

Bianchi, Francesco; Callegari, Giovanni; Hitaj, Ermal; Theodoridis, Konstantinos

Working Paper

Fiscal sustainability and policy interactions

Cardiff Economics Working Papers, No. E2024/13

Provided in Cooperation with:

Cardiff Business School, Cardiff University

Suggested Citation: Bianchi, Francesco; Callegari, Giovanni; Hitaj, Ermal; Theodoridis, Konstantinos (2024) : Fiscal sustainability and policy interactions, Cardiff Economics Working Papers, No. E2024/13, Cardiff University, Cardiff Business School, Cardiff

This Version is available at:

<https://hdl.handle.net/10419/309963>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Cardiff Economics Working Papers



Working Paper No. E2024/13

Fiscal Sustainability and Policy Interactions

*Francesco Bianchi, Giovanni Callegari, Ermal Hitaj, and
Konstantinos Theodoridis*

June 2024

ISSN 1749-6010

Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
business.cardiff.ac.uk

This working paper is produced for discussion purpose. These working papers are expected to be published in due course, in revised form.

Cardiff Economics Working Papers are available online from:

<http://econpapers.repec.org/paper/cdfwpaper/> and

https://carbsecon.com/wp/index_abstracts.html

Enquiries: EconWP@cardiff.ac.uk

Fiscal Sustainability and Policy Interactions*

Francesco Bianchi[†]

Johns Hopkins, CEPR and NBER

Giovanni Callegari[‡]

European Stability Mechanism

Ermal Hitaj[§]

European Stability Mechanism

Konstantinos Theodoridis[¶]

European Stability Mechanism

Cardiff Business School

February 2024

Final Draft of Working Paper

Abstract

We build a model to study the interaction between default risk, policy changes, and financial frictions within a monetary union. The model features a centralised central bank and decentralised fiscal authorities. Countries have different reputations for fiscal stability, modelled as different probabilities of moving to a Default regime. Borrowing costs for the fiscal authority and firms are affected by the possibility of default. This creates a feedback effect between debt accumulation, reputation, and the depth of a recession following adverse shocks. In this context, we discuss the benefits and limitations of a coordinated monetary and fiscal policy response that removes the risk of default. Adverse energy shocks generate more benign outcomes if accommodated, while a fiscal crisis leads to a vicious circle of debt accumulation, recession, and inflationary pressure. In this case, default and inflation risks can reinforce each other.

JEL Codes: E50, E62, E30.

Keywords: Euro Area, default, fiscal policy, inflation, large public debt, financial frictions.

*We would like to thank Roman Marimon, Anna Rogantini-Picco, Luca Zavalloni and Diana Zigraiova for their valuable insights. We also thank the participants of the ESM 2024 Debt Sustainability Seminar for their comments and suggestions. The views in this paper are solely those of the authors and should not be interpreted as reflecting the views of the European Stability Mechanism.

[†]francesco.bianchi@jhu.edu

[‡]g.callegari@esm.europa.eu

[§]e.hitaj@esm.europa.eu

[¶]k.theodoridis@esm.europa.eu

1 Introduction

The pandemic crisis showed the key role of the monetary and fiscal policy stances and their interaction in affecting the sustainability of public debt. Monetary-fiscal policy interactions can affect the dynamics of debt and its servicing cost, reducing or amplifying the available fiscal space. Interest rate decisions are a clear and direct example, but there is more. The way monetary and fiscal policy authorities coordinate their policy responses affects the relative transmission channels and generates a lasting impact on firms' and households' expectations. Central bank purchases of public debt during the pandemic enabled countries to respond to the crisis while keeping market pressures at bay. On the other hand, under certain conditions, a positive fiscal impulse can help monetary policy achieve its price stability objective in times of low inflation and binding zero-lower bound constraints.

The role of monetary-fiscal policy interaction strengthens in the presence of uncertainty. Monetary policy can help fiscal policy by insuring economic agents against certain risks. The central bank can do that by using different instruments and through an active management of sovereign bond prices at different maturities.¹ This insurance is particularly important in times of high volatility when anchoring the private sector's expectations is necessary to avoid self-fulfilling runs on public debt or sudden stops in capital markets, which might happen even with relatively healthy fundamentals. This additional role should not, however, limit the freedom and capacity of a central bank to achieve its price stability objective.

A comprehensive Debt Sustainability Assessment Framework (DSAF) needs to account for the role of monetary-fiscal policy interaction and uncertainty. The considerations above show the importance of accounting for monetary-fiscal policy interactions to assess public debt sustainability risks.² In this sense, the DSAF needs to become state-contingent, meaning it needs to change its assessment approach depending on the starting position. This requires a shift to a more "general equilibrium" approach, in which different transmission channels become relevant depending on the level of debt and the current and expected future policy stance.

In this paper, we build a model of the Euro area to study the interaction between default risk, policy changes, and financial frictions. Our analysis is motivated by the evolution of the policy arrangements that characterize the Euro Area and the challenges that lie ahead. The model features a centralized central bank and decentralized fiscal authorities. This setup is

¹See Angeletos (2002) on the ability of a structured debt maturity to replicate complete market outcomes. Buera and Nicolini (2004) show that the result of Angeletos (2002) requires the debt gross positions to be very high and increasing in the number of states.

²Note that here the meaning of monetary-fiscal policy interaction is very different by the one of Sargent and Wallace (1981b) and one linked to the Fiscal Theory of Price Level.

in line with the current institutional framework of the Euro Area in which the European Central Bank sets monetary policy for all country members while individual countries retain control of fiscal policy, subject to a series of constraints that have been more or less stringent over time. Like in Bianchi et al. (2022), we also allow for a hypothetical centralised fiscal authority capable of issuing Eurobonds as a way to capture a possible future evolution of the Euro Area institutional framework. However, this feature is not explored in this study, making the EA joint debt indistinguishable from central bank reserves.

The model features the possibility of changes in the monetary/fiscal policy mix. The standard policy mix is a monetary-led policy mix in which the country-level fiscal authorities are expected to stabilize debt without the monetary authority's help. This policy mix is in line with the early design of the Euro Area, characterized by stringent fiscal rules. However, countries differ in their reputation for fiscal stability, modelled as different probabilities of moving to a Default regime. We first consider a scenario in which the Default regime implies an increase in the probability of default, without materializing in sample. Borrowing costs for the fiscal authority and the private sector are affected by the possibility of default.

The fiscal policy response to a contractionary shock, e.g., a spike in energy prices, can vary across countries. However, for any given response, the macroeconomic outcomes depend on the reputation of the fiscal authority for debt sustainability. When spending is low, the probability of moving to the Default regime is zero, and countries with different reputations for fiscal sustainability experience similar, but not identical, macroeconomic outcomes. When spending is high, the probability of moving to the Default regime increases more for the low-reputation country. This creates a feedback loop between debt accumulation, reputation, and the depth of a recession following adverse shocks. If the country does move to the Default regime, this vicious circle becomes stronger, and the two countries move further apart.

In this context, a temporary deviation from strict fiscal rules to accommodate an adverse energy shock leads to similar outcomes in terms of inflation, but a substantial improvement in output because it removes the adverse effects of the risk of default. This scenario is modelled as a temporary deviation to a Fiscally-led regime as opposed to a Default regime. Under the Fiscally-led regime, the monetary authority keeps interest rates low as stringent fiscal rules are suspended. In this case, the resulting fiscal inflation acts as an automatic stabiliser, reducing the rate increase and distortionary taxation. However, this benign outcome requires a clear separation between stabilisation policies with respect to the commitment to long-term fiscal sustainability. The inflation outcome is similar because inflation is mainly caused by the exogenous energy price shock itself, while the fiscal consequences are less relevant.

A policy that removes default risk is, therefore, beneficial as long as it does not generate the expectation of a pervasive deviation from the commitment to debt sustainability. We

explore this idea in a second thought experiment. Instead of an adverse energy shock, we consider a fiscal crisis. This is modelled as a situation in which a portion of debt of the high-debt country is deemed as not sustainable because it is currently not backed by fiscal adjustments. We then hypothesize three possible resolutions of the fiscal crisis: Default, fiscal adjustment, and fiscal inflation. Before the resolution of the crisis, the central bank keeps increasing rates in response to inflation. Default is costly in itself because it leads to disruption of the financial sector. However, if fiscal inflation and default are both options considered by agents during the fiscal crisis, they reinforce each other, amplifying the costs of default, and making uncertainty about the resolution of the fiscal crisis costly. This is because the possibility of default determines a faster debt accumulation. The large stock of debt and the possibility that the crisis might be resolved by accommodating an increase in inflation generate inflationary pressure that the central bank tries to counteract increasing rates. The economy enters a cycle of faster debt accumulation, a deep recession, and high inflation.

Our results show that coordinated monetary and fiscal policies can be effective in smoothing out temporary adverse shocks with limited fiscal consequences. Lack of fiscal credibility requires instead different interventions. This does not mean that there are no situations in which the monetary authority accommodates the adverse fiscal consequences of large shocks (like a pandemic). However, this type of coordination should be limited in scope and meant to remedy the limits of monetary policy once constrained by the zero lower bound (Bianchi et al. (2022)).

The paper is organised as follows. Section 2 illustrates how our study contributes to the existing literature. Section 3 briefly reviews the EA’s governance framework and identifies the necessities calling for an updated debt sustainability framework. Section 4 reviews the model, and Section 5 discusses the calibration of the model parameters. The key findings of the analysis are presented in Section 6 and Section 7 concludes.

2 Relation with Existing Studies

This paper connects to a small but rapidly growing literature that focuses on monetary/fiscal policy interaction in a monetary union (Bergin (2000), Bianchi et al. (2022), Maćkowiak and Schmidt (2024)). With respect to this literature, we introduce the possibility of default and study the consequences of policy uncertainty. In this respect, the paper connects to Bianchi (2021), which introduces the possibility of default in a model of a small open economy, building on the work of Uribe (2006), Galí and Monacelli (2008), Corsetti et al. (2013), and Kriwoluzky et al. (2019). More broadly, the paper is connected to the vast literature

on monetary/fiscal policy interaction: Sargent and Wallace (1981a), Leeper (1991), Sims (1994), Woodford (1994, 1995, 2001), Schmitt-Grohe and Uribe (2000), Cochrane (1998, 2001), Bassetto (2002), Reis (2016), Bassetto (2002), Benhabib et al. (2002). A recent development of this literature has been the use of Bayesian methods to assess the effects of changes in the monetary/fiscal policy mix in the presence of nominal rigidities (Bianchi and Ilut (2017), Bianchi and Melosi (2017a), Bianchi et al. (2023)).

The paper connects the aforementioned theme of monetary/fiscal policy interaction to a literature that, as a result of the EA debt crises, has developed structural models with financial frictions to understand how the level of public debt and the associated risk of partial default could alter agents' decision rules (see Bi and Traum (2012) Chen et al. (2012), Corsetti et al. (2013), and Bi and Traum (2014) among others). Unlike those studies, we employ a substantially more quantitative model to capture dynamics within regions. In addition, the two-country dimension of our model allows us to study how default concerns that originate in one region and the resulting policy uncertainty can spillover to the rest of the EA.

Our work is also related to the literature that uses two-country structural models to understand the asymmetric propagation of EA-level shocks (see Jaccard and Smets (2020), Cardani et al. (2022) and Cardani et al. (2023) among others). We contribute to this literature by extending these large models to account for important policy-related non-linearities that dramatically affect agents' expectations and, consequently, current economic outcomes. The modeling framework leverages the Markov-switching framework discussed below. In this setting, economic agents consider different scenarios, modelled as regimes, that affect their decisions today even if they have not occurred yet. The interaction of these non-linear decision rules with the evolution of regimes gives rise to propagation mechanisms which cannot be systematically reproduced with fixed coefficient models.

Finally, our study contributes to the literature that uses open economy structural models (Coenen et al. (2012) Coenen et al. (2013), Coenen et al. (2021) Coenen et al. (2023)) to understand the effects of EA policies at the EA aggregate level. Relative to these studies, our setup allows us to understand how the effectiveness of these policies is altered once policy uncertainty is considered and how these policies are transmitted across the member states.

3 Historical Perspective and the Road Ahead

Over the years, the Euro Area has moved across different implicit and explicit policy frameworks to respond to the evolving challenges of its existence. This section reviews the key steps of this institutional evolution and the current policy arrangements. These arrangements serve as motivation for the rich model developed in Section 4.

3.1 Monetary-fiscal Policy Stance over Time and the Impact on Public Debt Sustainability

At the onset, the EMU framework allowed only for implicit coordination between monetary and fiscal policy (ECB, 2021). The euro area has a peculiar policy architecture which “matches a single monetary policy assigned at the supranational level with mostly national fiscal and economic policies”.³ The two cornerstones of the legal framework disciplining this interaction are the prohibition of monetary financing (Article 123 of the Treaty on European Union) and a fiscal framework as set under the Stability and Growth Pact (SGP).⁴ This framework per se does not envisage explicit coordination, as highlighted by the ECB (2021). The SGP was meant to ensure debt sustainability, and fiscal policy was meant to contribute to stabilisation only through automatic stabilisers, with very limited scope for discretionary fiscal action.

The minimum credit-rating threshold for the eligibility of sovereign bonds in the ECB’s collateral introduced a new interaction channel, especially after the Great Financial Crisis (GFC). In late 2005, the ECB clarified its approach to determining the eligibility of sovereign bonds as collateral for monetary policy operations.⁵ This had implications for debt sustainability. As emphasised by Orphanides (2017), rating downgrades could lead to an escalation in the country’s risk premia when the rating approaches the minimum threshold, independently from the factors underlying this downgrade. This, and the relative waiver for programme countries, played an important role after the 2008-2009 GFC and during the 2011-2012 sovereign crisis.

After the GFC and the following euro area inflation slowdown, the monetary policy instrument “hit” its effective lower bound (ELB), showing the limits of its capacity to manage aggregate demand.⁶ This regime turned out to be a structural feature of the euro area, as shown by the continued downward trend of the natural interest rates (see Brand et al. (2018)).⁷ When the ELB is binding, monetary policy has limited power in actively supporting demand and bringing inflation back towards the 2% target. The use of unconventional

³ECB (2021), p.10

⁴The SGP was also complemented by art. 125, which states that Member States cannot take on the debts of other member states. This article is – somehow inappropriately – labelled as the “no bailout clause” although the article does not prohibit the intervention of external funds as the ESM in case of loss of market access.

⁵Orphanides (2017) interpreted the clarification of the ECB’s asset eligibility criteria as a reaction to the 2005 reform of the Stability and Growth Pact.

⁶The ELB can also be referred to as the reversal rate as in Brunnermeier and Koby (2018).

⁷As reported by Brand et al. (2018) the natural (real) interest rate can be seen as “the real rate of interest that brings output into line with its potential or natural level in the absence of transitory shocks [...] or nominal adjustment frictions.”

monetary policy instruments (such as quantitative easing, long-term refinancing operations and negative interest rates) helped ease the constraint without removing it entirely.

With the pandemic, the indirect monetary-fiscal interaction gained importance, both in terms of macro-impulse and to provide insurance against the shock generated by the COVID-related restrictions. The strengthened link between the two policy areas was essentially driven by the nature of the shock. As ECB (2021) indicated, “the pandemic should be seen as an exceptional common shock with strong spillovers and, at the same time, potentially heterogeneous effects across countries”. The heterogeneous impact necessitated ample fiscal policy space, and the Pandemic Emergency Purchase Programme (PEPP) created ample liquidity conditions that generated that while preventing belief-driven risk spirals. This coordination helped generate policy impulse and provided insurance against self-fulfilling expectations. This regime continues at the present time, with the Transmission Protection Instrument (TPI) seeking to do the same in the context of the uncertainty related to the war in Ukraine.

Such a proactive monetary policy regime expanded the limits to debt sustainability, making the old debt thresholds less relevant. As the Japan example shows, albeit relying on a particular investor structure, there is no reason to doubt the sustainability of a relatively high but stable debt that can be refinanced at very low rates. In the so-called low-for-long interest rate regime before the war in Ukraine, a proactive monetary policy provided insurance against temporary spikes that could jeopardise debt service and cause debt distress. The ensuing expansion of the sustainability boundary is thus one of the outcomes of a “positive monetary policy interaction”. Shifts across monetary policy regimes (Bianchi and Melosi, 2017b) are thus important to understand and define debt sustainability.

3.2 Towards a New Debt Sustainability Assessment Framework

A suitable DSAF should provide a clear and transparent basis for assessing whether a country’s public debt is sustainable or not. A clear-cut, unequivocal judgment is difficult because it involves dealing with high uncertainties (on forecasts, modelling, and policies), which have increased in the wake of the COVID-19 pandemic. That said, the analysis can attempt to quantify these uncertainties and trace out their potential interactions and impact on the key question: how likely is it that debt service obligations might overwhelm the policy framework and lead to a potential crisis, and how should policies be framed to reduced that risks to an acceptable level?

We take the view that public debt is sustainable if it is not on an exploding path, forward-looking market participants are willing to hold it, and debt service obligations at any point

in the horizon can be met without unrealistic adjustment of the existing policy framework. In other words, debt is sustainable if it can be serviced without overwhelming the policy framework and potentially leading to a crisis. Meeting these obligations is contingent on future growth, fiscal decisions, and the ability to access markets, making the assessment both forward-looking and policy-dependent. The DSAF should also monitor short-term financing and market conditions to assess the risk of a rollover crisis. For both the short- and medium-term horizon, the role played by monetary policy and its potential alignment with fiscal policy play a key role.

We ultimately need a framework that allows for endogenous changes in monetary and fiscal policy regimes. With the emergence of supply-side inflationary pressures, including the energy price shocks triggered by the Russian invasion of Ukraine, the current and expected monetary policy stance has rapidly shifted. This rapid change in the policy regime has had an impact on fiscal fundamentals, affecting the space available to stabilise the economy. A suitable DSAF should internalise the possibility of regime transition and make the relative probability endogenous to policy decisions (e.g., OMT, TPI) and external shocks.

We propose a new approach that moves away from the threshold-based assessment frameworks and builds on the probabilistic one introduced by the IMF (2021). As done by the IMF (2021), we move away from the use of debt- or financing needs-to-GDP thresholds to assess debt sustainability. Instead, we seek to answer the question: what is the probability that markets might see the current fiscal policy as unsustainable, given uncertainty about the expected fiscal behaviour and interaction of monetary-fiscal policy authorities?⁸ The debt sustainability assessment framework that comes as an answer to this question would combine (i) A backward-looking empirical analysis of spreads determinants and probability of market distress, (ii) A forward-looking, general equilibrium model-based assessment of spread dynamics that accounts for the endogenous fiscal and monetary policy setting.

Our assessment framework is thus based on indicative thresholds derived from the debt distress probability generated by the combination of both backward- and forward-looking analysis. In this exercise, the backward-looking part consists of deriving probabilities of debt distress conditional on macroeconomic variables and policies. Since default episodes in the euro area are rare, debt distress episodes would be defined as significant spread spikes (above 350 bps). These backward-looking probability thresholds are then used to determine the risk of default in the forward-looking general equilibrium simulations. The event of default occurs when the projected conditions generate the probability distress threshold as estimated in the backward-looking component. This permits a full endogenisation of the dynamic of risk spreads.

⁸Conceptually similar to Blanchard (2019).

The use of a comprehensive general equilibrium approach is one of the main novelties compared to existing DSA frameworks. In the IMF new market access DSA (MAC DSA) framework, the forward-looking assessment of debt crisis probability is based on simulations based on backward-looking estimates (stochastic DSA approach). This approach, while useful and also included in our framework, can account only partially for changes in expectations and rapid shifts in monetary-fiscal policy regimes. The use of general equilibrium models for forward-looking simulations allows us to endogenise the monetary and fiscal policy stance and account for the possibility of policy regime changes. This allows a more comprehensive and internally consistent analysis of policy changes while explicitly considering the impact of structural breaks.

This is based on an explicit assessment of fiscal and monetary policy stances and their interactions. For example, in periods of binding ELB, low-for-long rates can help a given country service a relatively high debt level and slowly reduce it over time without needing a sharp consolidation. Asset purchases can help reduce rollover risk and rapid, short-term deterioration in market conditions. The monetary and fiscal policy rules are calibrated around country-specific conditions and can be changed in the presence of policy regime shifts or structural changes.⁹

4 A fiscal sustainability model of the euro area

This section presents a Two-Agent New Keynesian (TANK) model of a monetary union called the Euro Area (EA) that captures the salient features discussed in the previous section. Specifically, we build upon the model of the Euro Area developed in Bianchi et al. (2022) and add three distinctive features. First, financial frictions as in Chen et al. (2012) and Corsetti et al. (2013). Second, the possibility of partial default as in Bi and Traum (2012) and Corsetti et al. (2013). Third, the *risk* of default and policy uncertainty as in Bianchi (2021). We allow for a centralised monetary authority and a centralised fiscal authority that issues Eurobonds.

