	AR coeff. tax on labor rule
Monetary Policy		
ϕ_π	`phi_pi`	Monetary response to inflation
ϕ_y	`phi_y`	Monetary response to output
ρ_r	`rho_R`	AR coeff. monetary rule

B Deriving the Model

B.1 Households

Ricardian Agents. The Lagrangian associated to the Ricardian household's maximization problem is,

$$\begin{aligned}\mathbb{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Bigg[& e^{\zeta_{U,t}} \left(\log\left(C_t^{*R} - \eta \tilde{C}_{t-1}^{*R} \right) - \int_0^1 \frac{\chi e^{\zeta_{N,t}} \Phi_t^R \left(N_t^R(h) \right)^{1+\nu}}{1+\nu} \, dh \right) \\ & - \Lambda_t \Bigg((1+\tau_{C,t}) C_t^R + I_t^R + P_{S,t} \bar{B}_{S,t}^R + P_{L,t} \bar{B}_{L,t}^R - \frac{1}{\Pi_t} \bar{B}_{S,t-1}^R - \frac{1+\rho P_{L,t}}{\Pi_t} \bar{B}_{L,t-1}^R \\ & - \left[(1-\tau_{K,t}) R_{K,t} \Upsilon_t - a(\Upsilon_t) \right] K_{t-1}^R - \int_0^1 (1-\tau_{N,t}) \bar{W}_t(h) N_t^R(h) \, dh - T_t - D_t^R \Bigg) \\ & - \Psi_t \left(K_t^R - (1-\delta) K_{t-1}^R - e^{\zeta_{I,t}} \left[1 - S\left(\frac{I_t^R}{I_{t-1}^R} \right) \right] I_t^R \right) \Bigg]\end{aligned}$$

where Λ_t and Ψ_t are the Lagrange multipliers associated to the budget constraint and the law of motion of capital respectively. Let's define,

$$\bar{B}_{S,t}^R \equiv \frac{B_{S,t}^R}{P_t}, \quad \bar{B}_{L,t}^R \equiv \frac{B_{L,t}^R}{P_t}, \quad \bar{W}_t(h) \equiv \frac{W_t(h)}{P_t}, \quad \Pi_t \equiv \frac{P_t}{P_{t-1}}.$$

The FOCs are,

$$\frac{\partial \mathbb{L}}{\partial C_t^R} = 0 \Leftrightarrow \frac{e^{\zeta_{U,t}}}{C_t^{*R} - \eta \tilde{C}_t^{*R}} = \Lambda_t (1+\tau_{C,t})$$

$$\begin{aligned}\frac{\partial \mathbb{L}}{\partial I_t^R} = 0 \Leftrightarrow \Lambda_t = \Psi_t e^{\zeta_{I,t}} & \left[1 - S\left(\frac{I_t^R}{I_{t-1}^R} \right) - S'\left(\frac{I_t^R}{I_{t-1}^R} \right) \cdot \frac{I_t^R}{I_{t-1}^R} \right] \\ & + \beta \mathbb{E}_t \left[\Psi_{t+1} e^{\zeta_{I,t+1}} S'\left(\frac{I_{t+1}^R}{I_t^R} \right) \left(\frac{I_{t+1}^R}{I_t^R} \right)^2 \right]\end{aligned}$$

$$\frac{\partial \mathbb{L}}{\partial \bar{B}_{S,t}^R} = 0 \Leftrightarrow \Lambda_t P_{S,t} = \beta \mathbb{E}_t \left[\Lambda_{t+1} \frac{1}{\Pi_{t+1}} \right]$$

$$\frac{\partial \mathbb{L}}{\partial \bar{B}_{L,t}^R} = 0 \Leftrightarrow \Lambda_t P_{L,t} = \beta \mathbb{E}_t \left[\Lambda_{t+1} \frac{1+\rho P_{L,t+1}}{\Pi_{t+1}} \right]$$

$$\frac{\partial \mathbb{L}}{\partial \Upsilon_t} = 0 \Leftrightarrow (1-\tau_{K,t}) R_{K,t} = a'(\Upsilon_t)$$

$$\frac{\partial \mathbb{L}}{\partial K_t^R} = 0 \Leftrightarrow \Psi_t = \beta \mathbb{E}_t \left[\Lambda_{t+1} \left[(1-\tau_{K,t+1}) R_{K,t+1} \Upsilon_{t+1} - a(\Upsilon_{t+1}) \right] + \Psi_{t+1}(1-\delta) \right]$$

Using the expression of the short-term interest rate $R_{S,t}$, the long-term interest rate $R_{L,t}$ and the shadow price of capital $P_{K,t}$ given by,

$$R_{S,t} \equiv \frac{e^{-\zeta_{rp,t}}}{P_{S,t}}, \quad R_{L,t} \equiv \frac{1+\rho P_{L,t}}{P_{L,t-1}}, \quad P_{K,t} \equiv \frac{\Psi_t}{\Lambda_t}$$

allow us to rewrite the system as follows,

$$\frac{e^{\zeta_{U,t}}}{C_t^{*R} - \eta \tilde{C}_t^{*R}} = \Lambda_t(1 + \tau_{C,t})$$

$$1 = P_{K,t} e^{\zeta_{I,t}} \left[1 - S\left(\frac{I_t^R}{I_{t-1}^R}\right) - S'\left(\frac{I_t^R}{I_{t-1}^R}\right) \cdot \frac{I_t^R}{I_{t-1}^R} \right] + \beta \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} P_{K,t+1} e^{\zeta_{I,t+1}} S'\left(\frac{I_{t+1}^R}{I_t^R}\right) \left(\frac{I_{t+1}^R}{I_t^R}\right)^2 \right]$$

$$\Lambda_t = \beta \mathbb{E}_t \left[\Lambda_{t+1} \frac{R_{S,t}}{\Pi_{t+1}} \right] e^{\zeta_{rp,t}}$$

$$\Lambda_t = \beta \mathbb{E}_t \left[\Lambda_{t+1} \frac{R_{L,t+1}}{\Pi_{t+1}} \right]$$

$$(1 - \tau_{K,t}) R_{K,t} = a'(\Upsilon_t)$$

$$P_{K,t} = \beta \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} \left((1 - \tau_{K,t+1}) R_{K,t+1} \Upsilon_{t+1} - a(\Upsilon_{t+1}) + (1 - \delta) P_{K,t+1} \right) \right]$$

Hand-to-mouth Agents. Using the fact that $N_t^R(h) = N_t^H(h) = N_t(h)$, integrating (11) over h and dividing it by P_t yields,

$$(1 + \tau_{C,t}) C_t^H = (1 - \tau_{N,t}) \bar{W}_t N_t + T_t$$

B.2 Wage Setting

Labor packer's program. The representative labor packer's maximization program is,

$$\max_{N_t(h)} \quad W_t N_t - \int_0^1 W_t(h) N_t(h)\, dh$$

$$s.t. \quad N_t = \left(\int_0^1 N_t(h)^{\frac{\theta_w - 1}{\theta_w}}\, dh \right)^{\frac{\theta_w}{\theta_w - 1}}$$

The associated FOC is,

$$\Leftrightarrow N_t(h) = N_t \left(\frac{W_t(h)}{W_t} \right)^{\theta_w}$$

Thanks to the zero profit condition, the aggregate wage index W_t is implicitly defined as,

$$W_t N_t = \int_0^1 W_t(h) N_t(h)\, dh$$

Using the expression derived for $N_t(h)$ allows to recover the aggregate wage index W_t,

$$W_t N_t = \int_0^1 W_t(h) N_t \left(\frac{W_t(h)}{W_t} \right)^{\theta_w} dh$$

$$\Leftrightarrow W_t = \left(\int_0^1 W_t(h)^{1 - \theta_w}\, dh \right)^{\frac{1}{1 - \theta_w}}$$

Wage Setting. We can rearrange the reoptimization wage FOC so as to isolate $W_t^\star(h)$ and obtain,

$$\left(\frac{\bar{W}_t^\star(h)}{\bar{W}_t}\right)^{1+\nu\theta_w} = \frac{\mathbb{E}_t\left[\sum_{s=0}^{\infty}(\beta\alpha_w)^s \mu_w e^{\zeta_{U,t+s}+\zeta_{N,t+s}+\zeta_{W,t+s}}\,\chi\Phi_{t+s}^R\left(\frac{V_{t|t+s}^w}{\Pi_{t|t+s}^w}\right)^{-\theta_w(1+\nu)} N_{t+s}^{1+\nu}\right]}{\mathbb{E}_t\left[\sum_{s=0}^{\infty}(\beta\alpha_w)^s\Lambda_{t+s}(1-\tau_{N,t+s})\bar{W}_{t+s}\left(\frac{V_{t|t+s}^w}{\Pi_{t|t+s}^w}\right)^{1-\theta_w} N_{t+s}\right]} \equiv \frac{K_t^w}{F_t^w}$$

where $\Pi_{t|t+s}^w = \frac{W_{t+s}}{W_t}$ represents the cumulative wage inflation between the last wage adjustment at time t and period $t+s$.

