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Abstract

The recent Eurozone debt crisis has witnessed sharp decouplings in cross-country bond yields without commensurate shifts in relative fundamentals. We rationalize this phenomenon in a model wherein countries with different fundamentals are on different equilibrium paths all along, but which become discernible only during bad times. Key ingredients are cross-country differences in the volatility and persistence of fiscal revenue shocks combined with their unobservability by investors. Differences in the cyclicality of fiscal revenues affect the option value of borrowing and resulting default risk; unobservability of fiscal shocks makes bond pricing responsive to market actions. When tax revenues are hit by common positive shocks, no country increases net debt and interest spreads stay put. When a common negative revenue shock hits and is persistent, low volatility countries adjust spending while others resort to borrowing. This difference signals a relative deterioration of fiscal outlooks, interest spreads jump and decoupling takes place.

Key words: Eurozone Debt Crisis, Sovereign Debt, Default, Fiscal Gaps, Persistence, Volatility, Information Asymmetry, Perfect Bayesian Equilibrium.

JEL codes: E62, F34, G15, H3

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1 Introduction

From the times of Alexander Hamilton to Mario Draghi, debt crises have repeatedly dragged policy makers into taking a stand on a polemic question—namely, what triggers sudden decouplings of bond yields across national or sub-national borders following protracted spells of yield convergence? Such a reversal of fortunes has been at play in the Eurozone until very recently. As illustrated in Figure 1, from the eve of the monetary union in end-1998 to the onset of the global financial crisis ten years on, yield convergence was remarkable; this was so in terms of both magnitude and length, as well as in its defiance of widely known differences in institutions, fiscal performances, and productivity differentials across eurozone states. No less dramatic has been its post-2008 reversal: yield decoupling reached unprecedented heights, with the cross-country dispersion of bond yields surpassing even those during the severe market turbulences of the 1990s. These developments are all the more disconcerting since at the epicenter of the crisis lie countries not so long ago heralded as growth success stories of the advanced world, such as Ireland and Spain, as well as countries like Greece and Portugal which have been long declared as graduated from "debt intolerance" (Reinhart, Rogoff and Savastano 2003).

This paper proposes one mechanism – among possible others – that can rationalize these developments. We propose a model where government borrowing is a signaling device and the main driving forces behind distinct equilibria are the volatility and persistence of tax revenue realizations. The model's novelty is to combine these ingredients so that yield coupling and sudden decoupling arise in equilibrium without commensurate changes in relative country fundamentals. To support our argument that both the stochastic volatility and persistence of tax revenues are key, we provide evidence of substantial and long-lasting differences in those parameters across the Eurozone. Model calibrations illustrate how such differences can produce yield convergence after a good fiscal shock realization as well as sudden and non-trivial yield decoupling upon a bad fiscal shock realization.

Our model builds on the finite horizon textbook model of sovereign borrowing and default (see, e.g, Obsfeld and Rogoff, 1996 and Feenstra and Taylor, 2011). In that model, as well as ours, borrowing buys the option of defaulting, and the value of that option rises on the volatility of the income shock. We extend this setting in three directions, taking into account key ingredients highlighted in many accounts of the recent Euro crisis. First, by introducing an intermediate period in which the economy experiences a persistent shock and investors can re-price risk amidst continuous borrowing. Second, we relax the full information assumption; direct observation of fiscal shock realizations is a preserve of the sovereign borrower but not of the mass of lenders. This assumption gains extra realism in the context of our third model extension – namely, the relevant fiscal shock is to

government's tax revenues.

In our three-period model a country issues long-term (two-period) debt to finance investment that, upon maturity, is expected to yield sizable revenue gains. Fiscal revenues follow a stochastic path with realizations at the intermediate and final periods, which may cause tax revenue collection to fall short of planned spending. In response to the persistent middle period shock, the country can either adjust spending and refrain from borrowing, or it can tap capital markets to finance the emerging fiscal gap. The middle shock realization is directly observable by the sovereign but not by international lenders; the latter can only infer the fiscal path by observing the sovereign's actions, which can either be borrowing or non-borrowing in the middle period. In the final period, the country decides whether to repay or default. If it defaults, it faces some loss of income/fiscal revenues and lenders can recover potentially some (but not the full) face value of debt obligations. In this setting we model the interaction between the country and lenders as a game and solve for Perfect Bayesian Equilibria (PBE). We show that two types of equilibria exist: a separating equilibrium, in which the country's action depends on the shock realization, and a pooling equilibrium, in which the country's action is the same, regardless of the shock realization.

How can this framework help explain the pattern of country spreads illustrated in Figure 1? Consider two countries, one at each end of the yield dispersion spectrum. Suppose that Country-A, characterized by a set of weaker fundamentals (for example highly volatile tax revenues), sustains a separating equilibrium in which it stays put after a good fiscal shock and issues new debt after a bad fiscal shock. Conversely, suppose that Country-B is characterized by a set of stronger fundamentals (for example, lower tax revenue volatility) and sustains a pooling equilibrium in which it never taps the market regardless of the fiscal realization. When the two countries are hit by a positive fiscal shock, investors observe both countries refraining from borrowing and this generates only a small spread between country yields. The gap in country spreads that should prevail due to the gap in country fundamentals is dampened by the presence of informational noise. The situation is quite different following a large negative shock. In this case, the informational noise will amplify the effects on spreads of whatever differences in fundamentals were present prior to the shock: investors learn that country-A is on a negative fiscal path relative to country-B, so the interest spread between the two countries widens. Hence, our model provides a possible mechanism that can rationalize the 2000-2007 period of yield compression – when shocks to aggregate income and country-specific tax bases were either positive or only mildly negative across the eurozone (as we document in Section 2), and the posterior yield decoupling–when those same shocks were highly negative. In short, fiscal "discoveries" can thus explain both yield convergence and sudden yield decoupling.

Notice that the theoretical mechanism just described does not rationalize convergence and

sudden yield decoupling by a general cross-country shift from a pooling to a separating equilibrium. Instead, convergence and divergence obtain once a common shock hits countries that are already on different equilibrium paths–some on a separating and some on a pooling equilibrium path. Whether a country finds optimal to play a pooling or a separating strategy depends on the trade-off between the option value of borrowing vs. the high debt servicing cost in case the default option is not exercised. This trade-off depends on a variety of fundamental parameters such as the country's discount factor, initial debt levels, the income loss and hair-cut parameters that pin down the relative cost of default, and – central to our story – the underlying shock volatility and persistence.

Note that in our model each country is defined by a perfectly observed set of fundamentals that are public-knowledge. Hence, investors are not uncertain about whether a country is a "bad" or a "good" type: investors know that country A's fundamentals are weaker than country i's. What they do not observe is countries' A and B fiscal shock realizations. This distinction is important to the extent that it would be very difficult to defend an assumption of asymmetric information regarding countries' types concerning fundamentals that are readily apparent. Our model assumes that all macroeconomic fundamentals are perfectly observable. The assumption on informational asymmetry is subtler: it relates to the real time fiscal shock realizations. This is an easier assumption to defend and in Appendix A we provide a discussion as to why this is arguably realistic in the Eurozone context. In sum, it is the interaction between differences in known fundamentals (which pin-down the dominant country's strategy) and unknown shocks realizations that allows spreads to converge or diverge widely.

Model simulations yield the following results. First, countries with weaker fundamentals generally find it optimal to play a separating strategy, whereas those with stronger fundamentals opt for pooling. In particular, a separating equilibrium is more prevalent in countries for which the underlying variance and persistence of the tax revenue shock are higher. Second, higher short-run volatility relative to long-run volatility increases the dominance of separating equilibrium and raises spreads. Third, the persistence of revenue shocks has a quantitatively important effect on interest spreads. If the equilibrium is separating and the (AR1) persistence of its tax revenue shocks is raised by 0.2 (a typical difference in fiscal revenue persistence across Eurozone countries, as we document below), spreads can rise by more than 400 basis points. Interestingly, we find broad regions of parameter values (which are empirically relevant) on which equilibrium abruptly changes from pooling to separating. Hence, the resulting equilibria turn out to be quite sensitive to small perturbations in parameter values. Finally, our simulations also show that default is more likely in a separating equilibrium, despite being also plausible in a pooling equilibrium.

This paper relates to a large literature on sovereign borrowing and default risk, starting

with Eaton and Gersovitz's (1981) seminal contribution. As in the subsequent models such as Aguiar and Gopinath (2006), Arellano (2008), our model builds on the volatility and persistence of output shocks (tax revenue shocks in our setting) as drivers of country risk. Asymmetric information in our model (absent in these previous papers) transforms market actions into signals with tangible implications for bond pricing. In papers like Arellano (2008) and Aguiar and Gopinath (2006), the debt-output state space exhibits a sharp boundary – the so-called default frontier - between regions of certain non-default and certain default. This feature opens the possibility of highly non-linear yield behavior as a very small increase in debt levels generates a sizeable increase in spread (or a collapse in bond price), as shown in Aguiar and Gopinath (2006, Figure 3). There are, however, limits to the empirical relevance of this channel to explain yield decoupling of the sort experienced in the Eurozone as shown in Figure 1 above. First, this type of non-linearity in yield behavior featured in this class of models is highly knife-edged: you need to be in some very specific range of debt level for this to occur. This knife-edge feature is even stronger when we look at the effect of an output shock rather than changes in debt level: the economy typically needs to be in a very narrow debt range so that an output shock of the range observed before debt crises can generate a large non-linear effect on spreads. Outside this narrow range close to the default frontier, spreads vary very little, and the volatility of bond prices is counterfactually lower than the volatility of debt quantities. Second the non-linearity in bond yield in the neighborhood of the default frontier is far too dramatic to be realistic. As shown on Figure 3 in Aguiar and Gopinath (2006), an increase in debt of about 2 percent brings the price of the bond all the way from close to par to zero. Third and relatedly, this extreme non-linearity due to the sharp default frontier is precisely the reason for which their empirical performance is limited with too little spread in tranquil times, unplausible default risk spikes when the economy travels close enough to the default frontier, and too small equilibrium debt levels. By contrast, under our asymmetric information mechanism, the results do not depend at all on being in some specific debt region to start with – to make this point sharper, we assume that all countries have the same initial debt level – and are not knife-edged since there is a large range of fundamentals and a large range of shock process parameters that can sustain a non-linear yield behavior. In addition, the non-linearity that our model generates remains in some plausible range – an increase in yield between 2 and 10 percent.

Broner et al. (2013) offers a different interpretation of the Eurozone spread divergence based on a combination of credit discrimination and a crowding out effect of public debt on private investment. In bad times, discrimination risk leads to a reallocation of bonds from foreign creditors to domestic creditors. The ensuing crowding-out effect might lead to self-fulfilling crises. By contrast in our model, default costs are common knowledge ex-ante. They differ across countries but are similar for all creditors. Rather than being due a to

a self-fulfilling spiral, the spike in sovereign spreads reflects that countries with different fundamentals follow similar debt accumulation strategies in good times but different ones in bad times, leading to a sudden and potentially sharp re-pricing of default risk. The amplification mechanism comes from the existence all along of two different equilibria (pooling vs.separating) whose effect become apparent in bad times, not from a shift from a good to a bad equilibrium (following the tradition of models of self-fulfilling debt crises such as Cole and Kehoe (2000)). We see the Broner et al.(2013) mechanism as complementary to ours in explaining the effect of bond reallocation from foreigners to domestic creditors, a mechanism that we abstract from in our analysis. By contrast, our model deals with private sector risk and the persistence of shocks, which are absent from the analysis of Broner et al.(2013). While our model provides a rationale for the sharp divergence in Eurozone sovereign bond spread in the aftermath of the crisis, it does not address the issue of sovereign default contagion. Jeanne and Bolton (2011) demonstrate how financial integration among countries can amplify such contagion in the context of a financially, but not fiscally, integrated union.

In featuring asymmetric information and signaling through market tapping, our setting relates to Eaton (1996), Alfaro and Kanuzck (2005), Sandleris (2008), Catão, Fostel, and Kapur (2009), and D'Erasmo (2011) who also study how investors' uncertainty about either the country's type or shocks determine fluctuations in sovereign spreads. Yet, as mentioned above, there is an important difference. In our model countries are not "types". Investors are not uncertain about whether a country is a "bad" or a "good" type, as each country is defined by a perfectly observed set of fundamentals. Investors know that country A's fundamentals are weaker than country B's, but what they do not observe countries' fiscal shock realization.

In highlighting the role of market tapping as a signal of fiscal prospects, our paper is also related to an earlier literature on the timing of fiscal consolidations as Alesina and Drazen (1991) and Drudi and Prati (2000). In these papers, governments may find optimal to deviate from optimal tax smoothing in order to signal their "types", defined as capacity to embark on a lower vs. higher default risk fiscal path. As in our model, Drudi and Pratti (2000) find that there can be a pooling or a separating equilibrium in this game. Yet, their separating equilibrium is characterized by a "weaker" government always defaulting and a "stronger" government signaling that it can abstain from borrowing during bad times and never defaulting. Unlike in our model, investors' uncertainty pertains to what "type" of government is in charge – there is no uncertainty regarding output or fiscal revenue realizations; indeed, when equilibrium is separating, default by the weak government occurs in the model's middle period as a myopic administration takes office, so all uncertainty is then resolved and no further borrowing ensues. Thus, their model does not rationalize

yield decoupling amidst continuous borrowing; nor does it obtain a separating equilibrium in which default may not occur following a bad revenue outcome.

The remainder of the paper is structured as follows. Section 2 documents key facts on the 2008-2012 Eurozone debt crisis, which motivate our modeling strategy. Section 3 lays out the model while Section 4 presents the numerical results. Section 5 concludes. Appendix A presents a discussion about the asymmetric information assumption and Appendix B presents technical details regarding equilibria calculation in the model.

2 Empirics of the Eurozone Crisis

In this section we document the key empirical regularities that motivate our modeling choice. While the bond pricing dynamics that our model seeks to explain is featured in many past debt crises, other specifics of past crises may vary widely (for an overview and further references, see Rogoff and Reinhart, 2009). In what follows we keep the focus on Eurozone developments as the set of stylized facts to be explained.

Fact 1. For a given decline of real GDP, the decline in real government revenues was higher in eurozone peripheral countries relative to the "core" eurozone countries.

The triggering event of the ongoing Eurozone crisis has well-known origins—a string of defaults on tranched U.S. mortgage bonds in the summer of 2007 that culminated with the closure of Lehman Brothers.[1] From the Eurozone's viewpoint and for the purposes of our modeling exercise, this can basically be viewed as a common external shock that caused output and hence the tax base to contract, thus depressing real tax revenues.

A comparison between Figures 2a and 2b shows, however, that while the output and the government revenue cycles were quite synchronized and of similar magnitudes in the eurozone "core" (defined to comprise Austria, Belgium, France, Germany, and the Netherlands), there was far greater volatility and cross-country dispersion in government revenue cycles in "peripheral" eurozone economies that were at the epicenter of the 2010-2011 financial crisis. This highlights non-trivial differences in the pro-cyclicality of national tax systems across the Eurozone.

Figures 3a and 3b further illustrate these differences by showing that tax revenues have been nearly four times as elastic to output in Spain than, for instance, in Germany. More

[1] For a broad overview of background developments and the role of gross international funding exposures in exacerbating the contraction of global output, see Gourinchas (2011).

broadly, Table 1 shows that crisis countries in the Eurozone have displayed not only significantly higher conditional volatility but also higher persistence of government revenue shocks relative to non-crisis countries (Germany notably). Table 1 also shows that this is not a preserve of the crisis period: it goes far back in time, seemingly reflecting deep-seated structural factors. This has important implications for modeling and policy, as discussed in Sections 3 and 4.

Fact 2. With the exception of Ireland, eurozone countries at the epicenter of the crisis were, on average, more closed to foreign trade than core eurozone countries.

This is shown in the last column of Table 1. To the extent that openness to foreign trade is a proxy for the cost of default, as discussed in Rose (2005) and Borensztein and Panizza (2009), this seems also a relevant factor behind spread decoupling in Eurozone and a metric that we take into account in model calibrations. See Section 4.

Fact 3. There were significant differences in the adjustment of primary general government spending to the financial shock between peripheral and core eurozone countries.

