Exit and default premia in currency unions

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Abstract

The adoption of a common currency is not irreversible. In this paper, we study how expectations of a small member state's exit from the union impacts its economy. If the new currency, introduced upon exit, is expected to depreciate, all securities issued under domestic law carry an exit (or redenomination) premium. Contrasting exit premia to sovereign default premia gives rise to three results. First, exit and default premia tend to reinforce each other. Second, both premia can induce explosive dynamics of public debt while the economy still operates within the currency union. Third, exit and default premia impact macroeconomic dynamics differently. It is thus possible to identify exit and default premia in actual time-series data. Specifically, we estimate the model on Greek data and quantify the contribution of exit and default premia to macroeconomic outcomes during the period 2009–2012.

Keywords: Currency union, exit, fiscal policy, regime change, redenomination premium, euro, Greek crisis, Markov-switching linear rational expectations model

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1 Introduction

Currency unions provide a nominal anchor to inflation-prone member states (Alesina and Barro, 2002). Delegating monetary policy to a hawkish central bank reduces inflation bias and thus differences in nominal interest rates across member states. The euro area is a case in point. Figure 1 displays monthly yield spreads on government bonds for Italy, Spain, Ireland, and Greece relative to Germany: they fell strongly in the run up to the creation of the euro in 1999 and stayed close to zero for about a decade. Their rise after 2009, at times of protracted budget deficits and large public liabilities, is often interpreted as a compensation for the possibility of an outright sovereign default (Lane, 2012). Yet, in addition to default premia, these yield spreads may also reflect "fears of a reversibility of the euro" (ECB, 2013). Indeed, expectations of a member state's exit from the union may give rise to premia, too: if bonds are expected to be converted into a new, weaker currency, their prices decline prior to exit, driving up yields.[1]

In this paper, we ask how one can tell such exit and default premia apart. Both premia compensate bond holders for losses in the event of an exit or default. Both premia also share the adverse impact on public finances. Still, as we find in our model-based analysis, the macroeconomic implications of exit and default expectations differ substantially. This makes identification possible. Specifically, we develop a model of a small open economy which is a member of a currency union. Policy regimes may change, however, and market participants are fully aware of this possibility. Regime change includes, in a first scenario, exit from the currency union. In a second scenario, the policy regime entails a default on public debt.

Policy regimes change according to an exogenous probability. However, in the event, investors suffer losses proportional to outstanding government debt, such that exit and default premia fluctuate endogenously over time. Exit premia arise, because the country adopts an inflationary policy mix after exit. Specifically, the newly independent monetary policy adjusts interest rates less than one-for-one to inflation thereby permitting a revaluation of public debt. At the same time, fiscal policy stops adjusting taxes in a systematic way to the stock of outstanding public debt. As a result, the nominal exchange rate depreciates upon exit in proportion with the level of outstanding public debt—an instance of the fiscal theory of the price level.[2] We focus on the implications for the economy while it still operates within the

[1] For the euro area, there is evidence of exit expectations from the online betting markets (Shambaugh, 2012). In February 2012 Buiter and Rahbari (2012) coined the term "Grexit" and suggest a "likelihood of a Greek exit to 50% over the next 18 months". In May 2012 the German Ifo-think tank published a report on "Greece's exit from European Monetary Union: historical experience, macroeconomic implications and organisational implementation", see Born et al. (2012).

[2] We use simple rules to specify policies. Upon exit fiscal policy is assumed to be "active" in the sense of Leeper (1991), while monetary policy "passive" monetary policy; for the fiscal theory of the price level see

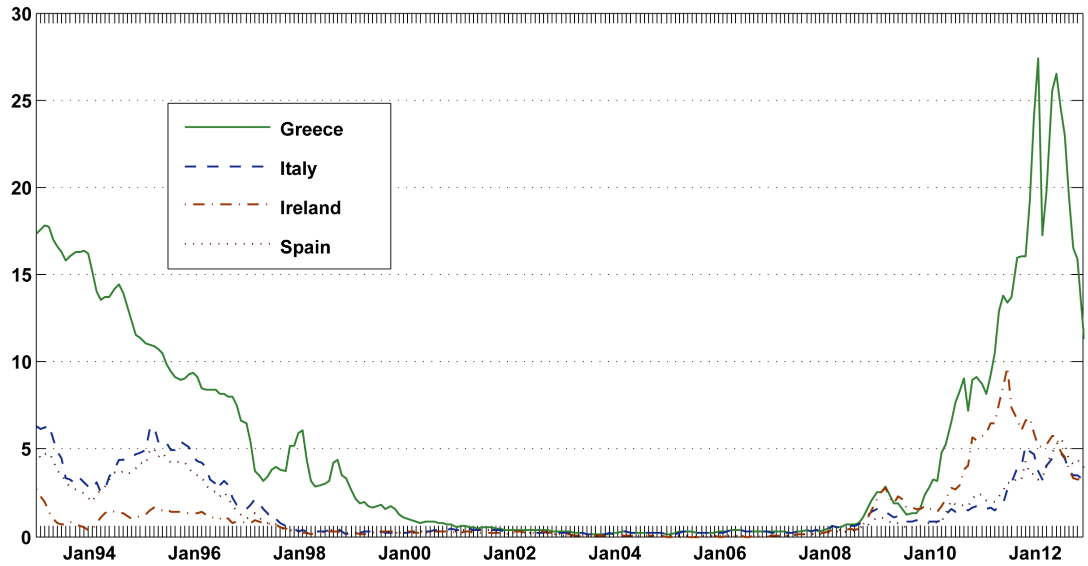

Figure 1: Interest rate spread vis-à-vis Germany. Notes: Long-term interest rates for convergence purposes, monthly observations 1993:1–2012:12; source: ECB.

currency union: securities expected to be converted into new currency carry an exit premium, reflecting expectations of debt redenomination and devaluation after exit. These premia rise with the level of public debt.

Default premia, in turn, arise because the government defaults in some states of the world by repudiating a constant fraction of its liabilities. Hence, also in this case, premia rise with the level of public debt. Of course, debt repudiation and currency redenomination often occur jointly. Na et al. (2014) rationalize this observation in a model where policy makers determine both default and exchange rates optimally. Central to their analysis is the assumption that governments are indebted in foreign currency, the 'original sin' of many emerging market economies. As a result, currency redenomination is ineffective in reducing the real value of debt and there is no devaluation premium. In our analysis, instead, we assume—in line with actual practise in the euro area—that public debt is governed by domestic law and can thus be converted into new currency by its issuer.