The term K_t^w can be expressed recursively by isolating the first term of the sum and adjusting the remaining terms accordingly. The following relationship holds,

$$\begin{aligned}K_t^w = {}& \mu_w e^{\zeta_{U,t}+\zeta_{N,t}+\zeta_{W,t+s}}\chi\Phi_t^R(N_t)^{1+\nu} \\ & + (\beta\alpha_w)\mathbb{E}_t\left[\sum_{s=1}^{\infty}(\beta\alpha_w)^{s-1}\mu_w e^{\zeta_{U,t+s}+\zeta_{N,t+s}+\zeta_{W,t+s}}\chi\Phi_{t+s}^R\right. \\ & \left.\left(\frac{V_{t|t+s}^w}{\Pi_{t|t+s}^w}\cdot\frac{\Pi_{t+1|t+s}^w}{V_{t+1|t+s}^w}\cdot\frac{V_{t+1|t+1+(s-1)}^w}{\Pi_{t+1|t+1+(s-1)}^w}\right)^{-\theta_w(1+\nu)}(N_{t+1+(s-1)})^{1+\nu}\right]\end{aligned}$$

The ratios inside the expectation simplify by exploiting the definitions of $V_{t|t+s}^w$and $\Pi_{t|t+s}^w$. Specifically, for all $s \geq 1$, the following identities hold,

$$\frac{V_{t|t+s}^w}{V_{t+1|t+s}^w} = \frac{e^{s\varkappa}\prod_{j=t}^{t+s-1}(\Pi_*)^{1-\gamma_w}(\Pi_j)^{\gamma_w}}{e^{(s-1)\varkappa}\prod_{j=t+1}^{t+s-1}(\Pi_*)^{1-\gamma_w}(\Pi_j)^{\gamma_w}} = e^{\varkappa}(\Pi_*)^{1-\gamma_w}(\Pi_t)^{\gamma_w}$$

Note that,

$$\frac{\Pi_{t+1|t+s}^w}{\Pi_{t|t+s}^w} = \frac{W_{t+s}/W_{t+1}}{W_{t+s}/W_t} = \frac{W_t}{W_{t+1}} = \frac{1}{\Pi_{t+1}^w}$$

Substituting these expressions yields the recursive formulation for K_t^w

$$K_t^w = \mu_w e^{\zeta_{U,t}+\zeta_{N,t}+\zeta_{W,t+s}}\chi\Phi_t^R(N_t)^{1+\nu} + (\beta\alpha_w)\mathbb{E}_t\left[\left(\frac{\Pi_{t+1}^w}{e^{\varkappa}(\Pi_*)^{1-\gamma_w}(\Pi_t)^{\gamma_w}}\right)^{(1+\nu)\theta_w} K_{t+1}^w\right]$$

A similar approach applies to F_t^w, which satisfies:

$$F_t^w = \Lambda_t(1-\tau_{N,t})\bar{W}_t N_t + (\beta\alpha_w)\mathbb{E}_t\left[\left(\frac{\Pi_{t+1}^w}{e^{\varkappa}(\Pi_*)^{1-\gamma_w}(\Pi_t)^{\gamma_w}}\right)^{\theta_w-1} F_{t+1}^w\right]$$

B.3 Production and Price Setting

Final good producer's program. The representative final good producer's maximization program is,

$$\max_{Q_t(h)} \quad P_tQ_t - \int_0^1 P_t(f)Q_t(f)\,df$$

$$s.t. \quad Q_t = \left(\int_0^1 Q_t(f)^{\frac{\theta_p-1}{\theta_p}}\,df\right)^{\frac{\theta_p}{\theta_p-1}}$$

The FOC yields the demand for intermediate good f,

$$Q_t(f) = \left(\frac{P_t(f)}{P_t}\right)^{-\theta_p} Q_t$$

Because final good producers are perfectly competitive and operate a constant-returns-to-scale technology, they make zero profits in equilibrium, implying,

$$Q_t = \int_0^1 \frac{P_t(f)}{P_t} Q_t(f)\, df$$

$$\Leftrightarrow P_t = \left(\int_0^1 P_t(f)^{1-\theta_p}\right)^{\frac{1}{1-\theta_p}}$$

Price setting. The price setting FOC can be rearranged as,

$$\frac{P_t^\star(f)}{P_t} = \frac{\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_p)^s \frac{\Lambda_{t+s}}{\Lambda_t} \mu_p e^{\zeta_{P,t+s}} S_{t+s} \left[\frac{V^p_{t|t+s} P_t}{P_{t+s}}\right]^{-\theta_p} Q_{t+s}}{\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_p)^s \frac{\Lambda_{t+s}}{\Lambda_t} \left[\frac{V^p_{t|t+s} P_t}{P_{t+s}}\right]^{1-\theta_p} Q_{t+s}}$$

Since the right-hand side does not depend on f, all reoptimizing firms set the same reset price. The optimal reset price is therefore denoted $P_t^\star$, and its relative form is defined as,

$$\bar{P}_t^\star \equiv \frac{P_t^\star}{P_t}$$

As for the wage setting block, we can use the price reoptimization FOC to define the following auxiliary expressions,

$$K_t^p \equiv \mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_p)^s \frac{\Lambda_{t+s}}{\Lambda_t} \mu_p S_{t+s} \left(\frac{V^p_{t|t+s} P_t}{P_{t+s}}\right)^{-\theta_p} Q_{t+s}$$

$$F_t^p \equiv \mathbb{E}_t \sum_{s=0}^{\infty} (\beta\alpha_p)^s \frac{\Lambda_{t+s}}{\Lambda_t} \left(\frac{V^p_{t|t+s} P_t}{P_{t+s}}\right)^{1-\theta_p} Q_{t+s}$$

so that the relative reset price can then be written compactly as,

$$\bar{P}_t^\star = \frac{K_t^p}{F_t^p}$$

Recursive expressions for K_t^p and F_t^p follow directly from this structure,

$$\begin{aligned} K_t^p = {} & \mu_p S_t Q_t \\ & + (\beta\alpha_p)\mathbb{E}_t \frac{\Lambda_{t+1}}{\Lambda_t} \sum_{s=1}^{\infty} (\beta\alpha_p)^{s-1} \frac{\Lambda_{t+1+(s-1)}}{\Lambda_{t+1}} \mu_p S_{t+1+(s-1)} \\ & \left(\frac{V^p_{t|t+s}}{V^p_{t+1|t+s}} \cdot \frac{P_t}{P_{t+1}} \cdot \frac{V^p_{t+1|t+1+(s-1)} P_{t+1}}{P_{t+1+(s-1)}}\right)^{-\theta_p} Q_{t+1+(s-1)} \end{aligned}$$

First, note that $\forall s \geq 1$,

$$\frac{V^p_{t|t+s}}{V^p_{t+1|t+s}} = \frac{\prod_{j=t}^{t+s-1}(\Pi_*)^{1-\gamma_p}(\Pi_j)^{\gamma_p}}{\prod_{j=t+1}^{t+s-1}(\Pi_*)^{1-\gamma_p}(\Pi_j)^{\gamma_p}} = (\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}$$

Using this result, along with iterated expectations and the law of motion for inflation, yields the recursive expression,

$$K^p_t = \mu_p S_t Q_t + (\beta\alpha_p)\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi_{t+1}}{(\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}}\right)^{\theta_p} K^p_{t+1}\right]$$

By the same reasoning, the term F^p_t satisfies,

$$F^p_t = Q_t + (\beta\alpha_p)\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi_{t+1}}{(\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}}\right)^{\theta_p-1} F^p_{t+1}\right]$$

B.4 Aggregate Price and Wage Level Dynamics

The zero profit condition states that,

$$P_t^{1-\theta_p} = \int_0^1 P_t(f)^{1-\theta_p}\, df$$

The goal is to determine a recursive expression for this equation. Recall that the share of firm that were able to reset their price in period t is $1-\alpha_p$. The rest is the share of firm with a sticky price that are obliged to follow the indexation rule. Thus,

$$P_t^{1-\theta_p} = \int_0^{\alpha_p}(P_t^\star)^{1-\theta_p}\, df + \int_{\alpha_p}^1 (\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}P_{t-1}(f)^{1-\theta_p}\, df$$

$$\Leftrightarrow P_t^{1-\theta_p} = (1-\alpha_p)(P_t^\star)^{1-\theta_p} + \alpha_p(\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}P_{t-1}(f)^{1-\theta_p}$$

Note that among the sticky firms in period t, some changed their price in period $t-1$, representing a share $\alpha_p(1-\alpha_p)$. And some were already stuck with an older price in period $t-1$. Thus,

$$P_t^{1-\theta_p} = (1-\alpha_p)(P_t^\star)^{1-\theta_p} + \alpha_p(1-\alpha_p)(P_{t-1}^\star)^{1-\theta_p} + \alpha_p^2 V^p_{t-2|t}P_{t-2}(f)^{1-\theta_p}.$$

with $V^p_{t-2|t}$ the price revision factor defined in section 2.3. Repeting these operations T times and taking the limit as $T\to\infty$, it yields,

$$P_t^{1-\theta_p} = (1-\alpha_p)\sum_{s=0}^{\infty}(\alpha_p)^s\left(V^p_{t-s|t}P^\star_{t-s}\right)^{1-\theta_p}.$$

Note that,

$$P_t^{1-\theta_p} = (1-\alpha_p)(P_t^\star)^{1-\theta_p} + (1-\alpha_p)\sum_{s=1}^{\infty}(\alpha_p)^s\left(V_{t-s|t}P^\star_{t-s}\right)^{1-\theta_p},$$

implying,

$$P_t^{1-\theta} = (1-\alpha_p)(P_t^\star)^{1-\theta_p} + (1-\alpha_p)\alpha_p(\Pi_*)^{1-\theta_p}\sum_{s=1}^{\infty}\left(V_{t-1-(s-1)|t-1}(\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}P^\star_{t-1-(s-1)}\right)^{1-\theta_p}$$

$$\Leftrightarrow P_t^{1-\theta_p} = (1-\alpha_p)(P_t^\star)^{1-\theta_p} + \alpha_p \left((\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p} P_{t-1}\right)^{1-\theta_p}$$