Figure 4a shows that primary government spending ran well ahead of revenues in 2008 and 2009 in all four countries that subsequently went through the debt crises in 2010 and 2011.[2] In this regard, a comparison between Germany and Greece is particularly striking: while on the eve of the crisis in 2007, government primary spending was entirely financed with revenues in both countries (with an identical ratio of 94%), that gap rose by close to 15% by 2009.[3] That is, Germany cut primary spending in tandem with its smaller fiscal revenue decline, whereas Greece did not. In the event, Figure 4b also shows that this led to a well-known perverse fiscal dynamics: as country risk increased, interest payments pushed overall public spending further up, widening the gap between fiscal balances in the two country groups.

Fact 4. Public debt to GDP ratios rose sharply across the eurozone periphery as market access remained broadly intact well into 2009 and not entirely lost in 2010.

The flip side of the fiscal dynamics documented above is that those peripheral eurozone governments resorted to extensive market tapping. Hence government debt to GDP ratios skyrocketed, as shown in Figure 5. In particular, countries that at the onset of the monetary union in 1999 had manageably low debt to GDP ratios (at around 50%) like Ireland and Portugal, saw their debt to GDP ratio approach double-digit levels. Extensive government

[2]This is true even if we add debt servicing costs (i.e., interest spending) and use the general government expenditure metric. The respective chart is not plotted to save space but is available from the authors upon request.

[3]Data for this and other various bilateral comparisons across the eurozone is not shown to conserve on space but is available from the authors upon request.

borrowing during 2009–10 implied that market access was not lost.[4] In short, as these countries' relative fiscal positions sharply deteriorated, new issuance rose while their yields started to decouple from other Eurozone peers, most notably Germany. Figure 6 shows that current accounts remained highly negative in two of the four crisis countries, Greece and Portugal, while their respective country spreads relative to Germany rose.

Fact 5. The ratio of external short-term debt in total external debt rose in 2009-2010 across the eurozone periphery.

This is shown in Figure 7. Once again the rise was steepest for Greece and much milder for Ireland, but all four peripheral countries increased short-term borrowing in absolute term as well as relative to the eurozone core. This ratio comes down in from 2011, as longer-term multilateral financing builds up.

3 Model

3.1 Fiscal Revenue Shocks and Sovereign Debt

We develop our argument in the simplest setting, which involves three periods, $t = 0, 1,$ and 2. A government issues bonds in international capital markets to finance long-term investment which can be related to physical infrastructure and/or human capital development. The investment undertaken in period 0, τ_0, (which we take as exogenous) generates expected fiscal revenues τ_1 and τ_2 in periods 1 and 2 respectively.

In period 1 government's fiscal revenue is given by $F_1 = \tau_1 + \tilde{\epsilon_1}$, where $\tilde{\epsilon_1}$ is a shock which assumes two values: $\epsilon_1^H = \alpha\tau_1$ and $\epsilon_1^L = -\alpha\tau_1$, with probability p and $1 - p$ respectively, and $\alpha < 1$. A key assumption throughout is that the shock is persistent, so that $\rho\epsilon_1$ still affects fiscal revenues in period 2, where $\rho < 1$ is the persistence parameter.

[4] According to data from Dealogic, the combined public and private sectors in Greece issued \$70.5 trillions in 2009 and \$73.3 trillions in 2010, up from \$12.8 trillions in 2008. In 2009 alone 94% of the new issuance was due to the public sector, before declining to 34% in 2010. Corresponding new issuances for Ireland amounted to \$142 and \$63 trillions in 2009 and 2010 respectively (from \$146 trillions in 2008), \$46 and \$32 trillions for Portugal (up from \$25 trillions in 2008), \$159 and \$150 trillions for Spain (up from \$72 trillion in 2008). While new issuance did fall sharply in 2011 for the first three countries, it still remained non-trivial; and in the case of Spain, it actually rose to an all-time high of \$192 trillion in 2011. Since the European Central Bank (ECB) bond repurchasing program did not start in ernest before May 2010 and relied on bond purchases from secondary (rather than primary) bond markets, it is plain that official financing cannot account for all financing obtained by those countries at the height of the crisis in 2010-2011. This clearly does not mean that official lending was unimportant from 2010, or that was not overwhelming for some sectors (such as Irish banking – see Bolton and Jeanne, 2011), but simply that frantic market tapping amidst rising spreads was a key development and that "loss of market access" appears to have been far more subtle and gradual than in major emerging market crises of the past.

In period 2 the government's fiscal revenue is given by $F_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2}$, where the new shock $\tilde{\epsilon_2}$ can assume two values, ϵ_2^H or ϵ_2^L with probability q and $1-q$ respectively.

The government has access to debt markets in periods 0 and 1. In order to finance the initial investment requirement at time 0, the sovereign issues long-term debt to be paid in period 2. More precisely, it issues $D_0 = \tau_0$ at time $t = 0$, it pays interest $r_0\tau_0$ at $t = 1$ and it promises to pay $(1 + r_0)\tau_0$ at maturity at $t = 2$.

At period 1, upon receiving the fiscal shock $\tilde{\epsilon_1}$ in the middle period, the borrower has two options:

1. "No-Action" (N).

   In this case, the borrower just pays interest due at time 1. Notice that total outstanding debt at the end of the middle period is τ_0.

2. "Fresh Issuance" (I).

   In this case the borrower issues new fresh one-period debt D_1. It issues $D_1 = \alpha\tau_1$, and promises to pay $(1 + r_1)\alpha\tau_1$ at $t = 2$. Notice that in this case total outstanding debt at the end of the middle period is larger than the stock of debt at time 0. The stock of debt at time 1 is $\alpha\tau_1 + \tau_0$ compared to the stock of debt at time 0, τ_0.

In the final period, upon the realization of the shock $\tilde{\epsilon_2}$, the government decides whether to pay or default in all outstanding debt. We assume that all debt has the same seniority, so once a country defaults, it defaults in all its debt. We also assume that there is no default on interest payments in the middle period.[5]

Figure 8 shows a timeline of fiscal revenue shocks and credit market access summarizing the previous discussion.

[5]The first assumption is for the sake of simplification. Adding seniority would complicate the model without adding significant insight on the issue at hand. As discussed in Chatterjee and Eyigungor (2012), the expected effect would be to increase the cost of issuance in the middle period and discourage further debt. The second assumption is easily justifiable. For example, suppose $r = 5\%$ and $D = \tau_0 = 100$, this means that repayment of interest would amount only to 5% of revenues. Clearly, this payment would be easily met even if a very bad shock still leaves you with say 40 or 50% of baseline revenues, i.e. an amount eight to ten times higher than interest charges.

3.2 Lenders and Cost of Default.

The bond market is competitive, with risk-neutral lenders who are willing to subscribe to bonds at any price that, given their beliefs, allows them to break-even. For modeling simplicity we treat the mass of lenders at every period as a single lender.

Lenders have access to a risk-free technology in every period, which pays a risk-less interest rate r_f, which is taken as exogenous and constant across time. There are two separate debt markets, a long-term debt market at $t = 0$ and a short-term debt market at $t = 1$.

There is a punishment technology in the model that consists of recovery rates and fiscal confiscation. More precisely, in the case of default, creditors receive $c(1 + dr)D$, where D is the debt issued (τ_0 or $\alpha\tau_1$), and $1 - c$ represents haircuts.[6] This parametrization allows us to consider two extreme situations. In the case in which $d = 1$, the haircut is calculated over both, interest and principal. However, in the case in which $d = 0$, the haircut is calculated over the principal alone. Moreover, as in any finite-horizon framework, in the absence of other penalties in the final period the borrower would default with probability one. To avoid the trivialities associated with this case, we assume that default in the final period is punished with sanctions that cause the sovereign to lose a fraction η of its current fiscal revenues per unit of face value. A proportion f of this fixed cost goes to creditors at time 0, whereas a proportion $1 - f$ goes to creditors at time 1. For example, if the sovereign decides to take no action in the middle period, then $f = 1$ and $1 - f = 0$, i.e, the total proportion η of fiscal revenues goes to creditors at time 0. On the other hand, if the sovereign decides to issue new debt in the middle period, then $f = \frac{1}{1+\alpha}$, which means that a proportion $f\eta = \frac{1}{1+\alpha}\eta$ of fiscal revenues goes to creditors at time 0, and a proportion $(1 - f)\eta = \frac{\alpha}{1+\alpha}\eta$ goes to creditors at time 1.[7] Hence, in this last scenario there is debt

[6] Recent work pins down the haircut from an endogenous bargaining process between sovereign and creditors over the surplus arising from default (Benjamin and Wright, 2008; Yue, 2010; D'Erasmo, 2011). One chief motivation to this line of research is to endogenously generate debt to output ratios in a DSGE setting that resemble those observed in the real data. In a finite horizon setting (such as the one presented in this paper where) default can take place in the last period, it is a natural shortcut to take c as an exogenously given parameter.

[7] We are thus assuming that the fiscal cost in the last period is captured by the creditors. As it is clear in Appendix B, this assumption simplifies the calculations. In standard models (like in Cohen and Sachs (1985)) a proportion η goes straight into the waste bin (deadweight losses). However, one can argue in favor of our modeling choice in several ways. For example, about 10% of Greek debt was issued in London. Hence upon default, London courts could in principle get 10% of τ_0 back. If $\tau_0 = 2\tau_2$ under a bad shock, then we get $\eta = 0.2$ (= 10% of τ_0), which as we will see later is our approximated calibration of η. While the recovery record of vulture funds is far from exemplary, it is not a zero return activity either. The November 2012 NYC court ruling on Argentine defaulted debt suggests that such a recovery assumption may not be too off-mark going forward. At any rate, if creditors are able to organize themselves better and extract fiscal surpluses later, this is realistic and all the more so under a common jurisdiction like the EU. In the model the present value of those would then be captured by $\eta\tau_2$. Further, the assumption of trivial deadweight losses may arguably be not so much of a stretch in the broader Eurozone context, as countries with stronger fundamentals indirectly benefit from the debt crisis via lower borrowing costs.

dilution in equilibrium.

Now we are ready to characterize lender's cash flows. Figure 9 describes the cash flow for a lender at $t = 0$. In period $t = 1$ the lender receives interest payments $r_0\tau$. With probability π_N the lender will face a "No-Action" path. In this case with probability $\pi^{'}$ the creditor receives a total revenue of $(1+r_f)r_0\tau_0 + (1+r_0)\tau_0$, which consists of the revenues from investing the interest received in the middle period in the risk free technology and the interest plus principal. With probability $1-\pi^{'}$ the borrower will default, and the creditor receives $(1+r_f)r_0\tau_0+c(1+dr_0)\tau_0+\eta F_2$. On the other hand, with probability π_I the lender will face a "New Issuance" situation in which case with probability $\pi^{''}$ the borrower will repay in the second period and with probability $1-\pi^{''}$ it will default and the creditor will receive $(1+r_f)r_0\tau_0 + (1+r_0)\tau_0$ and $(1+r_f)r_0\tau_0 + c(1+dr_0)\tau_0 + f\eta F_2$ respectively.

Figure 10 shows the cash flows associated to lending at $t = 1$. With probability π' the creditor is paid back interest plus principal, $(1+r_1)\alpha\tau_1$. With probability $1-\pi'$ the creditor faces sovereign default, in which case she receives $c(1+dr_1)\alpha\tau_1 + (1-f)\eta F_2$.

3.3 Sovereign Payoffs

The government is risk neutral, has a discount factor of β and maximizes expenditure $G = \sum_t \beta^t G_t$. The payoffs in each period are described below.

In period $t = 1$ there are two possibilities. If the borrower exerts No-Action, we have that

$$G_1 = F_1 - r_0\tau_0, \tag{1}$$

expenditures equals fiscal revenues at time 1, $F_1 = \tau_1 + \tilde{\epsilon_1}$, minus interest payment.

In the case the borrower issues fresh debt (I), then

$$G_1 = F_1 - r_0\tau_0 + \alpha\tau_1, \tag{2}$$

expenditures equals fiscal revenues at time 1 minus interest payments plus fresh debt issuance.

In the last period there are four possibilities. After No-Action the sovereign can repay or default. If it repays, we have that

$$G_2 = F_2 - (1+r_0)\tau_0, \tag{3}$$

expenditure equals fiscal revenues at time 2, $F_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2}$, minus debt re-payments.

If it defaults

$$G_2 = F_2 - c(1 + dr_0)\tau_0 - \eta F_2, \tag{4}$$

expenditure equals fiscal revenues at time 2 minus punishment due to default, given by remaining debt obligations after haircuts and fiscal confiscations.

On the other hand, after new debt issuance (I), if the sovereign repays

$$G_2 = F_2 - (1 + r_0)\tau_0 - (1 + r_1)\alpha\tau_1, \tag{5}$$

expenditure equals fiscal revenues at time 2 minus debt re-payments of debt issued at $t = 0$ and $t = 1$.

If it defaults

$$G_2 = F_2 - c(1 + dr_0)\tau_0 - c(1 + dr_1)\alpha\tau_1 - \eta F_2, \tag{6}$$

expenditure equals fiscal revenues minus punishments due to default on all debt.[8]

3.4 Fiscal Discoveries and Sovereign Defaults

An important ingredient of our model is asymmetric information between the sovereign borrower and international lenders: while the borrower can perfectly observe the realization of the middle period fiscal shock $\tilde{\epsilon_1}$, lenders cannot. While other building blocks of our model are more readily backed by the empirical evidence presented in Section 2, the assumption on informational noise is much harder to pin down empirically; yet, in appendix A we argue why it is less far-fetched than it might appear in some of the recent eurozone debt crisis (see also Nagar and Yu, 2014 for a more formal empirical discussion in other financial crisis contexts). In the model, we further circumscribe the form of such an information asymmetry: the only way lenders can infer some information about the realization of the shock is through the borrower's action in the middle period: No-Action (N) or Fresh Issuance (I). Lenders at $t = 1$, after observing the borrower action will update (when possible) their beliefs of future default and re-price debt accordingly.

We model the borrower and lender interaction as a game. The borrower's strategy consists of an initial debt issuance D_0, an action after observing the shock realization in period 1,

[8] When calculating the PBE equilibrium for the game, one clearly needs to impose that parameter values are such that budget constraints at the end are satisfied. For details see Appendix.

No-Action (N) or Fresh Issuance (I), and a repayment decision on all outstanding debt in period 2. The lenders' strategy is to set break-even interest rates in each period. Given the information asymmetry described above, lenders will update beliefs about the shock realization in period 1 after observing the borrower's action. A Perfect Bayesian equilibrium (PBE) is an equilibrium in which everybody's response is optimal given everybody else's responses and beliefs, and beliefs are consistent with strategies and updated using Bayes' rule (whenever possible).

There are potentially two types of equilibria in pure strategies: Separating and Pooling. In a separating equilibrium actions following each shock realization will be different, and hence completely revealing. In this case, the equilibrium interest rate charged in period 1 will differ from the interest rate charged at time 0.[9] On the other hand, in a pooling equilibrium actions following different shock realizations are the same. In this case, there is no information revelation and credit conditions remain unaffected.

In Section 4 we numerically solve for the PBE equilibria in this model for different sets of parameters. For some parameterizations, a separating equilibrium can be sustained. In equilibrium the sovereign exerts no-action (N) after a good fiscal shock realization and issues fresh debt (I) after a bad fiscal shock realization. Hence, the sovereign action is completely revealing and has credit market repercussions producing a spike in spreads which could make future default more likely. Moreover, there is a set of parameter values such that a pooling equilibrium can be sustained. In equilibrium the sovereign exerts no-action (N) regardless of the fiscal shock realization. In this case, there is no information revelation and hence pricing stays put.

Section 4 describes the parameterization sets under which each type of equilibrium arises. The general intuition is as follows. Whether a separating or a pooling equilibrium can be sustained depends on a trade-off between the benefit and the cost of borrowing in the intermediate period. In our model, a country may find convenient to borrow for two reasons. First, if the sovereign's discount factor β is lower from the investors' discount factor $1/(1+r_f)$, then the sovereign would find attractive to borrow in order to front load consumption. Second, since default is possible, taking on more debt increases the value of the default option.[10] To see this, note that from equation (5) and (6) the expected benefit

[9] The separating equilibrium is fully revealing. The interest rate at time 1 will reflect the low type's true probability of default. This is a consequence that in our model the space of signals, $\{N, I\}$ is as rich as the space of shock types $\{H, L\}$. If we were to add more shock types in our model, complete revelation would not happen anymore in a separating equilibrium, and hence asymmetric information would not only make pooling equilibrium possible but would also have an amplifying effect on pricing in the separating case. See Catão, Fostel and Kapur (2009).