However, also in our model exit and default premia are fundamentally intertwined. To see this, note that both exit and default premia impact public finances adversely. If fiscal policy fails to raise taxes sufficiently, public debt will rise. A vicious cycle ensues, as premia rise further and the stock of public debt builds up. This is a first result of our analysis. A second result is that until actual regime change—exit or default—takes place, exit and default premia,

Woodford (1995), Cochrane (2001), and Sims (2013); for the open-economy dimension, see Woodford (1996), Sims (1997) or Bergin (2000). Uribe (2006) studies sovereign default in a fiscal-theory environment.

each contributing to an ever rising debt stock, mutually reinforce each other. The economy may thus undergo a severe debt crisis, depending on how likely market participants consider exit and default to begin with. However, an economy's vulnerability to such a debt crisis also depends on its capacity to raise tax revenues in response to a weakening of the fiscal outlook. As a third result, we find that expectations about exit and default, while being reflected similarly in government bond yields, have distinct implications for how public debt impacts the economy. If public debt is high, expectations about exit drive up interest rates, not only for the sovereign, but also for private borrowers. As a result economic activity declines. At the same time, inflation takes off already before the actual exit takes place due to forward-looking price-setting decisions. Overall, exit expectations thus induce public debt to have a stagflationary effects. Given default expectations, public debt also has a recessionary effect if sovereign default premia spill over into the private sector (Bocola, 2014; Corsetti et al., 2013). The recessionary effect of default expectations, however, is accompanied by deflation, rather than inflation. This allows us to identify exit and default expectations in actual time-series data.

We do so by estimating the model on Greek data for the period between late 2009 and early 2012. The upward revision of the fiscal deficit at the beginning of this period presumably triggered expectations of exit and default in the first place. Indeed, the term "Grexit" has been coined at the time. In due course, with rising bond yields and a spiralling public debt-to-GDP ratio, the macroeconomic outlook deteriorated further. Eventually, debt was restructured in early 2012. We expose the model to the actual time series of the CPI and interest rates in the public and private sector. We find that exit premia contributed only little to the development of sovereign yields, but account for up to one third of the rise in yields in the private sector. As such, exit expectations did have a nonnegligible impact on the stagflationary developments observed in Greece during our sample period.

Our paper takes up a theme which featured prominently in earlier work on the stability of exchange rate regime, namely that an expected regime change tends to destabilize an existing regime (Krugman, 1979; Lahiri and Végh, 2003; Obstfeld, 1996). Models of the euro crisis which focus on sovereign default risk and abstract from the possibility of exit are put forward by Bi (2012) and Daniel and Shiamptanis (2012). There are also model-free attempts to identify redenomination risk. De Santis (2014) seeks to identify redenomination risk on the basis of CDS spreads, thereby de facto conditioning his findings on default taking place simultaneously with exit. Krishnamurthy et al. (2014) suggest an identification strategy which relies on the simultaneous use of sovereign and private-sector yields. Finally, the present paper relates to the regime-switching models of Davig and Leeper (2007b, 2011) and Bianchi and

Ilut (2012), who put forward models where monetary and fiscal policy rules changes over time. Andolfatto and Gomme (2003) analyze a model with changes in money growth rules and imperfect information. Yet these papers study closed-economy models.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 develops our main findings regarding the nature of exit and default premia. We discuss details regarding the estimation of the model in section 4. Section 5 concludes.

2 The model

We model an open economy which is sufficiently small so as to have a negligible impact on the rest of the world. There is a representative household and monopolistically competitive firms, restricted in their ability to adjust prices.[3] Households supply labor to firms, purchase goods produced domestically and in the rest of the world, and trade nominally non-contingent bonds with the rest of the world.

We capture the behavior monetary and fiscal policy through simple feedback rules. The government issues nominal debt and raises lump-sum taxes. Government debt carries a default premium, as the government reneges on its debt obligations in some states of the world. The economy either forms a currency union with the rest of the world or operates an independent monetary policy.

As a key feature of our analysis, we allow policy rules to change over time, in a way consistent with agents' expectations. Indeed, as stressed by Davig and Leeper (2007a), once it is recognized that policy regimes may differ across time, it seems desirable to endow agents in the model economy with this very insight. In order to keep the analysis tractable, we assume exogenously given beliefs of regime change within a Markov-Switching Rational Expectations Model.[4]

2.1 Model structure

In what follows we outline the model structure in general terms. Below, in section 2.2, we present a linear approximation to the equilibrium conditions and specify the transition across policy regimes.

[3]We thus consider a New Keynesian environment which have been studied extensively, also in the context of small open economies, see, for instance Kollmann (2001) or Galí and Monacelli (2005).

[4]In a stylized two-period model of exchange-rate policies, Drazen and Masson (1994) make beliefs about regime change a function of both the credibility of policy makers and the state of the economy.

2.1.1 Representative household

The representative household has preferences over consumption, C_t, and hours worked in firm $j \in [0,1]$, $H_t(j)$:

$$E_0 \sum_{t=0}^{\infty} \beta_t \left[\log C_t - \eta_t \int_0^1 \frac{H_t(j)^{1+\varphi}}{1+\varphi} dj \right],$$

where φ^{-1} the Frisch elasticity of labor supply and η_t captures a variation in preferences which acts as a cost-push shock for firms. The discount factor is endogenous and assumed to depend on the country's real net foreign asset position, scaled by steady state output, Y, in deviation from steady state:

$$\beta_{t+1} = \beta \left(1 + \alpha \left[\frac{\mathcal{E}_{t-1} \tilde{B}^*_{t-1}}{P_{H,t-1} Y} - \zeta_{B^*} \right] \right)^{-1} \beta_t, \quad \beta_0 = 1.$$

While quantitatively inconsequential for short-run dynamics, this assumption eliminates a unit root in the net foreign asset position, which otherwise plagues small open economies with incomplete international financial markets.[5] In this expression, $\mathcal{E}_t$ is the nominal exchange rate (the price of foreign currency in terms of home currency), $P_{H,t}$ is the producer price level and $\tilde{B}^*_t$ are the country's net foreign assets (denoted in terms of foreign currency). α is a positive constant and β is the discount factor in the rest of the world.
Consumption is a composite of goods produced at Home, $C_{H,t}$, and abroad, $C_{F,t}$, as follows

$$C_t = \left((1-\omega) C_{H,t}^{1-\sigma} + \omega C_{F,t}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}.$$

Here, σ denotes the elasticity of intratemporal substitution, and ω denotes the degree of home-bias in consumption. In turn, consumption at Home is a CES aggregate defined over different varieties

$$C_{H,t} = \left(\int_0^1 C_{H,t}(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}},$$

and analogous abroad. We denote $\varepsilon > 1$ the degree of substitutability between the different varieties. Expenditure minimization implies the following price indices for goods produced at home and imported goods

$$P_{H,t} = \left(\int_0^1 P_{H,t}(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}, \qquad P_{F,t} = \left(\int_0^1 P_{F,t}(j)^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}.$$

By the same token, the consumer price index is

$$P_t = \left((1-\omega) P_{H,t}^{1-\sigma} + \omega P_{F,t}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}.$$

[5] Below we seek to study stationary dynamics of an approximate model around a deterministic steady state. Schmitt-Grohe and Uribe (2003) discuss alternative strategies to "close" small open economy models.