It follows that,

$$1 = (1-\alpha_p)(\bar{P}_t^\star)^{1-\theta_p} + \alpha_p \left[\frac{\Pi_t}{(\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}}\right]^{\theta_p - 1}$$

The exact same reasoning apply to the wage setting block. Replacing P_t by W_t, using the corresponding indexation rule, and the wage setting parameters counterpart yields,

$$1 = (1-\alpha_w)\left(\frac{\bar{W}_t^\star}{\bar{W}_t}\right)^{1-\theta_w} + \alpha_w \left(\frac{\Pi_t^w}{e^{\varkappa}(\Pi_*)^{1-\gamma_w}(\Pi_{t-1})^{\gamma_w}}\right)^{\theta_w - 1}$$

The same reasoning also apply for the price and the wage dispersion index,

$$\Xi_t = (1-\alpha_p)(\bar{P}_t^\star)^{-\theta_p} + \alpha_p \left(\frac{\Pi_t}{(\Pi_\star)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}}\right)^{\theta_p} \Xi_{t-1}$$

$$\Delta_t^{\frac{1}{\nu}} = (1-\alpha_w)\left(\frac{\bar{W}_t^\star}{\bar{W}_t}\right)^{\frac{1}{\nu}} + \alpha_w \left[\frac{e^{\varkappa}(\Pi_*)^{1-\gamma_w}(\Pi_{t-1})^{\gamma_w}}{\Pi_t^w}\right]^{\frac{1}{\nu}} (\Delta_{t-1})^{\frac{1}{\nu}}$$

C Core System of Equations

C.1 Untransformed System

Hence, the focus turns to the dynamic equilibrium system that characterizes the economy described above. In equilibrium, the following condition holds,

$$C_t^R = \tilde{C}_t^R$$

The core system gathers the set of equations that are common to all policy configurations and involve only the non-policy variables. These include, Λ_t, C_t^{*R}, C_t^{*H}, I_t^R, $R_{K,t}$, $R_{L,t}$, $P_{K,t}$, $P_{L,t}^m$, Y_t, K_{t-1}^R, L_t, N_t, Δ_t, Q_t, Y_t, M_t, $\bar{W}_t$, S_t, S_t^{VA}, $\bar{W}_t^\star$, $\bar{W}_t$, $\bar{P}_t^\star$, Π_t, Π_t^w, K_t^w, K_t^p, F_t^w, F_t^p, and Ξ_t. It consists of the following set of equilibrium conditions,

$$\frac{e^{\zeta_{U,t}}}{C_t^{*R} - \eta C_t^{*R}} = \Lambda_t(1+\tau_{C,t}) \tag{C.1}$$

$$\begin{aligned} 1 = P_{K,t} e^{\zeta_{I,t}} &\left[1 - S\left(\frac{I_t^R}{I_{t-1}^R}\right) - S'\left(\frac{I_t^R}{I_{t-1}^R}\right)\cdot\frac{I_t^R}{I_{t-1}^R}\right] \\ &+ \beta\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{\Lambda_t} P_{K,t+1} e^{\zeta_{I,t+1}} S'\left(\frac{I_{t+1}^R}{I_t^R}\right)\left(\frac{I_{t+1}^R}{I_t^R}\right)^2\right] \end{aligned} \tag{C.2}$$

$$\Lambda_t = \beta\mathbb{E}_t\left[\Lambda_{t+1}\frac{R_{S,t}}{\Pi_{t+1}}\right] e^{\zeta_{rp,t}} \tag{C.3}$$

$$\Lambda_t = \beta\mathbb{E}_t\left[\Lambda_{t+1}\frac{R_{L,t+1}}{\Pi_{t+1}}\right] \tag{C.4}$$

$$(1-\tau_{K,t})R_{K,t} = a'(\Upsilon_t) \tag{C.5}$$

$$P_{K,t} = \beta \mathbb{E}_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} \left((1-\tau_{K,t+1}) R_{K,t+1} \Upsilon_{t+1} - a(\Upsilon_{t+1}) + (1-\delta) P_{K,t+1} \right) \right] \tag{C.6}$$

$$K_t^R = (1-\delta) K_{t-1}^R + e^{\zeta_{I,t}} \left[1 - S\left(\frac{I_t^R}{I_{t-1}^R} \right) \right] I_t^R \tag{C.7}$$

$$R_{L,t} = \frac{1 + \rho P_{L,t}}{P_{L,t-1}} \tag{C.8}$$

$$\Phi_t^R = \frac{Z_t}{C_t^{*R} - \eta C_{t-1}^{*R}} \tag{C.9}$$

$$Z_t = (Z_{t-1})^{1-\psi} (C_t^* - \eta C_{t-1}^*)^{\psi} \tag{C.10}$$

$$\left(\frac{\bar{W}_t^\star}{\bar{W}_t} \right)^{1+\nu\theta_w} = \frac{K_t^w}{F_t^w} \tag{C.11}$$

$$\Pi_t^w = \Pi_t \frac{\bar{W}_t}{\bar{W}_{t-1}} \tag{C.12}$$

$$K_t^w = \mu_w e^{\zeta_{U,t} + \zeta_{N,t} + \zeta_{W,t}} \chi \Phi_t^R (N_t)^{1+\nu} + (\beta \alpha_w) \mathbb{E}_t \left[\left(\frac{\Pi_{t+1}^w}{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_t)^{\gamma_w}} \right)^{(1+\nu)\theta_w} K_{t+1}^w \right] \tag{C.13}$$

$$F_t^w = \Lambda_t (1-\tau_{N,t}) \bar{W}_t N_t + (\beta \alpha_w) \mathbb{E}_t \left[\left(\frac{\Pi_{t+1}^w}{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_t)^{\gamma_w}} \right)^{\theta_w - 1} F_{t+1}^w \right] \tag{C.14}$$

$$1 = (1-\alpha_w) \left(\frac{\bar{W}_t^\star}{\bar{W}_t} \right)^{1-\theta_w} + \alpha_w \left(\frac{\Pi_t^w}{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_{t-1})^{\gamma_w}} \right)^{\theta_w - 1} \tag{C.15}$$

$$\Delta_t \cdot \frac{1-\tau_{N,t}}{1+\tau_{C,t}} \bar{W}_t = \chi e^{\zeta_{N,t}} Z_t (L_t)^{\nu} \tag{C.16}$$

$$U_t = \frac{L_t - N_t}{L_t} \tag{C.17}$$

$$\Delta_t^{\frac{1}{\nu}} = (1-\alpha_w) \left(\frac{\bar{W}_t^\star}{\bar{W}_t} \right)^{\frac{1}{\nu}} + \alpha_w \left[\frac{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_{t-1})^{\gamma_w}}{\Pi_t^w} \right]^{\frac{1}{\nu}} (\Delta_{t-1})^{\frac{1}{\nu}} \tag{C.18}$$

$$(1+\tau_{C,t}) C_t^H = (1-\tau_{N,t}) \bar{W}_t N_t + T_t \tag{C.19}$$

$$C_t = \omega C_t^H + (1-\omega) C_t^R \tag{C.20}$$

$$C_t^* = C_t + \alpha_G G_t \tag{C.21}$$

$$C_t^{*R} = C_t^R + \alpha_G G_t \tag{C.22}$$

$$Q_t = C_t + (1-\omega)I_t^R + G_t + a(\Upsilon_t)(1-\omega)K_{t-1}^R + M_t \tag{C.23}$$

$$\bar{P}_t^\star = \frac{K_t^p}{F_t^p} \tag{C.24}$$

$$K_t^p = \mu_p e^{\zeta_{P,t}} S_t Q_t + (\beta\alpha_p)\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi_{t+1}}{(\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}}\right)^{\theta_p} K_{t+1}^p\right] \tag{C.25}$$

$$F_t^p = Q_t + (\beta\alpha_p)\mathbb{E}_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\Pi_{t+1}}{(\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}}\right)^{\theta_p-1} F_{t+1}^p\right] \tag{C.26}$$

$$1 = (1-\alpha_p)(\bar{P}_t^\star)^{1-\theta_p} + \alpha_p\left(\frac{\Pi_t}{(\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}}\right)^{\theta_p-1} \tag{C.27}$$

$$S_t = s_M + (1-s_M)S_t^A \tag{C.28}$$

$$\bar{W}_t = A_t S_t^{VA}(1-\theta)\left(\frac{(1-\omega)\Upsilon_t K_{t-1}^R}{A_t N_t}\right)^{\theta} \tag{C.29}$$

$$R_{K,t} = S_t^{VA}\theta\left(\frac{(1-\omega)\Upsilon_t K_{t-1}^R}{A_t N_t}\right)^{\theta-1} \tag{C.30}$$

$$s_M Q_t \Xi_t = M_t \tag{C.31}$$

$$Y_t \Xi_t = ((1-\omega)\Upsilon_t K_{t-1}^R)^{\theta}(A_t N_t)^{1-\theta} - \kappa A_t \tag{C.32}$$

$$Y_t = (1-s_M)Q_t \tag{C.33}$$

$$\Xi_t = (1-\alpha_p)(\bar{P}_t^\star)^{-\theta_p} + \alpha_p\left(\frac{\Pi_t}{(\Pi_\star)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}}\right)^{\theta_p}\Xi_{t-1} \tag{C.34}$$

$$\begin{aligned} P_{L,t}\bar{B}_{L,t} + \tau_{N,t}\bar{W}_t N_t + \tau_{K,t}R_{K,t}\Upsilon_t(1-\omega)K_{t-1}^R + \tau_{C,t}C_t \\ = (1+\rho P_{L,t})\bar{B}_{L,t-1} + G_t + T_t \end{aligned} \tag{C.35}$$

$$S_{B,t} \equiv \frac{P_{L,t}\bar{B}_{L,t}}{Y_t + \frac{1}{\Pi_t}Y_{t-1} + \frac{1}{\Pi_t\Pi_{t-1}}Y_{t-2} + \frac{1}{\Pi_t\Pi_{t-1}\Pi_{t-2}}Y_{t-3}} \tag{C.36}$$

The above system also features policy variables, namely T_t, G_t, $\tau_{C,t}$, τ_{N_t}, τ_{K_t}, and $R_{S,t}$ which will be described in the policy block.