[10] Adding curvature to government preferences in the model would exacerbate this effect, rather than overturn it. So, it would not change qualitatively our results. It would change, however, the relative size of equilibrium regions: there would then be a consumption smoothing motive for debt, so a separating

of borrowing at time 1 is given by $\alpha\tau_1 + \pi^{''}(F_2 - R_0D_0 - R_1D_1 + (1-\pi^{''})((1-\eta)F_2 - c(R_0D_0 + R_1D_1))$, where $D_0 = \tau_0$ and $D_1 = \alpha\tau_1$ and $R_t = 1 + r_t, t = 0, 1$. It follows that for R_0, R_1 and D_0 fixed, the expected marginal benefit of borrowing in the intermediate period is $1 - \pi^{''}R_1 - (1-\pi^{''})cR_1 = 1 - R_1[\pi^{''}(1-c) + c]$. Hence, holding initial debt and interest rates constant and $c < 1$, the marginal benefit of an extra unit of borrowing is declining on the probability of repayment $\pi^{''}$. Following a bad shock, there is an incentive to borrow in the middle period even with linear preferences. Importantly, this incentive rises on the volatility of tax revenues as the latter positively affects default probabilities. Hence, countries with higher underlying volatility of fiscal revenues will tend to value the mid-period option of extra-borrowing higher. It is not therefore surprising that, as we show in the next section, higher volatility has a bearing on the prevalence of separating relative to pooling equilibria.[11]

However, borrowing has a cost since R_1 is clearly affected by D_1. In a standard setting with no information asymmetries, once extra borrowing takes place and the ratio of debt to revenues D_1/F_2 goes up, R_1 will go up to the point that investors' break-even condition is satisfied. Asymmetric information adds an extra channel through which D_1 affects R_1 given that borrowing becomes a signal, and all the more so since information asymmetry generates the possibility of either a pooling or a separating equilibrium. In addition, because of debt dilution, investors at time 0 will internalize the possibility of middle period borrowing and R_0 will go up for this reason as well. Thus higher R_0 and R_1 will detract from the sovereign's incentive to play a separating strategy borrowing in the middle period.

This trade-off is what determines whether a separating or pooling equilibrium can be sustained. For some parameter values, the country that receives a bad fiscal shock realization may find profitable to forego the option of borrowing so as to not face higher interest rates. When the benefit of issuing new debt is smaller than it cost, then only a pooling equilibrium can be sustained. Conversely, for some other parameter values, a country that received a bad fiscal shock may be willing to face higher interest rates. In this case, the benefits of issuing new debt far out-weight its costs and a separating equilibrium can be sustained. We study in detail how this trade-off plays out under distinct parametrizations in Section 4.

equilibrium would be easier to sustain. Another incentive to increase debt in the middle period is the presence of tax Laffer curve effects. When initial debt and tax rates are already sufficiently high that further hikes in rates are revenue-reducing, this can increase the incentive to borrow in t=1 upon a bad shock. For a discussion of tax Laffer curve effects on sovereign risk, see Bi (2012).

[11] See Broner et.al. (2007) for a discussion and evidence on the incentives to issue short-term debt.

3.5 Fiscal Discoveries and Sudden Yield decoupling

As stated in the introduction, a central goal of this paper is to show how the existence of these two distinct equilibria can rationalize the behavior of spreads shown in Figure 1. Answering this question involves a clear distinction between the concept of "country" and "type" in this model. Let country i be defined by $\theta^i(\delta^i, \epsilon^i)$, where δ^i is a vector of country i's fundamentals (recovery functions, hair-cuts, discount factor, etc) and ϵ^i is the vector of country i's fiscal shocks.

In our model, for a given country i, ϵ_1^i is private information and δ^i is common knowledge. Hence, a "type" in our model is defined by the shock realization, i.e., country i could be a high type (when shock realization is high) or a low type (when shock realization is low).[12]Hence, investors in our model can perfectly recognize the difference between different countries fundamentals, but cannot directly observe specifics of fiscal outlooks within each country in real time.

What is key is that the (common knowledge) vector of fundamentals δ^i is what determines the magnitude of the main trade-off explained before and hence the type of equilibrium that can be sustained. We explore quantitative aspects of such equilibria in Section 4, but the intuition is as follows. Consider for the sake of concreteness two countries: country-A, characterized by a set of weak fundamentals, who plays a separating strategy and country-B, characterized by a set of strong fundamentals, who plays a pooling strategy. Suppose countries are hit by a positive fiscal shock. In this case, investors will observe both countries refraining from borrowing and this will generate a very small difference in country spreads. The gap in country spreads that should prevail due to the gap in country fundamentals is dampened by the presence of informational noise. Though country-B received a good shock, investors do not learn in the pooling game, whereas they do learn in the separating game that country-A was on a good fiscal path. However, the situation is quite different following a negative fiscal shock. In this case, the informational noise works in the same direction as the gap in fundamentals: though investors do not learn from country-B's behavior, they do learn that country-A is on a negative fiscal path and hence spreads wildly diverge. Hence, fiscal discoveries provide a mechanism that can explain both, convergence and sudden yield decoupling.

It is worth re-emphasizing that we are not rationalizing convergence and sudden decoupling by a general cross-country shift from a pooling to a separating equilibrium. Instead, convergence and divergence obtain from the time series implications of pooling and separating

[12]In a more realistic situation the vector or fundamentals δ^i and fiscal shocks realizations ϵ^i, can be correlated and hence fundamentals would not be perfectly observable either. In this model we abstract from this complication.

equilibria played by different countries. In other words, our model-based interpretation is that yield decoupling takes place because distinct country groups were, at any given point of time (prior and post-2007), finding optimal to play different strategies– some were playing a pooling strategy, whereas others were playing (also all along) a a separating strategy. In other words, we rationalize the spread behavior in Figure 1 with a model wherein countries with different fundamentals are on different equilibrium paths all along, but which become discernible only during bad times.

Finally, it is worth elaborating on the role of asymmetric information in our results. As discussed above, asymmetric information introduces a non-trivial trade off between the option value of borrowing and interest rates given the signal nature of countries' issuance. Country-specific parameters will then determine whether countries find optimal to play a separating or a pooling strategy. Relative to the canonical model, our model delivers the possibility of explaining two central features observed in the recent debt crisis. First, spread stability despite a bad shock that lowers income and hence raises debt-to-income (D/Y) ratios. In the canonical model all country yields (relative to the risk free rate r_f) will go up. This is because the expected D/Y in the final period will go up even for those that do not borrow in the interim period. The possibility of pooling equilibrium in our model makes it possible that only a subset of countries spreads go up (see Figure 1). As a consequence, a model without information asymmetries will produce a smaller yield dispersion. Second, because for some countries the yield stays put, whereas for other will move, the country spread will be higher than under symmetric information. In short, asymmetric information generates yield stability during good times and greater yield dispersion during bad times.

4 Model Calibration

In this section, we numerically solve for our model's PBE under alternative parametrizations. In Appendix B we describe in detail all the equations that analytically characterize different types of equilibria–separating and pooling. We also describe the precise equilibrium finding procedures that involve a fixed point problem solution.[13]

The goal is threefold. First, we identify sets of parameters for which either a pooling equilibrium or a separating equilibrium exist.[14] When either pooling or separating equilibria

[13] All the actual computational programs done in Matlab are available upon request.

[14] We focus only on pure-strategies equilibria. We also found regions of non-existence. The possibility that no equilibrium exists for some regions of the parameters is a standard feature of models with asymmetric information. It may genuinely reflect either credit rationing in the first period or market freeze in the post-shock period. For the parameterizations that we considered, we also find that there is no multiple equilibria – equilibrium is either pooling or separating.

exist, we assess the corresponding impact on interest rates and default risk in good and bad times. Second, within these two possible types of equilibria, we distinguish various cases regarding the relationship between the nature of the shock, the reaction of bond yields, and the optimality of default. More precisely, in some cases bad shocks are not followed by either rising yields or a default; in others rising yields may or may not be followed by default; and finally there are cases in which default may not be preceded by higher yields. Third, we examine the sensitivity of equilibria to parameter changes. The parameters we are particularly interested in are: (i) parameters that characterize fiscal shocks–namely, the variance of the first and second period fiscal revenue shock and the persistence of the first period revenue shock; (ii) default costs, as gauged by the "haircut" on debt obligations and the confiscable share of fiscal revenues.

The simulations below show that for a given distribution of shocks, countries with "stronger" fundamentals generally find optimal to play a pooling strategy and those with "weaker" fundamentals find it optimal to play a separating strategy. However, what makes a country "strong" or "weak" is not obvious. Some countries may be stronger with regard to some fundamentals (e.g. deep capital markets and substantial worldwide linkages that make default extremely costly), but weaker with regard to others (e.g. being subject to larger shocks).

Further insight can be gained by considering four broad scenarios: (i) a *baseline* scenario in which the variance of the first and second period shock are equal; (ii) a *high short run risk* scenario in which the variance of the first period shock varies and is allowed to be much higher than in the final period. In the case of a negative shock, this scenario captures an immediate crisis situation in which the economy is subject to a sharp contraction in the first period while only facing small uncertainty in the second period; (iii) a *high long run risk* scenario in which the variance of the second period shock varies and is allowed to be much higher than the variance of the first period shock. This scenario is meant to describe an economy that is not subject to a major shock in the immediate future but faces large uncertainty in the medium-long run; (iv) a *high persistence* scenario in which the persistence of the first period shock is higher than in the baseline scenario.

Finally, within each of the two type of equilibria, pooling and separating, there can be distinct outcomes regarding default. We index each of this possible outcomes by a number, ranging from 1 to 6. [15] The different possible equilibria are the following:

1. Default never occurs.

2. Default occurs only after two consecutive negative shocks.

[15] See the technical appendix for a full characterization of these different equilibrium cases.

3. Default occurs only after a negative second period shock (regardless of the first period shock).

4. Default occurs only after a negative first period shock (regardless of the second period shock).

5. Default occurs after either a first or a second period negative shock.

6. Default always occurs.

4.1 Parametrization

The model contains thirteen parameters: (i) those regarding the initial level of borrowing (τ_0) and the sequence of expected fiscal revenues in period 1 and period 2 (τ_1, τ_2); (ii) those regarding fiscal shocks which consist of the probabilities of first and second good shock realizations p and q, the variance of the first and second period shocks ($\sigma(\varepsilon_1), \sigma(\varepsilon_2)$), and the persistence of the first period fiscal revenue shock (ρ); (iii) those regarding default costs captured by the recovery rate (c, d) – i.e., one minus the haircut– and the confiscated share of revenues (η); (iv) those regarding inter-temporal preferences, that is, the discount factor (β) and the risk-free interest rate (r). Table 2 shows parameter values for the baseline and alternative cases we consider.

Let us first discuss the parameter values in what we call the baseline scenario. The initial debt issuance in period 0 is normalized to 100. The mean fiscal revenues in period 1, τ_1, is set to 100. In many advanced countries – and particularly in the Eurozone, general government revenues are typically in the range of 40% to 50% of GDP, so this parametrization would thus imply an initial (pre-crisis) debt to GDP ratio in that range. This is not far-off the mark: the external debt to GDP ratios for Greece, Portugal, and Spain prior to the crisis (2005) were 55%, 45% and 36% respectively (see Catão and Milesi-Ferretti, 2014). We set the second period mean fiscal receipts, τ_2, to 135. This level is high enough so that a country hit by two negative shocks and defaulting is still able to meet default payments, and low enough so that there is significant default risk. Since our model features only two periods, the second period fiscal revenues could be understood as the present value of future government revenues that can be used to pay off government liabilities, so it should be substantially higher than in the initial period.

The two i.i.d. shocks, ε_1 and ε_2, have the same probability of good realization, $p = q = .5$, and standard deviation, $\sigma(\varepsilon_1) = \sigma(\varepsilon_2) = 10$. The persistence of the tax revenue shock is $\rho = 0.8$. As illustrated in Table 1, these are of a similar order of magnitude of the actual cyclical volatility and persistence of real tax revenues shocks, notably in countries at the

epicenter of the recent debt crisis (and even more so if we were to include the 2008-2012 period in the estimation of these parameters).

Following the rationale discussed earlier (see footnote 7), the fiscal confiscation parameter η varies between 0.1 and 0.3. Regarding the other default costs parameters, the recovery rates, we always consider $d = 1$ and we parameterize c to be between 0.5 and 0.9, consistent with the value range for the haircut (1-recovery rate) between 10% and 50%, as suggested by cross-country evidence (e.g. Cruces and Trebesh, 2011).

Finally, we set the discount factor β to be 0.96 and the risk-free rate to $1+r = 1/\beta+0.001$, implying that international lenders are only infinitesimally more patient than domestic borrowers. This effectively mitigates one of the incentives for borrowing typically found in infinite horizon versions of the canonical model, where the challenge is to engineer debt to GDP ratios in equilibria that are not unrealistically low, sometimes featuring much lower β values.[16]

In the other three alternative scenarios described in Table 2, the fiscal confiscation parameter η is set equal to 0.25, and we vary the short-run risk $\sigma(\varepsilon_1)$ between 0 and 30, the long-run risk $\sigma(\varepsilon_2)$ between 0 and 30, and the persistence ρ between 0.5 and 1 in the first, second and third alternative scenarios respectively.

4.2 Numerical Results

Each scenario is presented using two figures. In the first figure, panel (a) plots the nature of the equilibrium (separating or pooling) and non-existence regions, panel (b) plots the type of separating equilibrium (ranging from 1 to 6), and panel (c) plots the type of pooling equilibrium (ranging from 1 to 6), all as a function of the relevant varying parameters in each scenario. In the second figure, we plot the interest rates following the realization of the interim period shock as a function of the relevant varying parameters in each scenario. Panel (a) plots the interest rate in the case of a pooling equilibrium (which is the same after a good and a bad fiscal shock), whereas panels (b) and (c) plot the interest rates in a separating equilibrium, after a bad and a good fiscal shock realization respectively.

Baseline Scenario

Figure 11 presents the numerical results for the baseline scenario. In this case, we vary the default costs parameters η and $1 - c$ (see Table 2). When default costs are large enough (i.e. the confiscation parameter η is high and haircut is low) the optimal strategy for a

[16] See, e.g., Table 2 in Aguiar and Gopinath (2006).

country hit by a bad shock is not to issue new debt. This pooling equilibrium prevails for a wide range of parameters as long as a reduction in the recovery rate is compensated by an increase in the fiscal confiscation in order to maintain default costs high enough. Further, this pooling equilibrium is a type-1 equilibrium, i.e.no default occurs for any shock realization in the second period. The reason is that by not issuing, the country hit by a bad shock maintains its debt burden at a low enough level so that defaulting is never optimal. If default costs are smaller, however, incentives to issue following a bad shock are higher and a separating equilibrium emerges. In this separating equilibrium (a type-2 equilibrium), a country hit by a bad shock chooses to re-issue and it may default if it experiences a bad shock realization in the final period.

Figure 12 shows period-one interest rates as a function of the same parameters. Panel (a) shows the interest rate in the case of a pooling equilibrium. Since this equilibrium is default-free, the interest rate is equal to the risk-free rate (4.27%). Panel (b) shows the interest rate in a separating equilibrium following a good shock. Depending on the severity of the default costs, the interest in a separating equilibrium varies between 4.28% and 4.85%. In good times, the spread between a country playing a pooling and a country playing a separating strategy is therefore at most 0.58%. Notice that this is the case despite the fact that countries face different final default risks. Panel (c) shows the interest rate following a bad shock realization. In this case, the interest rate can be much higher (up to 7%) reflecting the potential of future default costs. The interest rate behavior just described is robust to parameter changes as presented below: after a good shock realization, countries with very different fundamentals face similar rates (so spreads are small); however after a bad shock realization spreads increase.

These baseline results yield two important insights. First, countries experiencing the same negative fiscal shock realization, but with different costs of defaulting, can be characterized by very different borrowing behavior and yields, and hence distinct default probabilities. In one case (pooling), countries will not issue debt and by doing so will remain riskless. In the other case (separating), they will compensate a bad shock by issuing more debt at a higher interest rate therefore risking default in the second period. Second, the ranges of parameters for which a pooling equilibrium and a separating equilibrium exist are adjacent. This implies that small differences in default costs can generate large differences in equilibrium outcomes. Therefore, it is plausible in this model that the equilibrium changes from pooling to separating following a modest re-assessment of the default costs, as arguably is in practice.