The EA is composed of two countries. Each country is populated by two types of households: savers and non-savers. Savers consume and invest in assets (financial assets and physical capital), whereas non-savers only consume but cannot invest. Both savers and non-savers supply labour to labour packers in a monopolistically competitive market. Labour packers aggregate all the varieties of labour into a homogeneous labour service that they sell to domestic intermediate firms producers in a competitive market. Intermediate firms rent

⁹Please note that this approach always assumes a monetary policy geared towards achieving its inflation target, with no fiscal dominance.

capital from savers of the same country in a competitive market. In each country, there are infinitely many intermediate firms. By combining labour and capital, these firms produce intermediate goods to be sold to the final goods producers of both countries. Final goods producers aggregate all the varieties of the domestic and foreign intermediate goods into a non-tradable homogeneous final good that the producers sell to households in a perfectly competitive market. Labour and capital are country-specific and cannot be traded across the country. We assume nominal rigidities in wage and price settings. Firm profits are rebated to domestic households.

In each country, there are financial intermediaries that issue deposits to savers to finance investments in the risk-free debt issued by the EA centralised authority and debt issued by the national government. EA assets are traded across countries, while debt issued by the national fiscal authorities is held domestically and stabilised by adjusting distortionary taxes, transfers, and government consumption. Finally, the centralised monetary authority sets the policy rate and, consequently, pins down the price of a one-period risk-free bond.

The structure of the economy is symmetric across countries, but the size of the two economies, as well as the calibration of the structural parameters, mimic a country with limited debt capacity versus the rest of the EA. For this reason, in what follows, we will just describe the decision problems faced by agents in one of the countries which we call high-debt country. Aggregate shocks (namely, risk premium shocks and technology shocks, which we will define below) hit both countries symmetrically.

4.1 Households

Each country's economy is populated by a continuum of households on the interval $[0, 1]$ of which a fraction μ is non-savers, and a fraction $1 - \mu$ is savers. Superscript S indicates a variable associated with savers and N to non-savers.

Savers. An optimizing saver household that supplies the differentiated labour input of type j , $L_t^S(j)$, derives utility from composite consumption $\tilde{C}_t^S(j) \equiv C_t^S(j) + \alpha_G G_t$, where $C_t^S(j)$ is private consumption and G_t is public consumption. Parameter α_G governs the degree of substitutability of the consumption goods: when $\alpha_G < 0$, private and public consumption are complements; when $\alpha_G > 0$, they are substitutes. The household values consumption relative to a habit stock defined in terms of lagged aggregate consumption of savers, \tilde{C}_{t-1}^S . Thus, savers' period utility function is given by $U_t^S = \left[\ln \left(\tilde{C}_t^S(j) - \tilde{C}_{t-1}^S \right) - \frac{L_t^S(j)^{1+\xi}}{1+\xi} \right]$, where ξ is the inverse of the Frisch labor elasticity.

Savers accumulate a stock of physical capital \bar{K}_t^S . This stock of capital depreciates at rate δ and accrues with investment I_t^S , net of adjustment costs. It follows the law of motion

$\bar{K}_t^S(j) = (1-\delta)\bar{K}_{t-1}(j) + \left[1 - s\left(\frac{I_t^S(j)}{\bar{K}_{t-1}^S(j)}\right)\right] I_t^S(j)$, where s indicates an investment adjustment cost function that satisfies the properties $s(e^\gamma) = s'(e^\gamma) = 0$ and $s''(e^\gamma) \equiv s > 0$. Effective capital K is the share of physical capital stock that households decide to rent to the domestic intermediate firms at a price R_t^K and is denoted by \bar{K} . In symbols, $K_t^S(j) = v_t(j)\bar{K}_{t-1}^S(j)$, where $v_t(j)$ is the utilization rate of capital. This utilization incurs a cost of $\Psi(v_t)$ per unit of physical capital. Given the steady-state utilization rate $v=1$ and $\Psi(1)=0$, the function Ψ has the following properties: $\Psi'(1)=0$ and $\frac{\Psi''(1)}{\Psi'(1)} = \frac{\psi}{1-\psi}$, where $\psi \in [0, 1)$. Rental income on effective capital is taxed at the rate $\tau_{\xi_t}^K$, and ξ_t is a three-stage Markov switching latent process discussed below.

Savers can deposit their savings with a financial intermediary and receive a return R_t^S , and they also have access to a complete set of contingent claims, $\Lambda_{t,t+1}$, traded within the country, and priced using the stochastic discount factor $Q_{t,t+1}$.

Savers receive after-tax wage and rental income, lump-sum transfers from the national government, $Z_{\xi_t}^S$, lump-sum transfers from the EA fiscal authority, $Z_t^{S,EA}$ and profits from firms, D . Wage and rental income are taxed at rate $\tau_{\xi_t}^L$ and $\tau_{\xi_t}^K$, respectively, by the national government. The centralized fiscal authority taxes these incomes at rates $\tau_t^{EA,L}$ and $\tau_t^{EA,K}$. Consumption is also taxed by the national governments and the EA fiscal authority at rate $\tau_{\xi_t}^C$ and $\tau_t^{EA,C}$, respectively. They spend income on consumption C^S , investment in future capital, I^S , state-contingent assets, and deposits (O_t). The nominal flow budget constraint for saver j in the state l is

$$\begin{aligned} & P_t^C (1 + \tau_{\xi_t}^C + \tau_t^{EA}) \tilde{C}_t^S + P_t^C I_t^S + Q_{t,t+1}(j) A_{t,t+1}(j) d\omega_{t,t+1}(j) + P_t^C O_t(j) \\ = & R_{t-1}^S P_{t-1}^C O_{t-1}(j) + (1 - \tau_{\xi_t}^L - \tau_t^{EA}) W_t(j) L_t^S(j) + (1 - \tau_{\xi_t}^K - \tau_t^{EA}) R_t^K v_t \bar{K}_{t-1}^S(j) \\ & - \psi(v_t) \bar{K}_{t-1}^S(j) + P_t^C Z_{\xi_t}^S + P_t^C Z_t^{S,EA} + D_t + A_t(j) \end{aligned} \quad (1)$$

Savers maximize lifetime discounted utility $E_t \sum_{t=0}^{\infty} \beta^t \mathcal{U}_t^S$ subject to the sequence of budget constraints.

Non-Savers. Non-savers have the same preferences as savers, but since they cannot trade assets, they end up consuming all their disposable income in every period, which consists of after-tax labour income, lump-sum transfers $Z_{\xi_t}^N$ from the national government, and lump-sum transfers from the EA fiscal authority, $Z_t^{N,EA}$. It is assumed that the hand-to-mouth households supply differentiated labour services and set their wage to be equal to the average wage that is optimally chosen by the savers, as described below. Using the superscript N to indicate the non-saving, hand-to-mouth households, their budget constraint can be written

as follows:

$$P_t^C(1 + \tau_{\xi_t}^C + \tau_t^{EA,C})C_t^N = (1 - \tau_{\xi_t}^L - \tau_t^{EA,L}) \int_{\mu}^1 W_t(j) L_t^N + P_t^C Z_{\xi_t} + P_t^C Z_t^{EA},$$

where it is assumed that both savers and non-savers face the same tax rates on consumption and labour income. We drop the subscript j because non-savers solve the same decision problem. Note that transfers from the national government and the EA fiscal authority are assumed to be the same across types of households.

4.2 Financial Intermediary

The financial intermediary firm issues deposits to savers paying a gross interest rate R_t^S . The firm then purchases a portfolio of EA and national government-issued bonds paying interest R_t and R_t^G . The balance sheet of this type of financial intermediary is

$$P_t^C O_t \exp(\vartheta_{\xi_{t+1}}^{\Delta} \Delta_{t+1}) = P_t^{EA} B_t^{EA} + P_t^C B_t^G \quad (2)$$

where

$$\Delta_t = \chi_{\xi_t} \left(\frac{B_t^G}{Y_t} - \frac{B^G}{Y} \right) \quad (3)$$

captures the amount of default (“haircut”) expressed as a percentage of GDP. The term $\exp(\vartheta_{\xi_t}^{\Delta} \Delta_t)$ plays a role similar to the reduced-form “net-worth” shock in Smets and Wouters (2007), which captures variations in the effective interest rate faced by households and corporations that are not caused by changes in the real interest rate. However, unlike in Smets and Wouters (2007), these variations are endogenous and reflect changes in the ability of banks to serve their obligations due to their asset deterioration as expectations about a government default arise.

The intermediary’s profit function is then given by

$$\begin{aligned} \Upsilon_t = & \frac{R_{t-1}^G (1 - \Delta_t)}{\Pi_t} B_{t-1}^G + \frac{R_{t-1} \varepsilon_t^{rp}}{\Pi_t \bar{p}_{t-1}^{EA}} B_{t-1}^{EA} + O_t e^{\vartheta_{\xi_t}^{\Delta} \Delta_t} - \frac{B_t^{EA}}{\bar{p}_t^{EA}} \\ & - B_t^G - \frac{R_{t-1}^S}{\Pi_t} O_{t-1} - \frac{\vartheta_{\xi_t}^B}{2\Pi_t} \left(\frac{\bar{p}_{t-1}^{EA} B_{t-1}^G}{B_{t-1}^{EA}} - \frac{B^G}{B^{EA}} \right)^2 \end{aligned}$$

where the term $\frac{\vartheta_{\xi_t}^B}{2\Pi_t} \left(\frac{\bar{p}_{t-1}^{EA} B_{t-1}^G}{B_{t-1}^{EA}} - \frac{B^G}{B^{EA}} \right)^2$ captures the cost of holding “risky” national government debt since they are as they are subject to “haircut” when default occurs (Chen et al. (2012), Liu et al. (2018), Chin et al. (2022)). The coefficients χ_{ξ_t} , $\vartheta_{\xi_t}^{\Delta}$ and $\vartheta_{\xi_t}^B$ are denoted as

regime-switching parameters, and their evolution is governed by the three stages of Markov process ξ_t that governs the evolution of policy regimes discussed below.

After a log-linear approximation around the deterministic steady-state, the solution to the above optimisation problem delivers expressions (4) and (5) below:

$$\hat{r}_t^G = \hat{r}_t + \underbrace{\vartheta_{\xi_t}^B \left(\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA} \right)}_{\text{Credit Liquidity Friction}} + \underbrace{\chi_{\xi_{t+1}} \left(\hat{b}_{t+1}^G - \hat{y}_{t+1} \right)}_{\text{Credit Default Friction } (\hat{d}_{t+1})} \quad (4)$$

$$\hat{r}_t^S = \hat{r}_t + \vartheta_{\xi_t}^B \frac{B^G}{B^{EA} + B^G} \left(\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA} \right) + \vartheta_{\xi_{t+1}}^\Delta \hat{d}_{t+1} \quad (5)$$

Absent liquidity ($\vartheta^B = 0$) and default ($\vartheta^\Delta = 0, \chi = 0$) frictions, the funding cost of serving debt faced by the government and the private sector's effective interest rate coincide with the policy rate ($\hat{r}_t^G = \hat{r}_t^S = \hat{r}_t$). Once the domestic asset is perceived as less liquid than EA debt ($\vartheta^B > 0$), the term $\vartheta_{\xi_t}^B \left(\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA} \right)$ captures the wedge between the policy rate and the government cost of serving debt. Domestic debt is owned by domestic agents, and as its liquidity deteriorates due to an expansion of supply relative to the EA assets, agents demand additional compensation to absorb it. When it comes to the private sector effective interest rate, this liquidity cost depends on the share of the EA assets $\left(\frac{B^G}{B^{EA} + B^G} \right)$ as domestic agents' exposure is mitigated when their portfolio is skewed towards EA assets. As in Uribe (2006) and Bianchi (2021), the term $\chi \left(\hat{b}_t^G - \hat{y}_t \right)$ captures the premium requested by agents if a partial default occurs. Unlike to Uribe (2006) and Bianchi (2021) and similar to Corsetti et al. (2013), the combination of $\vartheta_{\xi_t}^B \frac{B^G}{B^{EA} + B^G} \left(\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA} \right)$ and $\chi \left(\hat{b}_t^G - \hat{y}_t \right)$ implies that in our framework partial default has a direct effect on the real economy.

Finally, the term $\vartheta_{\xi_{t+1}}^\Delta \hat{d}_{t+1}$ captures the direct deterioration of the financial intermediaries' assets induced by default due to the sovereign-bank nexus. In other words, the value of the asset side of the bank's balance sheet "shrinks" after a partial default, causing the credit supply to contract more and, consequently, the effective interest rate to rise further.

4.3 Intermediate goods firms

Each firm i produces with a Cobb-Douglas technology, $Y_t(i) = K_t(i)^\alpha (A_t L_t(i))^{1-\alpha} - A_t \Omega$, where $\alpha \in [0, 1]$ and $\Omega > 0$ represents fixed costs of production that grow at the rate of technological progress. The term A_t is a permanent shock to technology. The logarithm of its growth rate, $u_t^a = \ln(A_t/A_{t-1})$, follows the stationary AR(1) process $u_t^a = (1-\rho)\gamma + \rho u_{t-1}^a + \epsilon_t^a$, $\epsilon_t^a \sim N(0, \sigma_a^2)$, where γ defines the steady-state log-change of technology.

Price setting in the intermediate goods markets is subject to a lottery a la Calvo. This assumption implies that only a fraction $(1 - \omega_p)$ of intermediate firms are allowed to re-optimize their price. Firms that cannot reoptimize partially index their last period's price $p_{t-1}(i)$ to past inflation according to the weighted geometric average of past inflation in the domestically-produced intermediate goods, $\pi_{t-1} \equiv \frac{P_{t-1}}{P_{t-2}}$, and the steady-state inflation rate in the domestically-produced intermediate goods, π . The weight associated with the past inflation rate controls the degree of price indexation and is denoted by χ_p . Intermediate goods firms that are allowed to reoptimize, choose their price in period $\tilde{p}_t(i)$ so as to maximize the expected discounted stream of profits. Formally,

$$E_t \sum_{s=0}^{\infty} (\beta \omega_p)^s \frac{\lambda_{t+s}}{\lambda_t} \left[\left(\prod_{k=1}^s (\pi_{t+k-1})^{\chi_p} (\pi)^{1-\chi_p} \right) (\tilde{p}_t(i) - MC_{t+s}) Y_{t+s}(i) \right],$$

where λ_t denotes savers' marginal utility of consumption.

4.4 Final goods producers

Similar to in 't Veld et al. (2014) and Burgess et al. (2013), the final good (Z_t) producers use the intermediate value added good (Y_t) and imports (M_t) and the following technology

$$Z_t = \left[v^{\frac{1}{\tau}} Y_t^{\frac{\tau-1}{\tau}} + (1-v)^{\frac{1}{\tau}} M_t^{\frac{\tau-1}{\tau}} \right]^{\frac{\tau}{\tau-1}} \quad (6)$$

The price of the final good is given by

$$P_t^C = v (P_t)^{1-\tau} + (1-v) (P_t^m)^{1-\tau} \quad (7)$$

where P_t and P_t^m are the price indices of the domestically produced and imported goods.

4.5 Importers

The import sector consists of a continuum of monopolistically competitive firms that buy a homogenous good M_t in the world market at price P_t^* . These firms have access to a costless technology and transform the homogenous good into a differentiated product – $M_{i,t}$ – used in the production of the final good. Similar to Adolfson et al. (2007) and Burgess et al. (2013) we assume local currency pricing in order to allow for an incomplete exchange rate pass-through to the import prices. To be precise, the importing firms follow the Calvo price-setting scheme, meaning that a fraction – $1 - \xi_m$ – of them is allowed to reset their price optimally – $P_t^{m,new}$ – only when they receive a random price change signal, while those firms

that missed this signal can only index their prices by past inflation – $P_t^m = (\Pi_{t-1}^m)^{\kappa_m} P_{t-1}^m$. The pricing problem of the firm becomes

$$\max_{P_{i,t}^{m,new}} E_t \sum_{j=0}^{\infty} (\beta \xi_m)^j \frac{\lambda_{t+j}}{\lambda_t} \left\{ \left(\prod_{s=1}^j (\Pi_{t+s-1}^m)^{\kappa_m} \bar{\Pi}_{t+s}^{1-\kappa_m} \frac{P_{i,t}^{m,new}}{P_{t+j}^m} - MC_t^m \right) M_{i,t} \right\} \quad (8)$$

where $MC_t^m \equiv \frac{S_t P_t^*}{P_t^m}$ is the real marginal cost of the importing firm and $S_t = 1$ is the nominal exchange rate.

The final import good is a composite of a continuum of these differentiated imported goods, and it is given by the following CES production function

$$M_t^d = \left[\int_0^1 (M_{i,t})^{\frac{1}{\lambda_m}} di \right]^{\lambda_m}. \quad (9)$$

Taking P_t^m and $P_{i,t}^m$ as given the final import goods producer's demand curve for $M_{i,t} = \left(\frac{P_{i,t}^m}{P_t^m} \right)^{-\frac{\lambda_m}{\lambda_m-1}} M_t^d$ can be derived from the profit maximisation problem

$$\max_{M_{i,t}} \left\{ P_t^m \left[\int_0^1 (M_{i,t})^{\frac{1}{\lambda_m}} di \right]^{\lambda_m} - \int_0^1 P_{i,t}^m M_{i,t} \right\} :$$

.

4.6 Wage setting

We assume that both savers and non-savers households are monopoly suppliers of a unit measure of differentiated labour service indexed by l . In every period, a fraction $(1 - \omega_w)$ of saver households get the opportunity to optimally readjust the wage rate at which they sell their differentiated labour service. If the wage cannot be reoptimised, it will be increased at the geometric average of the steady-state rate of inflation and of last period inflation according to the rule: $W_t(l) = W_{t-1}(l)(\Pi_{t-1} e^\gamma)^{\chi_w} (\Pi e^\gamma)^{1-\chi_w}$, where χ_w captures the degree of nominal wage indexation. Each differentiated labour service is supplied by both savers and non-savers, and demand is uniformly allocated among households. Non-savers set their wage to be the average wage of the savers.

A perfectly competitive labour packer purchases the differentiated labour inputs, $L_t(l)$, sold by savers and non-savers households and assembles them to produce a composite homogeneous labour service, L_t , using the packaging technology $L_t = \left[\int_0^1 L_t(l)^{\frac{1}{1+\eta_w}} dl \right]^{1+\eta_w}$, where η_w denotes the degree of substitutability among labor types. The labour packer sells the composite homogeneous labour input to the intermediate goods firms at the competitive

price W_t . The static cost minimisation problem yields the demand function for each type of labour $L_t(l) = L_t \left(\frac{W_t(l)}{W_t} \right)^{-\frac{1+\eta_w}{\eta_w}}$.

4.7 Policymakers

We denote the debt-to-GDP ratio of each country as the market value of outstanding national debt divided by the national GDP: $s_{b,t} = \frac{B_t}{Y_t}$. Similarly, we denote the debt-to-GDP ratio of the EA as the market value of outstanding Eurobonds divided by the EA GDP: $s_{b,t}^{EA} = \frac{B_t^{EA}}{Y_t^{EA}}$. In what follows, hatted variables denote percentage deviations from the steady state.

National fiscal authority. Each national government collects tax revenues from capital, labour, and consumption taxes and sells the nominal bond portfolio, B_t , to finance its interest payments and expenditures, G_t, Z_t^S, Z_t^N . The budget constraint of the national government in the home economy is:¹⁰

$$\frac{P_t^C B_t^G}{R_t^G} + \tau_t^K R_t^K K_t + \tau_t^L W_t L_t + P_t^C \tau_t^C C_t = (1 - \Delta_t) P_{t-1}^C B_{t-1}^G + P_t^C G_t + P_t^C Z_t + P_t^C Z_t^\Delta \quad (10)$$

In our baseline specification, we follow Corsetti et al. (2013) and assume that the part of debt that the government defaults on ($\Delta_t P_{t-1}^C B_{t-1}^G$) is transferred to households ($Z_t^\Delta = \Delta_t P_{t-1}^C B_{t-1}^G$) so country's fiscal position does not improve after default. Depending on the scope of the simulation exercise presented below, this feature is either switched on ($Z_t^\Delta = \Delta_t P_{t-1}^C B_{t-1}^G$) or off ($Z_t^\Delta = 0$). By setting $Z_t^\Delta \neq 0$, we implicitly capture default risk concerns that induce market participants to request a higher premium to invest in public assets, which results in a higher cost of serving debt for the fiscal authority even when the country never defaults. As it was discussed in Section 4.2, the higher default premium has an adverse effect on the real economy, which gives rise to a financial accelerator mechanism, as the drop in the economic activity leads to a further deterioration of the public finance and so on. Loosely speaking, we see the case $Z_t^\Delta \neq 0$ as a financial market stress regime. When introducing policy uncertainty, we instead follow Bianchi (2021), and think about default as a separate regime, capturing one possible resolution of the underlying policy uncertainty.