Note also that all equations are normalized by P_t, since the price level is non-stationary. This normalization removes P_t from the system, causes inflation Π_t to appear explicitly, and ensures that all equilibrium conditions are expressed in terms of stationary variables consistently defined in the model.

C.2 Stationary System

The goal is now to obtain a stationary system. To this end, trending variables are normalized by the technological process A_t that follows an exogenous process that is stationary in the growth rate, that is,

$$\ln A_t = \ln A_{t-1} + \tilde{\zeta}_{A,t}$$

with,

$$\tilde{\zeta}_{A,t} = (1-\rho_A)\varkappa + \rho_A \tilde{\zeta}_{a,t-1} + \varepsilon_{A,t}$$

It follows that A_t in logarithm is an ARIMA(1,1,0) process. At this stage, it is convenient to define,

$$\zeta_{A,t} \equiv \tilde{\zeta}_{A,t} - \varkappa$$

Using the equation governing the AR(1) process, we get,

$$\tilde{\zeta}_{A,t} = (1-\rho_A)\varkappa + \rho_A \tilde{\zeta}_{A,t-1} + \varepsilon_{A,t}$$

$$\Leftrightarrow \tilde{\zeta}_{A,t} - \varkappa = \rho_A(\tilde{\zeta}_{A,t-1} - \varkappa) + \varepsilon_{A,t}$$

Finally when using the definition of $\zeta_{A,t}$,

$$\Leftrightarrow \zeta_{A,t} = \rho_a \zeta_{A,t-1} + \varepsilon_{A,t}$$

Hence, the process for A_t can be equivalently be rewritten as,

$$\ln A_t = \varkappa + \ln A_{t-1} + \zeta_{A,t}$$

Implying,

$$\frac{A_t}{A_{t-1}} = e^{\varkappa + \zeta_{A,t}}$$

Let's now define the stationary variables that enter the system, $\hat{C}_t \equiv C_t A_t^{-1}$, $\hat{C}_t^R \equiv C_t^R A_t^{-1}$, $\hat{C}_t^H \equiv C_t^H A_t^{-1}$, $\hat{I}_t^R \equiv I_t^R A_t^{-1}$, $\hat{K}_t^R \equiv K_t^R A_t^{-1}$, $\hat{M}_t \equiv M_t A_t^{-1}$, $\hat{Q}_t \equiv Q_t A_t^{-1}$,$\hat{Y}_t \equiv Y_t A_t^{-1}$, $\hat{W}_t \equiv \bar{W}_t A_t^{-1}$, $\hat{W}_t^\star \equiv \bar{W}_t^\star A_t^{-1}$, $\hat{\Lambda}_t \equiv \Lambda_t A_t$, $\hat{K}_t^p \equiv K_t^p A_t^{-1}$, $\hat{F}_t^p \equiv F_t^p A_t^{-1}$.

Note that according to (C.1), as long as C_t grows like A_t, it must be the case that Λ_t grows like $\frac{1}{A_t}$. Hence,

$$\hat{C}_t = \frac{C_t}{A_t} \quad \text{and} \quad \hat{\Lambda}_t = \Lambda_t A_t$$

Using these definitions, the stationary system is given by,

$$\frac{e^{\zeta_{U,t}}}{\hat{C}_t^{*R} - \eta e^{-\varkappa - \zeta_{A,t}} \hat{C}_{t-1}^{*R}} = \hat{\Lambda}_t (1 + \tau_{C,t}) \tag{C.37}$$

$$\begin{aligned} 1 = \; & P_{K,t} e^{\zeta_{I,t}} \left[1 - S\left(e^{\varkappa + \zeta_{A,t}} \frac{\hat{I}_t^R}{\hat{I}_{t-1}^R} \right) - e^{\varkappa + \zeta_{A,t}} S'\left(e^{\varkappa + \zeta_{A,t}} \frac{\hat{I}_t^R}{\hat{I}_{t-1}^R} \right) \cdot \frac{\hat{I}_t^R}{\hat{I}_{t-1}^R} \right] \\ & + \beta \mathbb{E}_t \left[e^{-\varkappa - \zeta_{A,t}} \frac{\hat{\Lambda}_{t+1}}{\hat{\Lambda}_t} P_{K,t+1} \zeta_{A,t+1} S'\left(e^{\varkappa + \zeta_{A,t+1}} \frac{\hat{I}_{t+1}^R}{\hat{I}_t^R} \right) \left(e^{\varkappa + \zeta_{A,t+1}} \frac{\hat{I}_{t+1}^R}{\hat{I}_t^R} \right)^2 \right] \end{aligned} \tag{C.38}$$

$$\hat{\Lambda}_t = \beta \mathbb{E}_t \left[e^{-\varkappa - \zeta_{A,t+1}} \hat{\Lambda}_{t+1} \frac{R_{S,t}}{\Pi_{t+1}} \right] e^{\zeta_{rp,t}} \tag{C.39}$$

$$\hat{\Lambda}_t = \beta \mathbb{E}_t \left[e^{-\varkappa - \zeta_{A,t+1}} \hat{\Lambda}_{t+1} \frac{R_{L,t+1}}{\Pi_{t+1}} \right] \tag{C.40}$$

$$(1 - \tau_{K,t}) R_{K,t} = a'(\Upsilon_t) \tag{C.41}$$

$$P_{K,t} = \beta \mathbb{E}_t \left[e^{-\varkappa - \zeta^a_{t+1}} \frac{\hat{\Lambda}_{t+1}}{\hat{\Lambda}_t} \left((1 - \tau_{K,t+1}) R_{K,t+1} \Upsilon_{t+1} - a(\Upsilon_{t+1}) + (1 - \delta) P_{K,t+1} \right) \right] \tag{C.42}$$

$$\hat{K}^R_t = (1 - \delta) e^{-\varkappa - \zeta_{A,t}} \hat{K}^R_{t-1} + \zeta_{I,t} \left[1 - S \left(e^{\varkappa + \zeta_{A,t}} \frac{\hat{I}^R_t}{\hat{I}^R_{t-1}} \right) \right] \hat{I}^R_t \tag{C.43}$$

$$R_{L,t} = \frac{1 + \rho P_{L,t}}{P_{L,t-1}} \tag{C.44}$$

$$\Phi^R_t = \frac{\hat{Z}_t}{\hat{C}^{*R}_t - \eta e^{-\varkappa - \zeta_{A,t}} \hat{C}^{*R}_{t-1}} \tag{C.45}$$

$$\hat{Z}_t = (e^{-\varkappa - \zeta_{A,t}} \hat{Z}_{t-1})^{1-\psi} (\hat{C}^*_t - \eta e^{-\varkappa - \zeta_{A,t}} \hat{C}^*_{t-1})^{\psi} \tag{C.46}$$

$$\left(\frac{\hat{W}^\star_t}{\hat{W}_t} \right)^{1+\nu\theta_w} = \frac{K^w_t}{F^w_t} \tag{C.47}$$

$$\Pi^w_t = e^{\varkappa + \zeta_{A,t}} \Pi_t \frac{\hat{W}_t}{\hat{W}_{t-1}} \tag{C.48}$$

$$K^w_t = \mu_w e^{\zeta_{U,t} + \zeta_{N,t} + \zeta_{W,t}} \chi \Phi^R_t (N_t)^{1+\nu} + (\beta\alpha_w) \mathbb{E}_t \left[\left(\frac{\Pi^w_{t+1}}{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_t)^{\gamma_w}} \right)^{(1+\nu)\theta_w} K^w_{t+1} \right] \tag{C.49}$$

$$F^w_t = \hat{\Lambda}_t (1 - \tau_{N,t}) \hat{W}_t N_t + (\beta\alpha_w) \mathbb{E}_t \left[\left(\frac{\Pi^w_{t+1}}{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_t)^{\gamma_w}} \right)^{\theta_w - 1} F^w_{t+1} \right] \tag{C.50}$$

$$1 = (1 - \alpha_w) \left(\frac{\hat{W}^\star_t}{\hat{W}_t} \right)^{1-\theta_w} + \alpha_w \left(\frac{\Pi^w_t}{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_{t-1})^{\gamma_w}} \right)^{\theta_w - 1} \tag{C.51}$$

$$\Delta_t \cdot \frac{1 - \tau_{N,t}}{1 + \tau_{C,t}} \hat{W}_t = \chi e^{\zeta_{N,t}} \hat{Z}_t (L_t)^{\nu} \tag{C.52}$$