Short Run Risk Scenarios

Figures 13 and 14 present evidence on the sensitivity of the type of equilibria and of the attendant yields to changes in short-run uncertainty and haircuts. Relative to the baseline calibration (which sets $\sigma(\varepsilon_1) = 10$), now the short-run volatility can be up to three times as large since $\sigma(\varepsilon_1) \in [0, 30]$. Confiscation after default is fixed at $\eta = 0.25$ throughout these figures (see Table 2).

Figure 13 shows that pooling is harder to sustain when short-run volatility increases. At the baseline level, for a short-run volatility equal to 10, pooling can be sustained for any haircut lower than 0.28. When short-run volatility is 20, the range of pooling is much smaller, with pooling sustainable only for haircut lower than 0.2. The flip side is that the range of parameters over which a separating equilibrium obtains is now larger. The intuition is simple. Given substantial persistence ($\rho = 0.8$), higher short-run volatility (relative to second period volatility) implies that a large part of the uncertainty can be resolved after the first period shock, strongly conditioning the default vs. repayment outcome in the second period. Consider a country with a haircut equal to 0.25: when short-run volatility is set at the baseline level, the country is in a pooling equilibrium. However as soon as short-run volatility increases beyond 12, a separating equilibrium emerges with associated default risk in the second period. Moreover, as shown in panel (c), a new type of separating equilibrium (type-4) arises, implying that the first period shock is a perfect predictor of second period default. Countries hit by a bad shock face little prospect of recovery and default in the second period. Countries experiencing a positive shock remain solvent in the second period.[17] As a consequence the bond yield is higher than in the baseline case, ranging from 500 to 950 bps (see Figure 14 panel (c)). As seen in Section 2, this range is in line with recent debt crisis experience.

The main insight coming out of this scenario is that short run volatility can have a profound effect on countries default risk and yields. The higher the short-run volatility the easier it is to sustain a separating equilibrium. Once again, here "the Tarpeian Rock is not far from the Capitol" as the range of default costs for which following a bad shock, the country remains either riskless (pooling equilibrium of type 1) or defaulting for sure (separating equilibrium of type 4) are adjacent.

Long Run Risk Scenarios

Figures 15 and 16 present evidence on the sensitivity of the type of equilibria and of the attendant yields to changes in long-run volatility and haircuts. Relative to the baseline

[17] This illustrates a general feature of our model which is that default takes place during bad times. For empirical evidence on this regularity see Wright and Tomz (2007) and Yeyati and Panizza (2011).

calibration (which sets $\sigma(\varepsilon_2) = 10$), now the long-run volatility can be up to three times as large since $\sigma(\varepsilon_2) \in [0, 30]$. Confiscation after default is fixed at $\eta = 0.25$ throughout these figures (see Table 2).

As shown in Figure 15 panel (a), pooling dominates, specially when default costs (lower hair-cut) are high enough. Note that despite the high variance of the final period shock, the economy remains risk less (type-1 equilibrium), as shown in Figure 15 panel (b). Anticipating that borrowers will not find optimal to issue new debt following a bad shock, creditors do not face any dilution risk. However, as long-run volatility increases, the possibility of remaining default-free in all circumstances is somewhat reduced, implying that the combination of parameters for which pooling is an equilibrium shrinks slightly. As shown in Figure 15, a separating equilibrium is harder to sustain compared to the baseline scenario: when the long-run volatility increases, the region of parameters for which a separating equilibrium exists tends to shrink. And when long-run volatility is high enough, there is no separating equilibrium.

Interestingly, the timing of volatility matters greatly for the type of separating equilibrium. In the case of short-run volatility, an increase in short-run volatility shifts the type of separating equilibrium from type 2 (default occurs only in the eventuality of two subsequent negative shocks) to type 4 (defaults occurs for sure in the final period if a bad shock occurs in the interim period). The exact opposite occurs with long-run volatility. The reason for this contrast is due to the fact that under high short-run volatility, default risk is highly determined by the first period shock with little chance of avoiding default after a negative interim period shock. Under high long run volatility, uncertainty about the future means more chances to escape default.

The combination of a low debt level and a low interest rate (see Figure 16 panel (a)) makes it optimal for debtors to choose not to default even in the situation where they suffer two bad fiscal shock realizations in a row. In the tiny region where equilibrium is separating, the interest rate can be much higher than the risk free rate (see Figure 16 panel (c)).

The main insight coming out of this scenario is that long run volatility can have profound effect on countries default risk and yields. The higher the long-run volatility the harder it is to sustain a separating equilibrium. The reason for this is simple. When the second period shock is larger than in the baseline, there is a lot of future uncertainty on the ability to service debt.

Varying Persistence

Figures 17 and 18 present evidence on the sensitivity of the type of equilibria and of the attendant yields to changes in persistence and haircuts. Relative to the baseline calibration

(which sets $\rho = .8$), now we let persistence to vary from 0.5 to 1. Confiscation after default is fixed at $\eta = 0.25$ throughout these figures (see Table 2).

As shown in Figure 17 panel (a), the parameter range for pooling (separating) is somewhat smaller (larger) than in the baseline scenario. When equilibrium is pooling default never occurs (Figure 17 panel (b)) and hence the interest rate is very insensitive to persistence (Figure 18 panel (a)). As shown in Figure 17 panel (c), as persistence increases, two types of separating equilibria exist: a type-2 equilibrium when persistence is low enough, and a type-4 equilibrium when persistence is very high, and so default will happen for sure after a bad shock in t=1. When the equilibrium changes from type-2 to type-4, the interest rate increases sharply as the economy evolves from a situation in which default next period will occur only in case of a repeated bad shock to a situation in which default is unavoidable and the bond yield rate sky rockets (Figure 18 panel (d)).

The main insight coming out of this scenario is that persistence can have profound effects on default risk and hence on yields. The higher the persistence, the easier it is to sustain a separating equilibrium. The intuition is again simple: higher persistence improves the informational value of countries' middle period signal regarding default risk in the second period. This means that when fundamentals are not strong enough to ensure pooling, default risk and hence bond yields are extremely sensitive to shock persistence. Finally, note that there is an important difference between higher short-run volatility and higher persistence. As shown in Figure 12 and Figure 13, a separating equilibrium that exists with low short run volatility could disappear when short run volatility is high enough. This is not the case with persistence. As Figure 16 shows, a separating equilibrium that exists with low persistence, will continue to exist with higher persistence.

The Time Series Pattern of Interest Spreads

Given that a main empirical motivation of this paper is to explain the time-series evolution of cross-country bond yields, we can illustrate how our model can roughly reproduce the time series pattern of actual bond yields depicted in Figure 1. Using our baseline calibrations, we characterize two countries: a "strong-fundamentals" country, country B, (defined as having an expected hair-cut of only 0.15) vs. a "weak-fundamentals" one, country A, (defined as having a hair-cut twice as large). The two countries have the same value for all the other fundamentals including a common confiscation parameter of 0.25. In particular, they are facing the same shock structure. Under this parametrization, country B is in a pooling equilibrium and country A in an type-2 separating equilibrium (meaning that it will default only if it experiences two negative shocks in a row).

In order to produce time series patterns on borrowing terms and default decisions between time 0 and time T, we consider a repeated version of our two-period credit market game

between borrowers and creditors. This approach implicitly assumes that debtors issuing at time $t+2$ are not liable for the debt incurred at period t. While not ideal in general, this assumption is innocuous to describe a sequence in which repayment occurs with certainty – because of a series of consecutive good shocks - until the last period where default is possible – because of a bad shock realization.[18] The time series reports the "on the run" interest rate which is either the interest rate on the new issues, or the interest on the outstanding debt issued last period if no new debt has been issued.

Figure 19 plots a simulation of the interest rate of the two countries for $T = 10$: so there are 9 successive positive shocks followed by one negative shock.[19] In this case, during good times (i.e., before the negative shock hits), the bond of country A yields 4.7% return, whereas that of country B yields 4.3%. As in the data, the good times spread between a weak (A) and strong (B) fundamentals country is very narrow despite the fact that the strong fundamental country is default-free while the weak fundamental country faces a 25% chance of default in two periods.[20] After the final bad shock realization, the yield of country A rises to 6.5%. Hence, a significant yield decoupling takes place.

Keeping the parameterization of default costs at the same level ($c = 0.3$ for A and $c = 0.15$ for B), Figure 20 shows what happens if the weaker country A faces higher volatility (both short and long term) as well as higher persistence. When short-run volatility increases from 10% to 15%, the interest rate in good times increases very modestly, by 10 bps, but the interest rate following a bad shock increases sharply form 6.5% to 9.1%. Raising persistence from the baseline level of 0.8 to 0.9 also implies a rise in interest rate following a bad shock but more modest (to 7.2%). Halving long-run volatility from 10% to 5% reduces slightly the good times interest rate (by 5 bps) but actually it increases the interest rate following a bad shock (from 6.46% to 6.87%) reflecting the lower probability to offset the consequence of a negative shock in the interim period by a good shock in the final one. These results indicate that, conditional on some countries playing a separating equilibrium strategy, a bad shock can generate yield dispersion of considerable degree depending on the size of the shock and its persistence. This is broadly consistent with the evidence discussed in Section 2, where it is shown that the magnitude of tax revenue shocks – even if negative for all countries – display considerable cross-country differences.

[18] A more elaborate set-up would consider a dynamic game instead of a repeated game. In this case, the default decision at time t of the credit game starting at time $t-2$, would depend on the ability of the debtor to issue new debt at time t.

[19] We can interpret this sequence of shocks as reflecting the post euro-adoption period followed by the crisis of 2008.

[20] The default probability corresponds to the probability of experiencing two successive negative shocks.

5 Conclusion

Through the lens of our model, sovereign yield dispersion across the Eurozone can be rationalized by the co-existence of two country groups on distinct equilibrium paths all along: for one group, fundamentals are strong enough for a pooling strategy to be optimal; but not for all others. As the two groups were subject to smaller and mostly positive shocks between 1999 and 2007, yields converged except for residual gaps due to differences in common-knowledge fundamentals. But when the large negative common shock of 2008-09 hit and tax revenues dropped sharply, it was still optimal for the first group to adjust spending and refrain from borrowing, thus signaling a brighter fiscal outlook; in contrast, for those on a separating equilibrium it was optimal to resort to extensive borrowing. Higher debt ratios and expected deterioration of the fiscal outlook in the latter group translate into higher country risk.

Two key fundamentals that distinguish country groups in the model are the underlying volatility and persistence of fiscal revenue shocks. They give rise to distinct valuations for the option of extra borrowing: more volatile countries tend to benefit more from the option of borrowing to either default or gamble for resurrection. These differences in the underlying stochastics of revenue shocks have been non-trivial across the Eurozone. As we have documented, countries at the epicenter of the recent crisis have also been the ones where fiscal revenues have been historically more volatile and subject to more persistent shocks. A novelty of our model relative to previous models is to show how asymmetric information on the country-specific public finances can amplify yield decoupling.

Four results of our model's simulations deserves emphasis. First, the model re-assuringly delivers spreads that roughly match real world counterparts for sensible parameterizations. Second, it posits that high short-term uncertainty regarding fiscal revenues increases the dominance of separating equilibrium. Conversely, higher long-run uncertainty increases pooling. Third, there are sizable regions of continuity between the two equilibria around some (empirically) relevant parameter ranges; so some equilibria can be quite fragile. This can have far-reaching implications if (and when) parameter uncertainty is substantial; so, while parameter uncertainty does not explicitly feature in our setting, these results are suggestive that it is a potentially interesting avenue for future extensions. Fourth, we never obtain equilibrium regions where default occurs when equilibrium is pooling. If, instead, the equilibrium is separating, default may or may not ultimately materialize depending on the size and sequencing of shocks as well as the relative cost of default.

We draw the following policy implications. One is that structural reforms that bring the volatility of tax bases and of revenue collection closer to those of pooling countries

seem important to mitigate yield dispersion during bad times. At the same time, as we document, intra-Eurozone differences in volatility and persistence of fiscal revenues have been long lasting; so, their seemingly structural nature suggests that reforms may take time in narrowing such differences. Thus, a well-functioning system of fiscal transfers or a full-fledge fiscal union increase their appeal if mitigating yield dispersion and default risk during bad times is a central goal. Until such a system is fully functional, central banking policies may also have a role to play in mitigating default risk during bad times, for instance along the lines discussed in Reis (2013). While an analysis of the welfare implications of the various policy options clearly requires a more encompassing setting, we see our model as providing a tractable and readily calibratable tool to gauge a relevant mechanism of crisis transmission at play.

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Appendix

Appendix A: Information Frictions

While fiscal deterioration played an important role, a common view is that the magnitude of fiscal shocks and rising public debt are not per se sufficient to explain the actual sharpness of yield decoupling. One hypothesis is that the interaction between a deteriorating fiscal position, low precision of new fiscal information, and uncertainty about medium and long-term outlooks is what is key. Current fiscal deterioration and greater uncertainty on the medium-term fiscal outlooks are both consistent with the 5-year ahead IMF forecasts for the debt path in Eurozone crisis countries relative to others like the US and Germany.[21]

[21] These forecasts are all based on those published in the IMF semi-annual "World Economic Outlook" report which is publicly available from the IMF website. They are deemed to contain the best information *publicly* available at the time of the report.

While Figure A1 shows that all advanced countries—inside and outside the Eurozone—have seen their fiscal outlooks deteriorating, not only is the deterioration more dramatic in the Eurozone crisis countries but also the variance of such forecasts is much higher.[22]

Such large cross-country differences in the mean and variance of fiscal outlooks can be ascribed to three factors which have been highlighted by the press and which will also play a key role in our model. The first is the uncertainty regarding the economic recovery and hence the recovery of the tax revenue base. The second is the uncertainty about public spending adjustment - arising from dubious political resolve to streamline benefits as well as uncertainty regarding costs of financial sector bail-outs – coupled with uncertainty about the outcome of new revenue-enhancing measures. In the model we lump these two factors together in the form of a higher variance of future fiscal positions.

The third factor is associated with uncertainty about the accuracy of publicly announced fiscal statistics, both current and (sometimes) well past. Suggestive evidence on the low precision of past fiscal statistics can also be gauged from Figure A1 by comparing the 2008 debt/GDP figures across the different forecast vintages. Specifically, for the 2009–2011 forecast vintages, the 2008 debt to GDP ratio is not a forecast but an out-turn. For Germany and the U.S., all post-2008 forecast vintages start from around the same "starting point", indicating that revisions in the initial (2008) debt/GDP statistics have been minimal. This is clearly not the case for Greece or Portugal. Similarly, there has been greater uncertainty regarding the 2009 ratio for all Eurozone countries depicted (including Germany) than for the U.S., with such uncertainty being higher, once again, for crisis countries.

One may contend that such a "measurement uncertainty" may be equally shared by investors, governments, and general public, i.e., that such an information friction is "symmetric". Along these lines, it could be argued that statistical agencies in some countries are weak in terms of collecting and processing first round data, so substantial historical revisions can take place. Prima-facie, however, it is no less plausible that information about the true state of public finances is asymmetrically distributed, as current administrations have privileged access to tax records that most national laws shield away from public scrutiny. Indeed, when fiscal news are bad, the incumbent administration has clear incentives to either hide them or delay their release so as to smooth market reaction to the "true" shock. Recognition of this incentive to obfuscate or to only gradually reveal true in-

[22] One could argue that such a systematic dispersion of forecasts across time may reflect forecasting errors rather than increasing uncertainty on the macro outlook. Yet, this interpretation does not bode well with rational expectations, nor with the fact that it has been shared across forecasters. Furthermore, what is critical here is the much greater and systematic widening of the forecast variances in the crisis eurozone countries relative to other advanced countries. Forecast fiscal data for other advanced countries were omitted to save space but are available from the authors upon request.

formation on fundamentals is a key centerpiece of a sizable political economy literature on the pro-cyclicality of fiscal policy (see, e.g., Alesina et al, 2008). Sizable ex-post revisions of actual outurns of the non-trivial magnitudes shown in Figure A1 are suggestive of this possibility. There are other indications that uncertainty on fiscal positions is asymmetrically distributed. One comes from candid official narratives. For instance, an official report by the European commission on the state of Greek government debt and deficit statistics dated January 2010, thus at a crucial turning point of the crisis, states:

> "On 2 and 21 October 2009, the Greek authorities transmitted two different sets of complete Excessive Deficit Procedure (EDP) notification tables to Eurostat, covering the government deficit and debt data for 2005–2008, and a forecast for 2009. In the 21 October notification, the Greek government deficit for 2008 was revised from 5.0% of GDP (the ratio reported by Greece, and published and validated by Eurostat in April 2009) to 7.7% of GDP. At the same time, the Greek authorities also revised the planned deficit ratio for 2009 from 3.7% of GDP (the figure reported in spring) to 12.5% of GDP, reflecting a number of factors (the impact of the economic crisis, budgetary slippages in an electoral year and accounting decisions). According to the appropriate regulations and practices, this report deals with estimates of past data only."