We assume an isomorphic aggregation technology in the rest of the world. Furthermore, we assume the law of one price holds at the level of intermediate goods such that

$$P_{F,t} = \mathcal{E}_t P_t^*.$$

The household trades several securities on international financial markets. An important distinction in this regard is whether securities are issued under domestic or foreign law. Whenever the domestic economy is (starting to operate or already) operating an independent monetary policy, securities issued under domestic (foreign) law are denominated in domestic (foreign) currency. When the domestic economy is part of a currency union, all securities are denominated in common currency. Also in this case, however, the law under which securities are issued cannot be ignored, as payoffs are contingent on whether the domestic economy remains part of the currency union in the future.[6]

Specifically, letting B_t denote privately traded discount bonds issued under domestic law (in zero net supply), B_t^* discount bonds issued under foreign law, and D_t government debt assumed to be issued under domestic law, the budget constraint reads as follows

$$\begin{aligned} &Q_{D,t} D_t + Q_{B,t} B_t + Q_{B^*,t} B_t^* \mathcal{E}_t + P_t C_t \\ &\qquad = \int_0^1 \left(W_t H_t(j) + \mathcal{Y}_t(j) \right) dj - T_t + (1-\delta_t) D_{t-1} + B_{t-1} + B_{t-1}^* \mathcal{E}_t. \end{aligned}$$

In case the government defaults, it applies a haircut to its outstanding liabilities of size $\delta_t \in [0,1]$. W_t denotes wages and $\mathcal{Y}_t(j)$ are profits from firm j which accrue to the household. T_t are lump-sum taxes raised by the government.

Finally, regarding bond prices $Q_{i,t},\ i \in \{D, B, B^*\}$, we allow for the possibility that sovereign default risk spills over to the private sector:

$$Q_{B,t} = R_t^{-1} E_t (1 - \chi \delta_{t+1}), \quad Q_{B^*,t} = R^{*-1} E_t (1 - \chi \delta_{t+1}).$$

Here, R_t denotes the nominally risk-free (shadow) interest rate and R^* is the (constant) nominal interest rate in the rest of the world. The parameter $\chi \geq 0$ captures the degree of spillover. Following Corsetti et al. (2013) we rationalize a value of χ larger than zero by the observation that private-sector contracts may not be fully enforced in the event of a sovereign default. Importantly, however, we assume that even though lenders may not be fully serviced in the event of sovereign default, borrowers may not retains resources. Rather, resources meant

[6] The discussion of a possible Grexit suggests that securities issued under Greek law were indeed expected to be converted into new currency upon exit (see, for example, Buiter and Rahbari 2012). Similarly, historical examples of "forcible conversions" of debt issued in foreign currency, but under home law highlights the role of jurisdiction for currency conversions (Reinhart and Rogoff 2011).

for repayment of loans get lost in the event of a sovereign default.[7] Moreover, we stress that the household can borrow at the risk free rate neither domestically nor internationally, but rather has to pay an elevated interest rate.[8]

2.1.2 Firms

Firms operate in a monopolistically competitive environment and face price adjustment frictions à la Calvo. Furthermore, they are subject to distortionary sales taxation. A generic firm $j \in [0,1]$ operates a linear technology of the form

$$Y_t(j) = H_t(j)$$

and maximizes the present value of dicounted profits

$$\max_{P_{H,t}(j)} E_t \sum_{k=0}^{\infty} \xi^k \Xi_{t,t+k} Y_{t,t+k}(j) \left[P_{H,t}(j) - W_{t+k}\right]$$

subject to demand

$$Y_{t,t+k}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t+k}}\right)^{-\varepsilon} Y_{t+k}.$$

Here, $P_{H,t}(j)$ denotes the reset price of firm j at time t, ξ is the probability of not being able to reset, $\Xi_{t,t+1} \equiv \beta_{t+1}/\beta_t \frac{C_t}{C_{t+1}} \frac{P_t}{P_{t+1}}$ is the nominal stochastic discount factor of the household.

2.1.3 Monetary and fiscal policy

In case the country maintains a currency union with the rest of the world, there is no independent monetary policy. Formally, this is equivalent to monetary policy implementing a targeting rule for the exchange rate. Alternatively, if the country operates an independent monetary policy, we stipulate a simple interest-rate feedback rule. Formally, we thus have the following alternative specifications for monetary policy:

$$\mathcal{E}_t \equiv 1, \text{ or } \quad \log(R_t/R) = \phi_\pi \log(P_{H,t}/P_{H,t-1}).$$

We thus assume that an independent central bank targets producer-price inflation, and that steady-state inflation is equal to unity.[9]

[7]Otherwise, borrowers' *effective* interest rate would not rise with sovereign risk, see also Curdia and Woodford (2010). Bocola (2014) models the pass-through of sovereign risk while explicitly accounting for financial intermediation.

[8]As we consider a representative household in the domestic economy, we effectively assume that domestic financial markets are complete. Still, in this case sovereign risk may raise private sector rates to the extent that payoffs associated with a complete set of state-contingent assets are accessed only intermittently (Corsetti et al., 2013).

[9]Note that we assume the central bank policy rate is R_t, rather than the interest rate distorted by the sovereign risk channel, $Q_{B,t}^{-1}$. In our framework, this is without loss of generality, as there will be no risk of default in regimes where the central bank is independent.

As regards fiscal policy, the government's flow budget constraint evolves according to

$$Q_{D,t}D_t = D_{t-1}(1-\delta_t) - T_t.$$

We assume the government raises lump sum taxes in order to service the debt:

$$\frac{T_t}{P_{H,t}Y} = \frac{T}{PY} + \psi\left(\frac{D_{t-1}}{P_{H,t-1}Y} - \zeta_D\right) - \epsilon_t,$$

where ϵ_t constitutes a one-off transfer of ressources from the government to the household, or a "deficit shock". Furthermore, $\zeta_D := D/PY \geq 0$ denotes the debt-to-GDP ratio in steady state, and T/PY is the corresponding steady state tax revenue. The parameter ψ measures the responsiveness of taxes to the level of debt.
In turn, a sovereign default is of size

$$\delta_t = \delta\left(\frac{Q_D D_{t-1}}{P_{H,t}Y} - \zeta_D\right)/\zeta_D,$$

where $\delta \in [0,1]$. We therefore assume the government defaults on a fraction δ of its debt stock in excess of steady state.

2.1.4 Market Clearing

Denote $S_t \equiv P_{F,t}/P_{H,t}$ the Home country's terms of trade. Using that Home is small (i.e. that $P_t^* = P_{F,t}^*$ and $C_t^* = Y_t^*$), goods market clearing is given by

$$Y_t = (1-\omega)\left(\frac{P_{H,t}}{P_t}\right)^{-\sigma} C_t + \omega S_t^\sigma Y_t^*,$$

where we define $Y_t = \left(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}$ as a measure of aggregate output. Output in the rest of the world, Y_t^*, is exogenous from the perspective of the domestic economy.
Market clearing in the labour market implies

$$\Delta_t Y_t = H_t,$$

where $\Delta_t \equiv \int_0^1 \frac{Y_t(j)}{Y_t} dj$ is a measure of dispersion of activity among firms, equal to zero up to a first-order approximation (see for instance Galí and Monacelli 2005) and H_t is aggregate hours worked by the household.
Finally, market clearing in asset markets requires $B_t = 0$, and that aggregate net foreign assets equal net foreign assets at the individual level, $B_t^* = \tilde{B}_t^*$.