The home country's national fiscal authority follows the fiscal rules below, which we linearized around the steady state:

$$\hat{\tau}_t^J = \rho^J \hat{\tau}_{t-1}^J + (1 - \rho^J) \gamma_{\xi_t}^J \hat{s}_{b,t-1}, \quad (11)$$

¹⁰In this draft, fiscal and monetary rules are shown in log-linear deviations from steady state. But this is done for the convenience of exposition. It is straightforward to back out the nonlinear rules.

$$\hat{g}_t = \rho^G \hat{g}_{t-1} - (1 - \rho^G) \gamma_{\xi_t}^G \hat{s}_{b,t-1} \quad (12)$$

$$\hat{z}_t = \rho^Z \hat{z}_{t-1} - (1 - \rho^Z) \gamma_{\xi_t}^Z \hat{s}_{b,t-1} - (1 - \rho^Z) \phi^Y \hat{y}_{t-1} \quad (13)$$

where $J \in \{C, L, K\}$ and $\hat{s}_{b,t}$ is the debt-to-GDP ratio of the home country. The rule for fiscal transfers, \hat{z}_t , incorporates an automatic stabilizer component as it also reacts to output. The parameters $\gamma^J, \gamma^G, \gamma^Z, \phi^Y \geq 0$ capture the strength of the fiscal response to debt ratios and output.

Finally, the foreign country's national government's budget constraint and fiscal rules are analogously defined, but we assume that there is no risk of default in that case.

EA policymakers. The fiscal rule for the EA fiscal authority are isomorphic to the fiscal rules for the individual countries. The EA fiscal authority issues Eurobonds, B_t^{EA} , and collects tax revenues from capital, labour, and consumption taxes in both countries to finance its interest payments and its expenditures, $Z_t^{EA} + G_t^{EA}$. The budget constraint of the EA fiscal authority is as follows:

$$\begin{aligned} & \frac{P_t^{C,EA} B_t^{EA}}{R_t} + \tau_t^{EA,K} (R_t^K K_t + R_t^{K*} K_t^*) + \tau_t^{EA,L} (W_t L_t + W_t^* L_t^*) \\ & + \tau_t^{EA,C} (P_t^C C_t + P_t^{C*} C_t^*) = P_{t-1}^{C,EA} B_{t-1}^{EA} + P_t^C Z_t^{EA} + P_t^{C*} Z_t^{EA*}, \end{aligned} \quad (14)$$

where C_t and C_t^* denote aggregate consumption in the home and foreign country, respectively. We assume that the EA fiscal authority has four fiscal instruments: transfers, Z_t^{EA} , consumption taxes, $\tau_t^{EA,C}$, labour income taxes $\tau_t^{EA,L}$, and capital income taxes, $\tau_t^{EA,K}$. As shown in the households' budget constraints, the EA taxes are also distortive and are additive to national taxes. We made the assumption that the EA fiscal authority has the ability to directly collect taxes. We could have assumed transfers from the national governments to the EA instead. The results below do not depend on this assumption.

The EA monetary authority sets the EA interest rate R_t , which is the interest rate of the risk-free asset, so as to respond to the EA inflation rate $\hat{\pi}_t^{EA}$ and the EA output \hat{y}_t^{EA} :

$$\hat{R}_t = \rho_r \hat{R}_{t-1} + (1 - \rho_r) [\phi_{\xi_t}^\pi \hat{\pi}_t^{EA} + \phi_{\xi_t}^y \hat{y}_t^{EA}] \quad (15)$$

4.8 The Monetary/Fiscal Policy Mix

We study three different scenarios for the monetary and fiscal policy mix. First, we study *Fiscal Discipline*. National governments raise taxes and cut expenditures to stabilize their

national debt, and Eurobonds are also backed by future fiscal adjustments.¹¹ Monetary authority is active. *Fiscal Discipline* describes quite closely the pre-pandemic monetary and fiscal framework with the addition of the Eurobonds. This corresponds to a Monetary-led regime in which debt is fully backed by future taxes. Second, we consider a situation in which fiscal rules are suspended to accommodate an energy shock. In this case, monetary policy allows inflation to increase, while fiscal stabilization is suspended. Finally, we consider a situation in which the high-debt country unilaterally deviates from fiscal discipline. The resulting policy uncertainty can be resolved with a return to Fiscal Discipline, default, or a switch of the central bank to passive policy to accommodate the change in policy in the high debt country.

Under *Fiscal Discipline*, all three fiscal authorities are committed to stabilising the debt-to-GDP ratios. In other words, the parameters in the fiscal rules in equations (11)-(13) are such that debt is stable thanks to the behavior of the fiscal authority. In this case, the Taylor principle is satisfied, $\phi^\pi > 1$. When one or more countries deviate from fiscal discipline, the central bank can accommodate the change, in which case the Taylor principle is violated, $\phi^\pi \leq 1$, or try to keep controlling inflation with a response more than one-to-one. This second case cannot persist indefinitely because it would put debt and inflation on an explosive path. As explained in detail below, the resulting policy uncertainty can generate a feedback effect between inflation and the risk of default. We assume that EA debt is always backed by future taxes.

4.9 Solving the Model

The unit-root process followed by the labor-augmenting technology A_t implies that some variables are non-stationary. Hence, we first detrend the non-stationary variables, and then we log-linearise the model equations around the steady-state equilibrium (transfers and primary surplus are linearised).¹² When considering policy uncertainty modelled as regime changes, we solve the model using the solution algorithm of Farmer et al. (2008, 2011). The solution takes into the possibility of regime changes. The solution assumes the form of a Markov-switching VAR with cross-equation restrictions. Importantly, agents' beliefs about future outcomes impact the propagation of the shocks even if the future regimes are not realized in sample.

¹¹We assume that the EA fiscal authority makes these adjustments. However, this is not essential. We could write a model in which Eurobonds are repaid with fiscal adjustments decided by the national fiscal authorities, and our results would be unchanged.

¹²The list of the log-linearised equations of the model is reported in the Appendix.

5 Calibration

Our two-country model is calibrated to capture the dynamics between a high-debt country and the rest of the EA at a quarterly frequency. Table 1 reports the calibrated parameters for preferences, technology, and nominal and real frictions. The calibration of these parameters mainly relies on Warne et al. (2008), Coenen et al. (2013) and Albonico et al. (2019), which estimate dynamic stochastic general equilibrium models for the EA.

Table 2 reports steady-state calibration targets and policy parameters. The steady-state values of national debt-to-GDP ratios are set to 60%, according to the Maastricht Treaty rules. As Eurobonds have not been issued yet, we calibrate the EA debt-to-GDP ratio to match an annualized value of 7%, in line with the latest proposals of the European Council. The steady-state government expenditure-to-GDP ratio is calibrated to match each country's quarterly average in 2019, which is 0.187 and 0.215 for Italy and Germany, respectively.

Parameters related to tax rates are calibrated using the European Commission database and taxes in the EA. The EA values of steady-state tax rates on labour and consumption are set to the value of 3 - as the EA has no power to levy these taxes so far, we have calibrated EA steady-state tax rates to a low but not negligible value. The EA value of the steady-state tax rate on capital is set to 22.8%. We use steady-state tax rates on labour, capital and consumption of 20.0% for Italy. The persistence of tax rates is set by estimating their serial autocorrelation over the available time span of the taxation database. The persistence of government expenditure and transfers is estimated in a similar fashion by using data from the European Commission. As for the parameters that control the response of fiscal variables to debt-to-GDP, we assume that all fiscal instruments are used to stabilize debt. We calibrate γ^G , γ^Z , γ^L , γ^K , γ^C , and ϕ_Y so that the Italian debt-to-GDP ratio, which initially is 134.8%, can be brought back to a level of 60% in fifteen years. Parameters that characterize the behaviour of the monetary authority are set following Warne et al. (2008), Coenen et al. (2013) and Albonico et al. (2019). The interest rate response to EA inflation and output are set to 1.89 and 0.07, respectively, while the interest rate smoothing parameter is set to 0.88.

6 Results

In this section, we analyze the behaviour of the model to understand the consequences of deviations from Fiscal Discipline. We consider two scenarios. In the first scenario, the economy is hit by an energy shock. As a result of the shock, policymakers move from a low to a high level of spending. In the second scenario, we consider the possibility that part of the existing debt is perceived as non-sustainable.

Parameter	Description	Value	Target/Source
Preferences			
β	Discount Factor	0.999	Annual SS real rate of 1.35%
ξ	Inverse Frisch Elasticity	2	Coenen et al. (2013)
θ	Habit in Formation: High Debt Economy	0.60	Locarno et al. (2014)
θ^*	Habit in Formation: Low Debt Economy	0.59	Warne et al. (2008)
α^G	Substitutability of Private v.s. Public Consumption	-0.24	Leeper et al. (2017)
Frictions and technology			
γ	Steady-state log growth rate of technology: High Debt Economy	0.25	Albonico et al. (2019)
γ^*	Steady-state log growth rate of technology: Low Debt Economy	0.25	Albonico et al. (2019)
μ	Share of hand-to-mouth households: High Debt Economy	0.11	Albonico et al. (2019)
μ^*	Share of hand-to-mouth households: Low Debt Economy	0.18	Coenen et al. (2013)
α	Elasticity in production function	0.35	Albonico et al. (2019)
δ	Capital depreciation rate	0.025	Implies annual depreciation of 10%
s	Investment adjustment cost: High Debt Economy	5.77	Locarno et al. (2014)
s^*	Investment adjustment cost: Low Debt Economy	5.56	Coenen et al. (2013)
ψ^U	Capital Utilisation Cost	0.16	Leeper et al. (2017)
ω_p	Price Calvo parameter: High Debt Economy	0.75	Prices are reset every 4 quarters
ω_p^*	Price Calvo parameter: Low Debt Economy	0.89	Coenen et al. (2013)
ω_m	Import price Calvo parameter: High Debt Economy	0.75	Prices are reset every 4 quarters
ω_m^*	Import price Calvo parameter: Low Debt Economy	0.49	Warne et al. (2008)
ω_w	Wage Calvo parameter: High Debt Economy	0.75	Wages are reset every 4 quarters
ω_w^*	Wage Calvo parameter: Low Debt Economy	0.72	Warne et al. (2008)
χ_P	Price Indexation: High Debt Economy	0.50	
χ_P^*	Price Indexation: Low Debt Economy	0.48	Warne et al. (2008)
χ_m	Import Price Indexation: High Debt Economy	0.50	
χ_m^*	Import Price Indexation: Low Debt Economy	0.35	Warne et al. (2008)
χ_w	Wage Indexation: High Debt Economy	0.50	
χ_w^*	Wage Indexation: Low Debt Economy	0.53	Coenen et al. (2013)
λ_p	Steady-state price markup: High Debt Economy	1.163	
λ_p^*	Steady-state price markup: Low Debt Economy	1.35	
λ_w	Steady-state wage markup: High Debt Economy	1.286	
λ_w^*	Steady-state wage markup: Low Debt Economy	1.3	
μ_ψ	Price Import Elasticity: High Debt Economy	1.13	
μ_ψ^*	Price Import Elasticity: Low Debt Economy	1.35	

Table 1: This table reports the calibrated values for the model parameters controlling preferences, technology, and real frictions.

Parameter	Description	Value	Target/Source
Steady-state calibration targets			
BY	Quarterly debt-to-GDP: High Debt Economy	2.4	Annualized 60% Maastricht Treaty parameter
BY^{EA}	Quarterly debt-to-GDP: EA	0.28	Annualized 7%
BY^*	Quarterly debt-to-GDP: Low Debt Economy	2.4	
G	Gov. expenditure-to-GDP: High Debt Economy	0.187	Quarterly average in 2019, Eurostat
G^*	Gov. expenditure-to-GDP ratio: Low Debt Economy	0.215	
τ^L	Steady-state tax rate on labor: High Debt Economy	20%	
$\tau^{L,EA}$	Steady-state tax rate on labor: EA	3%	
τ^{L*}	Steady-state tax rate on labor: Low Debt Economy	12%	
τ^K	Steady-state tax rate on capital: High Debt Economy	20%	
$\tau^{K,EA}$	Steady state tax rate on capital: EA	22.8%	EC, DG Taxation and Customs union, 2018
τ^{K*}	Steady state tax rate on capital: Low Debt Economy	20%	
τ^C	Steady state tax rate on cons.: High Debt Economy	20%	
$\tau^{C,EA}$	Steady state tax rate on cons.: EA	3%	
τ^{C*}	Steady state tax rate on cons.: Low Debt Economy	18.3%	
lSS	Steady state hours: High Debt Economy	33.3%	
lSS^*	Steady state hours: Low Debt Economy	16%	
m/y	Steady state imports-to-GDP ratio: High Debt Economy	33.3%	
m^*/y^*	Steady-state imports-to-GDP ratio: Low Debt Economy	26.1%	
Fiscal authorities			
γ^G	Debt response for government spending: High Debt Economy	0.11	IT debt-to-GDP to SS in 15 years
γ^{G*}	Debt response for government spending: Low Debt Economy	0.02	
γ^Z	Debt response for transfers: High Debt Economy	0.11	IT debt-to-GDP to SS in 15 years
γ^{Z*}	Debt response for transfers: Low Debt Economy	0.18	
γ^L	Debt response for τ^L : High Debt Economy	0.11	IT debt-to-GDP to SS in 15 years
γ^{L*}	Debt response for τ^L : Low Debt Economy	0.05	
γ^K	Debt Response for τ^K : High Debt Economy	0.110	IT debt-to-GDP to SS in 15 years
γ^{K*}	Debt Response for τ^K : Low Debt Economy	0	
γ^C	Debt Response fro τ^C : High Debt Economy	0.110	IT debt-to-GDP to SS in 15 years
γ^{C*}	Debt Response fro τ^C : Low Debt Economy	0	
γ_Y	Automatic Stabiliser: High Debt Economy	0.110	IT debt-to-GDP to SS in 15 years
γ_{Y*}	Automatic Stabiliser: Low Debt Economy	0.1	
ρ^L	Persistence of τ^L : High Debt Economy	0.735	Estimated 2004-2020, EC, DG Taxation & Customs Union
$\rho^{L,EA}$	Persistence of τ^L : EA	0.726	Estimated 2004-2020, EC, DG Taxation & Customs Union
ρ^{L*}	Persistence of τ^L : Low Debt Economy	0.810	
ρ^K	Persistence of τ^K : High Debt Economy	0.606	Estimated 2006-2018, EC, DG Taxation & Customs Union
$\rho^{K,EA}$	Persistence of τ^K : EA	0.502	Estimated 2006-2018, EC, DG Taxation & Customs Union
ρ^{K*}	Persistence of τ^K : Low Debt Economy	0.000	
ρ^C	Persistence of τ^C : High Debt Economy	0.884	Estimated 2000-2020, EC, DG Taxation & Customs Union
$\rho^{C,EA}$	Persistence of τ^C : EA	0.895	Estimated 2000-2020, EC, DG Taxation & Customs Union
ρ^{C*}	Persistence of τ^C : Low Debt Economy	0.91	
ρ^Z	Persistence of transfer rule: High Debt Economy	0.785	Estimated over 1996-2019, Eurostat
$\rho^{Z,EA}$	Persistence of transfer rule: EA	0.785	Estimated over 2002-2019, Eurostat
ρ^{Z*}	Persistence of transfer rule: Low Debt Economy	0.720	
ρ^G	Persistence of government spending: High Debt Economy	0.659	Estimated over 2007-2019, Eurostat
ρ^{G*}	Persistence of government spending: Low Debt Economy	0.770	
ρ_ω	EC Coefficient	0.007	
Financial intermediaries			
ϑ^Δ	Banking Sector Default Elasticity: High Debt Economy	0.050	
$\vartheta^{\Delta*}$	Banking Sector Default Elasticity: Low Debt Economy	0.000	
ϑ^B	Banking Sector Debt Elasticity: High Debt Economy	0.050	
ϑ^{B*}	Banking Sector Debt Elasticity: Low Debt Economy	0.000	
χ_1	Default Premium Elasticity: No Financial Stress Regime: High Debt Economy	0.000	
χ_2	Default Premium Elasticity: Financial Stress Regime: High Debt Economy	1.000	
χ^*	Default Premium Elasticity: Low Debt Economy	0.000	
Monetary authority			
ϕ^π	Interest rate response to EA inflation	1.890	Coenen et al. (2013)
ϕ^y	Interest rate response to EA output	0.07	Albonico et al. (2019)
w^Y	EA GDP Weight	0.145	
w^P	EA CPI Weight	0.165	
ρ^γ	Monetary Policy Inertia	0.88	Coenen et al. (2013)
σ^r	Monetary Policy Uncertainty	0.11	
$\bar{\pi}$	Inflation Target	1.005	

Table 2: This table reports the calibrated values for the steady-state and policy parameters of the model.

6.1 Energy crisis

We study the consequences of an energy price shock that induces an increase in the level of spending under two different scenarios. In the first one, we consider the possibility that the high level of spending generates an increase in the probability of a partial default. In the second scenario, we consider the possibility of a temporary deviation to a Fiscally-led regime, i.e. an increase in inflation accommodated by the central bank and meant to stabilize debt. We assume that this increase in inflation is limited to the response to the energy shock.

6.1.1 Risk of default

In this first exercise, we consider the following scenario. An economy can fluctuate between a low and a high level of spending. When spending is low, the perceived probability of a default is zero. When spending is high, there are two cases. In the first one, the perceived probability of default remains zero, while in the second one, the default probability becomes positive. Thus, the second case captures the behaviour of an economy with no perfect credibility about fiscal sustainability, while the first case corresponds to an economy in which agents remain confident about long-run fiscal sustainability.

We model this idea by allowing for three regimes. Regime 1: Low spending, no expectation of default. Regime 2: High spending, no expectation of default. Regime 3: High spending, expectation of a partial default. To capture the fact that different countries have different levels of credibility, we consider two transition matrices:

$$P_1 = \begin{bmatrix} 0.9 & 0.15 & 0.1 \\ 0.1 & 0.7 & 0.2 \\ 0.0 & 0.15 & 0.7 \end{bmatrix}, P_2 = \begin{bmatrix} 0.9 & 0.3 & 0.1 \\ 0.1 & 0.7 & 0.2 \\ 0.0 & 0.0 & 0.7 \end{bmatrix}$$

In the first case, when spending is high, agents consider the possibility that the economy will move to the state with a high perceived probability of default (Regime 3). In the second case, the country can run a high level of spending without losing agents' confidence that debt will eventually be stabilized with a fiscal adjustment. Accordingly, in this second case, the probability of moving to the Default regime is set to zero.

We then conduct the following simulation. A sequence of oil shocks hit the Euro area for four quarters. The sequence of oil shocks increases inflation for both the country of interest and the rest of the Euro area. The central bank reacts with an increase in the policy rate, while the country reacts by moving to a high spending regime for four quarters. In period five, the country can return to low spending or continue with high spending. However, if it does so, the economy enters the Default regime. As explained before, this is a regime with a high perceived probability of default, even if default does not occur in sample.

The results are reported in Figure 1. Following the initial oil shock, the path for spreads is initially similar across the two countries because it is mostly driven by an exogenous event. All countries experience a decline in real activity, as we would expect following a supply-side shock that moves output and inflation in different directions. However, the decline in output is larger for the low-reputation country, as the probability of moving to the Default Regime is higher for this country. In the meantime, the amount of debt remains relatively stable across all simulations. This is because the high inflation generated by the oil shock counteracts the effects of the spending increase, eroding the real value of debt.

The paths start diverging more visibly in period 5. Let's first consider the case of a country with a low reputation for fiscal sustainability (solid and dashed blue lines with no circles). For this country, the decision of whether to continue with high or low spending is consequential. When moving back to low spending (solid blue line), sovereign spreads start declining, the economy experiences a faster recovery, and debt accumulation decelerates. These dynamics are the result of a *virtuous* feedback effect. The slower accumulation and eventual decline in debt help to lower the spreads and mitigate the recession. At the same time, lower spreads and output recovery help to lower debt.

However, if the low-reputation country continues with high spending and enters the Default regime, the picture is quite different. Recall that under the Default regime, we model a situation in which there is a high perceived probability of default that does not materialize in sample. This is to capture the situations experienced so far by most (but not all) of the high-debt countries of the Euro Area. Now, debt accumulation and spreads accelerate. This is not because of a change in the level of spending. Spending was higher starting from period 1. What drives the deterioration in the economy is now a *vicious* feedback effect. The concern about default determines an increase in spreads that lowers economic activity because of financial frictions. In turn, higher spreads and lower real activity determine faster debt accumulation, which determines a further increase in spreads and so on.

Let's now consider the case of the high-reputation country (solid and dashed red lines with circles). Output for the high-reputation country still declines because of the adverse oil shock, but by less compared to the low-reputation country. The absence of risk of entering the Default regime explains the difference between the low-reputation and the high-reputation country during the early phases of the simulation. In the beginning, the countries increase spending by the same amount, but for the high-reputation country, the probability of entering the Default state is zero.

If, in period 5, the country returns to low spending (red solid line with circles), spreads naturally decline, as in the case of the low-reputation country. Not surprisingly, when both countries choose a path of low spending, the differences in macroeconomic outcomes decline.

In fact, in a few quarters, the level of real activity in the low-reputation country catches up with that of the high-reputation country. This is because by keeping spending under control, the low-reputation country removes the recessionary pressure coming from the risk of default.

It is then interesting to consider a thought experiment in which the high-reputation country enters the Default regime, even if this event has zero probability ex-ante (red dashed line with circles). The simulation shows that even if the high-reputation country were to find itself in the Default regime, agents expect the country to move away from such a state with no expectation of returning to it. As a result, the effect on output is minimal. To understand why, notice that debt and the sovereign spread increase much less for the high-reputation country under the Default regime, as agents expect this situation to be resolved soon.