Clues in a similar vein appear more tame elsewhere but are not preserve of Greece. Indeed, as shown in Figure A1, there have also been substantial revisions in fiscal out-turns elsewhere among crisis-stricken countries.[23] Actual market responses are also suggestive. If information on the state of public finances and related fundamentals were fully public and credible to market participants, one might not expect extra market tapping per se to have a substantial impact on bond yields – at least for small open economies that account for a minuscule share of global asset tradings, like those at the crisis epicenter. Yet, this has not been the case: as widely documented in the media and well-known to any engaged observer, country spreads have often reacted strongly – and sometimes in a matter of hours – to the increased frequency of market tapping, even in the absence of new official data or

[23]Related claims have also sometimes surfaced during public administration transitions within the Eurozone. Not uncommonly, the magnitude of the unfunded deficit is suddenly and massively revised upon such transitions and previous incumbents are accused of successfully "hiding" the fiscal hole. For instance, on 31 January 2011, the Financial Times reported that: "Catalonia, one of the richest parts of Spain, needs to raise €10bn-€11bn in debt this year to cover deficits and repay earlier loans... Andreu Mas-Colell, finance minister in the newly elected Catalan nationalist government, conceded in an interview with the Financial Times that it was "not a negligible amount", as he added up the numbers and explained how he had inherited unfunded deficits from the previous, Socialist-led regional government. 'We're not yet guilty of anything,' he said, in an echo of the outraged complaints of Greek ministers in 2009 when they inherited a deficit from their predecessors in power that was much worse than previously announced."

public announcements on fiscal difficulties meanwhile.[24] Such dynamics is broadly consistent with that documented in recent work on the role of low precision publicly-announced statistics on crisis probabilities (see Nagar and Yu, 2014 and references therein), highlighting the interaction between deteriorating fundamentals and low precision disclosures as a key driver of asset market repricing.

Appendix B: Perfect Bayesian Equilibrium

Separating Equilibrium

In this section we describe the way we find a separating equilibrium. Step 1 begins by assuming that the borrowers exerts no-action after a good shock and issues fresh debt after a bad shock and establishes the optimality of all other choices and beliefs. Step 2 confirms the optimality of the period 1 borrowers strategy assumed before.

Step 1:

We assume that the borrower after receiving $\epsilon_1^H = \alpha\tau_1$ decides to follow strategy (N) and after receiving $\epsilon_1^L = -\alpha\tau_1$ decides to follow strategy (I). Total confiscation losses are given by η. In the case of re-issuance, I, a proportion of total confiscation $f = \frac{1}{1+\alpha}$ goes to creditors at time $t = 0$ and a proportion $1 - f = \frac{\alpha}{1+\alpha}$ goes to creditors at time $t = 1$.

1. Lender's beliefs at $t = 1$.

   Lender's beliefs are given by $\mu(H/N) = 1$ and $\mu(L/I) = 1$. The equilibrium is completely revealing.

2. Borrower's strategy at $t = 2$.

   Let us consider first the borrower that received a good shock in the middle period, an H-borrower. His revenue after repayment is $\tau_2 + \rho\epsilon_1^H + \tilde{\epsilon_2} - (1 + r_0)\tau_0$. On the other hand, if he defaults his revenue is $\tau_2 + \rho\epsilon_1^H + \tilde{\epsilon_2} - c(1 + dr_0)\tau_0 - \eta(\tau_2 + \rho\epsilon_1^H + \tilde{\epsilon_2})$. Hence an H borrower repays at the end if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 + \rho\alpha\tau_1)\eta + (1 + r_0)\tau_0 - c(1 + dr_0)\tau_0) = H_2 \tag{7}$$

   Now, let us consider an L- borrower. His revenue after repayment is $\tau_2 + \rho\epsilon_1^L + \tilde{\epsilon_2} - (1 + r_0)\tau_0 - (1 + r_1)\alpha\tau_1$. On the other hand, if he defaults his revenue is $\tau_2 + \rho\epsilon_1^L +$

[24] See, e.g., http://www.gardian.co.uk/business/2010/may/05/greece-debt-crisis-timeline.

$\tilde{\epsilon_2} - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1 - \eta(\tau_2 + \rho\epsilon_1^L + \tilde{\epsilon_2})$. Hence an L borrower repays at the end if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 - \rho\alpha\tau_1)\eta + (1+r_0)\tau_0 + (1+r_1)\alpha\tau_1 - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1) = L_2 \tag{8}$$

Before moving on to determine the pricing, notice that when we consider the last period shock, there are six cases:

- Case 1: $H_2 < L_2 < \epsilon_2^L < \epsilon_2^H$. Nobody defaults.
- Case 2: $H_2 < \epsilon_2^L < L_2 < \epsilon_2^H$. H never defaults, L only for a bad shock.
- Case 3: $\epsilon_2^L < H_2 < L_2 < \epsilon_2^H$. Both default for a bad shock.
- Case 4: $H_2 < \epsilon_2^L < \epsilon_2^H < L_2$. H never defaults, L always defaults.
- Case 5: $\epsilon_2^L < H_2 < \epsilon_2^H < L_2$. H defaults only for a bad shock. L always defaults.
- Case 6: $\epsilon_2^L < \epsilon_2^H < H_2 < L_2$. Both always default.

3. Lender's pricing at $t = 1$.

- Case 1: $H_2 < L_2 < \epsilon_2^L < \epsilon_2^H$. In this case

$$r_1 = r_f \tag{9}$$

- Case 2: $H_2 < \epsilon_2^L < L_2 < \epsilon_2^H$. Break-even condition implies that $q(1+r_1)\alpha\tau_1 + (1-q)(c(1+dr_1)\alpha\tau_1 + (1-f)\eta F_2^{LL}) = (1+r_f)\alpha\tau_1$, where $F_2^{LL} = \tau_2 - \rho\alpha\tau_1 + \epsilon_2^L$. This gives

$$r_1 = \frac{1+r_f}{q+(1-q)cd} - \frac{(q+(1-q)c)\alpha\tau_1 + (1-q)(1-f)\eta F_2^{LL}}{(q+(1-q)cd)\alpha\tau_1} \tag{10}$$

- Case 3: $\epsilon_2^L < H_2 < L_2 < \epsilon_2^H$. In this case r_1 is given by equation (11).
- Case 4: $H_2 < \epsilon_2^L < \epsilon_2^H < L_2$. In this case r_1 is given by

$$r_1 = \frac{1+r_f}{cd} - \frac{c\alpha\tau_1 + (1-f)\eta EF_2^L}{cd\alpha\tau_1} \tag{11}$$

  where $EF_2^L = qF_2^{LH} + (1-q)F_2^{LL}$, and $F_2^{LH} = \tau_2 - \rho\alpha\tau_1 + \epsilon_2^H$.
- Case 5: $\epsilon_2^L < H_2 < \epsilon_2^H < L_2$. In this case r_1 by equation (12).
- Case 6: $\epsilon_2^L < \epsilon_2^H < H_2 < L_2$. In this case r_1 is given by equation (12).

4. Lender's pricing at $t = 0$.

- Case 1: $H_2 < L_2 < \epsilon_2^L < \epsilon_2^H$. Break-even condition implies that $r_0\tau_0(1+r_f) + (1+r_0)\tau_0 = (1+r_f)^2\tau_0$. Which gives

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0}{(1+r_f)\tau_0 + \tau_0} \tag{12}$$

- Case 2: $H_2 < \epsilon_2^L < L_2 < \epsilon_2^H$. By the same break-even logic we have that

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0(p + (1-p)(q + (1-q)c)) - (1-p)(1-q)f\eta F_2^{LL}}{(1+r_f)\tau_0 + \tau_0(p + (1-p)(q + (1-q)cd))} \tag{13}$$

- Case 3: $\epsilon_2^L < H_2 < L_2 < \epsilon_2^H$.

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0(q + (1-q)c) - (1-q)(\eta p F_2^{HL} + f\eta(1-p)F_2^{LL})}{(1+r_f)\tau_0 + \tau_0(q + (1-q)cd)} \tag{14}$$

- Case 4: $H_2 < \epsilon_2^L < \epsilon_2^H < L_2$.

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0(p + (1-p)c) - (1-p)f\eta E F_2^L}{(1+r_f)\tau_0 + \tau_0(p + (1-p)cd)} \tag{15}$$

- Case 5: $\epsilon_2^L < H_2 < \epsilon_2^H < L_2$.

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0(p(q + (1-q)c) + (1-p)c) - p(1-q)\eta F_2^{HL} - (1-p)f\eta E F_2^L}{(1+r_f)\tau_0 + \tau_0(p(q + (1-q)cd) + (1-p)cd)} \tag{16}$$

- Case 6: $\epsilon_2^L < \epsilon_2^H < H_2 < L_2$.

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0 c - (\eta p E F_2^H + f\eta(1-p)E F_2^L)}{(1+r_f)\tau_0 + \tau_0 cd} \tag{17}$$

Step 2:

We first describe the payoffs of each borrower. Let us start with the L-borrower. His payoffs under no deviations, i.e. when playing the strategy assumed, I, are given by, first, in the case in which the borrower always repays:

$$\tau_1 - r_0\tau_0 + \beta(\tau_2 - \rho\alpha\tau_1 - (1+r_0)\tau_0 - (1+r_1)\alpha\tau_1) + E\tilde{\epsilon_2}) \tag{18}$$

when it repays only for a good shock:

$$\tau_1 - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \tag{19}$$

where $P^R = \tau_2 - \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0 - (1+r_1)\alpha\tau_1$ and $P^D = \tau_2 - \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1 - \eta F_2^{LL}$. Finally, when he always defaults

$$\tau_1 - r_0\tau_0 + \beta(\tau_2 - \tau_1\rho\alpha - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1 + E\tilde{\epsilon_2} - \eta EF_2^L)) \tag{20}$$

There are two things that change when an L-borrower decides to deviate and play the B strategy after receiving a bad shock in the middle period: the second period repayment threshold and his payoffs. Let us first describe the deviation threshold. By the same logic as before, he repays if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 - \rho\alpha\tau_1)\eta + (1+r_0)\tau_0 - c(1+dr_0)\tau_0) = L_2^d \tag{21}$$

His payoffs under deviations, i.e. when playing B, are given by, first, in the case in which the borrower always repays:

$$\tau_1(1-\alpha) - r_0\tau_0 + \beta(\tau_2 - \rho\alpha\tau_1 - (1+r_0)\tau_0 + E\tilde{\epsilon_2}) \tag{22}$$

when it repays only for a good shock:

$$\tau_1(1-\alpha) - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \tag{23}$$

where $P^R = \tau_2 - \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0$ and $P^D = \tau_2 - \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - \eta F_2^{LL}$. Finally, when he always defaults:

$$\tau_1(1-\alpha) - r_0\tau_0 + \beta(\tau_2 - \tau_1\rho\alpha - c(1+dr_0)\tau_0 + E\tilde{\epsilon_2} - \eta EF_2^L)). \tag{24}$$

Next we describe the payoffs of the H-borrower. His payoffs under no deviations, i.e. when playing the strategy assumed, N, are given by, in the case in which the borrower always repays:

$$\tau_1(1+\alpha) - r_0\tau_0 + \beta(\tau_2 + \rho\alpha\tau_1 - (1+r_0)\tau_0 + E\tilde{\epsilon_2}) \tag{25}$$

when it repays only for a good shock:

$$\tau_1(1+\alpha) - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \tag{26}$$

where $P^R = \tau_2 + \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0$ and $P^D = \tau_2 + \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - \eta F_2^{HL}$. Finally, when he always defaults:

$$\tau_1(1+\alpha) - r_0\tau_0 + \beta(\tau_2 + \tau_1\rho\alpha - c(1+dr_0)\tau_0 + E\tilde{\epsilon_2} - \eta EF_2^H)). \tag{27}$$

There are two things that change when an H-borrower decides to deviate and play the I strategy after receiving a good shock in the middle period: the second period repayment threshold and his payoffs. Let us first describe the deviation threshold. By the same logic as before, he repays if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2+\rho\alpha\tau_1)\eta+(1+r_0)\tau_0+(1+r_1)\alpha\tau_1-c(1+dr_0)\tau_0-c(1+dr_1)\alpha\tau_1) = H_2^d \quad (28)$$

His payoffs under deviation, i.e. when playing I, are given by, first, in the case in which the borrower always repays:

$$\tau_1(1+2\alpha) - r_0\tau_0 + \beta(\tau_2 + \rho\alpha\tau_1 - (1+r_0)\tau_0 - (1+r_1)\alpha\tau_1) + E\tilde{\epsilon_2}) \quad (29)$$

when it repays only for a good shock:

$$\tau_1(1+2\alpha) - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \quad (30)$$

where $P^R = \tau_2 + \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0 - (1+r_1)\alpha\tau_1$ and $P^D = \tau_2 + \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1 - \eta F_2^{HL}$. Finally, when he always defaults:

$$\tau_1(1+2\alpha) - r_0\tau_0 + \beta(\tau_2 + \tau_1\rho\alpha - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1 + E\tilde{\epsilon_2} - \eta EF_2^H)) \quad (31)$$

In order to check for the existence of the separating equilibrium, we need to check for possible deviations for each type. We have two cases in terms of thresholds: I) $H_2 < H_2^d < L_2^d < L_2$ and II) $H_2 < L_2^d < H_2^d < L_2$. Note, however, that for pricing we still just need to consider the six original cases since investors cannot observe deviations. However, in order to check for deviations some of these six cases may get subdivided in sub-cases, when we consider also the deviation thresholds. Tables A1 and A2 show all the possible cases that we need to check. Clearly, there will be parameter values that can sustain a separating equilibrium. This is ultimately a numerical question, which we discuss extensively in section 4. Finally, we need to check that parameter values are such that budget constraint holds at the final period. Repayments and after default payment obligations need to be feasible.

Pooling Equilibrium

Step 1:

We assume that the borrower after receiving $\epsilon_1^H = \alpha\tau_1$ and $\epsilon_1^L = -\alpha\tau_1$ the borrower decides to follow strategy N.

1. Lender's beliefs at $t = 1$.

   Lender's beliefs are given by the prior distribution, so $\mu(H) = p$ and $\mu(L) = 1 - p$.

2. Borrower's strategy at $t = 2$

   Let us consider first the H-borrower. By the same logic as before we have that

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 + \rho\alpha\tau_1)\eta + (1 + r_0)\tau_0 - c(1 + dr_0)\tau_0) = H_2 \tag{32}$$

   Now, let us consider an L-borrower. L repays if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 - \rho\alpha\tau_1)\eta + (1 + r_0)\tau_0 - c(1 + dr_0)\tau_0) = L_2 \tag{33}$$

3. Lender's pricing at $t = 1$.

   There is no credit market at 1.