2.2 Equilibrium with changing policy regimes

We base our analysis on a Markov-Switching Linear Rational Expectations (MS-LRE) model, which in a first step requires linearization of all equilibrium conditions around a deterministic steady state. We assume that the steady state is the same across policy regimes. In a second step, we specify the transition across policy regimes.

2.2.1 Linear approximation of equilibrium conditions

We approximate equilibrium conditions around a zero inflation steady state. Furthermore purchasing power parity holds in steady state while public debt and net foreign assets possibly differ from zero. In what follows, we refer to variables in terms of log-deviations from this steady state using small-case letters. Hats above a variable denote percentage-point deviation. Note also that we only consider shocks which affect the domestic economy and treat the rest of the world as exogenous. All derivations can be found in the appendix.

A first set of equilibrium conditions is *invariant across policy regimes.* Optimal household behavior requires the following Euler equation to be satisfied

$$c_t = E_t c_{t+1} - (r_t + \chi E_t \delta_{t+1} - \alpha \hat{b}^*_{t-1} - E_t \pi_{t+1}). \tag{2.1}$$

Note the household's consumption-saving decision is altered by sovereign default risk whenever $\chi > 0$. Net foreign assets $\hat{b}^r_{t-1}$ appear in the Euler equation because of the endogenous discount factor. Finally, $\pi_t := p_t - p_{t-1}$ is CPI inflation.

Optimal intratemporal decisions of the household give rise to the consumption-labor tradeoff

$$w_t - p_t = c_t + \varphi h_t + \eta_t. \tag{2.2}$$

An Euler equation prices net foreign assets, which yields the familiar uncovered interest parity (UIP) condition

$$r_t = E_t \Delta e_{t+1}. \tag{2.3}$$

The net foreign asset position, in turn, evolves as

$$\beta \hat{b}^*_t + \zeta_c c_t = y_t - \zeta_c \omega s_t + \hat{b}^*_{t-1} + \zeta_{B^*}(\beta \chi E_t \delta_{t+1} - \pi_{H,t} + \Delta e_t). \tag{2.4}$$

Here, ζ_{B^*} denotes net foreign assets in steady state. We assume it to be negative in order to rationalize possible spillovers from sovereign default premia into private borrowing conditions. $\zeta_c = 1 + (1-\beta)\zeta_B$ corresponds to consumption over output in steady state.

The behavior of firms requires the following relations to hold in equilibrium

$$y_t = h_t \tag{2.5}$$

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa(w_t - p_{H,t}), \tag{2.6}$$

where $\pi_{H,t} := p_{H,t} - p_{H,t-1}$ denotes producer price inflation and $\kappa := (1-\beta\xi)(1-\xi)/\xi$. Good market clearing requires

$$y_t = ((1-\omega)\zeta_c + \zeta_{y^*})\omega\sigma s_t + (1-\omega)\zeta_c c_t + \omega\zeta_{y^*} y_t^*, \tag{2.7}$$

where y_t^* effectively is a rest-of-the-world demand shock and $\zeta_{y^*} = 1 - (1-\omega)(1-\beta)\zeta_c/\omega$ is world demand over output in steady state.

The consumer price index relates to producer prices, the nominal exchange rate and the terms of trade as

$$p_t = (1-\omega)p_{H,t} + \omega e_t \tag{2.8}$$

$$s_t = e_t - p_{H,t}. \tag{2.9}$$

Now turn to fiscal policy. The country's debt-to-GDP ratio evolves as

$$\beta\hat{d}_t^r = \hat{d}_{t-1} - \hat{\tau}_t + \zeta_D(\beta i_t - \pi_{H,t} - \delta_t) - \hat{t}_t, \tag{2.10}$$

where and i_t is the government bond yield. It satisfies the following no-arbitrage condition:

$$i_t = r_t + E_t\delta_{t+1}. \tag{2.11}$$

A second set of equilibrium relationships *varies across policy regimes*. Specifically, fiscal policy can be described by

$$\hat{t}_t = \psi_{\varsigma_t}\hat{d}_{t-1} - \epsilon_t, \tag{2.12}$$

where ψ_{ς_t} captures the responsiveness of taxes to debt which varies across regimes and ϵ_t denotes the deficit shock. The haircut is

$$\delta_t = \zeta_D^{-1}\delta_{\varsigma_t}\hat{d}_{t-1} \tag{2.13}$$

and applies only in regimes where $\delta_{\varsigma_t} \neq 0$. More specifically, the parameters ψ and δ evolve according to a Markov chain specified below. In turn, monetary policy is summarized by

$$e_t = 0 \quad \text{or} \quad r_t = \phi_\pi \pi_{H,t}. \tag{2.14}$$

2.2.2 Policy regimes and stability

We consider the following three policy regimes, reflecting the particular interest of our analysis:

Union:	$e_t = 0,$	$\psi > 1-\beta,$	$\delta = 0$	(2.14 - 1)
Union Default:	$e_t = 0,$	$\psi > 1-\beta,$	$\delta > 0$	(2.14 - 2)
Float:	$r_t = \phi_\pi\pi_{H,t}$ $(\phi_\pi < 1),$	$\psi = 0,$	$\delta = 0$	(2.14 - 3)

Regimes "Union" and "Union Default" are characterized by membership in a currency union. In both regimes, ψ is strictly positive such that taxes adjust with movements in debt-to-GDP. Indeed, ψ is assumed big enough such that, absent expectations about regime change, fiscal policy ensures intertemporal solvency. This corresponds to "passive fiscal policy" in the terminology of Leeper (1991). Moreover, in regime "Union Default", the government engineers a haircut of size $\delta_t > 0$ on its debt.
By contrast, regime "Float" is characterized by monetary autonomy. In this regime, fiscal policy is "active", as it does not adjust taxes with the level of debt (Leeper 1991). By contrast, monetary poliy is assumed "passive", adjusting interest rates less than one-by-one with inflation ($\phi_\pi < 1$).

We are now in the position to define an equilibrium, following Farmer et al. (2011). First, we restate equations (2.1) - (2.14) more compactly:

$$\Gamma_{\varsigma_t} x_t = E_t x_{t+1} + \Psi_{\varsigma_t} \varepsilon_t, \quad \varsigma_t \in \{\text{Union, Union Default, Float, Union}\}, \tag{2.15}$$

where $x_t = (y_t, h_t, r_t, i_t, \delta_t, \pi_{H,t}, p_{H,t}, \pi_t, p_t, w_t, e_t, s_t, , \hat{d}_t, \hat{t}_t, \hat{b}_t^*)'$ and $\pi_{H,t} = p_{H,t} - p_{H,t-1}$, $\pi_t = p_t - p_{t-1}$. The shocks are summarized by $\varepsilon_t = (\epsilon_t, \eta_t, y_t^*)'$. The matrices Γ_{ς_t} and Ψ_{ς_t} contain the model's deep parameters and ς_t indicates that they are regime dependent. Regime transitions are governed by a matrix $P = [p_{ij}] = [Prob(\varsigma_t = j; \varsigma_{t-1} = i)]$ specified below. Note that "Union" appears twice in the states of the Markov chain, such that the Markov chain has four regimes despite their being only three options for policy.[10]

Definition 1. A rational expectations equilibrium is a mean square stable (MSS) stochastic process that, given the Markov chain $\{\varsigma_t\}$, satisfies equation (2.15).