6.1.2 Temporary deviation to Fiscally-led policy mix

In this subsection, we consider the possibility of a different response to the energy crisis. As before, we consider a scenario in which the Euro area is hit by a sequence of adverse oil shocks for four periods. After these shocks start reabsorbing, the home country and the rest of the Euro area can move back to a Monetary-led policy mix with low spending or accommodate the shock by temporarily moving to a Fiscally-led policy mix with high spending. For now, we assume that this is a coordinated strategy that does not cause concerns about the possibility of a conflict between the centralized monetary authority and the different fiscal authorities. Furthermore, we assume that this coordinated policy is limited to the response to the specific circumstances faced by the Euro Area. Thus, we remove the risk of default for all countries. We will return to this point below.

Figure 2 plots the impulse responses. In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which policymakers return to the Monetary-led policy mix with low spending, while the red dashed lines correspond to the case in which policymakers move to the Fiscally-led regime with high spending.

The first clear result is that the path for inflation is actually quite similar across the two policy responses. After one year of rising inflation due to the oil shock, inflation declines fairly quickly across the two cases. On the other hand, the response in terms of output is visibly different. Accommodating the shock with a shift to the Fiscally-led regime substantially reduces the output losses. Interestingly, this is true for both countries, as the shock affects both of them. This result is consistent with what was discussed in Bianchi and Melosi (2022). If inflation is mostly due to mark-up shocks, it tends to be short-lasting and quite similar across different policy responses.

The amount of inflation generated by moving to a Fiscally-led regime is quite moderate here for two reasons. First, agents expect that, eventually, they will return to a Monetary-led policy mix. Second, the deviation is only in response to a particular shock. This is a general lesson: If policymakers are able to clearly communicate their intentions and coordinate on a well-thought policy response, a moderate level of inflation can, in fact, be beneficial. This is even more true if fiscal inflation helps remove the default risk, as in this example.

So far, we have implicitly assumed that (1) the deviation from the Monetary-led policy mix in response to the shock does not affect beliefs about the overall commitment to long-run fiscal sustainability and (2) that the increase in inflation is entirely due to an energy shock. In reality, there might be a misalignment between policymakers' *intentions* and markets' *perceptions* about their actions. In this context, an increase in inflation could be in part fueled by the concern that countries with high debt will favour inflationary policies that go beyond what is strictly necessary to stabilize an adverse energy shock, causing the risk of a much larger increase in fiscal inflation. We consider these issues in the next section.

6.2 Fiscal crisis

In this subsection, we consider a different scenario. Instead of assuming that inflationary pressure arises from an adverse energy shock, we study the consequences of a lack of credibility about long-run debt sustainability. Based on current fiscal policy, we assume that a share of the outstanding debt is perceived as unsustainable. We first assess the consequences of this lack of sustainability if agents fear that, eventually, a default will occur. We then study the case in which agents expect that inflation will be allowed to rise to stabilise debt. Finally, we consider the interaction between the two aforementioned possibilities when agents are uncertain about the final outcome. Importantly, we see these exercises as a way to model the consequences of policy uncertainty and risk. As shown below, even if these events do not materialize in sample, they can still have important consequences for real activity.

In this exercise, we want to isolate the impact that the risk of default as a possible resolution of the policy uncertainty stemming from the unsustainable debt dynamics has on agents' decisions. For this reason, we switch off the financial fictions and the partial default discussed in Sections 4.2 and 4.7, i.e. $\chi_{st} = 0$ and $Z_t^\Delta = 0$, respectively.

6.2.1 Risk of default

We assume that a certain share of debt in the high-debt country, equivalent to 20% of the debt-to-GDP ratio, is not currently backed by future primary surpluses, and agents believe that, eventually, this will lead to a default. Note that this is not a scenario that is currently at

work, but it is a useful thought experiment to understand the results presented below about the interaction between the risk of default and the risk of fiscal inflation. The following transition matrix represents this scenario:

$$P_{NU} = \begin{matrix} & \begin{matrix} NCC \\ DF \\ ML \end{matrix} \end{matrix} \begin{bmatrix} 0.9 & 0 & 0 \\ 0.1 & 0 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

The economy is currently in a non-cooperation regime (NC), where the central bank follows an active rule, but the fiscal authority in the high-debt country is unable or unwilling to stabilize a portion of the existing debt. In every period, agents believe that there is a 10% probability of defaulting in the next period on the accumulated portion of the debt. This event is captured by the second regime, the default regime (DF). After the default, agents expect a return to a Monetary-led policy mix (ML, the third regime). We assume that the economy remains in Regime 1 for 10 periods, then a default occurs, and the economy moves to the Monetary-led regime. Importantly, the dynamics over the first ten periods simply reflect the risk of default.

Figure 3 reports the results. We consider two cases: Costly default and non-costly default. The non-costly default is a useful benchmark that will become useful when studying the interaction between default and fiscal inflation risk below. The costly default is obviously more realistic, as we know that default leads to disruption. In the costly default case, default lowers the stationary component of TFP. Specifically, a 10pps haircut of the debt to GDP ratio lowers TFP by 1%.

The risk of default implies a large contraction of real activity in the high-debt country and the rest of the Euro Area. Not surprisingly, the decline is significantly larger for the high-debt country. Even if default were eventually not to materialize, the simple risk of it occurring in the future generates contractionary pressure. Importantly, the longer this situation persists, the more debt is accumulated and the more output declines in the high-debt country. If the default were to materialize (period 11), the decline in potential output triggered by the decline in TFP would lower output and increase inflation in the high-debt country by large amounts, while the rest of the Euro Area would recover fairly quickly and experience only a moderate increase in inflation.

The alternative case of non-costly default is in itself less interesting but offers a useful benchmark to be able to isolate the effects of policy uncertainty in Subsection 6.2.3. In this case, the risk of default does not cause an output loss, as default is not costly in itself. Agents simply require to be compensated for the probability of not receiving a payment in the next period. If a default occurs, there is a mild contraction in output due to the fall in

government spending caused by the fact that fiscal policy becomes passive (i.e. responds to lag debt to GDP ratio). This channel fades away from the period 12 onwards, as the debt to GDP ratio reduces to its steady state value, but the persistence component of the rule remains. This channel has very small effects on real activity before the default.

6.2.2 Risk of fiscal inflation

We now consider the case in which the same portion of debt of the high-debt country is not backed by future primary surpluses, but agents expect that this will eventually lead to inflation, as opposed to a default. In other words, agents expect that the central bank will eventually accept an increase in inflation to lower the fiscal burden of the high-debt country. A similar case is analyzed in Bianchi et al. (2022).

To model this scenario, we consider the following transition matrix:

$$P_{NU} = \begin{matrix} NCC \\ FL \end{matrix} \begin{bmatrix} 0.9 & 0 \\ 0.1 & 1 \end{bmatrix}$$

As before, under the first regime, policymakers are not cooperating, as the fiscal authority is not implementing the necessary fiscal adjustments. However, now agents believe that in every period, there is a 10% probability that the central bank will let inflation increase to stabilize the unfunded portion of the debt of the high-debt country. As before, we assume agents are only uncertain about when this will happen. This is not supposed to be a realistic characterization of the current situation in the Euro Area, but rather a way to isolate the mechanism we are interested in.

Figure 4 reports the results under two sets of assumptions with respect to the frequency of price adjustment. In the first one, the frequency of price adjustment in the Fiscally-led regime is low and equal to the frequency of price adjustment in the non-cooperation regime. In the second one, prices and wages become more flexible. Specifically, the domestic price (ω_p) and wage (ω_w) Calvo probabilities are decreased to 0.25. We find this second case interesting because it is realistic to assume that if agents expect to move to a regime with higher and more volatile inflation, they might also expect less sticky prices.¹³

In both cases, the expectation that the unfunded share of debt will result in inflation generates inflationary pressure even before the switch occurs. The central bank tries to counteract this inflationary pressure, pushing the economy into a deeper and deeper recession. This mechanism is exacerbated when prices are expected to become more flexible following

¹³While we consider this scenario realistic, we do not microfound the relation between the policy regime and the frequency of price adjustment. We consider this an interesting direction for future research but beyond the scope of this paper.

the switch to the Fiscally-led regime. Both the high-debt country and the rest of the Euro Area experience a large contraction in real activity. This is very different from the case of default studied above. This result occurs because the inflationary pressure stemming from the risk of a change to a Fiscally-led regime induces contractionary monetary policy. Furthermore, the rest of the Euro also keeps increasing taxes as debt is accumulated as a result of the recession. Thus, this scenario is particularly pernicious for both the high-debt country and the rest of the Euro area. However, unlike the case of costly default, once the policy change occurs, the drop in real interest rates generates a rebound in real activity.

6.2.3 Uncertainty

We are now ready to consider the effects of policy uncertainty with respect to the resolution of the debt crisis. In this scenario, we assume that agents do not know whether the debt crisis will result in a default or inflation. We assume that they find the two events equally likely. These beliefs can be summarised by the following transition matrix:

$$P_U = \begin{matrix} & \begin{matrix} NCC \\ DF \\ ML \\ FL \end{matrix} \end{matrix} \begin{bmatrix} 0.9 & 0 & 0 & 0 \\ 0.05 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0.05 & 0 & 0 & 1 \end{bmatrix}$$

The first regime is once again the non-cooperation regime. However, now agents believe that in every period, there is a 5% probability of moving to a Fiscally-led regime and a 5% probability that the high-debt country will default and the Euro Area will return to a Monetary-led regime.¹⁴

We focus on the case of costly default because it is arguably more interesting and realistic. This is reported in Figure 5. We report the case on non-costly default in the Appendix. We compare the outcomes under uncertainty to the case in which agents are certain that the debt crisis will result in inflation. A series of important stylized facts stand out. The possibility of default and inflation interact with each other. Fiscal inflation induces the central bank to keep interest rates, pushing the High Debt Country into a deeper and deeper recession. The recession and the high interest rates spread on the debt of the High Debt Country determine an even larger debt accumulation than under the non-uncertainty case. On the other hand,

¹⁴Figure 6 also considers the situation where the probability of the probability of switching to a Fiscally-led

or default regime increases to 10%, i.e. $P_U = \begin{matrix} & \begin{matrix} NCC \\ DF \\ ML \\ FL \end{matrix} \end{matrix} \begin{bmatrix} 0.8 & 0 & 0 & 0 \\ 0.1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0.1 & 0 & 0 & 1 \end{bmatrix}$

the recession in the Low debt country is lower because there is no certainty that inflation will eventually occur, and real interest rates for the Low debt country are lower.

If uncertainty is resolved in favour of a large increase in inflation, both countries will experience a larger increase in inflation. This is because the amount of debt that needs to be stabilised with inflation is larger than under the No uncertainty scenario. In this sense, the lack of certainty about the final outcome makes the cost in terms of inflation larger. If, instead, uncertainty is resolved with a default, both countries experience a recession due to the fact that the two economies are largely integrated. Thus, the possibility of default does not necessarily ameliorate the outcomes for the Euro Area members, and it can, in fact, amplify the amount of inflation that will eventually occur.

7 Conclusions

In this paper, we have built a model of the Euro area featuring the possibility of default and changes in the monetary/fiscal policy mix. We first used the model to study the consequences of an adverse energy shock across different policy scenarios. The reputation for fiscal sustainability plays a key role. Countries with high reputation experience better outcomes, and spreads can increase quickly for countries with low reputation that engage in high levels of spending. This creates a vicious circle for which debt accumulation determines an increase in spreads that, in turn, contribute to depressing real activity, generating further debt accumulation. In this context, a coordinated response to the oil shock, with the whole Euro Area accommodating the shock with a temporary shift to a Fiscally-led regime, delivers better outcomes. In this case, the recession is largely mitigated, while the path for inflation is quite similar with respect to a return to the Monetary-led regime. A benefit of this strategy is that it removes the risk of default. However, the results are obtained under the implicit assumption that all countries retain a commitment to long-term fiscal sustainability.

We then considered a different scenario in which policymakers face a fiscal crisis. We assume that a portion of debt accumulated by a high debt country is not backed by future fiscal adjustments. In this case, agents might face the risk of default or high fiscal inflation. We explain why both scenarios can lead to large contractions in real activity, even for the low debt country. Uncertainty about the resolution of the fiscal crisis can reinforce the negative spiral of low growth, debt accumulation, and inflation. Thus, whether Euro Area countries should deviate from fiscal rules strongly depends on the credibility of a return to fiscal discipline.

References

- Adolfson, M., J. Linde, and M. Villani (2007). Forecasting performance of an open economy dsge model. *Econometric Reviews* 26(2-4), 289–328.
- Albonico, A., L. Calés, R. Cardani, O. Croitorov, F. D. Dio, F. Ferroni, M. Giovannini, S. Hohberger, B. Pataracchia, F. Pericoli, and P. Pfeiffer (2019, July). The Global Multi-Country Model (GM): An Estimated DSGE Model for Euro Area Countries. European Economy - Discussion Papers 102, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.
- Angeletos, G.-M. (2002). Fiscal Policy with Noncontingent Debt and the Optimal Maturity Structure. *The Quarterly Journal of Economics* 117(3), 1105–1131.
- Bassetto, M. (2002). A Game-Theoretic View of the Fiscal Theory of the Price Level. *Econometrica* 70(6), 2167–2195.
- Benhabib, J., S. Schmitt-Grohe, and M. Uribe (2002). Avoiding Liquidity Traps. *Journal of Political Economy* 110(3), 535–563.
- Bergin, P. R. (2000). Fiscal solvency and price level determination in a monetary union. *Journal of Monetary Economics* 45(1), 37–53.
- Bi, H. and N. Traum (2012, May). Estimating Sovereign Default Risk. *American Economic Review* 102(3), 161–166.
- Bi, H. and N. Traum (2014, November). Estimating Fiscal Limits: The Case Of Greece. *Journal of Applied Econometrics* 29(7), 1053–1072.
- Bianchi, F. (2021). Fiscal inflation and cosmetic defaults in a small open economy.
- Bianchi, F., R. Faccini, and L. Melosi (2023). A fiscal theory of persistent inflation. *The Quarterly Journal of Economics*, qjad027.
- Bianchi, F. and C. Ilut (2017). Monetary/Fiscal Policy Mix and Agent’s Beliefs. *Review of Economic Dynamics* 26, 113–139.
- Bianchi, F. and L. Melosi (2017a). Escaping the Great Recession. *The American Economic Review* 107(4), 1030–1058.
- Bianchi, F. and L. Melosi (2017b, April). Escaping the Great Recession. *American Economic Review* 107(4), 1030–1058.
- Bianchi, F. and L. Melosi (2022, 08). Inflation as a Fiscal Limit. Working paper series, Federal Reserve Bank of Chicago.
- Bianchi, F., L. Melosi, and A. Rogantini Picco (2022). Who is afraid of eurobonds?
- Blanchard, O. (2019, April). Public Debt and Low Interest Rates. *American Economic Review* 109(4), 1197–1229.
- Brand, C., M. Bielecki, and A. Penalver (2018, December). The natural rate of interest: esti-

- mates, drivers, and challenges to monetary policy. Occasional Paper Series 217, European Central Bank.
- Brunnermeier, M. K. and Y. Koby (2018, December). The Reversal Interest Rate. NBER Working Papers 25406, National Bureau of Economic Research, Inc.
- Buera, F. and J. P. Nicolini (2004, April). Optimal maturity of government debt without state contingent bonds. *Journal of Monetary Economics* 51(3), 531–554.
- Burgess, S., E. Fernandez-Corugedo, C. Groth, R. Harrison, F. Monti, K. Theodoridis, and M. Waldron (2013, May). The Bank of England’s forecasting platform: COMPASS, MAPS, EASE and the suite of models. Bank of England working papers 471, Bank of England.
- Cardani, R., O. Croitorov, M. Giovannini, P. Pfeiffer, M. Ratto, and L. Vogel (2022). The euro area’s pandemic recession: A DSGE-based interpretation. *Journal of Economic Dynamics and Control* 143.
- Cardani, R., P. Pfeiffer, M. Ratto, and L. Vogel (2023). The COVID-19 recession on both sides of the Atlantic: A model-based comparison. *European Economic Review* 158.
- Chen, H., V. Cúrdia, and A. Ferrero (2012, November). The Macroeconomic Effects of Large-scale Asset Purchase Programmes. *Economic Journal* 122(564), 289–315.
- Chin, M., F. De Graeve, T. Filippeli, and K. Theodoridis (2022). International Long-Term Interest Rate Comovement. *Advances in Econometrics*, forthcoming.
- Cochrane, J. H. (1998). A Frictionless Model of U.S. Inflation. In B. S. Bernanke and J. J. Rotemberg (Eds.), *NBER Macroeconomics Annual 1998*, pp. 323–384. Cambridge, MA: MIT Press.
- Cochrane, J. H. (2001). Long Term Debt and Optimal Policy in the Fiscal Theory of Price Level. *Econometrica* 69, 69–116.
- Coenen, G., C. Montes-Galdón, and S. Schmidt (2021). Macroeconomic stabilisation and monetary policy effectiveness in a low-interest-rate environment. *Journal of Economic Dynamics and Control* 132(C).
- Coenen, G., C. Montes-Galdón, and F. Smets (2023, June). Effects of State-Dependent Forward Guidance, Large-Scale Asset Purchases, and Fiscal Stimulus in a Low-Interest-Rate Environment. *Journal of Money, Credit and Banking* 55(4), 825–858.
- Coenen, G., R. Straub, and M. Trabandt (2012, May). Fiscal Policy and the Great Recession in the Euro Area. *American Economic Review* 102(3), 71–76.
- Coenen, G., R. Straub, and M. Trabandt (2013). Gauging the effects of fiscal stimulus packages in the euro area. *Journal of Economic Dynamics and Control* 37(2), 367–386.
- Corsetti, G., K. Kuester, A. Meier, and G. J. Müller (2013, February). Sovereign Risk, Fiscal Policy, and Macroeconomic Stability. *Economic Journal* 0, 99–132.

- Corsetti, G., K. Kuester, and G. J. Müller (2013). Floats pegs and the transmission of fiscal policy. *Series on Central Banking Analysis and Economic Policies no. 17*.
- ECB (2021, July). An Overview of the ECB’s Monetary Policy Strategy. *Economic Bulletin Articles 5*, 78–89.
- Farmer, R. E., D. F. Waggoner, and T. Zha (2011). Minimal State Variable Solutions to Markov-Switching Rational Expectations Models. *Journal of Economic Dynamics and Control 35*(12), 2150–2166.
- Farmer, R. E. A., D. Waggoner, and T. Zha (2008). Minimal State Variable Solutions to Markov-Switching Rational Expectations Models. Bank of Atlanta Working Paper 2008-23.
- Galí, J. and T. Monacelli (2008). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies 72*(3), 707–734.
- IMF (2021). Review of The Debt Sustainability Framework For Market Access Countries. Policy Paper 2021/003, IMF.
- in ’t Veld, J., R. Kollmann, B. Pataracchia, M. Ratto, and W. Roeger (2014). International capital flows and the boom-bust cycle in Spain. *Journal of International Money and Finance 48*(PB), 314–335.
- Jaccard, I. and F. Smets (2020, April). Structural Asymmetries and Financial Imbalances in the Eurozone. *Review of Economic Dynamics 36*, 73–102.
- Kriwoluzky, A., G. J. Müller, and M. Wolf (2019). Exit expectations and debt crises in currency unions. *Journal of International Economics 121*, 103253.
- Leeper, E. M. (1991). Equilibria Under Active and Passive Monetary and Fiscal Policies. *Journal of Monetary Economics 27*, 129–147.
- Leeper, E. M., N. Traum, and T. B. Walker (2017, August). Clearing Up the Fiscal Multiplier Morass. *American Economic Review 107*(8), 2409–2454.
- Liu, P., K. Theodoridis, H. Mumtaz, and F. Zanetti (2018). Changing macroeconomic dynamics at the zero lower bound. *Journal of Business & Economic Statistics 0*(0), 1–14.
- Locarno, A., A. Notarpietro, and M. Pisani (2014). Sovereign risk, monetary policy and fiscal multipliers: A structural model-based assessment. In L. Paganetto (Ed.), *Wealth, Income Inequalities, and Demography*, Cham, pp. 163–210. Springer International Publishing.
- Maćkowiak, B. and S. Schmidt (2024). Fiscal backing for price stability in a monetary union.
- Orphanides, A. (2017, May). The Fiscal-Monetary Policy Mix in the Euro Area: Challenges at the Zero Lower Bound. CEPR Discussion Papers 12039, C.E.P.R. Discussion Papers.
- Reis, R. (2016). QE in the Future: the Central Bank’s Balance Sheet in a Fiscal Crisis. Working Paper 22415, National Bureau of Economic Research.
- Sargent, T. and N. Wallace (1981a). Some Unpleasant Monetarist Arithmetic. *Federal*

- Reserve Bank of Minneapolis Quarterly Review* Fall, 1–17.
- Sargent, T. J. and N. Wallace (1981b). Some unpleasant monetarist arithmetic. *Quarterly Review* 5(Fall).
- Schmitt-Grohe, S. and M. Uribe (2000). Price level determinacy and monetary policy under a balanced-budget requirement. *Journal of Monetary Economics* 45(1), 211–246.
- Sims, C. A. (1994). A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy. *Economic Theory* 4, 381–399.
- Smets, F. and R. Wouters (2007). Shocks and frictions in US business cycles: a Bayesian DSGE approach. *American Economic Review* 97, 586–606.
- Uribe, M. (2006, November). A fiscal theory of sovereign risk. *Journal of Monetary Economics* 53(8), 1857–1875.
- Warne, A., G. Coenen, and K. Christoffel (2008, October). The new area-wide model of the euro area: a micro-founded open-economy model for forecasting and policy analysis. Working Paper Series 944, European Central Bank.
- Woodford, M. (1994). Monetary Policy and Price Level Determinacy in a Cash-in-Advance Economy. *Economic Theory* 4, 345–389.
- Woodford, M. (1995). Price Level Determinacy without Control of a Monetary Aggregate. *Carnegie-Rochester Series of Public Policy* 43, 1–46.
- Woodford, M. (2001). Fiscal Requirements of Price Stability. *Journal of Money, Credit, and Banking* 33, 669–728.