$$U_t = \frac{L_t - N_t}{L_t} \tag{C.53}$$

$$\Delta_t^{\frac{1}{\nu}} = (1 - \alpha_w) \left(\frac{\hat{W}^\star_t}{\hat{W}_t} \right)^{\frac{1}{\nu}} + \alpha_w \left[\frac{e^{\varkappa} (\Pi_*)^{1-\gamma_w} (\Pi_{t-1})^{\gamma_w}}{\Pi^w_t} \right]^{\frac{1}{\nu}} (\Delta_{t-1})^{\frac{1}{\nu}} \tag{C.54}$$

$$(1 + \tau_{C,t}) \hat{C}^H_t = (1 - \tau_{N,t}) \hat{W}_t N_t + \hat{T}_t \tag{C.55}$$

$$\hat{C}_t = \omega \hat{C}_t^H + (1-\omega)\hat{C}_t^R \tag{C.56}$$

$$\hat{C}_t^* = \hat{C}_t + \alpha_G \hat{G}_t \tag{C.57}$$

$$\hat{C}_t^{*R} = \hat{C}_t^R + \alpha_G \hat{G}_t \tag{C.58}$$

$$\hat{Q}_t = \hat{C}_t + (1-\omega)\hat{I}_t^R + \hat{G}_t + a(\Upsilon_t)(1-\omega)e^{-\varkappa-\zeta_{A,t}}\hat{K}_{t-1}^R + \hat{M}_t \tag{C.59}$$

$$\bar{P}_t^\star = \frac{\hat{K}_t^p}{\hat{F}_t^p} \tag{C.60}$$

$$\hat{K}_t^p = \mu_p e^{\zeta_{P,t}} S_t \hat{Q}_t + (\beta\alpha_p)\mathbb{E}_t\left[\frac{\hat{\Lambda}_{t+1}}{\hat{\Lambda}_t}\left(\frac{\Pi_{t+1}}{(\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}}\right)^{\theta_p}\hat{K}_{t+1}^p\right] \tag{C.61}$$

$$\hat{F}_t^p = \hat{Q}_t + (\beta\alpha_p)\mathbb{E}_t\left[\frac{\hat{\Lambda}_{t+1}}{\hat{\Lambda}_t}\left(\frac{\Pi_{t+1}}{(\Pi_*)^{1-\gamma_p}(\Pi_t)^{\gamma_p}}\right)^{\theta_p-1}\hat{F}_{t+1}^p\right] \tag{C.62}$$

$$1 = (1-\alpha_p)(\bar{P}_t^\star)^{1-\theta_p} + \alpha_p\left(\frac{\Pi_t}{(\Pi_*)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}}\right)^{\theta_p-1} \tag{C.63}$$

$$S_t = s_M + (1-s_M)S_t^{VA} \tag{C.64}$$

$$\hat{W}_t = S_t^{VA}(1-\theta)\left(\frac{(1-\omega)\Upsilon_t\hat{K}_{t-1}^R}{e^{\varkappa+\zeta_{A,t}}N_t}\right)^\theta \tag{C.65}$$

$$R_{K,t} = S_t^{VA}\theta\left(\frac{(1-\omega)\Upsilon_t K_{t-1}^R}{e^{\varkappa+\zeta_{A,t}}N_t}\right)^{\theta-1} \tag{C.66}$$

$$s_M\hat{Q}_t\Xi_t = \hat{M}_t \tag{C.67}$$

$$\hat{Y}_t\Xi_t = \left((1-\omega)\Upsilon_t e^{-\varkappa-\zeta^{A,t}}\hat{K}_{t-1}^R\right)^\theta N_t^{1-\theta} - \kappa \tag{C.68}$$

$$\hat{Y}_t = (1-s_M)\hat{Q}_t \tag{C.69}$$

$$\Xi_t = (1-\alpha_p)(\bar{P}_t^\star)^{-\theta_p} + \alpha_p\left(\frac{\Pi_t}{(\Pi_\star)^{1-\gamma_p}(\Pi_{t-1})^{\gamma_p}}\right)^{\theta_p}\Xi_{t-1} \tag{C.70}$$

$$\begin{aligned}P_{L,t}\hat{B}_{L,t} + \tau_{N,t}\hat{W}_tN_t + \tau_{K,t}R_{K,t}\Upsilon_t e^{-\varkappa-\zeta_{A,t}}(1-\omega)\hat{K}_{t-1}^R&\\ +\tau_{C,t}\hat{C}_t =&\frac{R_{L,t}}{e^{\varkappa+\zeta_{A,t}}\Pi_t}P_{L,t-1}\hat{B}_{L,t-1} + \hat{G}_t + \hat{T}_t\end{aligned} \tag{C.71}$$

$$S_{B,t} = \frac{P_{L,t}\hat{B}_{L,t}}{\hat{Y}_t + \frac{e^{-\varkappa-\zeta_{A,t}}}{\Pi_t}\hat{Y}_{t-1} + \frac{e^{-2\varkappa-\zeta_{A,t}-\zeta_{A,t-1}}}{\Pi_t\Pi_{t-1}}\hat{Y}_{t-2} + \frac{e^{-3\varkappa-\zeta_{A,t}-\zeta_{A,t-1}-\zeta_{A,t-2}}}{\Pi_t\Pi_{t-1}\Pi_{t-2}}\hat{Y}_{t-3}} \tag{C.72}$$

C.3 Implied Steady-State Restrictions

The steady-restrictions are,

$$\hat{\Lambda}_* = \frac{1}{(1+\tau_{C_*})(1-\eta e^{-\varkappa})\hat{C}_*^{*R}} \tag{C.73}$$

$$P_{K_*} = 1 \tag{C.74}$$

$$1 = \beta e^{-\varkappa} \frac{R_{S_*}}{\Pi_*} \tag{C.75}$$

$$1 = \beta e^{-\varkappa} \frac{R_{L_*}}{\Pi_*} \tag{C.76}$$

$$(1-\tau_{K_*})R_{K_*} = a'(\Upsilon_*) \tag{C.77}$$

$$1 = \beta e^{-\varkappa} \left((1-\tau_{K_*})R_{K_*}\Upsilon_* - a(\Upsilon_*) + (1-\delta)\right) \tag{C.78}$$

$$(1-(1-\delta)e^{-\varkappa})\hat{K}_*^R = \hat{I}_*^R \tag{C.79}$$

$$R_{L_*} = \frac{1+\rho P_{L_*}}{P_{L_*}} \tag{C.80}$$

$$\Phi_*^R = \frac{\hat{Z}_*}{(1-\eta e^{-\varkappa})\hat{C}_*^{*R}} \tag{C.81}$$

$$\hat{Z}_* = (e^{-\varkappa})^{\frac{1-\psi}{\psi}}(1-\eta e^{-\varkappa})\hat{C}_*^* \tag{C.82}$$

$$\frac{\hat{W}_*^\star}{\hat{W}_*} = 1 \tag{C.83}$$

$$\Pi_*^w = e^{\varkappa}\Pi_* \tag{C.84}$$

$$K_*^w = \frac{1}{1-\beta\alpha_w}\mu_w \chi \Phi_*^R (N_*)^{1+\nu} \tag{C.85}$$

$$F_*^w = \frac{1}{1-\beta\alpha_w}\hat{\Lambda}_*(1-\tau_{N_*})\hat{W}_* N_* \tag{C.86}$$

$$\frac{1}{(1-\eta e^{-\varkappa})\hat{C}_*^{*R}} \cdot \frac{(1-\tau_{N_*})}{(1+\tau_{C_*})}\hat{W}_* = \mu_w \chi \Phi_*^R N_*^\nu \tag{C.87}$$

$$\frac{1-\tau_{N_*}}{1+\tau_{C_*}}\hat{W}_* = \chi \hat{Z}_* (L_*)^\nu \tag{C.88}$$

$$U_* = \frac{L_* - N_*}{L_*} \tag{C.89}$$

$$\Delta_* = 1 \tag{C.90}$$

$$(1+\tau_{C_*})\hat{C}_*^H = (1-\tau_{N_*})\hat{W}_* N_* + \hat{T}_* \tag{C.91}$$

$$\hat{C}_* = \omega \hat{C}_*^H + (1-\omega)\hat{C}_*^R \tag{C.92}$$

$$\hat{C}_*^* = \hat{C}_* + \alpha_G \hat{G}_* \tag{C.93}$$

$$\hat{C}_*^{*R} = \hat{C}_*^R + \alpha_G \hat{G}_* \tag{C.94}$$

$$\hat{Q}_* = \hat{C}_* + (1-\omega)\hat{I}_*^R + \hat{G}_* + \hat{M}_* \tag{C.95}$$

$$\hat{P}_*^\star = 1 \tag{C.96}$$

$$\hat{K}_*^p = \frac{1}{1-\beta\alpha_p}\mu_p S_* \hat{Q}_* \tag{C.97}$$

$$\hat{F}_*^p = \frac{1}{1-\beta\alpha_p}\hat{Q}_* \tag{C.98}$$

$$1 = \mu_p S_* \tag{C.99}$$

$$S_* = s_M + (1-s_M)S_*^{VA} \tag{C.100}$$

$$\hat{W}_* = S_*^{VA}(1-\theta)\left(\frac{(1-\omega)\Upsilon_* \hat{K}_*^R}{e^{\varkappa} N_*}\right)^{\theta} \tag{C.101}$$

$$R_{K_*} = S_*^{VA}\theta\left(\frac{(1-\omega)\Upsilon_* \hat{K}_*^R}{e^{\varkappa} N_*}\right)^{\theta-1} \tag{C.102}$$

$$s_M \hat{Q}_* \Xi_* = \hat{M}_* \tag{C.103}$$

$$\hat{Y}_* = \left((1-\omega)\Upsilon_* e^{-\varkappa}\hat{K}_*^R\right)^{\theta} N_*^{1-\theta} - \kappa \tag{C.104}$$

$$\hat{Y}_* = (1-s_M)\hat{Q}_* \tag{C.105}$$

$$\Xi_* = 1 \tag{C.106}$$

$$\begin{aligned} P_{L_*}\hat{B}_{L_*} + \tau_{N_*}\hat{W}_* N_* + \tau_{K_*} R_{K_*} e^{-\varkappa}(1-\omega)\hat{K}_*^R \\ +\tau_{C_*}\hat{C}_* = \frac{R_{L_*}}{e^{\varkappa}\Pi_*} P_{L_*}\hat{B}_{L_*} + \hat{G}_* + \hat{T}_* \end{aligned} \tag{C.107}$$

$$S_{B_*} = \frac{1}{1 + \frac{1}{e^{\varkappa}\Pi_*} + \frac{1}{(e^{\varkappa}\Pi_*)^2} + \frac{1}{(e^{\varkappa}\Pi_*)^3}} S'_{B_*} \tag{C.108}$$

Note that we use the steady-state expression of the debt-to-GDP ratio implied by the model,

$$S'_{B_*} = \frac{P_{L_*}\hat{B}_{L_*}}{\hat{Y}_*}$$

to express the steady-state debt-to-GDP ratio implied by the data S_{B_*}. In practice S_{B_*} is calibrated in order to retrieve S'_{B_*} that will appear in the final set of equations.