Definition 2. An $n-$dimensional process $\{x_t\}$ is MSS if there exists an $n-$vector x_∞ and an $n \times n$ matrix Σ_∞ such that

- $\lim_{n\to\infty} E_t[x_{t+n}] = x_\infty$
- $\lim_{n\to\infty} E_t[x_{t+n}\ x_{t+n}'] = \Sigma_\infty$.

Note that the concept of stability as defined above differs somewhat from stability as it is commonly applied in fixed-regime models. Intuitively, explosive trajectories in some regimes are not an issue, if the economy does not stay in these regimes for too long. What matters is

[10]See below the graphical representation of the Markov chain. Formally, regimes one and four – both of which obey the policy rules from "Union" – are different regimes of the Markov chain given that regime four is absorbing while regime one is not. We choose to give both regimes the same name in the interest of streamlining the paper.

that trajectories are not globally explosive, which is ruled out by MSS. The expected duration of a regime is thus key for stability. It is governed by the transition matrix on which we impose a specific structure

$$P = \begin{pmatrix} \mu & (1-\mu)\lambda & 0 & (1-\mu)(1-\lambda) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}. \tag{2.16}$$

It implies that regime one is transitory (unless $\mu = 1$), while regimes three and four are absorbing states. By contrast, regime two is transitory to be left for regime three immediately. We assume that the economy is initially in regime one (monetary union). Graphically, our Markov chain specifies the following sequence of regime transitions:

$$\text{Union}_{\circlearrowleft\mu} \qquad \longrightarrow_{1-\mu} \qquad \begin{cases} \lambda & \text{Union Default}_{\circlearrowleft 0} \quad \longrightarrow_{1} \quad \text{Union}_{\circlearrowleft 1} \\ 1-\lambda & \text{Float AF}_{\circlearrowleft 1}. \end{cases}$$

Given this sequence, expectations about regime change will generally impact the allocation in the initial regime. More precisely, in any period, the economy stays in Union with probability μ, and leaves this regime with probability $1-\mu$. λ, in turn, is the probability weight assigned to a one-time haircut. In the period after the haircut, the economy moves back to "Union" with probability one. By contrast, a change in the conduct of monetary policy, that is, exit from the monetary union, takes place with probability $1-\lambda$. Note that both regimes three and four are absorbing states of the Markov chain, in the sense that these regimes will remain in place indefinitely.[11]

In its most general form, the model does not exhibit a closed form solution. Therefore, we solve the model using the algorithm described in Farmer et al. (2011). We subsequently check the solution for mean square stability. For the parameter space which we consider, we find that at most one solution satisfies the relevant criterion.[12]

3 Exit versus default premia

In this section, we explore the interplay between exit and default premia. In particular, we ask to what extent haircut expectations versus expectations about exit from a currency

[11] Assuming absorbing states allows us to keep the analysis tractable. At the same time we acknowledge that reentering a monetary union or another haircut in the future cannot be ruled out in practice. Yet we abstract from these possibilities as their effect on the equilibrium outcome in the initial regime is bound to be small.

[12] Note that in general MS-LRE models may have multiple fundamental ('non-sunspot') equilibria, see Farmer et al. (2011) for an example. In our analysis, we consider minimum state variable MSS solutions of the form $x_t = F_{\varsigma_t} x_{t-1} + G_{\varsigma_t} \varepsilon_t \ \forall \varsigma_t$, see our closed form example below.

union impact equilibrium outcomes in the initial regime, that is, as long as the country is still a member of the currency union. We obtain three results. First, default and exit risk are mutually reinforcing. Second, both premia may give rise to explosive debt dynamics, depending on the small country's fiscal stance. Finally, in the context of the full model we establish that expectations about exit have stagflationary effects in the presence of public debt.

3.1 Expectations of regime change and debt dynamics

Consider first a special case of the model for which we are able to obtain a closed-form solution. We well draw on this solution in our discussion below. Specifically, for the special case we let prices be flexible ($\xi = 0$), assume that there is no spillover in sovereign risk ($\chi = 0$) and that the elasticity of substitution between goods produced at home and abroad is unity ($\sigma = 1$). Furthermore, we abstract from wage mark-up and foreign-demand shocks ($\eta_t = y_t^* = 0$).
In this case, one can show that $y_t = c_t = s_t = p_t = h_t = \hat{b}_t^* = w_t - p_{H,t} = 0$, such that the *regime invariant* part of the model reduces to the bond price equations

$$r_t = E_t \Delta e_{t+1}, \quad i_t = r_t + E_t \delta_{t+1}, \tag{3.1}$$

to an equation relating the price level to the nominal exchange rate

$$e_t = p_{H,t}, \tag{3.2}$$

and to the debt-flow equation

$$\beta \hat{d}_t = \hat{d}_{t-1} + \zeta_D(\beta i_t - \pi_{H,t} - \delta_t) - \hat{t}_t. \tag{3.3}$$

The *regime-dependent* part of the model is

$$\delta_t = \zeta_D^{-1} \delta_{\varsigma_t} \hat{d}_{t-1}, \quad \hat{t}_t = \psi_{\varsigma_t} \hat{d}_{t-1} - \epsilon_t. \tag{3.4}$$

for fiscal policy and

$$e_t = 0 \quad \text{or} \quad r_t = \phi_\pi \pi_{H,t} \tag{3.5}$$

describing monetary policy.
By recognizing that regimes three and four are absorbing states of the Markov chain, we can solve the simple model backwards using the method of undetermined coefficients. This yields the following closed-form solution for variables in the initial regime.
First, currency union membership implies $e_t = 0$, so purchasing power parity ties down the domestic price level

$$p_{H,t} = e_t = 0. \tag{3.6}$$

Moreover, bond prices in the first regime solve

$$r_t = \Theta^r \left((1-\psi)\hat{d}_{t-1} + \epsilon_t\right), \quad i_t = \Theta^i \left((1-\psi)\hat{d}_{t-1} + \epsilon_t\right), \tag{3.7}$$

whereas public debt is given by

$$\hat{d}_t = \Theta^d \left((1-\psi)\hat{d}_{t-1} + \epsilon_t\right). \tag{3.8}$$

In these expressions, the Θ coefficients are functions of the structural parameters of the model:

$$\Theta^d = [\beta(\mu + (1-\mu)\lambda(1-\delta))]^{-1} \tag{3.9}$$

for government debt and

$$\Theta^r = (1-\mu)(1-\lambda)\zeta_D^{-1}\Theta^d, \quad \Theta^i = (1-\mu)(1-\lambda+\lambda\delta)\zeta_D^{-1}\Theta^d \tag{3.10}$$

for the bond prices.[13]

We are now in a position to explore how expectations of regime change impact debt dynamics while the economy still operates within the currency union. We start from the observation that the interest rate r_t reflects expectations of future policies via a version of the uncovered interest parity (UIP) condition, equation (2.3). This condition holds under all policy regimes, but the case of a currency union is of particular interest. In this case $e_t = 0$, while $e_{t+1} \neq 0$ only if the country exits the currency union.