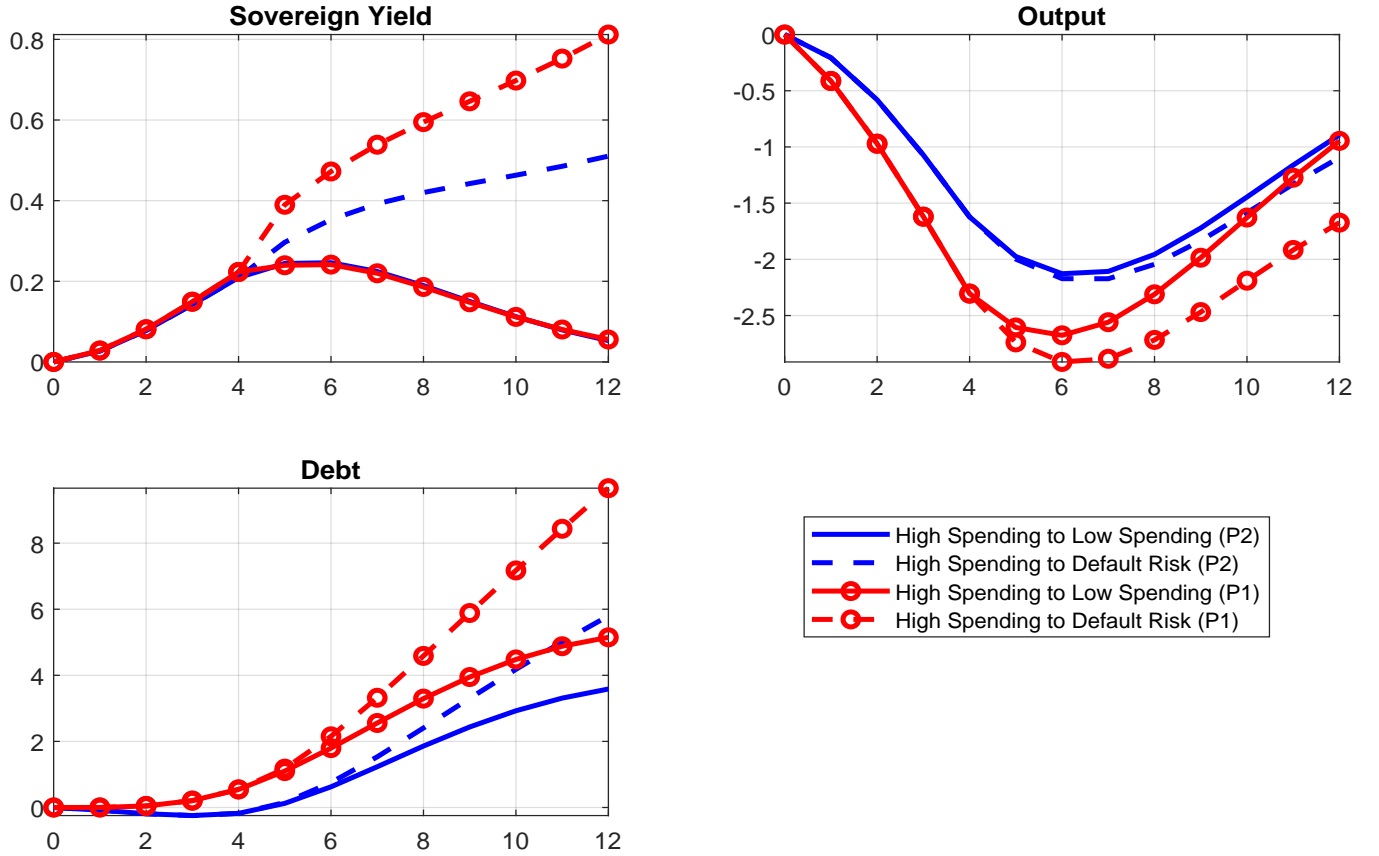


Figure 1: **Impulse responses to an oil shock based on different policy scenarios.** The economy is hit by a sequence of oil shocks for the first four periods (formally, mark-up shocks). In response to the oil shocks, policymakers move to a high-spending regime for four periods. In period 5, we consider two scenarios. In the first scenario, policymakers return to low spending (solid lines). In the second scenario, they keep with high spending, raising concerns about the possibility of a default (dashed lines). For each scenario, we analyze the case of a high-reputation country (blue lines with no circles) and a low-reputation country (red lines with circles).

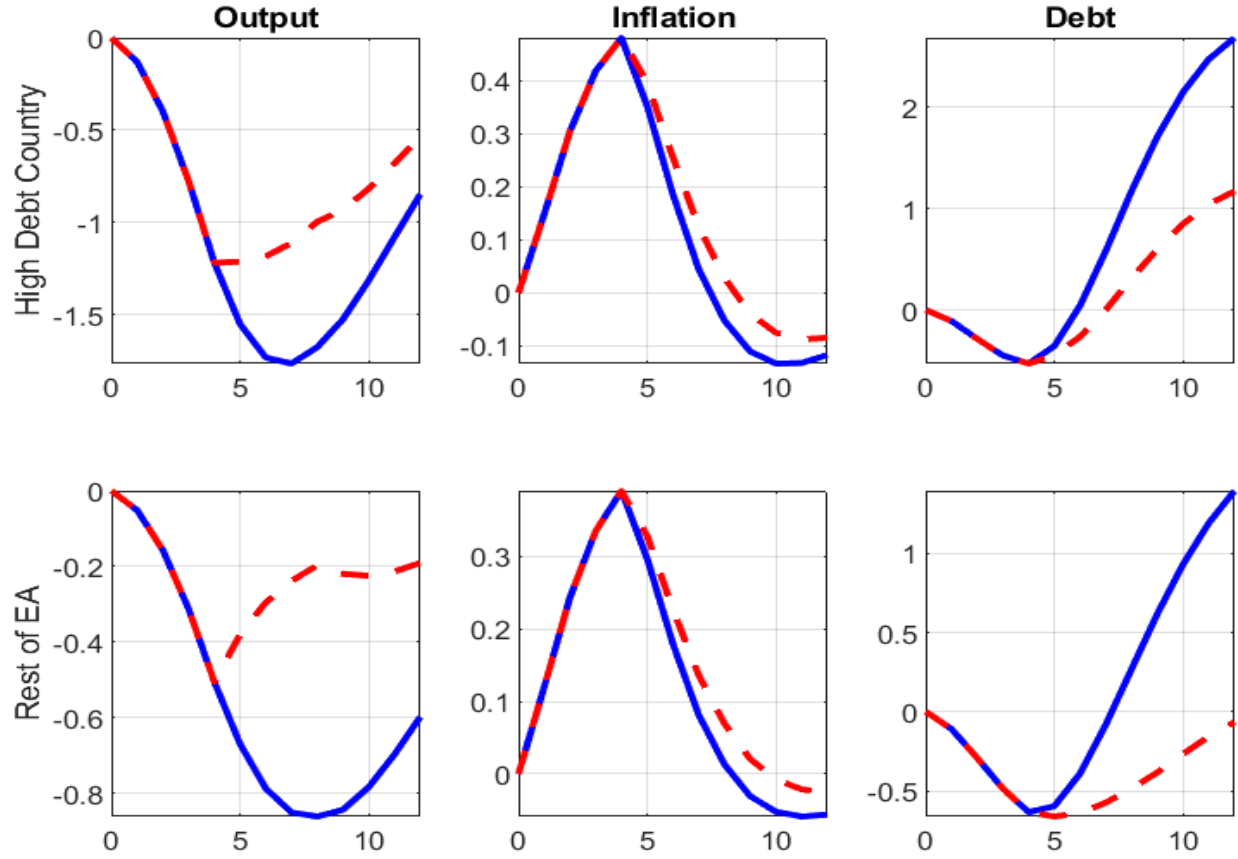


Figure 2: **Monetary-led vs Fiscally-led regime.** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which policymakers return to the Monetary-led policy mix with low spending, while the red dashed lines correspond to the case in which policymakers move to the Fiscally-led regime with high spending.

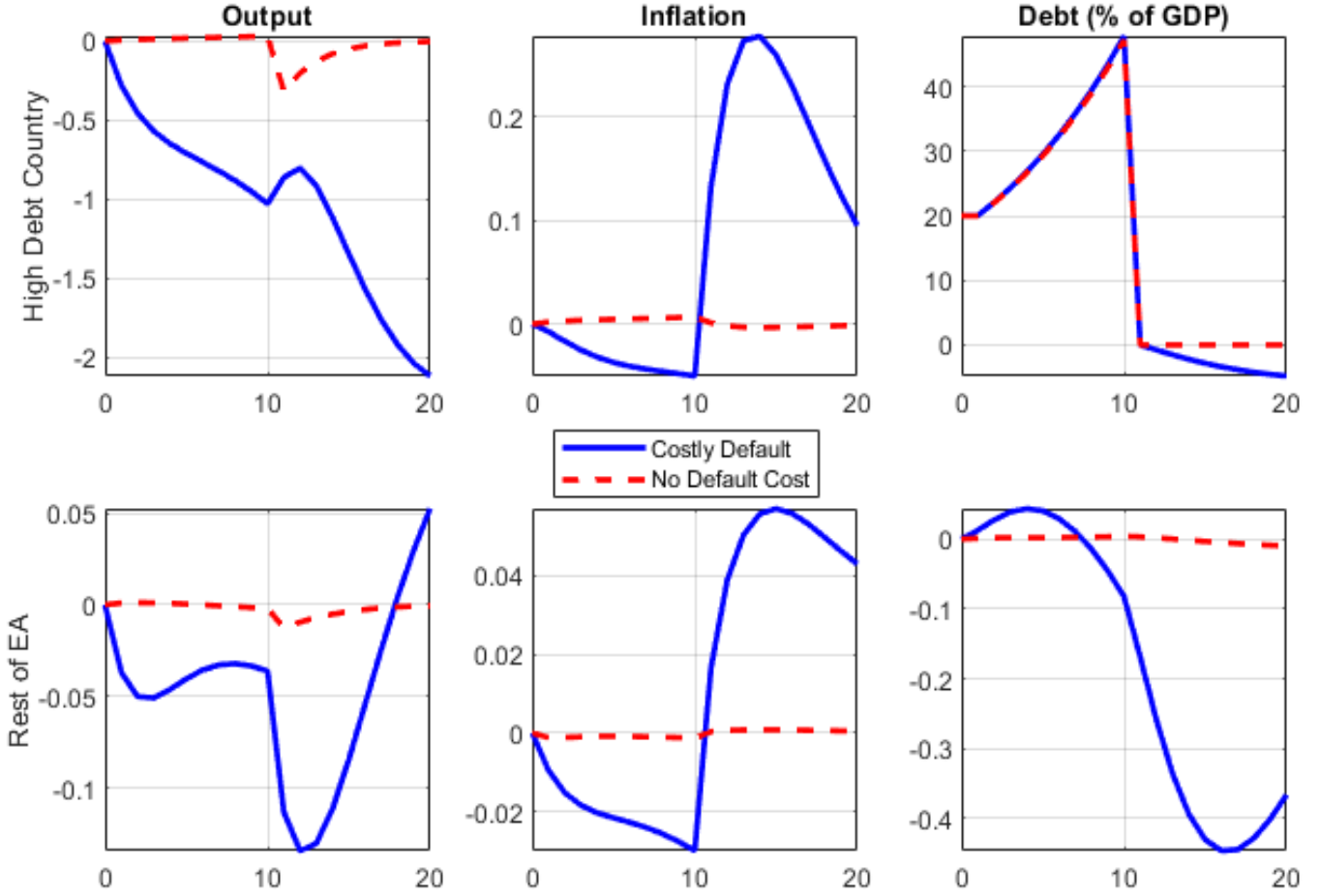


Figure 3: **No Regime Uncertainty: No Coordination – > Default – > Monetary Policy Led** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which default is not costly, while the red dashed lines correspond to the case in which default is costly.

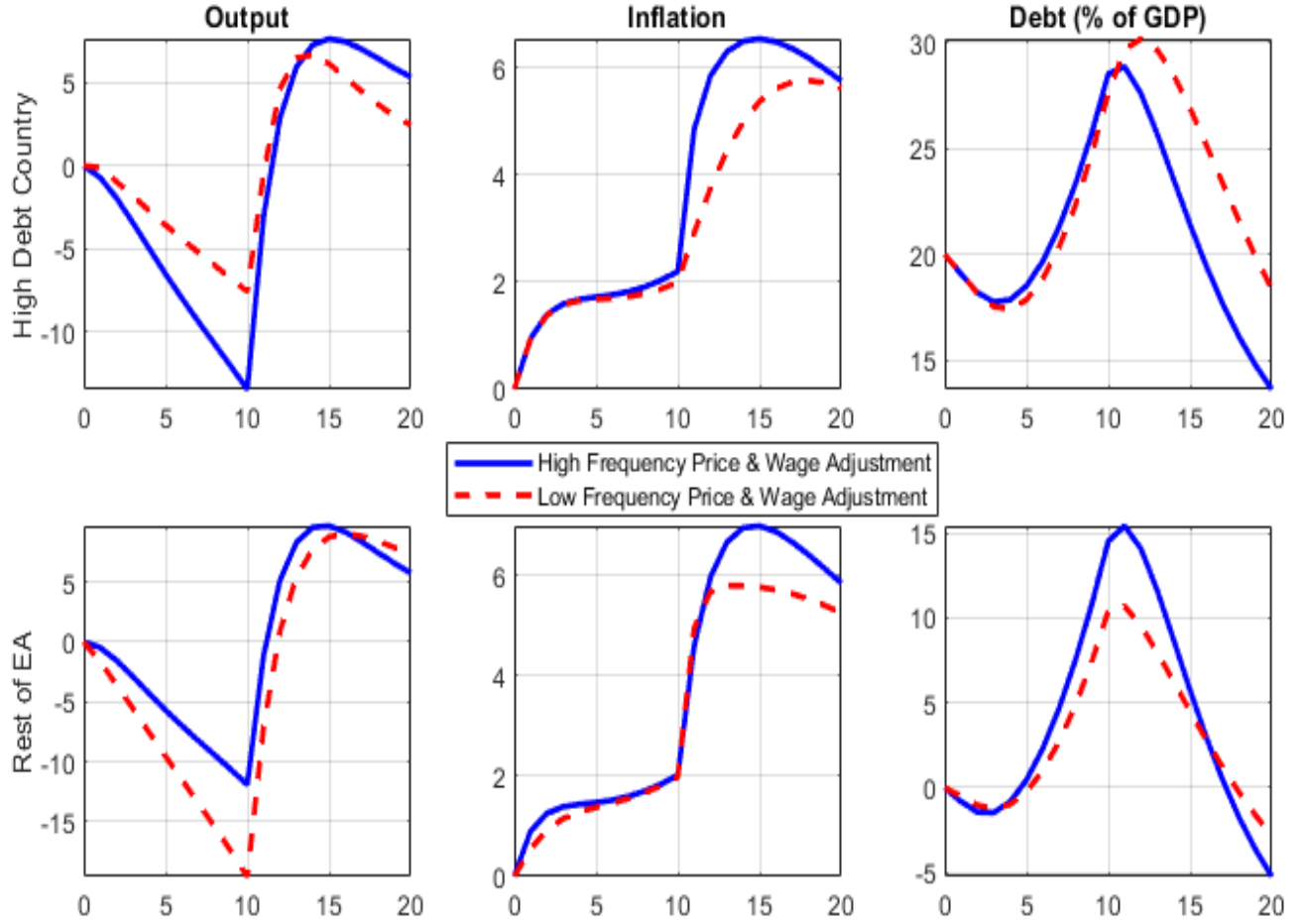


Figure 4: **No Regime Uncertainty: No Coordination => Fiscal Policy Led** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which price and wage are reset infrequently, while the red dashed lines correspond to the case in which price and wage are reset highly frequently.

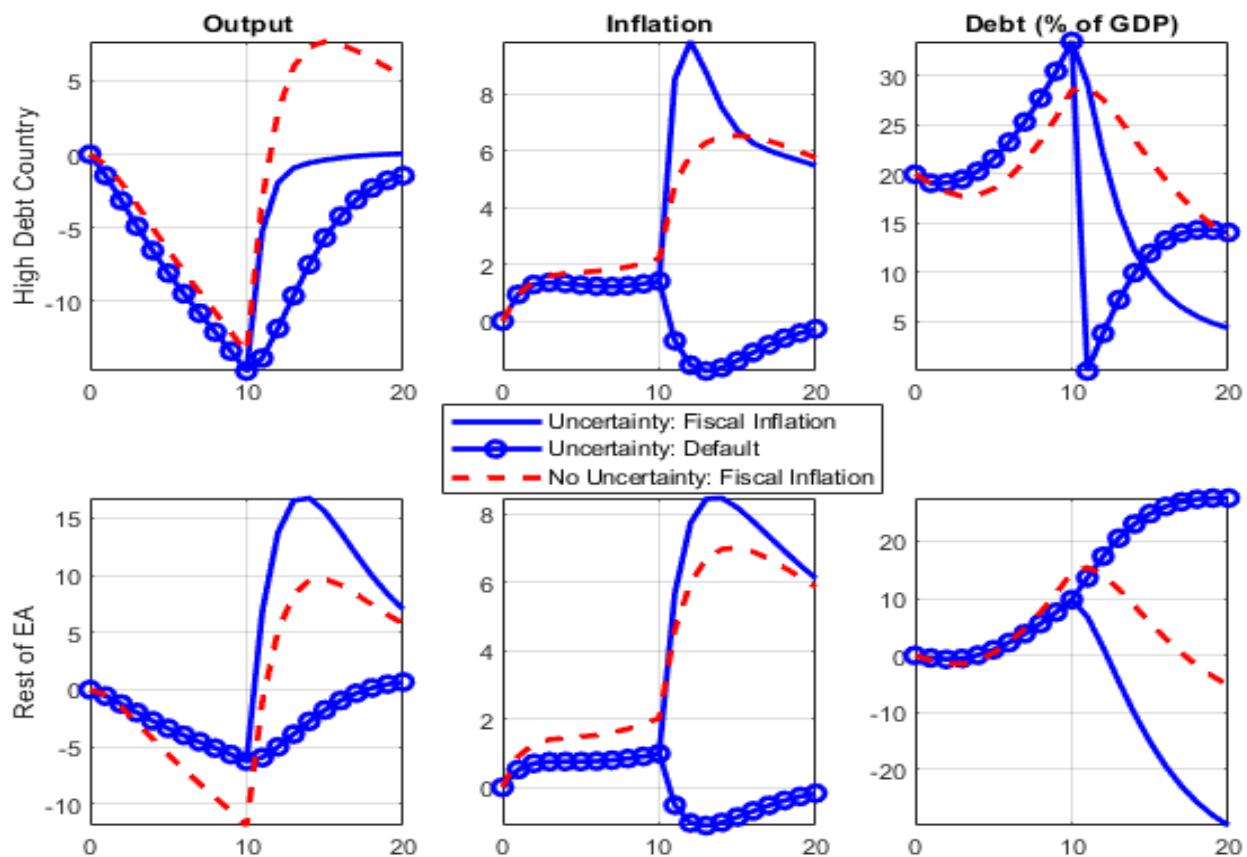


Figure 5: **Regime Uncertainty (Probability of Switch 5%) Costly Default:** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which the evolution of regimes is uncertain, and the economy moves from the NC to FL regime; the blue circle line captures regime uncertainty again, but the economy moves from NCC to DF and ML regimes, while the red dashed lines correspond to the case in which agents know that the lack of policy coordination will be resolved with high inflation.