C.4 Steady-State Equations

This subsection presents the derivation of steady-state expressions and ratios that are instrumental for characterizing the log-linear system, based on the restrictions established in Section C.3.

Given that the fixed cost κ is set to ensure that aggregate real stationary profits are zero in steady state, and using equation (C.104) along with the assumption $\Upsilon_* = 1$, the fixed cost is given by,

$$\kappa = \hat{Y}_* - \left(\frac{(1-\omega)e^{-\varkappa}\hat{K}_*^R}{N_*} \right)^{\theta} N_*.$$

Real stationary profits satisfy the condition,

$$\hat{Q}_* - \hat{W}_* N_* - R_{K_*}(1-\omega)e^{-\varkappa}\hat{K}_*^R - M_* = 0,$$

Substituting the steady-state expression for materials from equation (C.103) yields,

$$\hat{Y}_* - \hat{W}_* N_* - R_{K_*}(1-\omega)e^{-\varkappa}\hat{K}_*^R = 0.$$

Employing the definitions of the real wage and the real rental rate of capital from equations (C.101) and (C.102), respectively, leads to,

$$\hat{Y}_* - S_*^{VA}(1-\theta) \left(\frac{(1-\omega)e^{-\varkappa}\hat{K}_*^R}{N_*} \right)^{\theta} N_* - (1-\omega)e^{-\varkappa}\hat{K}_*^R S_*^{VA}\theta \left(\frac{(1-\omega)e^{\varkappa}K_*^R}{N_*} \right)^{\theta-1} = 0$$

$$\Leftrightarrow \hat{Y}_* - S_*^{VA}(1-\theta) \underbrace{\left(\frac{(1-\omega)e^{-\varkappa}\hat{K}_*^R}{N_*} \right)^{\theta} N_*}_{\hat{Y}_*+\kappa} - S_*^{VA}\theta \underbrace{\left(\frac{(1-\omega)e^{-\varkappa}K_*^R}{N_*} \right)^{\theta} N_*}_{\hat{Y}_*+\kappa} = 0.$$

Recognizing that the two terms underbraced represent the same quantity, $\hat{Y} * + \kappa$, the expression simplifies to,

$$\hat{Y}_* - \left[(1-\theta)S_*^{VA} + \theta S_*^{VA}\right] \left(\hat{Y}_* + \kappa\right) = 0.$$

Substituting in the expressions for the price markup and real marginal cost from equations (C.99) and (C.100) gives,

$$S_* = \frac{1}{\mu_p}, \quad \text{and} \quad S_*^{VA} = \frac{1 - s_M \mu^p}{\mu_p(1-s_M)},$$

which implies,

$$\frac{\mu_p(1-s_M)}{1-\mu_p s_M} = \frac{\hat{Y}_* + \kappa}{\hat{Y}_*}.$$

This yields the following steady-state income shares,

$$\frac{\hat{W}_* N_*}{\hat{Y}_*} = 1 - \theta, \quad \text{and} \quad \frac{R_{K_*}(1-\omega)e^{-\varkappa}\hat{K}_*^R}{\hat{Y}_*} = \theta.$$

The steady-state expressions for the short-term and long-term interest rates follow from equations (C.75) and (C.76),

$$R_{S_*} = \frac{e^{\varkappa}\Pi_*}{\beta}, \quad \text{and} \quad R_{L_*} = \frac{e^{\varkappa}\Pi_*}{\beta}.$$

Using Equation (C.78), the steady-state effective capital-to-output ratio is given by,

$$\frac{(1-\omega)e^{-\varkappa}\hat{K}_*^R}{\hat{Y}_*} = \frac{\beta(1-\tau_{K_*})\theta}{e^{\varkappa} - \beta(1-\delta)}.$$

Equation (C.79) implies the steady-state investment-to-output ratio S_{I*} as,

$$S_{I_*} \equiv \frac{(1-\omega)\hat{I}_*^R}{\hat{Y}_*} = (e^{\varkappa} - (1-\delta))\frac{\beta(1-\tau_{K_*})\theta}{e^{\varkappa} - \beta(1-\delta)}$$

Applying the Ressource constraint identity in steady state, as given by Equation (C.95), and the definition of stationary consumption $\hat{C}_t \equiv \frac{C_t}{A_t}$, yields the private consumption-to-output ratio S_{C*},

$$S_{C_*} \equiv \frac{\hat{C}_*}{\hat{Y}_*} = 1 - S_{I_*} - S_{G_*},$$

where S_{G*} is the calibrated steady-state ratio of government consumption to output.

Using the government budget constraint and the above ratios, the steady-state tax-to-output ratio S_{T*} is obtained as,

$$S_{T_*} \equiv \frac{\hat{T}_*}{\hat{Y}_*} = \tau_{N_*}(1-\theta) + \tau_{K_*}\theta + \tau_{C_*}S_{C_*} - \frac{1-\beta}{\beta}S'_{B_*} - S_{G_*}.$$

Equation (C.91) gives the steady-state hand-to-mouth consumption share $S_{C_*^H}$,

$$S_{C_*^H} \equiv \frac{\hat{C}_*^H}{\hat{Y}_*} = \frac{1}{1+\tau_{C_*}}\left[(1-\tau_{N_*})(1-\theta) + S_{T_*}\right],$$

which leads to the Ricardian consumption-to-output ratio,

$$S_{C_*^R} \equiv \frac{\hat{C}_*^R}{\hat{Y}_*} = \frac{1}{1-\omega}\left[S_{C_*} - \omega S_{C_*^H}\right]$$

An expression for equilibrium labor supply N_* is obtained by combining the steady-state taste shifter (C.81), the consumption trend (C.82), and the household first-order conditions,

$$N_* = \left[\frac{1-\theta}{\mu_w \chi (e^{-\varkappa})^{\frac{1-\psi}{\psi}}(1-\eta e^{-\varkappa})S_{C_*^*}} \cdot \left(\frac{1-\tau_{N_*}}{1+\tau_{C_*}}\right)\right]^{\frac{1}{1+\nu}},$$

where $S_{C_*^*}$ the total consumption-to-output ratio, is defined as,

$$S_{C_*^*} \equiv \frac{C_*^*}{Y_*} = S_{C_*} + \alpha_G S_{G_*}.$$

The unemployment rate in steady state is derived by combining the wage-setting condition, marginal labor disutility, and the unemployment identity,

$$U_* = 1 - \left(\frac{1}{\mu^w}\right)^{\frac{1}{\nu}},$$

which can be rewritten as,

$$\frac{U_*}{1-U_*} = (\mu_w)^{\frac{1}{\nu}} - 1.$$

Combining the capital first-order condition (C.78), real marginal cost (C.100), and rental rate of capital (C.102) yields the steady-state capital stock,

$$(1-\omega)e^{-\varkappa}\hat{K}_*^R = \left[\frac{(1-s_M)\mu_p\left(e^{\varkappa} - \beta(1-\delta)\right)}{(1-\mu_p s_M)\,\beta\theta(1-\tau_{K_*})}\right]^{\frac{1}{\theta-1}} N_*.$$

Finally, the stationary output level is obtained from the production function (C.104),

$$\hat{Y}_* = \left[\frac{1-\mu_p s_M}{(1-s_M)\mu_p}\right]\left[(1-\omega)e^{-\varkappa}\hat{K}_*^R\right]^{\theta} N_*^{1-\theta}.$$

The complete set of steady-state equations used in the final log-linearized system is presented below.

$$\frac{U_*}{1-U_*} = (\mu_w)^{\frac{1}{\nu}} - 1 \tag{C.109}$$

$$S_{G_*} \equiv \frac{\hat{G}_*}{\hat{Y}_*} \tag{C.110}$$

$$S_{I_*} = (e^{\varkappa} - (1-\delta))\frac{\beta(1-\tau_{K_*})\theta}{e^{\varkappa} - \beta(1-\delta)} \tag{C.111}$$

$$S_{C_*} = 1 - S_{I_*} - S_{G_*} \tag{C.112}$$

$$S_{C_*^*} = S_{C_*} + \alpha_G S_{G_*} \tag{C.113}$$

$$S_{T_*} = \tau_{N_*}(1-\theta) + \tau_{K_*}\theta + \tau_{C_*}S_{C_*} - \frac{1-\beta}{\beta}S_{B_*} - S_{G_*} \tag{C.114}$$

$$S_{C_*^H} = \frac{1}{1+\tau_{C_*}}\left[(1-\tau_{N_*})(1-\theta) + S_{T_*}\right] \tag{C.115}$$

$$S_{C_*^R} = \frac{1}{1-\omega}\left[S_{C_*} - \omega S_{C_*^H}\right] \tag{C.116}$$

$$S'_{B_*} = \left[1 + \frac{1}{e^{\varkappa}\Pi_*} + \frac{1}{(e^{\varkappa}\Pi_*)^2} + \frac{1}{(e^{\varkappa}\Pi_*)^3}\right] S_{B_*} \tag{C.117}$$

D Log-linear System

D.1 Core System and Policy Block

This section presents the full log-linearized system of the model. The model being solved with a first-order perturbation method, all equations from the core system and the policy block are expressed in log-deviations around the deterministic steady state.