In our setup, r_t corresponds to the spread in the yields of the one-period discount bond issued under domestic law, which pays off one unit of common currency if no exit occurs and one unit of new currency if exit does occur, vis-à-vis the bond issued under foreign law, where the latter pays one unit of common currency in all states of the world. It corresponds to the *spread* because the prices of home and foreign law discount bonds are equally affected by any spillover of sovereign default risk.

The UIP condition holds in equilibrium and rules out arbitrage possibilities as market participants are able to trade discount bonds both under domestic and under foreign law. Imagine that exit from the currency union cannot be ruled out and that, upon exit, the newly created domestic currency is expected to depreciate ($E_t(\Delta e_{t+1}) > 0$). In this case, domestic discount bonds must promise high returns in equilibrium, as foreign discount bonds pay off strictly

[13] This is the unique mean square stable minimum state variable solution to the simple model whenever $\mu\left((1-\psi)\Theta^d\right)^2 < 1$, which holds unless μ and λ are both close to zero. See Farmer et al. (2009) for further reference on the concept of mean square stability. In general, a minimum state variable solution is mean square stable whenever the eigenvalues of $(P' \otimes I_{n^2})\text{diag}(F_{\varsigma_1} \otimes F_{\varsigma_1}, ..., F_{\varsigma_h} \otimes F_{\varsigma_h})$ are all inside the unit circle, where h denotes the number of regimes and $\otimes$ is the Kronecker product.

better (in terms of new domestic currency) in those states of the world where exit and depreciation occurs: r_t therefore represents an "exit premium". We note that the exit premium affects sovereign bond yields i_t through equation (2.11), because government debt is issued under domestic law. Moreover, equation (2.11) shows as well that government debt also pays a default premium whenever expectations of default are non-zero.

These considerations can be shown formally for the special case of the model discussed at the start of this section. Consider the coefficients which govern the response of yields to debt and deficits, given in expression (3.10). For them to be non-zero, we require $\mu < 1$, that is, regime change must not be ruled out. Furthermore, we have that $\Theta^r \geq 0$ and $\Theta^i \geq 0$ because λ, μ and δ are all within zero and one. If $\lambda = 1$, such that exit is ruled out, $\Theta^r \equiv 0$ and private sector spreads are zero at all times. Even in this case, $\Theta^i > 0$ whenever $\delta > 0$, such that government debt still pays a default premium.[14] More precisely, by decomposing sovereign spreads into exit and default premia as follows

$$\Theta^i = \Theta^r + \Theta^\delta,$$

one can show that

$$i_t = \underbrace{\Theta^r \left((1-\psi)\hat{d}_{t-1} + \epsilon_t\right)}_{=r_t} + \underbrace{\Theta^\delta \left((1-\psi)\hat{d}_{t-1} + \epsilon_t\right)}_{E_t \delta_{t+1}},$$

where

$$\Theta^\delta = (1-\mu)\delta\lambda\zeta_D^{-1}\Theta^d.$$

Note that $\Theta^\delta = 0$ in case default is ruled out ($\delta = 0$), in which case $\Theta^r = \Theta^i$ and therefore $i_t = r_t$, that is, both private and sovereign spreads coincide paying only an exit premium.

We further highlight that exit and default expectations are *mutually reinforcing* in our setup. A ceteris paribus increase in haircut expectations (say, through an increase in δ) pushes up the exit premium through an increase in Θ^r, and thereby in r_t. The reason is that if $E_t\delta_{t+1}$ goes up, the resulting increase in next period's debt level (through higher bond yields, thus higher refinancing costs) also pushes up expected depreciation, and thus the exit premium. This channel is particularly strong in case exit and default premia induce explosive debt dynamics. Public debt may indeed be on an explosive trajectory as long as the economy is part of the currency union. Consider again the special case and note that $(1-\psi)\Theta^d$, the autoregressive root on debt in equation (3.8), may be either above or below unity depending on the size of Θ^d. In case regime shift is ruled out ($\mu = 1$), or if exit is ruled out and no haircut is expected

[14]Once we allow for the sovereign risk channel $\chi > 0$, private sector spreads rise with δ, too, a case which we address in section 3.2 below.

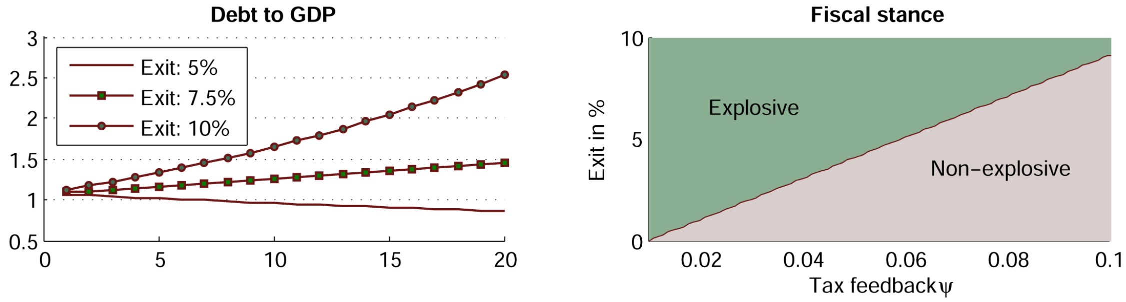

Figure 2: Explosive dynamics in initial regime. The left panel displays an impulse response of debt-to-GDP, in percentage point deviation from steady state, following a one-time deficit shock, as a function of (per-quarter) exit expectations. The right panel displays explosive versus non-explosive behaviour in the ψ - exit expectations plane. We assume $\mu = 0.5, \beta = 0.99, \delta = 0$, in both panels, $\psi = 0.07$ in the left panel, for different λ.

($\lambda = 1$ and $\delta = 0$), equation (3.8) reduces to

$$\hat{d}_t = (1-\psi)/\beta \hat{d}_{t-1} + 1/\beta \epsilon_t,$$

which is mean reverting by assumption.[15] However, default and exit premia may raise Θ^d to the point where debt becomes explosive. The reason is that as debt builds up, expected losses to be realized in some states of the world also increase. Investors are compensated by lower bond prices, but this leads to public debt rising further—a vicious cycle ensues. As a result, the size of the necessary adjustment, be it through outright default or through exit and inflation, increases in the duration of the initial regime.

Figure 2 illustrates this graphically for the case of exit premia. The left panel displays an impulse responses of debt following a deficit shock which we assume purely transitory, and equal to one percent of steady state output, in the initial period. In the graph, while horizontal axes measure time in quarters, vertical axes measure deviations from steady state. In each instant, market participants attach some probability on regime change taking place in the next period. Still, in the scenario under consideration regime change does not actually materialize, such that the initial regime is maintained throughout.[16] As we see, a rise in exit expectations may lead to explosive dynamics (here: for a 7.5% chance to exit, per quarter). The point at which this occurs depends on the small country's fiscal stance, captured by the parameter ψ. In panel 3, therefore, we show the sensitivity of explosiveness with respect to this paramter, noting that a reaction coefficient which is sufficiently strong shields the economy from explosive dynamics.