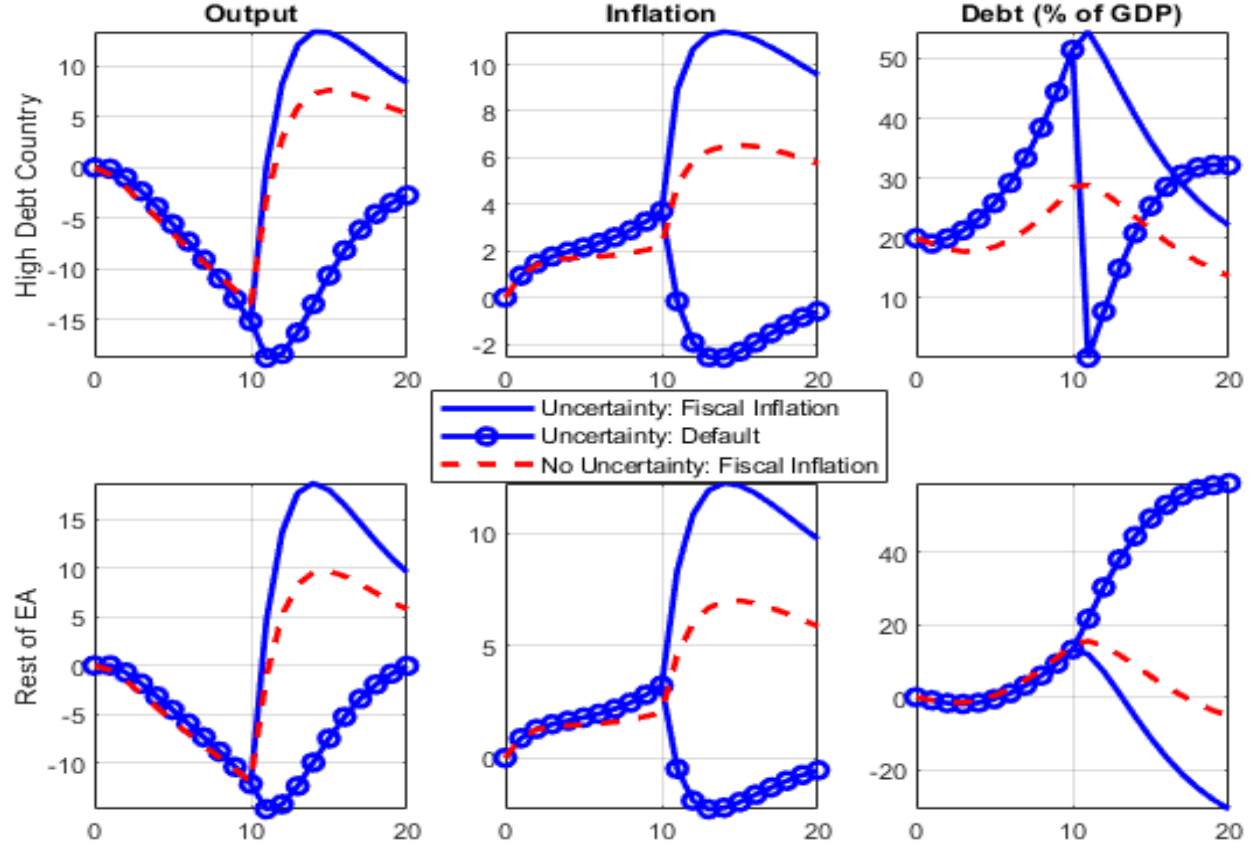


Figure 6: **Regime Uncertainty (Probability of Switch 10%) Costly Default:** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which the evolution of regimes is uncertain, and the economy moves from the NC to FL regime; the blue circle line captures regime uncertainty again, but the economy moves from NCC to DF and ML regimes, while the red dashed lines correspond to the case in which agents know that the lack of policy coordination will be resolved with high inflation.

A Equilibrium Conditions

In this appendix, we provide additional details about the model, such as the complete set of first order conditions and their linearized counterpart.

A.0.1 Savers

Composite consumption:

$$\tilde{C}_t^S(j) = C_t^S(j) + \alpha_G G_t \quad (16)$$

where $C_t^S(j)$ and G_t are private and public consumption, respectively.

The utility function

$$U_t^S = \ln \left(\tilde{C}_t^S(j) - \vartheta \tilde{C}_{t-1}^S \right) - \frac{L_t^S(j)^{1+\xi}}{1+\xi} \quad (17)$$

Capital accumulation equation

$$\bar{K}_t^S = (1 - \delta) \bar{K}_{t-1}^S + \left[1 - s \left(\frac{I_t^S(j)}{I_{t-1}^S(j)} \right) \right] I_t^S(j) \quad (18)$$

Capital services

$$K_t^S(j) = v_t(j) \bar{K}_{t-1}^S(j) \quad (19)$$

Budget constraint

$$\begin{aligned} & P_t^C (1 + \tau_t^C + \tau_t^{EA}) \tilde{C}_t^S + P_t^C I_t^S + Q_{t,t+1}(j) A_{t,t+1}(j) d\omega_{t,t+1}(j) + P_t^C O_t(j) \\ = & R_{t-1}^S P_{t-1}^C O_{t-1}(j) + (1 - \tau_t^L - \tau_t^{EA}) W_t(j) L_t^S(j) + (1 - \tau_t^K - \tau_t^{EA}) R_t^K v_t \bar{K}_{t-1}^S(j) \\ & - \psi(v_t) \bar{K}_{t-1}^S(j) + P_t^C Z_t^S + P_t^C Z_t^{S,EA} + D_t + A_t(j) \end{aligned} \quad (20)$$

Lagrange equation

$$L_t = E_{t=0}^\infty \beta^i \left\{ + \Lambda_{t+i}(j) \left[\begin{aligned} & \ln \left(\tilde{C}_{t+i}^S(j) - \vartheta \tilde{C}_{t+i-1}^S \right) - \chi_0 \frac{L_{t+i}^S(j)^{1+\xi}}{1+\xi} \\ & R_{t+i-1}^S P_{t-1+i}^C O_{t-1+i}(j) + (1 - \tau_{t+i}^L - \tau_{t+i}^{EA}) W_{t+i}(j) L_{t+i}^S(j) \\ & + (1 - \tau_{t+i}^K - \tau_{t+i}^{EA}) P_{t+i}^C R_{t+i}^K v_{t+i} \bar{K}_{t+i-1}^S(j) - P_{t+i}^C (1 + \tau_{t+i}^C + \tau_{t+i}^{EA}) \tilde{C}_{t+i}^S - P_{t+i}^C I_{t+i}^S \\ & - \psi(v_{t+i}) P_{t+i}^C \bar{K}_{t+i-1}^S(j) + P_{t+i}^C Z_{t+i}^S + P_{t+i}^C Z_{t+i}^{S,EA} + D_{t+i}(j) + A_{t+i}(j) \\ & - P_{t+i}^C O_{t+i}(j) - Q_{t+i,t+i+1}(j) A_{t+i,t+i+1}(j) d\omega_{t+i,t+i+1}(j) \\ & + \Phi_{t+i}(j) \left\{ (1 - \delta) \bar{K}_{t+i-1}^S + \left[1 - s \left(\frac{I_{t+i}^S(j)}{I_{t+i-1}^S(j)} \right) \right] I_{t+i}^S(j) - \bar{K}_{t+i}^S \right\} \end{aligned} \right] \right\} \quad (21)$$

First Order Conditions (a symmetric equilibrium is imposed):

Consumption

$$\Lambda_t P_t^C = \frac{1}{(1 + \tau_t^C + \tau_t^{EA}) (\tilde{C}_t^S - \vartheta \tilde{C}_{t-1}^S)} \quad (22)$$

Deposits

$$\Lambda_t = \beta \Lambda_{t+1} R_t^S \quad (23)$$

Capital

$$0 = -\Phi_t^K + \beta \{ \Lambda_{t+1} P_{t+1}^C [(1 - \tau_{t+i}^K - \tau_{t+i}^{EA}) R_{t+1}^K - \psi(v_{t+1})] + \Phi_{t+1} (1 - \delta) \}$$

Define Tobin's $Q_t^K = \frac{\Phi_t^K}{\Lambda_t P_t^C}$ then

$$Q_t^K = \beta \frac{\Lambda_{t+1} P_{t+1}^C}{\Lambda_t P_t^C} [(1 - \tau_{t+i}^K - \tau_{t+i}^{EA}) R_{t+1}^K v_{t+1} - \psi(v_{t+1}) + Q_{t+1}^K (1 - \delta)] \quad (24)$$

Utilisation

$$\psi'(v_t) = (1 - \tau_t^K - \tau_t^{EA}) R_t^K \quad (25)$$

Investment

$$0 = -\Lambda_t P_t^C + \Phi_t \left[1 - s \left(\frac{I_t^S}{I_{t-1}^S} \right) - s' \left(\frac{I_t^S}{I_{t-1}^S} \right) \right] + \beta \Phi_{t+1} s' \left(\frac{I_{t+1}^S}{I_t^S} \right) I_t^S$$

or

$$1 = Q_t^K \left[1 - s \left(\frac{I_t^S}{I_{t-1}^S} \right) - s' \left(\frac{I_t^S}{I_{t-1}^S} \right) \right] + \beta Q_{t+1}^K \frac{\Lambda_{t+1} P_{t+1}^C}{\Lambda_t P_t^C} s' \left(\frac{I_{t+1}^S}{I_t^S} \right) I_t^S \quad (26)$$

A.0.2 Wages

$$\max_{W_t^{new}} E_t \sum_{i=0}^{\infty} (\beta \xi_w)^i \left\{ -\chi_0 \frac{L_{t+i}^S(j)^{1+\xi}}{1+\xi} + \lambda_{t+i} \prod_{s=1}^i \frac{\Pi_{t+s-1}^{\chi_w} (\Pi_{t+s}^*)^{1-\chi_w} \gamma}{\Pi_{t+s}} (1 - \tau_{t+i}^L - \tau_{t+i}^{EA}) W_{t+i}(j) L_{t+i}^S(j) \right\} \quad (27)$$

subject to

$$L_{t+j}(j) = \left(\prod_{s=1}^i \frac{\Pi_{t+s-1}^{\chi_w} (\Pi_{t+s}^*)^{1-\chi_w} \gamma}{\Pi_{t+s}} \frac{\tilde{W}_t(\kappa)}{\tilde{W}_{t+i}} \right)^{-\frac{\lambda_w}{\lambda_w-1}} L_{t+i}^d \quad (28)$$

The first order is summarised by the following recursive equations

$$\begin{aligned}
\tilde{v}_t &= \tilde{\lambda}_t \frac{1}{\lambda_w} \left(\tilde{W}_t^{new} \right)_t^{\frac{1}{1-\lambda_w}} \tilde{W}_t^{\frac{\lambda_w}{\lambda_w-1}} (1 - \tau_t^L - \tau_t^{EA}) L_t^d + \beta \xi_w E_t \left(\frac{\Pi_t^{\chi_w} (\Pi_{t+1}^*)^{1-\chi_w} \gamma}{\Pi_{t+1}} \right)^{\frac{1}{1-\lambda_w}} \left(\frac{\tilde{W}_{t+1}^{new}}{\tilde{W}_t^{new}} \right)^{\frac{1}{\lambda_w-1}} \\
\tilde{v}_t &= \chi_0 \left(\frac{\tilde{W}_t}{\tilde{W}_t^{new}} \right)^{\frac{(1+\xi)\lambda_w}{\lambda_w-1}} (L_t^d)^{1+\xi} + \beta \xi_w E_t \left(\frac{\Pi_t^{\chi_w} (\Pi_{t+1}^*)^{1-\chi_w} \gamma}{\Pi_{t+1}} \right)^{\frac{(1+\xi)\lambda_w}{1-\lambda_w}} \left(\frac{\tilde{W}_{t+1}^{new}}{\tilde{W}_t^{new}} \right)^{\frac{(1+\xi)\lambda_w}{\lambda_w-1}} \tilde{v}_{t+1} \\
\tilde{W}_t^{\frac{1}{1-\lambda_w}} &= \omega_w \left(\frac{\Pi_{t-1}^{\chi_w} (\Pi_t^*)^{1-\chi_w} \gamma}{\Pi_t} \right)^{\frac{1}{1-\lambda_w}} \tilde{W}_{t-1}^{\frac{1}{1-\lambda_w}} + (1 - \omega_w) \left(\tilde{W}_t^{new} \right)^{\frac{1}{1-\lambda_w}}
\end{aligned}$$

A.0.3 No Savers

$$P_t^C (1 + \tau_t^C + \tau_t^{EA}) C_t^N = (1 - \tau_t^L - \tau_t^{EA}) W_t L_t + P_t^C Z_t^N + P_t^{EA} Z_t^{N,EA} \quad (32)$$

A.1 Financial Intermediary

Balance sheet

$$P_t^C O_t e^{\vartheta \Delta_t} = P_t^{EA} B_t^{EA} + P_t^C B_t^G + S_t P_t^{RoW} B_t^{RoW} \quad (33)$$

$$O_t e^{\vartheta \Delta_t} = \frac{B_t^{EA}}{\bar{p}_t^{EA}} + B_t^G + Q_t^{RoW} B_t^{RoW} \quad (34)$$

Profit function

$$\begin{aligned}
\Upsilon_t &= \frac{R_{t-1}^G (1 - \Delta_t)}{\Pi_t} B_{t-1}^G + \frac{R_{t-1} \varepsilon_t^{rp}}{\Pi_t \bar{p}_{t-1}^{EA}} B_{t-1}^{EA} + \frac{Q_t^{RoW}}{Q_{t-1}^{RoW}} \frac{R_{t-1}^{RoW} B_{t-1}^{RoW}}{\Pi_t^{RoW}} + O_t e^{\vartheta \Delta_t} - \frac{B_t^{EA}}{\bar{p}_t^{EA}} - B_t^G - \frac{R_{t-1}^S}{\Pi_t} O_{t-1} - \frac{s_B}{2\Pi_t} \\
\Upsilon_t &= \frac{R_{t-1}^G (1 - \Delta_t)}{\Pi_t} B_{t-1}^G + \frac{R_{t-1} \varepsilon_t^{rp}}{\Pi_t \bar{p}_{t-1}^{EA}} B_{t-1}^{EA} + \frac{Q_t^{RoW}}{Q_{t-1}^{RoW}} \frac{R_{t-1}^{RoW} B_{t-1}^{RoW}}{\Pi_t^{RoW}} - \frac{R_{t-1}^S}{\Pi_t e^{\vartheta \Delta_t}} \left(\frac{B_{t-1}^{EA}}{\bar{p}_{t-1}^{EA}} + B_{t-1}^G + Q_{t-1}^{RoW} B_{t-1}^{RoW} \right) -
\end{aligned}$$

Demand for EA bonds

$$0 = \frac{R_t \varepsilon_{t+1}^{rp}}{\Pi_{t+1} \bar{p}_t^{EA}} - \frac{R_t^S}{\Pi_{t+1} \bar{p}_t^{EA} e^{\vartheta \Delta_{t+1}}} + \frac{s_B}{\Pi_{t+1}} \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B_t^{EA}} \right) \frac{\bar{p}_t^{EA} B_t^G}{(B_t^{EA})^2}$$

$$\begin{aligned}
\frac{R_t^S}{\Pi_{t+1} \bar{p}_t^{EA} e^{\vartheta \Delta_{t+1}}} &= \frac{R_t \varepsilon_{t+1}^{rp}}{\Pi_{t+1} \bar{p}_t^{EA}} + \frac{s_B}{\Pi_{t+1}} \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B_t^{EA}} \right) \frac{\bar{p}_t^{EA} B_t^G}{(B_t^{EA})^2} \\
\frac{R_t^S}{e^{\vartheta \Delta_{t+1}}} &= R_t \varepsilon_{t+1}^{rp} + s_B \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B_t^{EA}} \right) \frac{(\bar{p}_t^{EA})^2 B_t^G}{(B_t^{EA})^2}
\end{aligned}$$

The demand for Government bonds

$$0 = \frac{R_t^G (1 - \Delta_{t+1})}{\Pi_{t+1}} - \frac{R_t^S}{\Pi_{t+1} e^{\vartheta \Delta_{t+1}}} - \frac{s_B}{\Pi_{t+1}} \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B^{EA}} \right) \frac{\bar{p}_t^{EA}}{B_t^{EA}}$$

$$\begin{aligned} R_t^G (1 - \Delta_{t+1}) &= R_t \varepsilon_{t+1}^{rp} + s_B \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B^{EA}} \right) \frac{(\bar{p}_t^{EA})^2 B_t^G}{(B_t^{EA})^2} + s_B \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B^{EA}} \right) \frac{\bar{p}_t^{EA}}{B_t^{EA}} \\ R_t^G (1 - \Delta_{t+1}) &= R_t \varepsilon_{t+1}^{rp} + s_B \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B^{EA}} \right) \frac{\bar{p}_t^{EA}}{B_t^{EA}} \left(1 + \frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} \right) \\ R_t^G (1 - \Delta_{t+1}) &= R_t \varepsilon_{t+1}^{rp} + s_B \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B^{EA}} \right) \frac{\bar{p}_t^{EA}}{B_t^{EA}} \frac{B_t^{EA} + \bar{p}_t^{EA} B_t^G}{B_t^{EA}} \\ R_t^G (1 - \Delta_{t+1}) &= \frac{1}{1 - E_t \Delta_{t+1}} \left\{ R_t \varepsilon_{t+1}^{rp} + s_B \left(\frac{\bar{p}_t^{EA} B_t^G}{B_t^{EA}} - \frac{B_t^G}{B^{EA}} \right) \frac{\bar{p}_t^{EA} B_t^{EA} + (\bar{p}_t^{EA})^2 B_t^G}{(B_t^{EA})^2} \right\} \end{aligned} \quad (35)$$

A.2 Firms

A.2.1 Intermediate Good Producers

Production Function

$$Y_t(\kappa) = (A_t L_t^d(\kappa))^{1-\alpha} K_t(\kappa)^\alpha - A_t \Omega \quad (36)$$

Demand for labour

$$P_t^C W_t = \varrho_t (1 - \alpha) \frac{P_t Y_t}{L_t^d}$$

Demand for Capital Services

$$P_t^C R_t^K = \varrho_t \alpha \frac{P_t Y_t}{K_t}$$

Capital-labour ratio

$$\frac{K_t}{L_t^d} = \frac{\alpha}{1 - \alpha} \frac{W_t}{R_t^K} \quad (37)$$

A.2.2 The Marginal Cost

The marginal cost is recovered by setting the intermediate supply equal to one and using the definition of real cost

Real Intermediate Production Cost

$$\begin{aligned}
RC_t &= \frac{P_t^C}{P_t^H} W_t L_t^d + \frac{P_t^C}{P_t^H} R_t^K K_t \\
&= \frac{P_t^C}{P_t^H} W_t L_t^d + \frac{P_t^C}{P_t^H} \frac{\alpha}{1-\alpha} W_t L_t^d \\
&= \frac{P_t^C}{P_t^H} \frac{1}{1-\alpha} W_t L_t^d
\end{aligned}$$

$$\begin{aligned}
1 &= (A_t L_t^d)^{1-\alpha} \left(\frac{\alpha}{1-\alpha} \frac{W_t}{R_t^K} L_t^d \right)^\alpha \\
L_t^d &= (A_t)^{-(1-\alpha)} \left(\frac{\alpha}{1-\alpha} \right)^{-\alpha} \left(\frac{W_t}{R_t^K} \right)^{-\alpha}
\end{aligned}$$

The substitution of the latter expression to the definition of the real cost delivers the

Marginal Cost

$$MC_t = \left(\frac{1}{1-\alpha} \right)^{1-\alpha} \left(\frac{W_t}{\bar{p}_t^H A_t} \right)^{1-\alpha} \left(\frac{1}{\alpha} \right)^\alpha \left(\frac{R_t^K}{\bar{p}_t^H} \right)^\alpha \quad (38)$$

A.2.3 Pricing Decisions

Prices as a solution to the following maximisation problem

Profit Maximisation Function

$$\max_{p_{i,t}^{new}} E_t \sum_{j=0}^{\infty} (\beta \omega_p)^j \frac{\tilde{\lambda}_{t+j}}{\tilde{\lambda}_t} \left\{ \left(\prod_{s=1}^j \Pi_{t+s-1}^{\chi_p} (\Pi_{t+s}^*)^{1-\chi_p} \frac{P_{i,t}^{new}}{P_{t+j}} - MC_{t+j} \right) Y_{i,t+j} \right\} \quad (39)$$

subject to

Demand for domestically produced intermediate output

$$\tilde{Y}_{i,t+j} = \left(\prod_{s=1}^j \Pi_{t+s-1}^{\chi_p} (\Pi_{t+s}^*)^{1-\chi_p} \frac{P_{i,t}^{new}}{P_{t+j}} \right)^{-\frac{\lambda_p}{\lambda_p-1}} \tilde{Y}_{t+j}^d \quad (40)$$

The first-order condition is expressed as a system of difference equations

$$F_{1,t} = \tilde{\lambda}_t MC_t \tilde{Y}_t^d + \beta \xi_p E_t \left(\frac{\Pi_t^{i_p} (\Pi_{t+1}^*)^{1-\chi_p}}{\Pi_{t+1}} \right)^{-\frac{\lambda_p}{\lambda_p-1}} F_{1,t+1} \quad (41)$$

$$F_{2,t} = \tilde{\lambda}_t \bar{\Pi}_t \tilde{Y}_t^d + \beta \xi_d E_t \left(\frac{\Pi_t^{i_p} (\Pi_{t+1}^*)^{1-\iota_p}}{\Pi_{t+1}} \right)^{-\frac{1}{\lambda_p-\chi_p-1}} \left(\frac{\bar{\Pi}_t}{\bar{\Pi}_{t+1}} \right) F_{2,t+1} \quad (42)$$

$$0 = \lambda_p F_{1,t} - F_{2,t} \quad (43)$$

$$1 = \xi_p \left(\frac{\Pi_{t-1}^{i_p} (\Pi_t^*)^{1-\iota_p}}{\Pi_t} \right)^{-\frac{1}{\lambda_p-1}} + (1 - \xi_p) \bar{\Pi}_t^{-\frac{1}{\lambda_p-1}} \quad (44)$$

where $\bar{\Pi}_t \equiv \frac{P_t^{new}}{P_t}$.