Consumption FOC:

$$\lambda_t + \frac{\tau_{C_*}}{1+\tau_{C_*}}\hat{\tau}_{C,t} = \zeta_{U,t} - \frac{1}{(1-\eta e^{-\varkappa})}\left[c_t^{*R} - \eta e^{-\varkappa}(c_{t-1}^{*R} - \zeta_{A,t})\right] \tag{D.1}$$

Investment FOC:

$$p_{K,t} + \zeta_{I,t} = e^{2\varkappa}\nu_I\left[\zeta_{A,t} + i_t^R - i_{t-1}^R\right] - \beta e^{2\varkappa}\nu_I \mathbb{E}_t\left[\zeta_{A,t+1} + i_{t+1}^R - i_t^R\right] \tag{D.2}$$

Short-term bond FOC:

$$\lambda_t = \mathbb{E}_t\left[\lambda_{t+1} - \zeta_{A,t+1} + r_{S,t} - \pi_{t+1}\right] + \zeta_{rp,t} \tag{D.3}$$

Long-term bond FOC:

$$\lambda_t = \mathbb{E}_t\left[\lambda_{t+1} - \zeta_{A,t+1} + r_{L,t+1} - \pi_{t+1}\right] \tag{D.4}$$

Capital utilization FOC:

$$r_{K,t} - \frac{\tau_{K_*}}{1-\tau_{K_*}}\hat{\tau}_{K,t} = \nu_\Upsilon \upsilon_t \tag{D.5}$$

Shadow price of capital:

$$p_{K,t} = \mathbb{E}_t\left[\lambda_{t+1} - \lambda_t - \zeta_{A,t+1} + (1-(1-\delta))\left[r_{K,t} - \frac{\tau_{K_*}}{1-\tau_{K_*}}\hat{\tau}_{K,t+1}\right] + \beta e^{-\varkappa}(1-\delta)p_{K,t+1}\right] \tag{D.6}$$

Law of motion for capital:

$$k_t^R = (1-\delta)e^{-\varkappa}\left[k_{t-1}^R - \zeta_{A,t}\right] + (1-(1-\delta)e^{-\varkappa})\left[i_t^R + \zeta_{I,t}\right] \tag{D.7}$$

Long-term bond price:

$$p_{L,t} = \frac{e^{\varkappa}\Pi_*}{\rho\beta}(r_{L,t} + p_{L,t-1}) \tag{D.8}$$

Taste shifter:

$$\varphi_t^R = z_t - \frac{1}{1-\eta e^{-\varkappa}}\left[c_t^{*R} - \eta e^{-\varkappa}(c_{t-1}^{*R} - \zeta_{A,t})\right] \tag{D.9}$$

Consumption trend:

$$z_t = (1-\psi)\left[z_{t-1} - \zeta_{A,t}\right] + \frac{\psi}{1-\eta e^{-\varkappa}}\left[c_t^* - \eta e^{-\varkappa}(c_{t-1}^* - \zeta_{A,t})\right] \tag{D.10}$$

Wage inflation:

$$\pi_t^w = \pi_t + w_t - w_{t-1} + \zeta_{A,t} \tag{D.11}$$

Labor supply condition:

$$\nu l_t + z_t + \zeta_{N,t} - w_t + \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t} + \frac{\tau_{C_*}}{1+\tau_{C_*}}\hat{\tau}_{C,t} = 0 \tag{D.12}$$

Unemployment:

$$\frac{U_*}{1-U_*}u_t = l_t - n_t \tag{D.13}$$

Hand-to-mouth budget constraint:

$$\begin{aligned} c_t^H + \frac{\tau_{C_*}}{1+\tau_{C_*}}\hat{\tau}_{C,t} = \frac{(1-\tau_{N_*})(1-\theta)}{(1-\tau_{N_*})(1-\theta)+S_{T_*}}\left[w_t + n_t - \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t}\right] \\ + \frac{S_{T_*}}{(1-\tau_{N_*})(1-\theta)+S_{T_*}}\tau_t \end{aligned} \tag{D.14}$$

Private consumption:

$$c_t = \frac{\omega S_{C_*^H}}{\omega S_{C_*^H} + (1-\omega)S_{C_*^R}}c_t^H + \frac{\omega S_{C_*^R}}{\omega S_{C_*^H} + (1-\omega)S_{C_*^R}}c_t^R \tag{D.15}$$

Total consumption:

$$c_t^* = \frac{S_{C_*}}{S_{C_*^*}}c_t + \frac{\alpha_G S_{G_*}}{S_{C_*^*}}g_t \tag{D.16}$$

Ricardian agents total consumption:

$$c_t^{*R} = \frac{S_{C_*^R}}{S_{C_*^R} + \alpha_G S_{G_*}}c_t^R + \frac{\alpha_G S_{G_*}}{S_{C_*^R} + \alpha_G S_{G_*}}g_t \tag{D.17}$$

Ressource contraint:

$$y_t = S_{C_*}c_t + S_{I_*}i_t^R + S_{G_*}g_t + (1-\tau_{K_*})\theta\upsilon_t \tag{D.18}$$

Real marginal cost:

$$s_t = (1-\mu_p s_M)s_t^{VA} \tag{D.19}$$

Real wage:

$$w_t = s_t^{VA} + \theta\left[\upsilon_t + k_{t-1}^R - n_t - \zeta_{A,t}\right] \tag{D.20}$$

Real rental rate of capital:

$$r_{K,t} = s_t^{VA} + (\theta-1)\left[\upsilon_t + k_{t-1}^R - n_t - \zeta_{A,t}\right] \tag{D.21}$$

Production function:

$$\frac{1-\mu_p s_M}{\mu_p(1-s_M)}y_t = \theta\left[\upsilon_t + k_{t-1}^R - \zeta_{A,t}\right] + (1-\theta)n_t \tag{D.22}$$

Government budget constraint:

$$\begin{aligned} S'_{B_*}\left[p_{L,t} + b_{L,t}\right] + \tau_{N_*}(1-\theta)\left[\hat{\tau}_{N,t} + w_t + n_t\right] \\ + \tau_{K_*}\theta\left[\hat{\tau}_{K,t} + r_{K,t} - \zeta_{A,t} + k_{t-1}^R + \upsilon_t\right] + \tau_{C_*}S_{C_*}\left[\hat{\tau}_{C,t} + c_t\right] \\ = \frac{1}{\beta}S'_{B_*}\left[r_{L,t} + p_{L,t-1} + b_{L,t-1} - \zeta_{A,t} - \pi_t\right] + S_{G_*}g_t + S_{T_*}\tau_t \end{aligned} \tag{D.23}$$

Debt-to-output ratio:

$$
\begin{aligned}
s_{B,t} = p_{L,t} + b_{L,t} - \left[\frac{1}{1 + e^{-\varkappa}\Pi_*^{-1} + e^{-2\varkappa}\Pi_*^{-2} + e^{-3\varkappa}\Pi_*^{-3}}\right] \Bigg[& y_t + y_{t-1} + y_{t-2} + y_{t-3} \\
& - \left(e^{-\varkappa}\Pi_*^{-1} + e^{-2\varkappa}\Pi_*^{-2} + e^{-3\varkappa}\Pi_*^{-3}\right)[\pi_t + \zeta_{A,t}] \\
& - \left(e^{-2\varkappa}\Pi_*^{-2} + e^{-3\varkappa}\Pi_*^{-3}\right)[\pi_{t-1} + \zeta_{A,t-1}] \\
& - \left(e^{-3\varkappa}\Pi_*^{-3}\right)[\pi_{t-2} + \zeta_{A,t-2}] \Bigg]
\end{aligned}
\tag{D.24}
$$

New Keynesian Wage Philips Curve:

$$
\pi_t^w - \gamma_w \pi_{t-1} = \frac{(1-\beta\alpha_w)(1-\alpha_w)}{\alpha_w\,[1+\nu\theta_w]}\nu(n_t - l_t) + \beta\mathbb{E}_t\left[\pi_{t+1}^w - \gamma_w\pi_t\right] + \zeta_{W,t} \tag{D.25}
$$

New Keynesian Price Philips Curve:

$$
\pi_t - \gamma_p\pi_{t-1} = \frac{(1-\beta\alpha_p)(1-\alpha_p)}{\alpha_p} s_t + \beta\mathbb{E}_t[\pi_{t+1} - \gamma_p\pi_t] + \zeta_{P,t} \tag{D.26}
$$

Monetary rule:

$$
r_{S,t} = \rho_r r_{S,t-1} + (1-\rho_r)\left[\phi_\pi(\pi_t - \pi_t^F) + \phi_y y_t\right] + \zeta_{m,t} \tag{D.27}
$$