4. Lender's pricing at $t = 0$.

   - Case 1: $H_2 < L_2 < \epsilon_2^L < \epsilon_2^H$. Break-even condition implies that $r_0\tau_0(1 + r_f) + (1 + r_0)\tau_0 = (1 + r_f)^2\tau_0$. Which gives

$$r_0 = \frac{(1 + r_f)^2\tau_0 - \tau_0}{(1 + r_f)\tau_0 + \tau_0} \tag{34}$$

   - Case 2: $H_2 < \epsilon_2^L < L_2 < \epsilon_2^H$. By the same break-even logic we have that

$$r_0 = \frac{(1 + r_f)^2\tau_0 - \tau_0(p + (1 - p)(q + (1 - q)c)) - (1 - p)(1 - q)\eta F_2^{LL}}{(1 + r_f)\tau_0 + \tau_0(p + (1 - p)(q + (1 - q)cd))} \tag{35}$$

   - Case 3: $\epsilon_2^L < H_2 < L_2 < \epsilon_2^H$. In this case, r_0 is given by

$$r_0 = \frac{(1 + r_f)^2\tau_0 - \tau_0(q + (1 - q)c) - (1 - q)\eta(pF_2^{HL} + (1 - p)F_2^{LL})}{(1 + r_f)\tau_0 + \tau_0(q + (1 - q)cd)} \tag{36}$$

   - Case 4: $H_2 < \epsilon_2^L < \epsilon_2^H < L_2$. In this case, by the same logic we have that

$$r_0 = \frac{(1 + r_f)^2\tau_0 - \tau_0(p + (1 - p)c) - (1 - p)\eta EF_2^L}{(1 + r_f)\tau_0 + \tau_0(p + (1 - p)cd)} \tag{37}$$

   - Case 5: $\epsilon_2^L < H_2 < \epsilon_2^H < L_2$. In this case r_0 is given by

$$r_0 = \frac{(1 + r_f)^2\tau_0 - \tau_0(p(q + (1 - q)c) + (1 - p)c) - p(1 - q)\eta F_2^{HL} - (1 - p)f^I\eta EF_2^L}{(1 + r_f)\tau_0 + \tau_0(p(q + (1 - q)cd) + (1 - p)cd)} \tag{38}$$

- Case 6: $\epsilon_2^L < \epsilon_2^H < H_2 < L_2$. In this case r_0 is given by

$$r_0 = \frac{(1+r_f)^2\tau_0 - \tau_0 c - \eta(pEF_2^H + (1-p)EF_2^L)}{(1+r_f)\tau_0 + \tau_0 cd} \tag{39}$$

Step 2:

We first describe the payoffs of each borrower. Let us start with the L-borrower. His payoffs under no deviations, i.e. when playing the strategy assumed, N, are given by, first, in the case in which the borrower always repays:

$$\tau_1(1-\alpha) - r_0\tau_0 + \beta(\tau_2 - \rho\alpha\tau_1 - (1+r_0)\tau_0) + E\tilde{\epsilon_2}) \tag{40}$$

when it repays only for a good shock:

$$\tau_1(1-\alpha) - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \tag{41}$$

where $P^R = \tau_2 - \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0$ and $P^D = \tau_2 - \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - \eta F_2^{LL}$. Finally, when he always defaults

$$\tau_1(1-\alpha) - r_0\tau_0 + \beta(\tau_2 - \tau_1\rho\alpha - c(1+dr_0)\tau_0 + E\tilde{\epsilon_2} - \eta EF_2^L)) \tag{42}$$

There are two things that change when an L-borrower decides to deviate and play the I strategy after receiving a bad shock in the middle period: the second period repayment threshold and his payoffs. Let us first describe the deviation threshold. Hence, he repays if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 - \rho\alpha\tau_1)\eta + (1+r_0)\tau_0 + (1+r_1)\alpha\tau_1 - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1) = L_2^d \tag{43}$$

where r_1 is given by the value in the separating proof.

His payoffs under deviations, i.e. when playing I, are given by, first, in the case in which the borrower always repays:

$$\tau_1 - r_0\tau_0 + \beta(\tau_2 - \rho\alpha\tau_1 - (1+r_0)\tau_0 - (1+r_1)\alpha\tau_1 + E\tilde{\epsilon_2}) \tag{44}$$

when it repays only for a good shock:

$$\tau_1 - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \tag{45}$$

where $P^R = \tau_2 - \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0 - (1+r_1)\tau_1\alpha$ and $P^D = \tau_2 - \tau_1\rho\alpha + \epsilon_2^L -$

$c(1+dr_0)\tau_0 - c(1+dr_1)\tau_1\alpha - \eta F_2^{LL}$. Finally, when he always defaults:

$$\tau_1 - r_0\tau_0 + \beta(\tau_2 - \tau_1\rho\alpha - c(1+dr_0)\tau_0 - c(1+dr_1)\tau_1\alpha + E\tilde{\epsilon_2} - \eta E F_2^L)). \tag{46}$$

Next we describe the payoffs of the H-borrower. His payoffs under no deviations, i.e. when playing the strategy assumed, N, are given by, in the case in which the borrower always repays:

$$\tau_1(1+\alpha) - r_0\tau_0 + \beta(\tau_2 + \rho\alpha\tau_1 - (1+r_0)\tau_0 + E\tilde{\epsilon_2}) \tag{47}$$

when it repays only for a good shock:

$$\tau_1(1+\alpha) - r_0\tau_0 + \beta(qP^R + (1-q)P^D) \tag{48}$$

where $P^R = \tau_2 + \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0$ and $P^D = \tau_2 + \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - \eta F_2^{HL}$. Finally, when he always defaults:

$$_1(1+\alpha) - r_0\tau_0 + \beta(\tau_2 + \tau_1\rho\alpha - c(1+dr_0)\tau_0 + E\tilde{\epsilon_2} - \eta E F_2^H) \tag{49}$$

There are two things that change when an H-borrower decides to deviate and play the I strategy after receiving a good shock in the middle period: the second period repayment threshold and his payoffs. Let us first describe the deviation threshold. Hence, he repays if and only if

$$\tilde{\epsilon_2} \geq (1/\eta)(-(\tau_2 + \rho\alpha\tau_1)\eta + (1+r_0)\tau_0 + (1+r_1)\alpha\tau_1 - c(1+dr_0)\tau_0 - c(1+dr_1)\alpha\tau_1) = H_2^d \tag{50}$$

His payoffs under deviation, i.e. when playing I, are given by, first, in the case in which the borrower always repays:

$$\tau_1(1+2\alpha) - r_0\tau_0 + \beta(\tau_2 + \rho\alpha\tau_1 - (1+r_0)\tau_0 - (1+r_1)\alpha\tau_1 + E\tilde{\epsilon_2}) \tag{51}$$

when it repays only for a good shock:

$$\tau_1(1+2\alpha) - r_0\tau_0 + \beta(q + (1-q)P^D) \tag{52}$$

where $P^R = \tau_2 + \tau_1\rho\alpha + \epsilon_2^H - (1+r_0)\tau_0 - (1+r_1)\tau_1\alpha$ and $P^D = \tau_2 + \tau_1\rho\alpha + \epsilon_2^L - c(1+dr_0)\tau_0 - c(1+dr_1)\tau_1\alpha - \eta F_2^{HL}$. Finally, when he always defaults:

$$\tau_1(1+2\alpha) - r_0\tau_0 + \beta(\tau_2 + \tau_1\rho\alpha - c(1+dr_0)\tau_0 - c(1+dr_1)\tau_1\alpha + E\tilde{\epsilon_2} - \eta E F_2^H)). \tag{53}$$

In order to check for the existence of a N-pooling equilibrium, we need to check for possible deviations for each type.This is analogous to procedure in the first part of the theorem. All cases are described in table A3. Finally, the same check regarding end of the game budget constraint need to be checked.

Tables

Table 1: Volatility and Persistence of (HP)-Detrended Real Tax Revenues.

Country	Tax Revenues Parameters Unconditional Volatility (sd)	Openness Persistence (AR1)	Exports/GDP		
	1980-2007	1990-2007	1980-2007	1990-2007	2007
Austria	3.9	2.6	0.4	0.6	58%
Belgium	4.1	2.9	0.7	0.7	81%
France	2.5	1.6	0.6	0.6	27%
Germany	3.5	3.7	0.5	0.5	47%
Greece	6.1	6.6	0.6	0.7	21%
Italy	2.6	2.6	0.4	0.5	20%
Ireland	4.9	5.6	0.8	1.0	80%
Netherlands	2.8	3.5	0.5	0.6	71%
Portugal	7.1	3.4	0.7	0.3	32%
Spain	7.6	8.2	0.9	0.8	27%
Crisis Countries	*6.6*	*6.1*	*0.8*	*0.8*	*30%*
Non-Crisis Countries	*3.5*	*2.9*	*0.5*	*0.6*	*58%*

Table 2: Parameter Values

Parameter	Parameter Name	Baseline	Short-Run Risk	Long-Run Risk	Persistence
τ_0	Initial Borrowing	100	–	–	–
τ_1	Fiscal Revenues at t=1	100	–	–	–
τ_2	Fiscal Revenues at t=2	135	–	–	–
p	Probability of good shock at t=1	0.5	–	–	–
q	Probability of good shock at t=2	0.5	–	–	–
ρ	Persistence	0.8	–	–	[0.5,1]
$\sigma(\epsilon_1)$	St Dev of shock at t=1	10	[0,30]	–	–
$\sigma(\epsilon_2)$	St Dev. of shock at t=2	10	–	[0,30]	–
c	Recovery (1-haircut)	[0.1,0.5]	–	–	–
d	Recovery (1-haircut)	1	–	–	–
η	Fiscal confiscation	[0.1,0.3]	0.25	0.25	0.25
β	Discount Factor	0.96	–	–	–
r	Risk less interest rate	4.27%			

Table A1: Separating Equilibrium Deviation Conditions. Case I) $H_2 < H_2^d < L_2^d < L_2$

Region	No Deviation Condition for H	No Deviation Condition for L
1.1) $H_2 < H_2^d < L_2^d < L_2 < \varepsilon_2^L < \varepsilon_2^H$	(19) $\geq$ (23)	(12) $\geq$ (16)
2.1) $H_2 < H_2^d < L_2^d < \varepsilon_2^L < L_2 < \varepsilon_2^H$	(19) $\geq$ (23)	(13) $\geq$ (16)
2.2) $H_2 < H_2^d < \varepsilon_2^L < L_2^d < L_2 < \varepsilon_2^H$	(19) $\geq$ (23)	(13) $\geq$ (17)
2.3) $H_2 < \varepsilon_2^L < H_2^d < L_2^d < L_2 < \varepsilon_2^H$	(19) $\geq$ (24)	(13) $\geq$ (17)
3.1) $\varepsilon_2^L < H_2 < H_2^d < L_2^d < L_2 < \varepsilon_2^H$	(20) $\geq$ (24)	(13) $\geq$ (17)
4.1) $H_2 < H_2^d < L_2^d < \varepsilon_2^L < \varepsilon_2^H < L_2$	(19) $\geq$ (23)	(14) $\geq$ (16)
4.2) $H_2 < H_2^d < \varepsilon_2^L < L_2^d < \varepsilon_2^H < L_2$	(19) $\geq$ (23)	(14) $\geq$ (17)
4.3) $H_2 < \varepsilon_2^L < H_2^d < L_2^d < \varepsilon_2^H < L_2$	(19) $\geq$ (24)	(14) $\geq$ (17)
4.4) $H_2 < H_2^d < \varepsilon_2^L < \varepsilon_2^H < L_2^d < L_2$	(19) $\geq$ (23)	(14) $\geq$ (18)
4.5) $H_2 < \varepsilon_2^L < H_2^d < \varepsilon_2^H < L_2^d < L_2$	(19) $\geq$ (24)	(14) $\geq$ (18)
4.6) $H_2 < \varepsilon_2^L < \varepsilon_2^H < H_2^d < L_2^d < L_2$	(19) $\geq$ (25)	(14) $\geq$ (18)
5.1) $\varepsilon_2^L < H_2 < H_2^d < L_2^d < \varepsilon_2^H < L_2$	(20) $\geq$ (24)	(14) $\geq$ (17)
5.2) $\varepsilon_2^L < H_2 < H_2^d < \varepsilon_2^H < L_2^d < L_2$	(20) $\geq$ (24)	(14) $\geq$ (18)
5.3) $\varepsilon_2^L < H_2 < \varepsilon_2^H < H_2^d < L_2^d < L_2$	(20) $\geq$ (25)	(14) $\geq$ (18)
6.1) $\varepsilon_2^L < \varepsilon_2^H < H_2 < H_2^d < L_2^d < L_2$	(21) $\geq$ (25)	(14) $\geq$ (18)

Table A2: Separating Equilibrium Deviation Conditions. Case II) $H_2 < L_2^d < H_2^d < L_2$

Region	No Deviation Condition for H	No Deviation Condition for L
1.1) $H_2 < L_2^d < H_2^d < L_2 < \varepsilon_2^L < \varepsilon_2^H$	(19) $\geq$ (23)	(12) $\geq$ (16)
2.1) $H_2 < L_2^d < H_2^d < \varepsilon_2^L < L_2 < \varepsilon_2^H$	(19) $\geq$ (23)	(13) $\geq$ (16)
2.2) $H_2 < L_2^d < \varepsilon_2^L < H_2^d < L_2 < \varepsilon_2^H$	(19) $\geq$ (24)	(13) $\geq$ (16)
2.3) $H_2 < \varepsilon_2^L < L_2^d < H_2^d < L_2 < \varepsilon_2^H$	(19) $\geq$ (24)	(13) $\geq$ (17)
3.1) $\varepsilon_2^L < H_2 < L_2^d < H_2^d < L_2 < \varepsilon_2^H$	(20) $\geq$ (24)	(13) $\geq$ (17)
4.1) $H_2 < L_2^d < H_2^d < \varepsilon_2^L < \varepsilon_2^H < L_2$	(19) $\geq$ (23)	(14) $\geq$ (18)
4.2) $H_2 < L_2^d < \varepsilon_2^L < H_2^d < \varepsilon_2^H < L_2$	(19) $\geq$ (24)	(14) $\geq$ (16)
4.3) $H_2 < \varepsilon_2^L < L_2^d < H_2^d < \varepsilon_2^H < L_2$	(19) $\geq$ (24)	(14) $\geq$ (17)
4.4) $H_2 < L_2^d < \varepsilon_2^L < \varepsilon_2^H < H_2^d < L_2$	(19) $\geq$ (25)	(14) $\geq$ (16)
4.5) $H_2 < \varepsilon_2^L < L_2^d < \varepsilon_2^H < H_2^d < L_2$	(19) $\geq$ (25)	(14) $\geq$ (17)
4.6) $H_2 < \varepsilon_2^L < \varepsilon_2^H < L_2^d < H_2^d < L_2$	(19) $\geq$ (25)	(14) $\geq$ (18)
5.1) $\varepsilon_2^L < H_2 < L_2^d < H_2^d < \varepsilon_2^H < L_2$	(20) $\geq$ (24)	(14) $\geq$ (17)
5.2) $\varepsilon_2^L < H_2 < L_2^d < \varepsilon_2^H < H_2^d < L_2$	(20) $\geq$ (25)	(14) $\geq$ (17)
5.3) $\varepsilon_2^L < H_2 < \varepsilon_2^H < L_2^d < H_2^d < L_2$	(20) $\geq$ (25)	(14) $\geq$ (18)
6.1) $\varepsilon_2^L < \varepsilon_2^H < H_2 < L_2^d < H_2^d < L_2$	(21) $\geq$ (25)	(14) $\geq$ (18)

Table A3: Pooling Equilibrium Deviation Conditions. Case I) $H_2 < H_2^d < L_2 < L_2^d$

Region	No Deviation Condition for H	No Deviation Condition for L
1.1) $H_2 < H_2^d < L_2 < L_2^d < \varepsilon_2^L < \varepsilon_2^H$	(41) $\geq$ (45)	(34) $\geq$ (38)
1.2) $H_2 < H_2^d < L_2 < \varepsilon_2^L < L_2^d < \varepsilon_2^H$	(41) $\geq$ (45)	(34) $\geq$ (39)
1.3) $H_2 < H_2^d < L_2 ¡ \varepsilon_2^L < \varepsilon_2^H < L_2^d$	(41) $\geq$ (45)	(34) $\geq$ (40)
2.1) $H_2 < H_2^d < \varepsilon_2^L < L_2 < L_2^d < \varepsilon_2^H$	(41) $\geq$ (45)	(35) $\geq$ (39)
2.2) $H_2 < \varepsilon_2^L < H_2^d < L_2 < L_2^d < \varepsilon_2^H$	(41) $\geq$ (46)	(35) $\geq$ (39)
2.3) $H_2 < H_2^d < \varepsilon_2^L < L_2 < \varepsilon_2^H < L_2^d$	(41) $\geq$ (45)	(35) $\geq$ (40)
2.4) $H_2 < \varepsilon_2^L < H_2^d < L_2 < \varepsilon_2^H < L_2^d$	(41) $\geq$ (46)	(35) $\geq$ (40)
3.1) $\varepsilon_2^L < H_2 < H_2^d < L_2 < L_2^d < \varepsilon_2^H$	(42) $\geq$ (46)	(35) $\geq$ (39)
3.2) $\varepsilon_2^L < H_2 < H_2^d < L_2 < \varepsilon_2^H < L_2^d$	(42) $\geq$ (46)	(35) $\geq$ (40)
4.1) $H_2 < H_2^d < \varepsilon_2^L < \varepsilon_2^H < L_2 < L_2^d$	(41) $\geq$ (45)	(36) $\geq$ (40)
4.2) $H_2 < \varepsilon_2^L < H_2^d < \varepsilon_2^H < L_2 < L_2^d$	(41) $\geq$ (46)	(36) $\geq$ (40)
4.3) $H_2 < \varepsilon_2^L < \varepsilon_2^H < H_2^d < L_2 < L_2^d$	(41) $\geq$ (47)	(36) $\geq$ (40)
5.1) $\varepsilon_2^L < H_2 < H_2^d < \varepsilon_2^H < L_2 < L_2^d$	(42) $\geq$ (46)	(36) $\geq$ (40)
5.2) $\varepsilon_2^L < H_2 < \varepsilon_2^H < H_2^d < L_2 < L_2^d$	(42) $\geq$ (47)	(36) $\geq$ (40)
6.1) $\varepsilon_2^L < \varepsilon_2^H < H_2 < H_2^d < L_2 < L_2^d$	(43) $\geq$ (47)	(36) $\geq$ (40)

Figures

Figure 1: Long-Term Bond Yields of Selected Eurozone Sovereigns.