A.2.4 Importers

$$P_t^M = P_t^{H*}$$

Relative prices

$$\frac{P_t^M}{P_t^C} = \frac{P_t^{H*}}{P_t^{C*}} \frac{P_t^{C*}}{P_t^C}$$

$$\bar{P}_t^M = \bar{P}_t^{H*} Q_t$$

Marginal cost

$$mcm_t = \frac{\bar{P}_t^{H*} Q_t}{\bar{P}_t^M} \quad (45)$$

A.2.5 Final Good Producers

Production Function

$$N_t = \left[(1 - v_n)^{\frac{1}{\mu_n}} (Y_t)^{\frac{\mu_n-1}{\mu_n}} + v_n^{\frac{1}{\mu_n}} M_t^{\frac{\mu_n-1}{\mu_n}} \right]^{\frac{\mu_n}{\mu_n-1}} \quad (46)$$

$$P_t^C N_t = P_t^H Y_t + P_t^M M_t \quad (47)$$

CPI

$$P_t^C = \left[(1 - v_n) (P_t^H)^{1-\mu_n} + v_n (P_t^F)^{1-\mu_n} \right]^{\frac{1}{1-\mu_n}} \quad (48)$$

Demand for domestically produced output

$$Y_t = (1 - v_n) \left(\frac{P_t^H}{P_t^C} \right)^{-\mu_n} N_t \quad (49)$$

Demand for Imports

$$M_t = v_n \left(\frac{P_t^F}{P_t^C} \right)^{-\mu_n} N_t \quad (50)$$

A.3 Policymakers

A.3.1 National Fiscal Authority

Government Budget Constrains

$$\frac{P_t^C B_t}{R_t^G} + \tau_t^K P_t^C R_t^K K_t + \tau_t^W P_t^C W_t + \tau_t^C P_t^C C_t = (1 - \Delta_t) P_{t-1}^C B_{t-1} + P_t^C G_t + P_t^C Z_t + P_t^C Z_t^\Delta \quad (51)$$

Fiscal Rules

$$\hat{\tau}_t^J = \rho^J \hat{\tau}_{t-1}^J + (1 - \rho^J) \gamma^J (\hat{b}_{t-1} - \hat{y}_{t-1}) \quad (52)$$

$$\hat{g}_t = \rho^G \hat{g}_{t-1} - (1 - \rho^G) \gamma^G (\hat{b}_{t-1} - \hat{y}_{t-1}) \quad (53)$$

$$\hat{z}_t = \rho^Z \hat{z}_{t-1} - (1 - \rho^Z) \gamma^Z (\hat{b}_{t-1} - \hat{y}_{t-1}) - (1 - \rho^Z) \phi^Z \hat{y}_{t-1} \quad (54)$$

A.3.2 EA Authorities

EA Budget Constraints

$$\begin{aligned} & \frac{P_t^{EA,C} B_t^{EA}}{R_t} + \tau_t^{EA,K} \left(P_t^C R_t^K K_t + P_t^{C,*} R_t^{K,*} K_t^* \right) \\ & + \tau_t^{EA,W} \left(P_t^C W_t L_t + P_t^{C,*} W_t^* L_t^* \right) + \tau_t^{EA,C} \left(P_t^C C_t + P_t^{C,*} C_t^* \right) \\ & = P_{t-1}^{EA,C} B_{t-1}^{EA} + P_t^C Z_t^{EA} + P_t^{C,*} Z_t^{EA,*} \end{aligned} \quad (55)$$

Fiscal Rules

$$\hat{\tau}_t^{EA,J} = \rho^J \hat{\tau}_{t-1}^{EA,J} + (1 - \rho^J) \gamma^J (\hat{b}_{t-1}^{EA} - \hat{y}_{t-1}^{EA}) \quad (56)$$

$$\hat{z}_t^{EA} = \rho^Z \hat{z}_{t-1}^{EA} - (1 - \rho^Z) \gamma^Z (\hat{b}_{t-1}^{EA} - \hat{y}_{t-1}^{EA}) - (1 - \rho^Z) \phi^Z \hat{y}_{t-1}^{EA} \quad (57)$$

Taylor Rule

$$\hat{r}_t = \rho_r \hat{r}_{t-1} + (1 - \rho_r) (\phi_\pi \hat{\pi}_t^{EA} + \phi_y \hat{y}_t^{EA}) + u_t^r \quad (58)$$

A.4 Market Clearing Conditions

$$\Psi_t = C_t + I_t + G_t + X_t + \psi(v_t) \bar{K}_{t-1}^S(j) \quad (59)$$

$$Y_t^{EA} = (Y_t)^{w_y} (Y_t^*)^{(1-w_y)} \quad (60)$$

$$P_t^{C,EA} = (P_t^C)^{w_p} (P_t^{C,*})^{1-w_p} \quad (61)$$

$$C_t = (1 - \mu) C_t^S + \mu C_t^N \quad (62)$$

A.5 Stationary Equations

A.5.1 Households

Consumption Aggregator

$$\tilde{c}_t^S = c_t^S + \alpha_G g_t \quad (63)$$

Capital

$$\bar{k}_t^S = (1 - \delta) \frac{\bar{k}_{t-1}^S}{\gamma_t} + \left[1 - \frac{s}{2} \left(\frac{i_t \gamma}{i_{t-1} \gamma_t} - 1 \right)^2 \right] i_t \quad (64)$$

Consumption

$$\lambda_t \left(1 + \tau_t^C + \tau_t^{C,EA} \right) = \left(\tilde{c}_t^S - \frac{\vartheta \tilde{c}_{t-1}^S}{\gamma_t} \right)^{-1} \quad (65)$$

EA Bonds

$$\frac{\gamma_{t+1} \pi_{t+1}}{r_t \varepsilon_t^{rp}} = \beta E_t \frac{\lambda_{t+1}}{\lambda_t} \quad (66)$$

Government Yields

$$r_t^G = \frac{r_t \varepsilon_t^{rp}}{1 - \Delta_{t+1}} \quad (67)$$

Capital

$$q_t^K = \beta \frac{\lambda_{t+1}}{\lambda_t \gamma_{t+1}} \left[\left(1 - \tau_{t+1}^K - \tau_{t+1}^{K,EA} \right) r_{t+1}^K v_{t+1} - \psi(v_{t+1}) + q_{t+1}^K (1 - \delta) \right] \quad (68)$$

Utilisation

$$\psi'(v_t) = (1 - \tau_t^K - \tau_t^{EA}) r_t^K \quad (69)$$

$$\begin{aligned} \psi(v_t) &= \psi_1(v_t - 1) + \frac{\psi_2}{2} (v_t - 1)^2 \\ \psi'(v_t) &= \psi_1 + \psi_2 (v_t - 1) \end{aligned}$$

Investment

$$\begin{aligned} 1 &= q_t^K \left[1 - \frac{s}{2} \left(\frac{i_t \gamma_t}{i_{t-1} \gamma} - 1 \right)^2 - s \left(\frac{i_t \gamma_t}{i_{t-1} \gamma} - 1 \right) \frac{i_t \gamma_t}{i_{t-1} \gamma} \right] \\ &\quad + \beta q_{t+1}^K \beta \frac{\lambda_{t+1}}{\lambda_t \gamma_{t+1}} s \left(\frac{i_{t+1} \gamma_{t+1}}{i_t \gamma} - 1 \right) \left(\frac{i_{t+1}}{i_t} \right)^2 \frac{\gamma_{t+1}}{\gamma} \end{aligned} \quad (70)$$

Capital services

$$k_t = v_t \frac{\bar{k}_{t-1}}{\gamma_t} \quad (71)$$

Non savers

$$\left(1 + \tau_t^C + \tau_t^{C,EA}\right) c_t^N = \left(1 - \tau_t^L - \tau_t^{L,EA}\right) w_t l_t + z_t^N + \frac{z_t^{N,EA}}{\bar{p}_t^{EA}} \quad (72)$$

A.5.2 Firms

Productions function

$$y_t = (l_t^d)^{1-\alpha} k_t^\alpha - \Omega \quad (73)$$

Capital to labour ratio

$$\frac{k_t}{l_t^d} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t^K} \quad (74)$$

Marginal Cost

$$mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha} w_t^{1-\alpha} \left(\frac{1}{\alpha}\right)^\alpha (r_t^K)^\alpha \frac{1}{\bar{p}_t^H} \quad (75)$$

Price PP curve

$$f_{1,t} = \lambda_t mc_t y_t^d + \beta \omega_p E_t \left(\frac{\pi_t^{\chi_p} \pi^{1-\chi_p}}{\pi_{t+1}} \right)^{-\frac{\lambda_p}{\lambda_p-1}} f_{1,t+1} \quad (76)$$

$$f_{2,t} = \lambda_t \bar{\pi}_t \theta_t^d + \beta \omega_p E_t \left(\frac{\pi_t^{\chi_p} \pi^{1-\chi_p}}{\pi_{t+1}} \right)^{-\frac{1}{\lambda_p-\chi_p-1}} \left(\frac{\bar{\pi}_t}{\bar{\pi}_{t+1}} \right) f_{2,t+1} \quad (77)$$

$$0 = \lambda_p F_{1,t} - F_{2,t} \quad (78)$$

$$1 = \omega_p \left(\frac{\pi_t^{\chi_p} \pi^{1-\chi_p}}{\pi_t} \right)^{-\frac{1}{\lambda_p-1}} + (1 - \omega_p) \bar{\pi}_t^{-\frac{1}{\lambda_p-1}} \quad (79)$$

where $\bar{\pi}_t \equiv \frac{P_t^{new}}{P_t}$.

Production Function

$$n_t = \left[(1 - v_n)^{\frac{1}{\mu_n}} (y_t)^{\frac{\mu_n-1}{\mu_n}} + v_n^{\frac{1}{\mu_n}} (m_t \varpi_t)^{\frac{\mu_n-1}{\mu_n}} \right]^{\frac{\mu_n}{\mu_n-1}} \quad (80)$$

CPI

$$1 = \left[(1 - v_n) (\bar{p}_t^H)^{1-\mu_n} + v_n (\bar{p}_t^F)^{1-\mu_n} \right]^{\frac{1}{1-\mu_n}} \quad (81)$$

Demand for domestically produced output

$$y_t = (1 - v_n) (\bar{p}_t^H)^{-\mu_n} n_t \quad (82)$$

Demand for Imports

$$m_t \varpi_t = v_n (\bar{p}_t^F)^{-\mu_n} n_t \quad (83)$$

$$n_t = \bar{p}_t^H y_t + \bar{p}_t^F m_t \quad (84)$$

A.5.3 Wage PP Curve

$$v_t = \lambda_t \frac{1}{\lambda_w} (w_t^{new})_t^{\frac{1}{1-\lambda_w}} w_t^{\frac{\lambda_w}{\lambda_w-1}} (1 - \tau_t^L - \tau_t^{EA}) l_t^d + \beta \xi_w E_t \left(\frac{\pi_t^{\chi_w} \pi^{1-\chi_w} \gamma}{\pi_{t+1}} \right)^{\frac{1}{1-\lambda_w}} \left(\frac{w_{t+1}^{new} \gamma_{t+1}}{w_t^{new}} \right)^{\frac{1}{\lambda_w-1}} \quad (85)$$

$$v_t = \chi_0 \left(\frac{w_t}{w} \right)^{\frac{(1+\xi)\lambda_w}{\lambda_w-1}} (l_t^d)^{1+\xi} + \beta \xi_w E_t \left(\frac{\pi_t^{\chi_w} \pi^{1-\chi_w} \gamma}{\pi_{t+1}} \right)^{\frac{(1+\xi)\lambda_w}{1-\lambda_w}} \left(\frac{w_{t+1}^{new} \gamma_{t+1}}{w_t^{new}} \right)^{\frac{(1+\xi)\lambda_w}{\lambda_w-1}} v_{t+1} \quad (86)$$

$$w_t^{\frac{1}{1-\lambda_w}} = \omega_w \left(\frac{\pi_{t-1}^{\chi_w} \pi^{1-\chi_w} \gamma}{\pi_t} \right)^{\frac{1}{1-\lambda_w}} \left(\frac{w_{t-1}}{\gamma_t} \right)^{\frac{1}{1-\lambda_w}} + (1 - \omega_w) (w_t^{new})^{\frac{1}{1-\lambda_w}} \quad (87)$$

A.5.4 Policymakers

Government Budget Constrains

$$b_t + \tau_t^K r_t^K k_t + \tau_t^W w_t l_t + \tau_t^C c_t = \frac{r_t^G}{\pi_t \gamma_t} (1 - \Delta_t) b_{t-1} + g_t + z_t + z_t^\Delta \quad (88)$$

EA Budget Constraint

$$\begin{aligned} & b_t^{EA} + \tau_t^{EA,K} \left(\bar{p}_t^{EA} r_t^K k_t + \bar{p}_t^{*,EA} r_t^{K,*} k_t^* \right) + \tau_t^{EA,W} \left(\bar{p}_t^{EA} w_t l_t + \bar{p}_t^{*,EA} w_t^* l_t^* \right) + \tau_t^{EA,C} \left(\bar{p}_t^{EA} c_t + \bar{p}_t^{*,EA} c_t^* \right) \\ &= \frac{r_t b_{t-1}^{EA}}{\gamma_t \pi_t^{EA}} + \bar{p}_t^{EA} z_t^{EA} + \bar{p}_t^{*,EA} z_t^{EA,*} \end{aligned} \quad (89)$$

Fiscal Rules

$$\hat{\tau}_t^J = \rho^J \hat{\tau}_{t-1}^J + (1 - \rho^J) \gamma^J (\hat{b}_{t-1} - \hat{y}_{t-1}) \quad (90)$$

$$\hat{g}_t = \rho^G \hat{g}_{t-1} - (1 - \rho^G) \gamma^G (\hat{b}_{t-1} - \hat{y}_{t-1}) \quad (91)$$

$$\hat{z}_t = \rho^Z \hat{z}_{t-1} - (1 - \rho^Z) \gamma^Z (\hat{b}_{t-1} - \hat{y}_{t-1}) - (1 - \rho^Z) \phi^Z \hat{y}_{t-1} \quad (92)$$

$$\hat{\tau}_t^{EA,J} = \rho^J \hat{\tau}_{t-1}^{EA,J} + (1 - \rho^J) \gamma^J (\hat{b}_{t-1}^{EA} - \hat{y}_{t-1}^{EA}) \quad (93)$$

$$\hat{z}_t^{EA} = \rho^Z \hat{z}_{t-1}^{EA} - (1 - \rho^Z) \gamma^Z (\hat{b}_{t-1}^{EA} - \hat{y}_{t-1}^{EA}) - (1 - \rho^Z) \phi^Z \hat{y}_{t-1}^{EA} \quad (94)$$

Fiscal Rules Taylor Rule

$$\hat{r}_t = \rho_r \hat{r}_{t-1} + (1 - \rho_r) (\phi_\pi \hat{\pi}_t^{EA} + \phi_y \hat{y}_t^{EA}) + u_t^r \quad (95)$$

A.5.5 Market Clearing Conditions

$$n_t = c_t + i_t + g_t + x_t + \psi(v_t) \frac{k_{t-1}}{\gamma_t} \quad (96)$$

Or

$$\bar{p}_t^H y_t = c_t + i_t + g_t + x_t - \bar{p}_t^F m_t \quad (97)$$

$$y_t^{EA} = (y_t)^{w_y} (y_t^*)^{(1-w_y)} \quad (98)$$

$$1 = \left(\frac{1}{\bar{p}_t^{EA}} \right)^{w_p} \left(\frac{1}{\bar{p}_t^{*,EA}} \right)^{1-w_p} \quad (99)$$

$$c_t = (1 - \mu) c_t^S + \mu c_t^N \quad (100)$$

A.6 Steady States

$$r = \frac{\gamma\pi}{\beta} \quad (101)$$

$$r^K = \frac{\gamma - (1 - \delta)\beta}{(1 - \tau^K - \tau^{EA})\beta} \quad (102)$$

$$mc = \frac{\varepsilon - 1}{\varepsilon} \quad (103)$$

$$w = \left(\frac{mc}{\left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^\alpha (r^K)^\alpha} \right)^{\frac{1}{1-a}} \quad (104)$$

Set $l = 1/3$ then

$$k = \frac{\alpha}{1 - \alpha} \frac{w}{r^K} l \quad (105)$$

$$i = \left(\frac{\gamma - 1 + \delta}{\gamma} \right) \bar{k} \quad (106)$$

Zero profits condition

$$\begin{aligned} y - wl - r^K k &= 0 \\ l^{1-\alpha} k^\alpha - \Omega - wl - r^K k &= 0 \\ l^{1-\alpha} k^\alpha - wl - r^K k &= \Omega \end{aligned}$$

Given $\frac{g}{y}$, $\frac{x}{y}$ and $\frac{m}{y}$ then

$$\frac{c}{y} = 1 - \frac{i}{y} - \frac{g}{y} - \frac{x}{y} + \frac{m}{y} \quad (107)$$

$$n = y + m \quad (108)$$

$$v_n = \frac{m}{n} \quad (109)$$

$$\psi_1 = \frac{\gamma - (1 - \delta) \beta}{\beta} \quad (110)$$

$$r_t^G = r \quad (111)$$

$$r_t^S = r \quad (112)$$

$$z = b \left(1 - \frac{r^G}{\pi \gamma} \right) + \tau^K r^K k + \tau^W w l + \tau^C c - g \quad (113)$$

$$\begin{aligned} (1 + \tau^C + \tau^{C,EA}) c^N &= (1 - \tau^L - \tau^{L,EA}) w l + z^N + z^{N,EA} \\ z^{N,EA} &= (1 + \tau^C + \tau^{C,EA}) c - (1 - \tau^L - \tau^{L,EA}) w l \end{aligned} \quad (114)$$

A.7 Linearised Equations Domestic Economy

A.7.1 Households

Consumption Aggregator

$$\widehat{c}_t^S = \frac{c}{\bar{c}} \widehat{c}_t^S + \alpha_G \frac{g}{\bar{c}} \widehat{g}_t \quad (115)$$

Capital

$$\widehat{k}_t = \frac{1 - \delta}{\gamma} \left(\widehat{k}_{t-1} - \widehat{\gamma}_t \right) + \frac{i}{\bar{k}} \widehat{i}_t \quad (116)$$

Consumption

$$\widehat{\lambda}_t + \frac{\tau^C}{1 + \tau^C + \tau^{C,EA}} \widehat{\tau}_t^C + \frac{\tau^{EA}}{1 + \tau^C + \tau^{EA}} \widehat{\tau}_t^{C,EA} = -\frac{\gamma}{\gamma - \vartheta} \widehat{c}_t^S + \frac{\vartheta}{\gamma - \vartheta} \widehat{c}_{t-1}^S - \frac{\vartheta}{\gamma - \vartheta} \widehat{\gamma}_t \quad (117)$$

EA Bonds

$$\widehat{\lambda}_t = E_t \widehat{\lambda}_{t+1} + E_t \left(\widehat{r}_t^S - \widehat{\gamma}_{t+1} - \widehat{\pi}_{t+1} \right) \quad (118)$$

Capital

$$\begin{aligned} \widehat{q}_t^K &= E_t \widehat{\lambda}_{t+1} - \widehat{\lambda}_t - \widehat{\gamma}_{t+1} + \frac{\gamma - (1 - \delta) \beta}{\gamma} \left(\widehat{r}_{t+1}^K + \widehat{v}_{t+1} \right) - \frac{(\gamma - (1 - \delta) \beta) \tau^K}{\gamma (1 - \tau^K - \tau^{K,EA})} \widehat{\tau}_{t+1}^K \\ &\quad - \frac{(\gamma - (1 - \delta) \beta) \tau^{K,EA}}{\gamma (1 - \tau^K - \tau^{K,EA})} \widehat{\tau}_{t+1}^{K,EA} + \frac{\beta (1 - \delta)}{\gamma} \widehat{q}_{t+1}^K \end{aligned} \quad (119)$$