Public consumption rule:

$$
g_t = \rho_g g_{t-1} - (1-\rho_g)\gamma_g(s_{B,t-1} - s_{B,t-1}^F) + \zeta_{G,t} \tag{D.28}
$$

Public transfers rule:

$$
\tau_t = \rho_\tau \tau_{t-1} - (1-\rho_\tau)\left[\phi_{\tau y} y_t + \gamma_\tau(s_{B,t-1} - s_{B,t-1}^F)\right] + \zeta_{T,t} + \zeta_{F,t} \tag{D.29}
$$

Consumption tax rule:

$$
\hat{\tau}_{C,t} = \rho_C \hat{\tau}_{C,t-1} + (1-\rho_C)(s_{B,t-1} - s_{B,t-1}^F) \tag{D.30}
$$

Capital tax rule:

$$
\hat{\tau}_{K,t} = \rho_K \hat{\tau}_{K,t-1} + (1-\rho_K)(s_{B,t-1} - s_{B,t-1}^F) \tag{D.31}
$$

Labor tax rule:

$$
\hat{\tau}_{N,t} = \rho_N \hat{\tau}_{N,t-1} + (1-\rho_N)(s_{B,t-1} - s_{B,t-1}^F) \tag{D.32}
$$

D.2 Deriving the New Keynesian Phillips Curves (NKPCs)

New Keynesian Wage Phillips Curve. The wage setting block is composed of equations (C.47), (C.49), (C.50), and (C.51). In log-linear form, this system can be re-expressed as follows,

$$
[1+\nu\theta_w]\,(w_t^\star - w_t) = k_t^w - f_t^w \tag{i}
$$

$$
\begin{aligned}
k_t^w = (1-\beta\alpha_w)&\left[\zeta_{U,t} + \zeta_{N,t} + \zeta_{W,t} + \varphi_t^R + (1+\nu)n_t\right] \\
&+ \beta\alpha_w\mathbb{E}_t\left[(1+\nu)\theta_w(\pi_{t+1}^w - \gamma_w\pi_t) + k_{t+1}^w\right]
\end{aligned}
\tag{ii}
$$

$$f_t^w = (1-\beta\alpha_w)\left[\lambda_t - \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t} + w_t + n_t\right] + \beta\alpha_w\mathbb{E}_t\left[(\theta_w - 1)(\pi_{t+1}^w - \gamma_w\pi_t) + f_{t+1}^w\right] \tag{iii}$$

$$w_t^\star - w_t = \frac{\alpha_w}{1-\alpha_w}(\pi_t^w - \gamma_w\pi_{t-1}) \tag{iv}$$

Subtracting equations (ii) and (iii) provides an expression for the difference $k_t^w - f_t^w$,

$$\begin{aligned} k_t^w - f_t^w = (1-\beta\alpha_w)&\left[\zeta_{U,t} + \zeta_{N,t} + \zeta_{W,t} + \varphi_t^R + \nu n_t - \lambda_t - w_t + \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t}\right] \\ &+ \beta\alpha_w\mathbb{E}_t\left[\left[1+\nu\theta_w\right](\pi_{t+1}^w - \gamma_w\pi_t) + k_{t+1}^w - f_{t+1}^w\right] \end{aligned}$$

Substituting this expression into equation (i) yields a relation for the difference between the reset and average wage,

$$\begin{aligned} w_t^\star - w_t = \frac{1-\beta\alpha_w}{1+\nu\theta_w}&\left[\zeta_{U,t} + \zeta_{N,t} + \zeta_{W,t} + \varphi_t^R + \nu n_t - \lambda_t - w_t + \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t}\right] \\ &+ \beta\alpha_w\mathbb{E}_t\left[\pi_{t+1}^w - \gamma_w\pi_t + w_{t+1}^* - w_{t+1}\right] \end{aligned}$$

Applying the wage indexation rule from equation (iv) allows the derivation of a forward-looking wage inflation equation,

$$\begin{aligned} \pi_t^w - \gamma_w\pi_{t-1} = \frac{(1-\beta\alpha_w)(1-\alpha_w)}{\alpha_w\left[1+\nu\theta_w\right]}&\left[\zeta_{U,t} + \zeta_{N,t} + \zeta_{W,t} + \varphi_t^R + \nu n_t - \lambda_t - w_t + \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t}\right] \\ &+ \beta\mathbb{E}_t\left[\pi_{t+1}^w - \gamma_w\pi_t\right] \end{aligned}$$

Using the log-linearized taste shifter equation (D.9) and the consumption first-order condition (D.1) gives,

$$\varphi_t^R = z_t - \zeta_{U,t} + \lambda_t + \frac{\tau_{C_*}}{1+\tau_{C_*}}\hat{\tau}_{C_*}$$

Substituting this result into the previous equation yields,

$$\begin{aligned} \pi_t^w - \gamma_w\pi_{t-1} = \frac{(1-\beta\alpha_w)(1-\alpha_w)}{\alpha_w\left[1+\nu\theta_w\right]}&\left[\zeta_{N,t} + \zeta_{W,t} + z_t + \frac{\tau_{C_*}}{1+\tau_{C_*}}\hat{\tau}_{C_*} + \nu n_t - w_t + \frac{\tau_{N_*}}{1-\tau_{N_*}}\hat{\tau}_{N,t}\right] \\ &+ \beta\mathbb{E}_t\left[\pi_{t+1}^w - \gamma_w\pi_t\right] \end{aligned}$$

Finally, invoking the marginal labor supply condition (D.12) allows simplification to,

$$\pi_t^w - \gamma_w\pi_{t-1} = \frac{(1-\beta\alpha_w)(1-\alpha_w)}{\alpha_w\left[1+\nu\theta_w\right]}\left[\zeta_{W,t} + \nu(n_t - l_t)\right] + \beta\mathbb{E}_t\left[\pi_{t+1}^w - \gamma_w\pi_t\right].$$

Redefining the shock term for notational simplicity as,

$$\frac{(1-\beta\alpha_w)(1-\alpha_w)}{\alpha_w\left[1+\nu\theta_w\right]}\zeta_{W,t} \to \zeta_{W,t},$$

leads to the New-Keynesian Wage Phillips curve (NKPC-W) in its final form,

$$\pi_t^w - \gamma_w\pi_{t-1} = \frac{(1-\beta\alpha_w)(1-\alpha_w)}{\alpha_w\left[1+\nu\theta_w\right]}\nu(n_t - l_t) + \beta\mathbb{E}_t\left[\pi_{t+1}^w - \gamma_w\pi_t\right] + \zeta_{W,t}.$$

New Keynesian Price Phillips Curve. The price-setting block in log-linear form is described by the following set of equations,

$$p_t^\star = k_t^p - f_t^p \tag{v}$$

$$\begin{aligned} k_t^p = (1-\beta\alpha_p)\left[\zeta_{P,t} + s_t + q_t\right] + \\ \beta\alpha_p\mathbb{E}_t\left[\lambda_{t+1} - \lambda_t + \theta_p(\pi_{t+1} - \gamma_p\pi_t) + k_{t+1}^p\right] \end{aligned} \tag{vi}$$

$$\begin{aligned} f_t^p = (1-\beta\alpha_p)q_t + \\ \beta\alpha_p\mathbb{E}_t\left[\lambda_{t+1} - \lambda_t + (\theta_p - 1)(\pi_{t+1} - \gamma_p\pi_t) + f_{t+1}^p\right] \end{aligned} \tag{vii}$$

$$p_t^\star = \frac{\alpha_p}{1-\alpha_p}(\pi_t - \gamma_p\pi_{t-1}) \tag{viii}$$

As before, start by forming $k_t^p - f_t^p$, yielding,

$$k_t^p - f_t^p = (1-\beta\alpha_p)\left[\zeta_{P,t} + s_t\right] + \beta\alpha_p\mathbb{E}_t\left[\pi_{t+1} - \gamma^p\pi_t + k_{t+1}^p - f_{t+1}^p\right]$$

Using the definition of the reset price (v) leads to,

$$p_t^\star = (1-\beta\alpha_p)\left[\zeta_{P,t} + s_t\right] + \beta\alpha_p\mathbb{E}_t\left[\pi_{t+1} - \gamma^p\pi_t + p_{t+1}^\star\right],$$

then using (viii),

$$\pi_t - \gamma_p\pi_{t-1} = \frac{(1-\beta\alpha_p)(1-\alpha_p)}{\alpha_p}\left[\zeta_{P,t} + s_t\right] + \beta\mathbb{E}_t[\pi_{t+1} - \gamma_p\pi_t].$$

Redefining the shock term with the same logic as before,

$$\frac{(1-\beta\alpha_p)(1-\alpha_p)}{\alpha_p}\zeta_{P,t} \to \zeta_{P,t}$$

we finally obtain the NKPC-P,

$$\pi_t - \gamma_p\pi_{t-1} = \frac{(1-\beta\alpha_p)(1-\alpha_p)}{\alpha_p}s_t + \beta\mathbb{E}_t[\pi_{t+1} - \gamma_p\pi_t] + \zeta_{P,t}.$$

E Estimation

E.1 Data and Codes

The dataset is constructed using a Python script that accesses the ECB SDW API. The accompanying Jupyter notebook details which series are collected, the transformations applied, and the purpose of each step. All relevant Python and Matlab code for data retrieval, model solution, and estimation are available at: `https://github.com/EliotSatta/Master-Thesis---Replication`.

E.2 Priors and Posteriors