[15]Recall that we assume $\psi > 1 - \beta$ throughout, see equation (2.14). In the case of $\psi < 1 - \beta$, debt sets on an exploding path even absent risk premia. We do not look into this case in the present paper.

[16]Put differently, yield spreads reflect expected losses which are not observed in the sample under consideration, as in the case of "peso problems".

In the simple model, deficits associated with both default and exit premia are neutral for the allocation. In the case of default premia, this is because the remaining debt stock (once the haircut has been applied) is known to be serviced once the regime switch has occured. Ricardian equivalence thus obtains even under the initial regime.[17] As for exit premia, note first that the nominal interest rate r_t is the margin relevant for the intertemporal allocation of expenditure, as we can see from Euler equation (2.1). Under our assumptions from this section, however, the *real* interest rate does not change with a change in r_t, as

$$r_t - E_t\pi_{t+1} = E_t(\Delta e_{t+1} - \pi_{t+1}) = E_t(\Delta e_{t+1} - \pi_{H,t+1}) = 0, \tag{3.11}$$

where the first equality follows from the UIP condition (3.1), the second from $s_t = 0$ (and therefore $p_t = p_{H,t}$ from equations (2.8) and (2.9)) and the third from the fact that $e_t = p_{H,t}$. In other words, while agents expect *nominal* depreciation upon exit, which raises *nominal* interest rates, they do not expect *real* depreciation, such that *real* interest rates are unchanged. This will be different in the full model, where price stickiness upon exit guarantees that prices adjust only sluggishly with the nominal exchange rate.

3.2 Macroeconomic dynamics

We now explore the distinct roles of exit versus default premia in the full model. As before, we look at the transmission of deficit shocks while the economy operates under the initial regime. For this purpose we rely on model simulations using parameter values in line with our calibration of the model to Greek data, detailed in Section 4.1 below. An exception are the parameters δ, χ and λ which we vary in what follows. Figure 3 displays impulse responses of selected variables to a one-time deficit shock, as before in Figure 2. We show results for the two polar cases: a scenario where there are only expectations about exit ($\lambda = 0.5, \delta = \chi = 0$), represented by solid lines, and a scenario where there is only the risk of default and a sovereign spillover of 50% ($\lambda = 1, \delta = \chi = 0.5$), represented by dashed lines.

The upper left panel displays the deficit shock. As before in Figure 2, it is assumed to be purely transitory and equal to one percent of steady-state output. In response to the shock, public debt (upper right panel) and sovereign yields (2$^{\text{nd}}$ row left panel) rise steadily, irrespectively of whether there are only exit expectations or expectations about default. Thus, exit and default premia induce explosive dynamics in this example. This is because—in the

[17] This result also holds for the non-linear model and independently of the size of the haircut parameter. On the one hand, fewer taxes are required to service debt *ex post* if the haircut is large. On the other hand, if the (expected) haircut is large, the stock of debt grows faster *ex ante* through higher bond yields. If bonds are priced correctly, both effects offset each other, leaving the expected present value of future taxes unchanged. Yet, if taxes are assumed to be distortionary, default premia have allocative consequences (Bi, 2012). We analyze this case in a robstness check at the end of section 4.

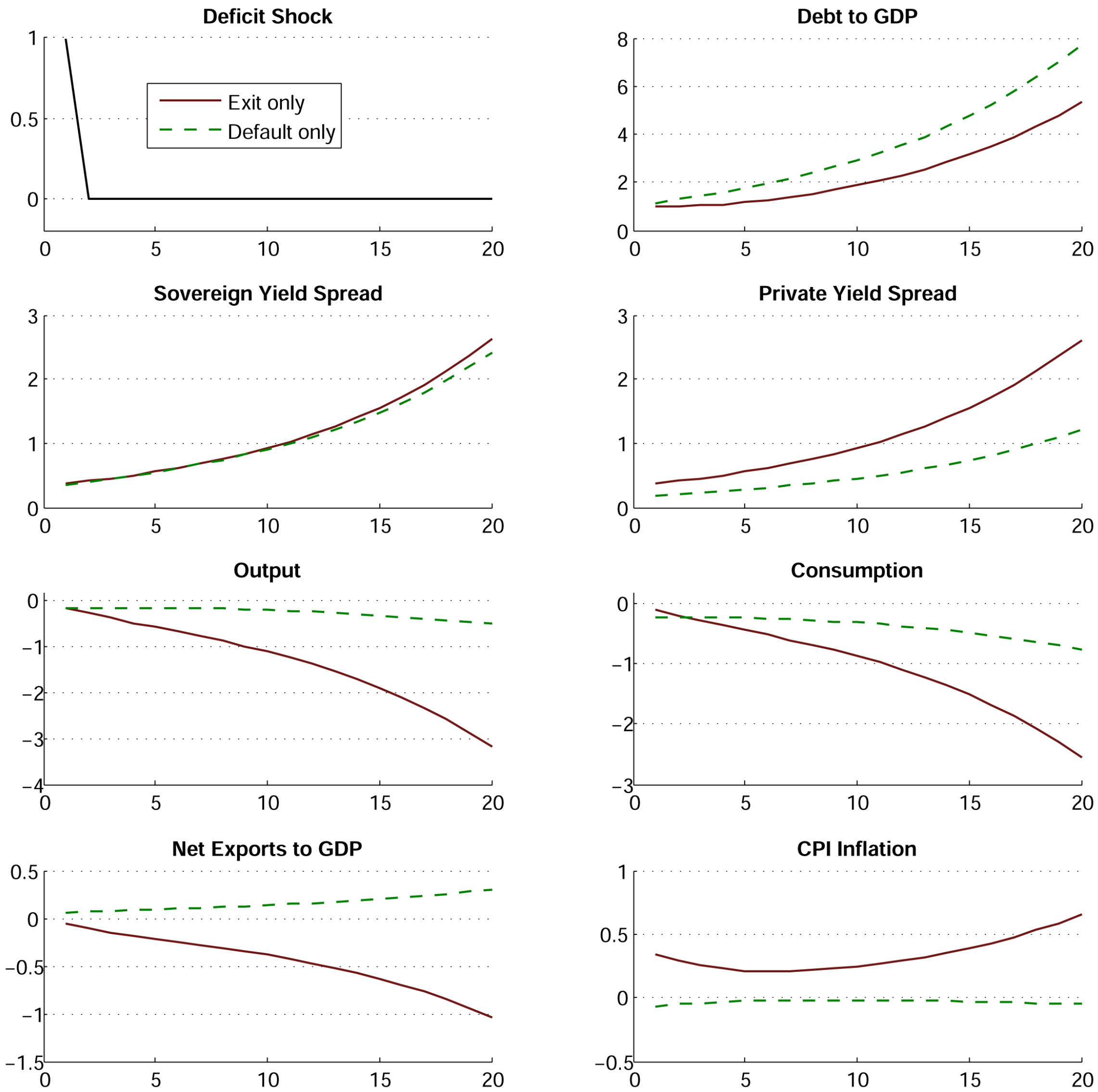

Figure 3: Impulse responses to a deficit shock conditional on staying in first regime. Notes: deficit shock equal to one percent of (annual) steady-state GDP. Horizontal axes measure quarters. Vertical axes measure deviations from steady state in percent, and percentage points in case of debt to GDP, net exports to GDP and the deficit shock (annual steady-state GDP in all cases). CPI inflation and the interest rates are annualized.

initial regime—neither taxes nor the price level adjust (sufficiently) to stabilize the real value of public debt. As such, we note that a one-time deficit shock induces long-lasting effects—the model generates substantial internal propagation.