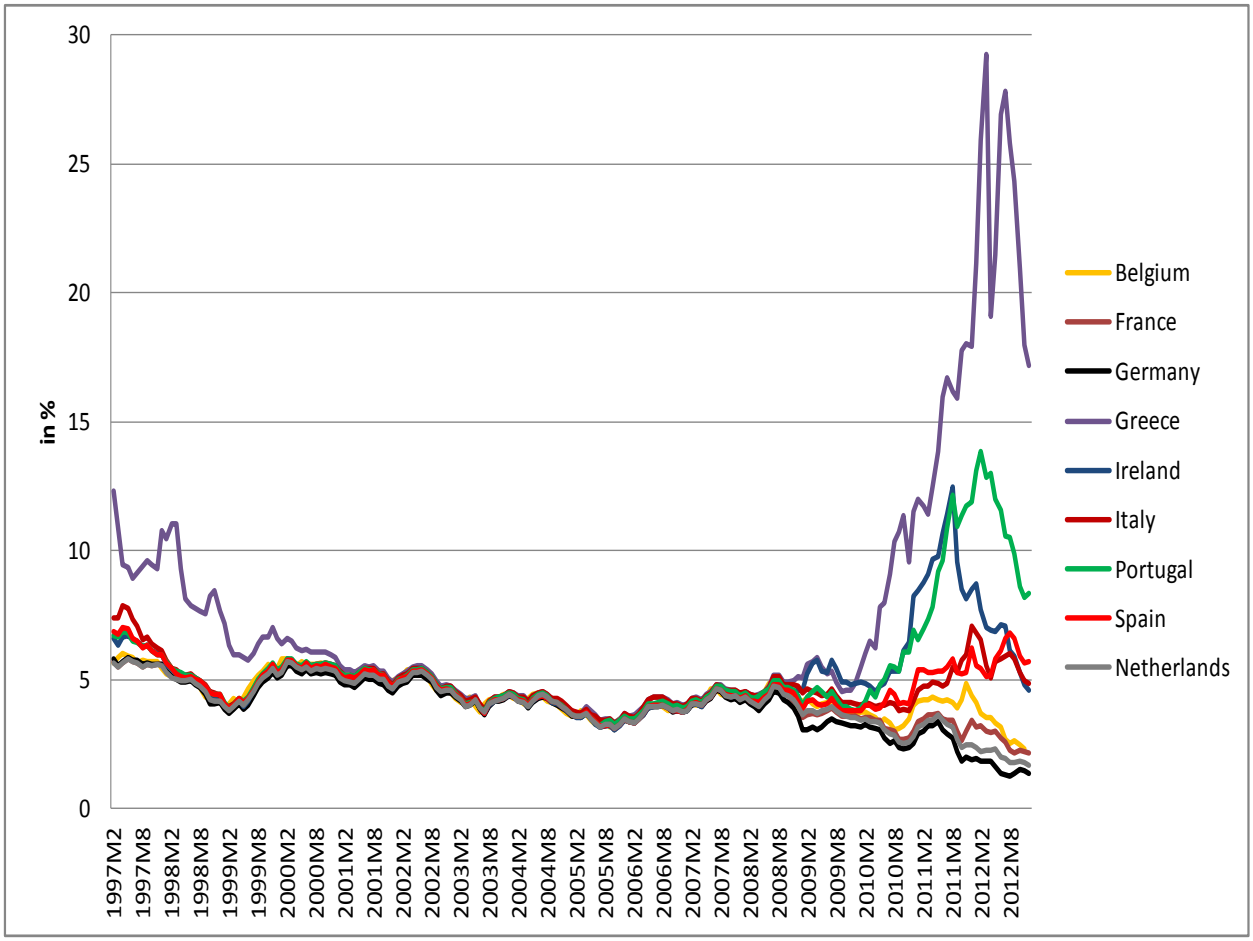

Figure 2a: Real GDP Growth in Eurozone (EZ) Core and Selected Peripheral Countries.

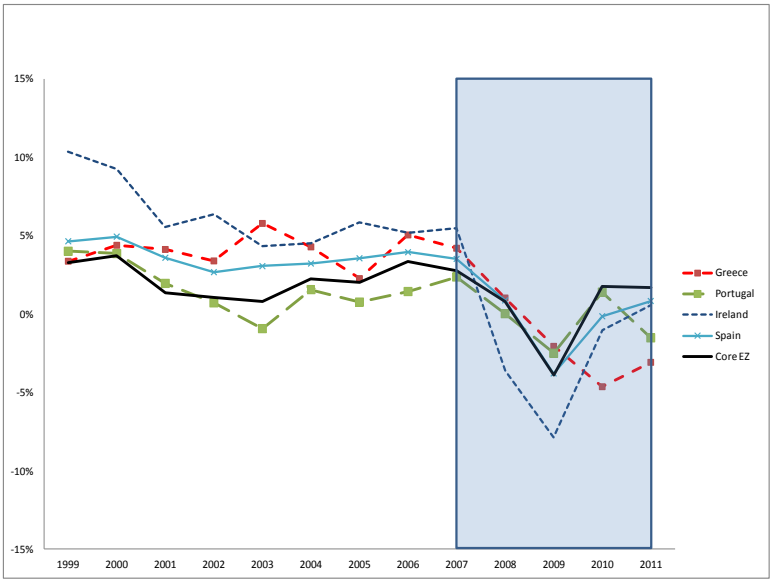

Figure 2b: Growth of General Government Revenues (CPI deflated) in Eurozone Core and Selected Peripheral Countries.

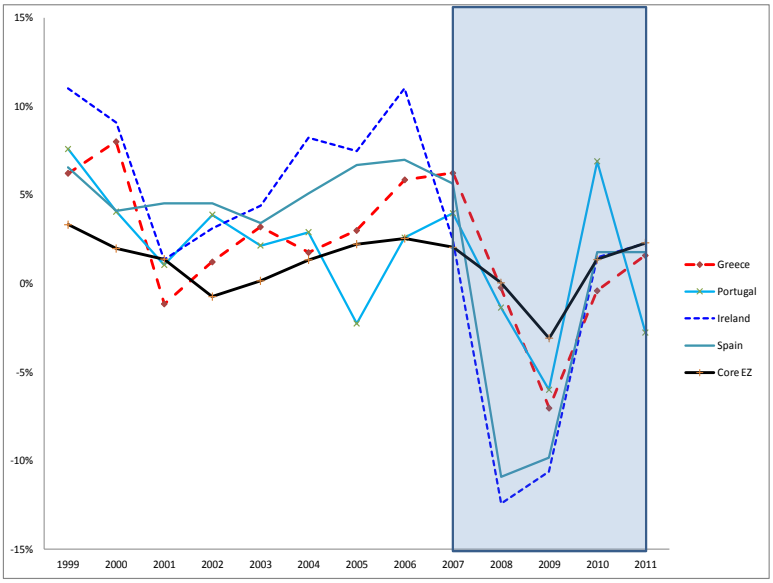

Figure 3a: Real GDP and Real General Government Revenues (HP-de trended): Spain.

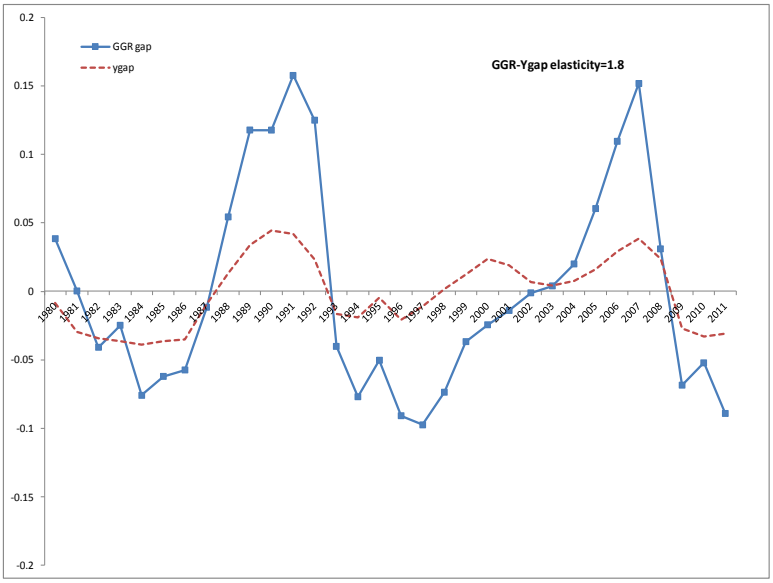

Figure 3b: Real GDP and Real General Government Revenues (HP-de trended): Germany.

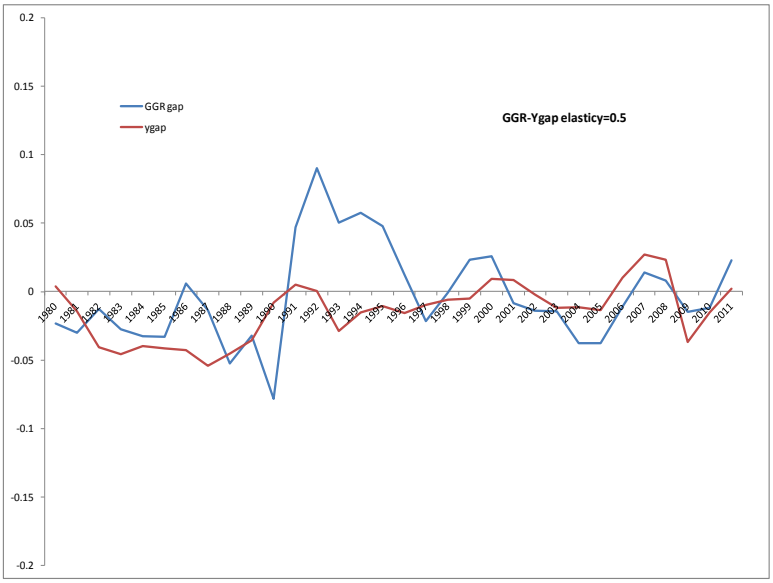

Figure 4a: Ratio of General Government Primary Expenditures to Revenues.

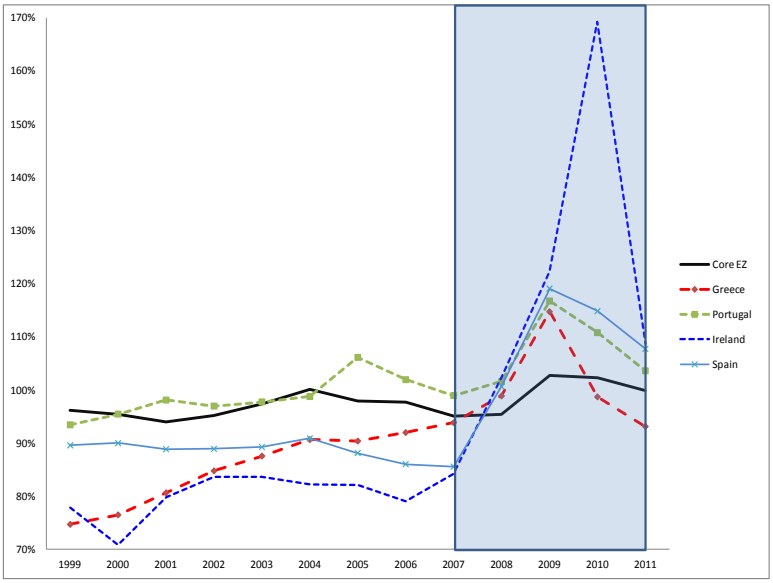

Figure 4b: Share of Interest Expenditures in General Government Revenues in Eurozone Core and Selected Peripheral Countries.

Figure 5: Ratio of General Government Debt to GDP in Eurozone Core and Selected Peripheral Countries.

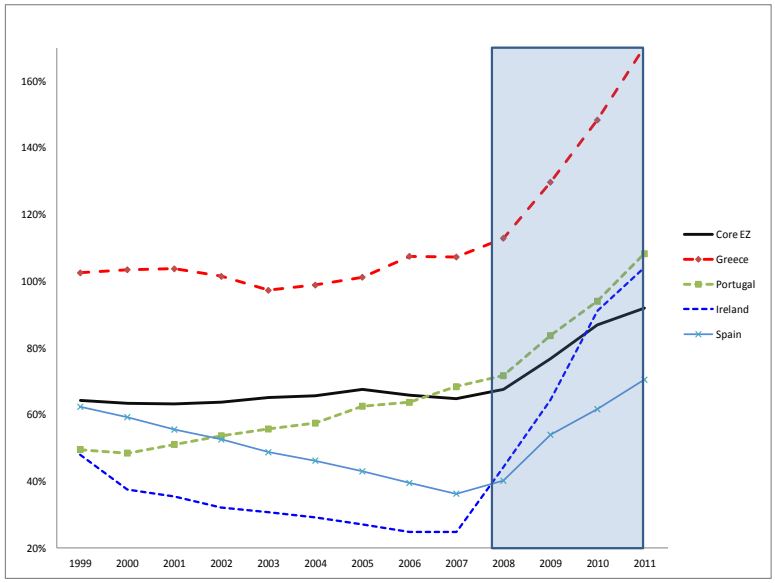

Figure 6: Net External Borrowing and Sovereign Spreads in Selected Peripheral Economies.

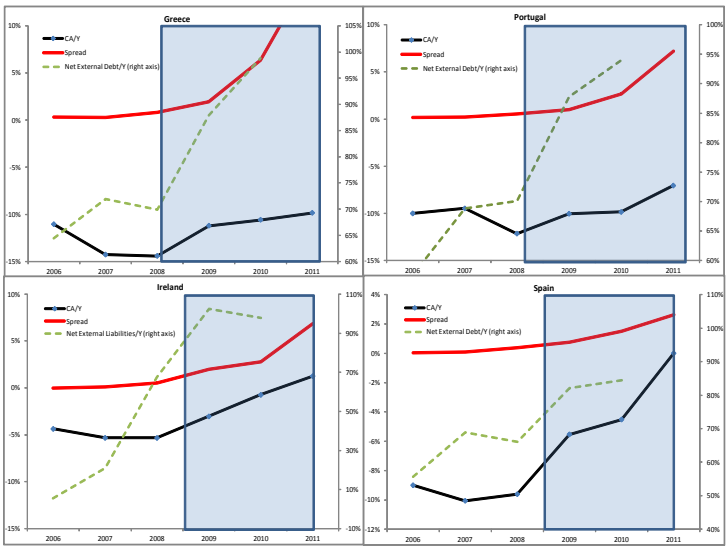

Figure 7: . Ratio of Short-Term External Debt to Total External Debt in Selected Eurozone Peripheral Countries.

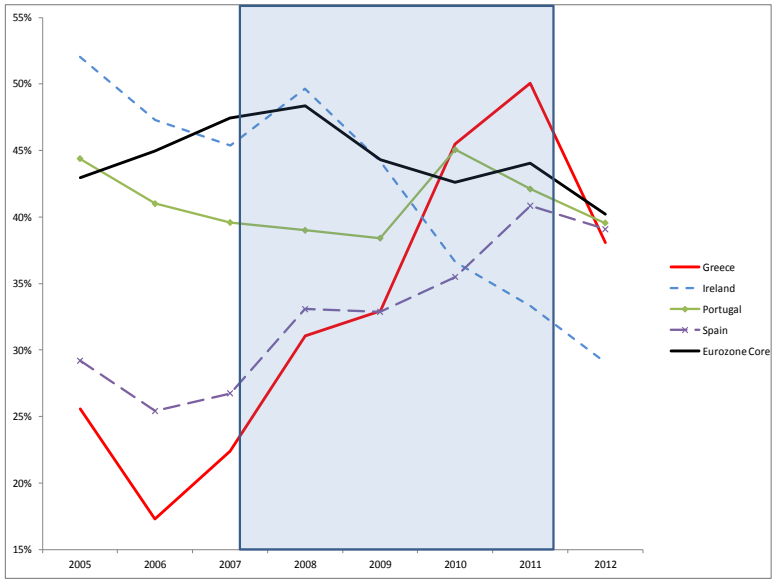

Figure 8: Fiscal Revenue and Debt Dynamics.