Utilisation

$$\begin{aligned}
\psi_2 \hat{v}_t &= (1 - \tau^K - \tau^{K,EA}) r^K \hat{r}_t^K - \tau^K r^K \hat{r}_t^K - \tau^K r^K \hat{r}_t^{K,EA} \\
\frac{\psi_2}{(1 - \tau^K - \tau^{EA}) r^K} \hat{v}_t &= \hat{r}_t^K - \frac{\tau^K r^K}{(1 - \tau^K - \tau^{K,EA}) r^K} \hat{r}_t^K - \frac{\tau^K r^{K,EA}}{(1 - \tau^K - \tau^{K,EA}) r^K} \hat{r}_t^{K,EA} \\
\hat{r}_t^K &= \frac{\psi}{1 - \psi} \hat{v}_t + \frac{\tau^K}{1 - \tau^K - \tau^{K,EA}} \hat{r}_t^K + \frac{\tau^{K,EA}}{1 - \tau^K - \tau^{K,EA}} \hat{r}_t^{K,EA} \quad (120)
\end{aligned}$$

Investment

$$\hat{i}_t = \frac{1}{1 + \beta} (\hat{i}_{t-1} - \hat{\gamma}_t) + \frac{\beta}{1 + \beta} (\hat{i}_{t+1} + \hat{\gamma}_{t+1}) + \frac{1}{(1 + \beta)s} \hat{q}_t^K$$

Capital services

$$\hat{k}_t = \hat{v}_t + \hat{k}_{t-1} - \hat{\gamma}_t \quad (121)$$

Non savers

$$\begin{aligned}
\hat{c}_t^N &= \frac{(1 - \tau^L - \tau^{L,EA}) w l}{(1 + \tau^C + \tau^{C,EA}) c^N} (\hat{w}_t + \hat{l}_t) - \frac{\tau^L w l}{(1 + \tau^C + \tau^{C,EA}) c^N} \hat{r}_t^L - \frac{\tau^C}{1 + \tau^C + \tau^{C,EA}} \hat{r}_t^C \\
&\quad - \frac{\tau^{C,EA}}{1 + \tau^C + \tau^{C,EA}} \hat{r}_t^{C,EA} - \frac{\tau^{L,EA} w l}{(1 + \tau^C + \tau^{C,EA}) c^N} \hat{r}_t^{LEA} + \frac{z^N}{(1 + \tau^C + \tau^{EA}) c^N} \hat{z}_t^N \\
&\quad + \frac{z^{N,EA}}{(1 + \tau^C + \tau^{EA}) c^N} (\hat{z}_t^{N,EA} - \hat{p}_t^{EA})
\end{aligned}$$

A.7.2 Financial Intermediaries

$$\begin{aligned}
\hat{r}_t^G &= \hat{d}_{t+1} + \hat{r}_t + \hat{\varepsilon}_{t+1}^{rp} + s_B \frac{B^{EA} + B^G}{r (B^{EA})^2} \frac{B^G}{B^{EA}} (\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA}) \\
\hat{r}_t^G &= \hat{r}_t + \hat{d}_{t+1} + \hat{\varepsilon}_{t+1}^{rp} + \tilde{s}_B (\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA}) \quad (122)
\end{aligned}$$

$$\begin{aligned}
\hat{r}_t^S - \vartheta \hat{d}_{t+1} &= \hat{r}_t + \hat{\varepsilon}_{t+1}^{rp} + \frac{B^G}{r (B^{EA})^2} \frac{B^G}{B^{EA}} (\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA}) \\
\hat{r}_t^S - \vartheta \hat{d}_{t+1} &= \hat{r}_t + \hat{\varepsilon}_{t+1}^{rp} + \frac{B^{EA} + B^G}{r (B^{EA})^2} \frac{B^G}{B^{EA}} \frac{B^G}{B^{EA} + B^G} (\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA}) \\
\hat{r}_t^S &= \hat{r}_t + \hat{\varepsilon}_{t+1}^{rp} + \tilde{s}_B \frac{B^G}{B^{EA} + B^G} (\hat{b}_t^G + \hat{p}_t^{EA} - \hat{b}_t^{EA}) + \vartheta \hat{d}_{t+1} \quad (123)
\end{aligned}$$

A.7.3 Firms

Productions function

$$\hat{y}_t = \frac{y + \Omega}{y} \left[(1 - \alpha) \hat{l}_t + \alpha \hat{k}_t \right] \quad (124)$$

Capital to labour ratio

$$\hat{k}_t - \hat{l}_t = \hat{w}_t - \hat{r}_t^K \quad (125)$$

Marginal Cost Domestic Firms

$$\widehat{mc}_t = (1 - a) \hat{w}_t + \alpha \hat{r}_t^K - \widehat{p}_t^H$$

Domestic Price PP curve

$$\hat{\pi}_t^H = \frac{\beta}{1 + \chi_p \beta} E_t \hat{\pi}_{t+1}^H + \frac{\chi_p}{1 + \chi_p \beta} \hat{\pi}_{t-1}^H + \frac{(1 - \omega_p)(1 - \beta \omega_p)}{\omega_p(1 + \beta \chi_p)} \widehat{mc}_t$$

Marginal Cost Importing Firms

$$\widehat{mcm}_t = \hat{q}_t + \widehat{p}_t^{H,*} - \widehat{p}_t^F$$

Import Price PP curve

$$\hat{\pi}_t^F = \frac{\beta}{1 + \chi_m \beta} E_t \hat{\pi}_{t+1}^F + \frac{\chi_m}{1 + \chi_m \beta} \hat{\pi}_{t-1}^F + \frac{(1 - \omega_m)(1 - \beta \omega_m)}{\omega_m(1 + \beta \chi_m)} \widehat{mcm}_t$$

CPI

$$\hat{\pi}_t = (1 - v_n) \hat{\pi}_t^H + v_n \hat{\pi}_t^F \quad (126)$$

Demand for domestically produced output

$$\hat{y}_t = -\mu_\psi \widehat{p}_t^H + \hat{n}_t \quad (127)$$

Demand for Imports

$$\hat{m}_t + \hat{\omega}_t = -\mu_\psi \widehat{p}_t^F + \hat{n}_t \quad (128)$$

Final output producers' constraint

$$\hat{n}_t = \frac{y}{n} \left(\widehat{p}_t^H + \hat{y}_t \right) + \frac{m}{n} \left(\widehat{p}_t^F + \hat{m}_t \right) \quad (129)$$

A.7.4 Wage PP Curve

$$\begin{aligned}
\hat{w}_t = & \frac{1}{1+\beta} \hat{w}_{t-1} + \frac{\beta}{1+\beta} E_t \hat{w}_{t+1} + \frac{\chi_w}{1+\beta} \hat{\pi}_{t-1} - \frac{1+\beta\chi_w}{1+\beta} \hat{\pi}_t + \frac{\beta}{1+\beta} E_t \hat{\pi}_{t+1} \\
& - \frac{(1-\omega_w\beta)(1-\omega_w)}{\omega_w(1+\beta)\left(1+\xi\left(1+\frac{1}{\lambda_w}\right)\right)} \left(\hat{w}_t - \xi \hat{l}_t + \hat{\lambda}_t - \frac{\tau^L}{1-\tau^L-\tau^{L,EA}} \hat{\tau}_t^L - \frac{\tau^{L,EA}}{1-\tau^L-\tau^{L,EA}} \hat{\tau}_t^{L,EA} \right) \\
& + \frac{\chi_w}{1+\beta} \hat{\gamma}_{t-1} - \frac{1+\beta\chi_w-\rho_\gamma\beta}{1+\beta} \hat{\gamma}_t
\end{aligned} \tag{130}$$

A.7.5 Policymakers

Government Budget Constrains

$$\begin{aligned}
& \frac{b}{y} \hat{b}_t + \frac{\tau^K r^K k}{y} \left(\hat{\tau}_t^K + \hat{r}_t^K + \hat{k}_t \right) + \frac{\tau^L w l}{y} \left(\hat{\tau}_t^L + \hat{w}_t + \hat{l}_t \right) + \frac{\tau^C c}{y} \left(\hat{\tau}_t^C + \hat{c}_t \right) \\
= & \frac{b}{y} \frac{1}{\beta} \hat{b}_{t-1} + \frac{b}{y} \frac{1}{\beta} \left(\hat{r}_{t-1}^G - \hat{\pi}_t - \hat{\gamma}_t \right) - \frac{b}{y} \frac{1}{\beta} \hat{d}_t + \frac{g}{y} \hat{g}_t + \frac{z}{y} \hat{z}_t + \frac{z^\Delta}{y} \hat{z}_t^\Delta
\end{aligned} \tag{131}$$

We set as in xxxx to limit the positive economic effect from the default

$$\frac{z^\Delta}{y} \hat{z}_t^\Delta = \frac{b}{y} \frac{1}{\beta} \hat{d}_t$$

In this case

$$\begin{aligned}
& \frac{b}{y} \hat{b}_t + \frac{\tau^K r^K k}{y} \left(\hat{\tau}_t^K + \hat{r}_t^K + \hat{k}_t \right) + \frac{\tau^L w l}{y} \left(\hat{\tau}_t^L + \hat{w}_t + \hat{l}_t \right) + \frac{\tau^C c}{y} \left(\hat{\tau}_t^C + \hat{c}_t \right) \\
= & \frac{b}{y} \frac{1}{\beta} \hat{b}_{t-1} + \frac{b}{y} \frac{1}{\beta} \left(\hat{r}_{t-1}^G - \hat{\pi}_t - \hat{\gamma}_t \right) + \frac{g}{y} \hat{g}_t + \frac{z}{y} \hat{z}_t
\end{aligned}$$

EA Budget Constrains

$$\begin{aligned}
& \frac{b^{EA}}{y^{EA}} \hat{b}_t^{EA} + \frac{\tau^{EA,K} r^K k}{y^{EA}} \left(\hat{\tau}_t^{K,EA} + \hat{r}_t^K + \hat{k}_t + \hat{p}_t^{EA} \right) + \frac{\tau^{K,EA} r^{K*} k^*}{y^{EA}} \left(\hat{\tau}_t^{K*,EA} + \hat{r}_t^{K*} + \hat{k}_t^* + \hat{p}_t^{*,EA} \right) \\
& + \frac{\tau^{L,EA} w l}{y^{EA}} \left(\hat{\tau}_t^{L,EA} + \hat{w}_t + \hat{l}_t + \hat{p}_t^{EA} \right) + \frac{\tau^{L,EA} w^* l^*}{y^{EA}} \left(\hat{\tau}_t^{L,EA} + \hat{w}_t^* + \hat{l}_t^* + \hat{p}_t^{*,EA} \right) \\
& + \frac{\tau^{C,EA} c}{y^{EA}} \left(\hat{\tau}_t^{C,EA} + \hat{c}_t + \hat{p}_t^{EA} \right) + \frac{\tau^{C,EA} c^*}{y^{EA}} \left(\hat{\tau}_t^{C,EA} + \hat{c}_t^* + \hat{p}_t^{*,EA} \right) \\
= & \frac{b^{EA}}{y^{EA}} \frac{1}{\beta} \hat{b}_{t-1}^{EA} + \frac{b^{EA}}{y^{EA}} \frac{1}{\beta} \left(\hat{r}_{t-1} - \hat{\pi}_t^{EA} - \hat{\gamma}_t^{EA} \right) + \frac{z^{EA}}{y^{EA}} \hat{z}_t^{EA}
\end{aligned} \tag{132}$$

Fiscal Rules

$$\hat{\tau}_t^J = \rho^J \hat{\tau}_{t-1}^J + (1 - \rho^J) \gamma^J (\hat{b}_{t-1} - \hat{y}_{t-1}) \quad (133)$$

$$\hat{g}_t = \rho^G \hat{g}_{t-1} - (1 - \rho^G) \gamma^G (\hat{b}_{t-1} - \hat{y}_{t-1}) \quad (134)$$

$$\hat{z}_t = \rho^Z \hat{z}_{t-1} - (1 - \rho^Z) \gamma^Z (\hat{b}_{t-1} - \hat{y}_{t-1}) - (1 - \rho^Z) \phi^Z \hat{y}_{t-1} \quad (135)$$

$$\hat{\tau}_t^{EA,J} = \rho^J \hat{\tau}_{t-1}^{EA,J} + (1 - \rho^J) \gamma^J (\hat{b}_{t-1}^{EA} - \hat{y}_{t-1}^{EA}) \quad (136)$$

$$\hat{z}_t^{EA} = \rho^Z \hat{z}_{t-1}^{EA} - (1 - \rho^Z) \gamma^Z (\hat{b}_{t-1}^{EA} - \hat{y}_{t-1}^{EA}) - (1 - \rho^Z) \phi^Z \hat{y}_{t-1}^{EA} \quad (137)$$

Fiscal Rules Taylor Rule

$$\hat{r}_t = \rho_r \hat{r}_{t-1} + (1 - \rho_r) (\phi_\pi \hat{\pi}_t^{EA} + \phi_y \hat{y}_t^{EA}) + u_t^r \quad (138)$$

A.7.6 Market Clearing Conditions

$$\hat{\psi}_t = \frac{c}{\psi} \hat{c}_t + \frac{i}{\psi} \hat{i}_t + \frac{g}{\psi} \hat{g}_t + \frac{x}{\psi} \hat{x}_t + \frac{\psi'(1)k}{\psi\gamma} \hat{v}_t \quad (139)$$

$$\hat{y}_t^{EA} = w_y \hat{y}_t + (1 - w_y) \hat{y}_t \quad (140)$$

$$0 = w_p \widehat{\bar{p}}_t^{EA} + (1 - w_p) \widehat{\bar{p}}_t^{*,EA} \quad (141)$$

$$\hat{c}_t = (1 - \mu) \hat{c}_t^S + \mu \hat{c}_t^N \quad (142)$$

$$\bar{p}_t^{EA} = \bar{p}_t^{EA*} - q_t \quad (143)$$

B No Costly Default Figures

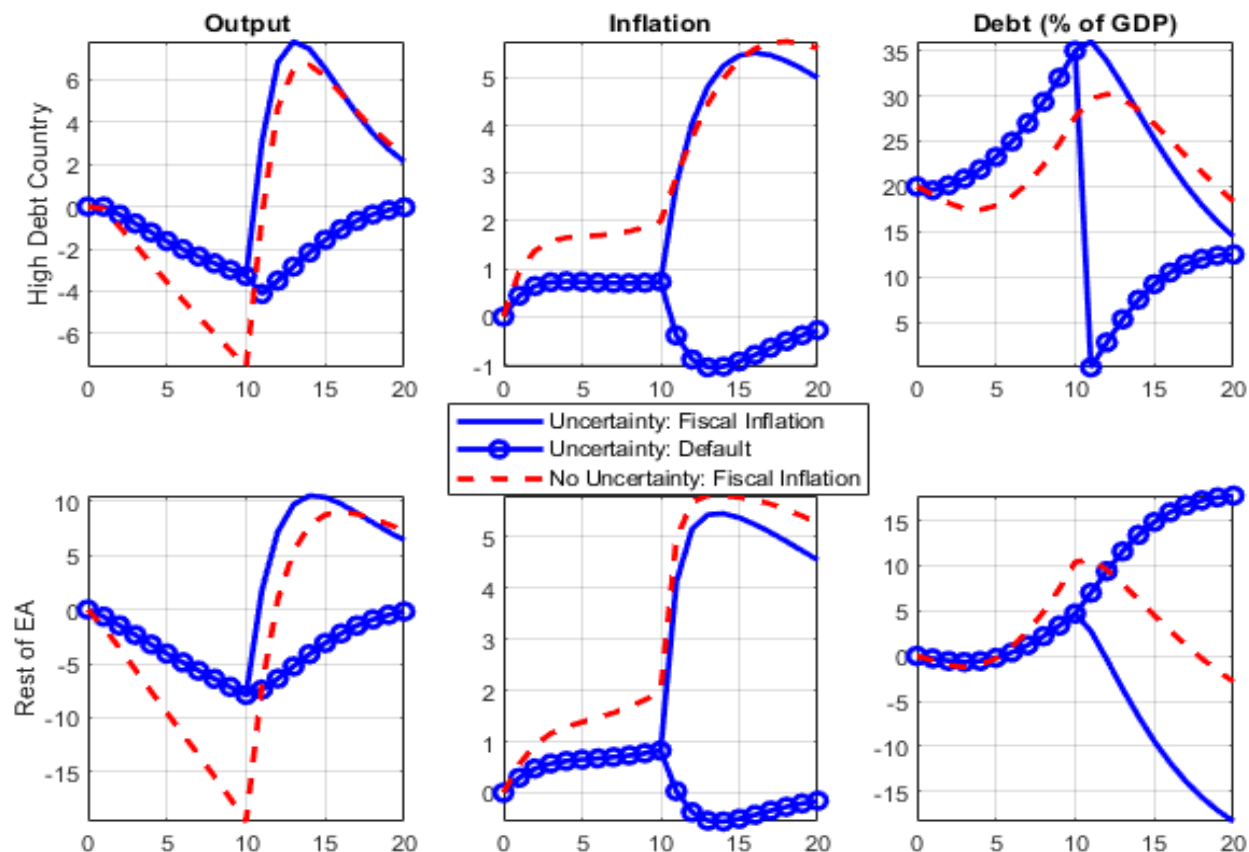


Figure 7: **Regime Uncertainty (Probability of Switch 5%) No Costly Default:** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which the evolution of regimes is uncertain, and the economy moves from the NC to FL regime; the blue circle line captures regime uncertainty again, but the economy moves from NCC to DF and ML regimes, while the red dashed lines correspond to the case in which agents know that the lack of policy coordination will be resolved with high inflation.

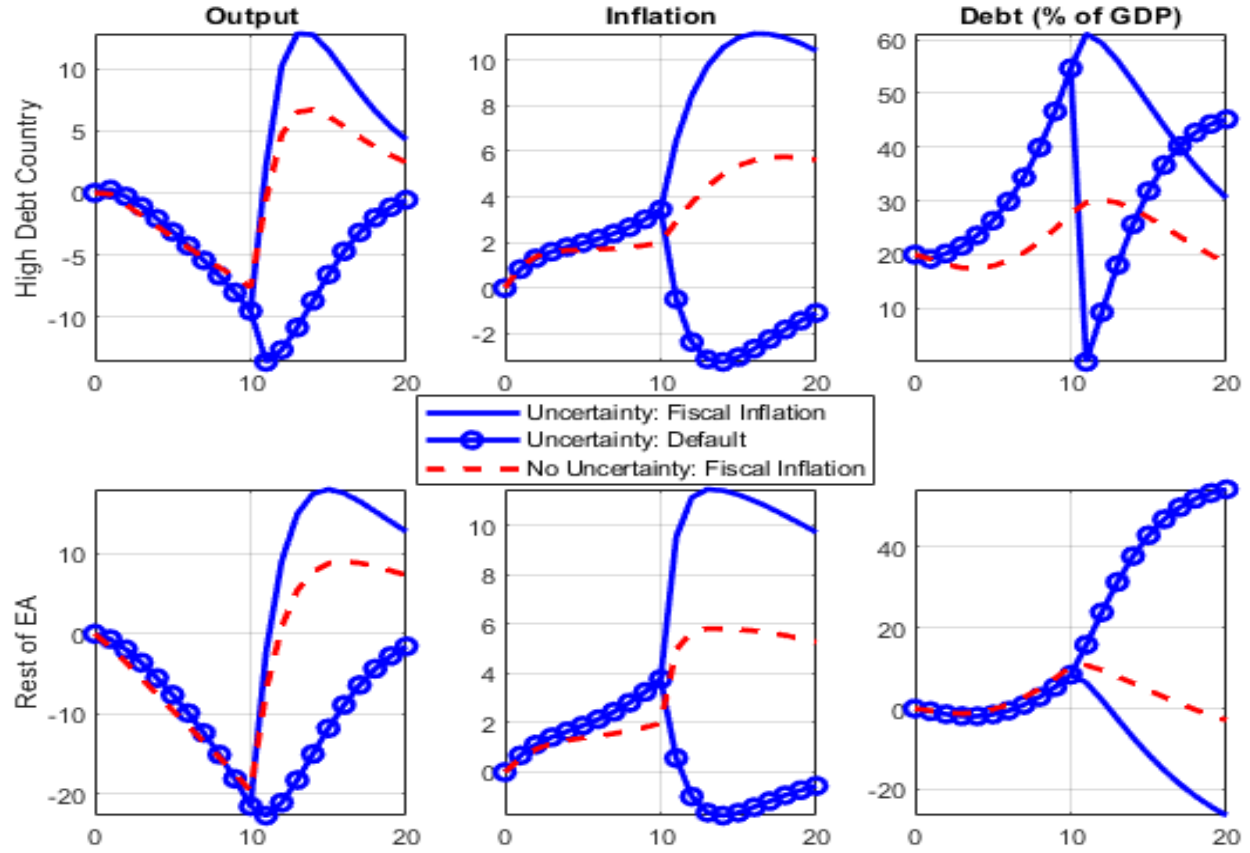


Figure 8: **Regime Uncertainty (Probability of Switch 10%) No Costly Default:** In the first row, we report the responses for the high-debt country, while in the second row, we report the responses for the rest of the Euro Area. The blue solid lines correspond to the case in which the evolution of regimes is uncertain, and the economy moves from the NC to FL regime; the blue circle line captures regime uncertainty again, but the economy moves from NCC to DF and ML regimes, while the red dashed lines correspond to the case in which agents know that the lack of policy coordination will be resolved with high inflation.