The dynamic adjustment of the economy differs fundamentally, however, depending on whether there are expectations about exit or expectations about default. In the default case (dashed lines), private spreads (2^{nd} row, right panel) rise along with sovereign spreads through the sovereign risk channel, crowding out consumption and thereby overall economic activity (3^{rd} row). Slack in the economy leads to a fall in prices (lower right panel), depreciating the real exchange rate thereby crowding in some net exports (lower left panel).[18] Quantitatively, however, the overall effects of default risk appear to be rather muted, and indeed, they disappear altogether once the sovereign risk channel is shut off.[19]

By contrast, in the exit case (solid lines), private yield spreads rise one-for-one with sovereign spreads. Output declines along with consumption as before, though by more than in the case of default-only. At the same time, inflation rises, appreciating the real exchange rate thereby crowding out net exports. Hence, deficit shocks turn out to be stagflationary in the presence of exit expectations.

To better understand the economy's response to deficit shocks in the presence of exit expectations, we conduct an additional experiment where exit from the currency union actually materializes in period 10. To simplify the discussion, we again assume that default is not possible ($\lambda = 0.5, \delta = \chi = 0$). Figure 4 shows the responses of selected variables. We contrast results for the baseline case (solid lines) with those for an alternative setup, where price rigidity upon exit declines to an intermediate level (solid lines with squares) or disappears altogether (solid line with circles).[20]

The upper left panel shows the response of the nominal exchange rate. Upon exit there is a discrete upward shift and further, more gradual depreciation thereafter. The exchange rate response is stronger, the more flexible prices are in the new regime. This is consistent with the response of inflation (upper right panel): it increases sharply in case prices are flexible after exit. While inflation also takes up in the baseline case, its response is muted relative to a scenario of more flexible prices. In fact, if prices are fully flexible after exit, the real exchange

[18] The real exchange rate is given by $q_t = e_t - p_t$. We note that, as the nominal exchange rate stays constant and prices fall, the real exchange rate must depreciate. See Figure 4 for the path of the real exhange rate in the exit-only case.

[19] In this case, as in the simple model analyzed in section 3.1, the deficit shock has no bearing on the economy other than on public finances and in particular, private yield spreads r_t are zero.

[20] This is to highlight that rigidity *upon exit* is crucial for our results. In fact, the same pattern obtains if price rigidity declines globally, i.e. also in the initial regime. Technically, to allow for the possibility of a change in rigidity, we modify the Phillips curve in the first regime such that firms anticipate that the frequency of price adjustment changes with a change in the regime. The derivation of the modified Phillips curve is available on request.

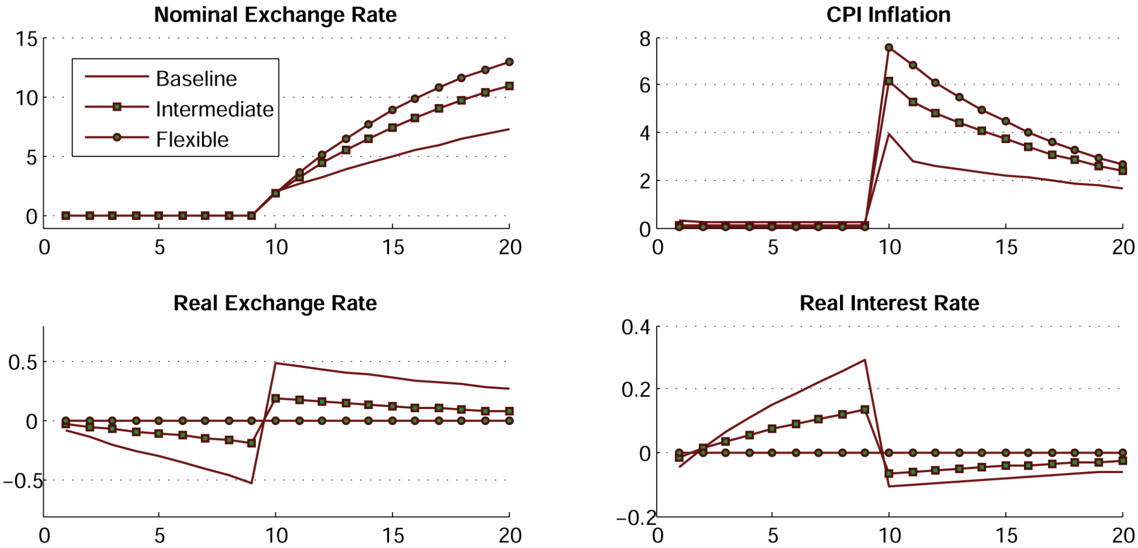

Figure 4: Impulse responses to a deficit shock in first regime, with exit from the currency union occuring in period 10, for different levels of price rigidity upon exit. Horizontal axes measure quarters. Vertical axes measure deviations from steady state in percent. The solid line corresponds to the baseline case (unchanged price rigidity); squares indicate an intermediate degree of price rigidity ($\xi = 0.75$), and circles indicate flexible prices after exit. CPI inflation and the real interest rate are annualized.

rate does not adjust after exit (lower left panel). Instead, in the baseline case, the sluggish response of inflation after exit induces the real exchange rate to depreciate upon exit, along with the nominal exchange rate. Importantly, large devaluations tend to be associated with a strong improvement in competitiveness, because prices tend to adjust more sluggishly than the nominal exchange rate—as in our baseline calibration (Burstein et al., 2005).[21]

Prior to exit, equilibrium requires that an expected real depreciation is met by increased real interest rates (lower right panel), as discussed above (see equation (3.11)).Moreover, consumption is on a declining trajectory, since the size of adjustment increases the longer the initial regime lasts (see Figure 3). Finally, inflation rises already prior to exit, implying an appreciation of the real exchange rate. Intuitively, forward looking firms tend to raise prices, given that they expect inflation and depreciation upon exit which, in turn, will raise marginal costs.[22]

[21]Burstein et al. (2005) consider five large devaluations and find that the real exchange rate response is on average about 90 percent of the nominal exchange rate response. In our baseline calibration, this ratio is about 50 percent, while in case prices are flexible upon exit it is zero, see Figure 4.

[22]Under an alternative interpretation, prices rise in the initial regime so as to equate the real value of outstanding public debt and the present value of future expected real surpluses, which is an instance of "fiscal inflation" as put forward by Cochrane (2011). He further argues that fiscal inflation would likely come with

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stagnation, as expected inflation constitutes an adverse shift in the Phillips curve—as in our analysis.

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