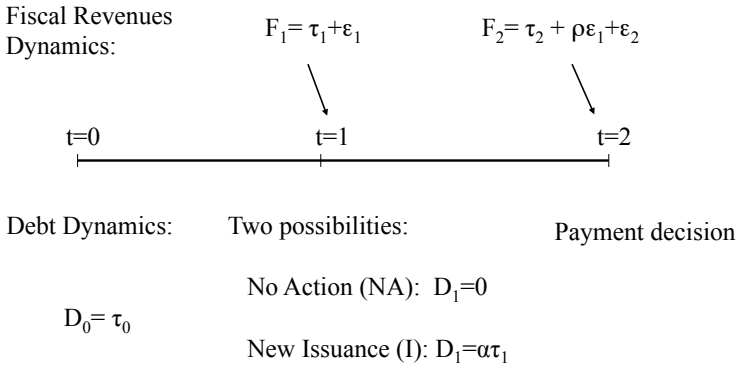

Figure 9: Lending at $t = 0$.

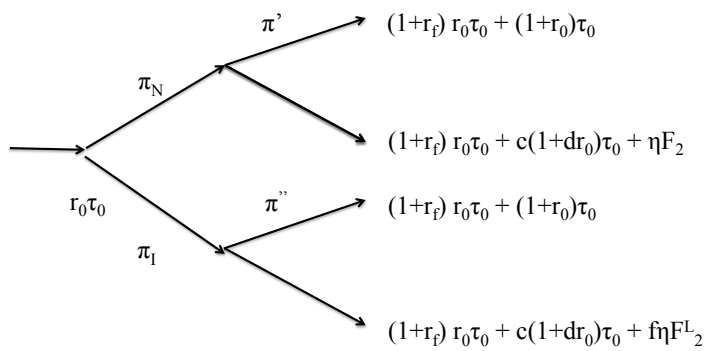

Figure 10: Lending at $t = 1$.

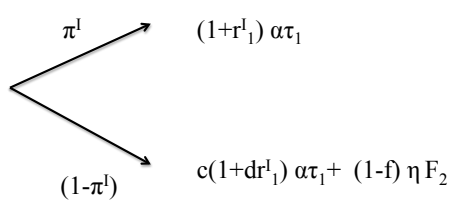

Figure 11: Baseline Scenario. Equilibrium.

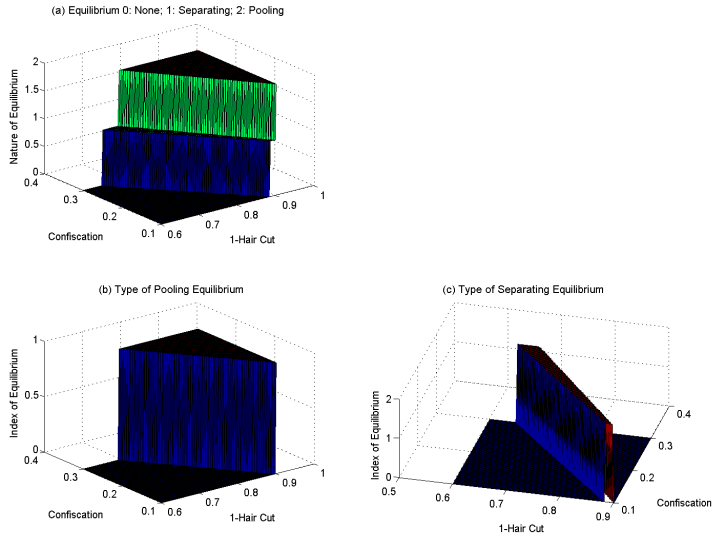

Figure 12: Baseline Scenario. Interest Rates.

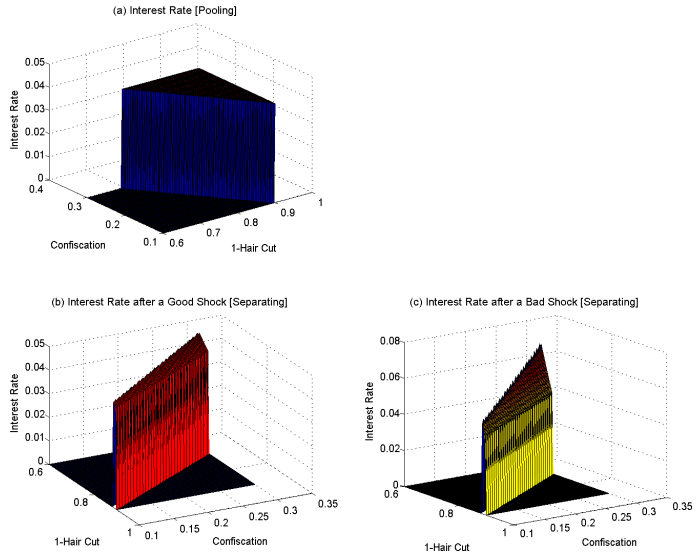

Figure 13: Short Run Risk Scenario. Equilibrium.

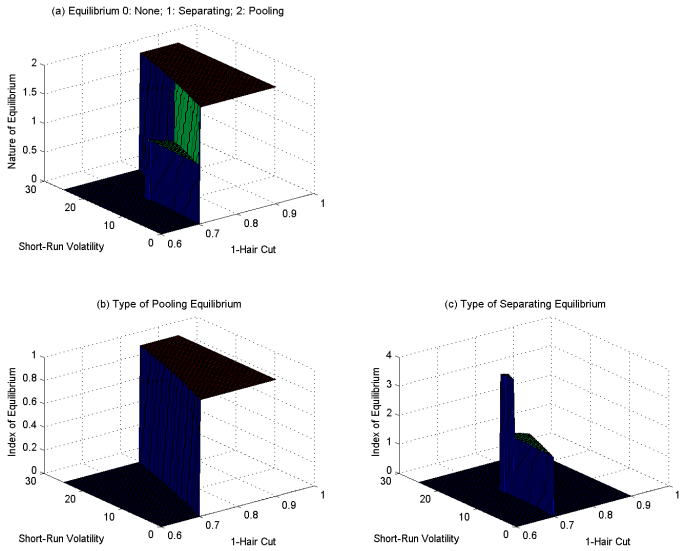

Figure 14: Short Run Risk Scenario. Interest Rates.

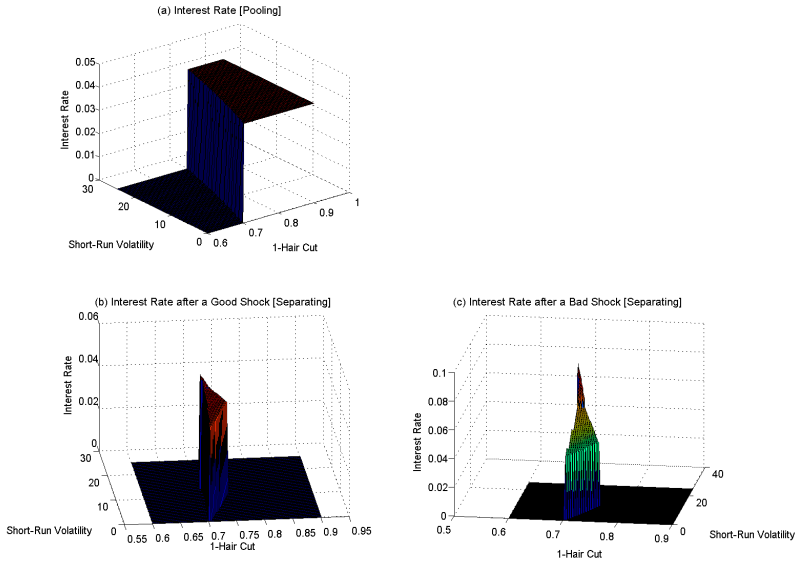

Figure 15: Long Run Risk Scenario. Equilibrium.

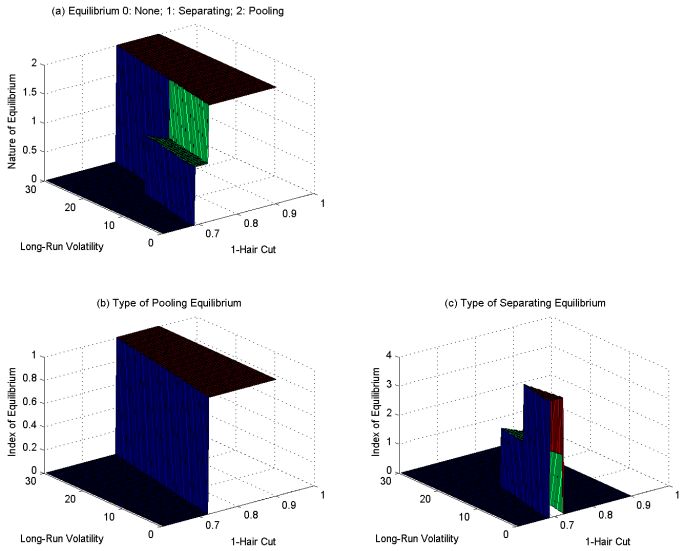

Figure 16: Long Run Risk Scenario. Interest Rates.

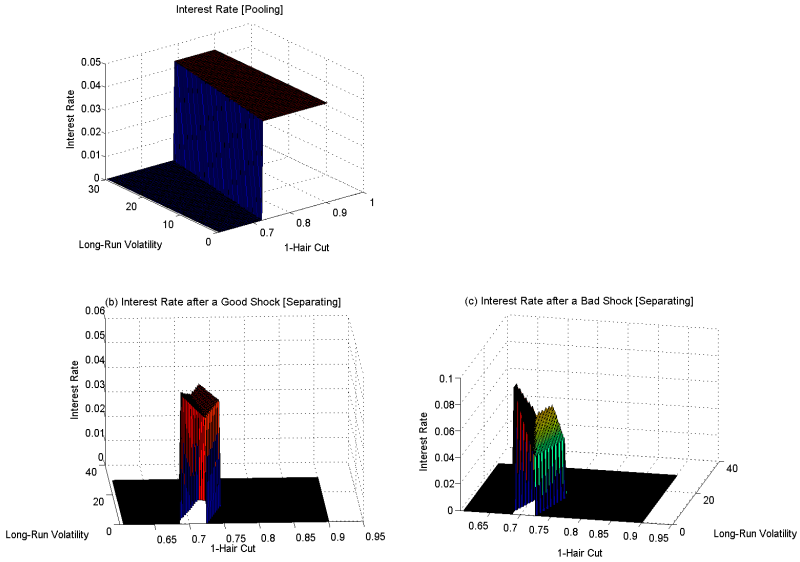

Figure 17: Persistence Scenario. Equilibrium.

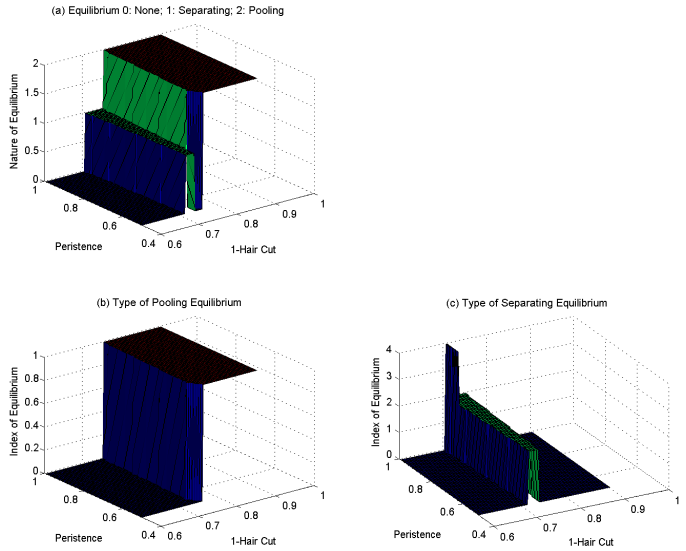

Figure 18: Persistence Scenario. Interest Rates.

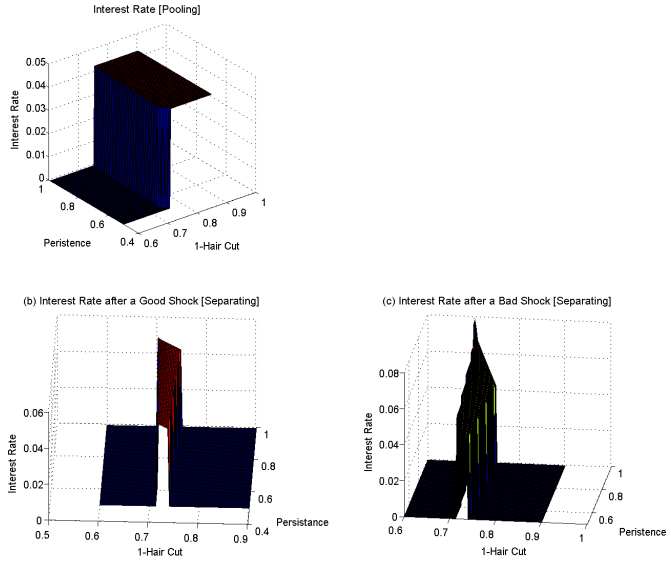

Figure 19: Yield Decoupling in the Model. Baseline Case.

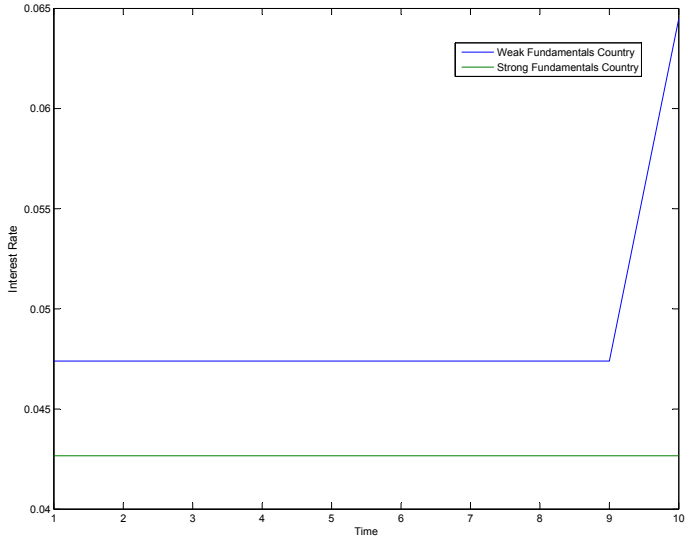

Figure 20: Yield Decoupling in the Model. Alternative Parameterizations.

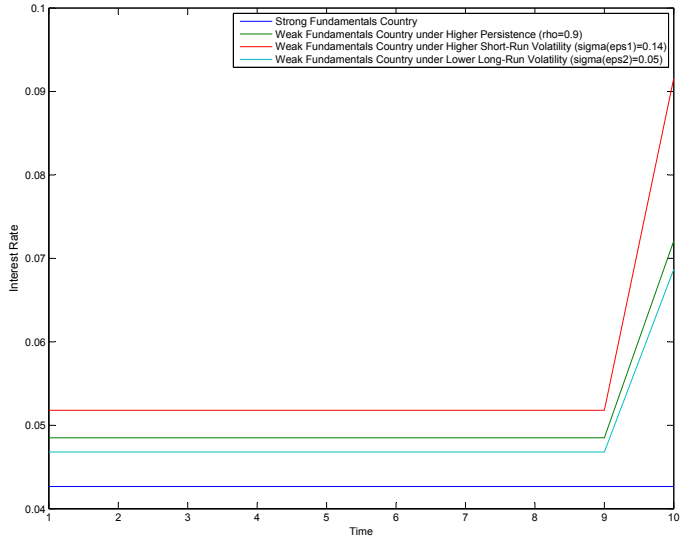

Figure A1: IMF Forecasts of Public Debt in the US and Euroarea across Forecast Vintages.