Sudden Stops and Sovereign Defaults.

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Abstract

Recent debt crises in Europe have highlighted the role of asymmetric information about fiscal shocks in accounting for sudden hikes in country risk. We develop a model where such asymmetry of information combined with the persistence of tax shocks can produce a sudden inward shift in the supply of loanable funds to a sovereign. Unlike previous models, such a sudden stop (SS) shows up in bond prices but not in borrowing flows until outright default materializes. The key trigger is an unexpected and large external financing tapping by the sovereign: under asymmetric information, even if the tapping is successful and net borrowing goes up, this signals a persistent negative shock to tax revenues and hence to debt repayment capacity, which raises spreads and in turn lowers the cost of a subsequent default. Under various parametrizations, the model generates a separating equilibrium where the SS preceeds both the default and the eventual drop in net inflows, as well as a pooling equilibrium in which spreads stay put and the SS will not preceeds a sovereign default. We provide evidence that such a parcimonious model captures rather well the main stylized facts surrounding several recent and past episodes of sudden stops and sovereign defaults.

Keywords: Sudden Stops, Sovereign Default, Asymmetric Information.

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1 Introduction

Countries not so long ago heralded as growth success stories of the advanced world such as Ireland and Spain have witnessed, over the past year and a half, skyrocketing spreads on their sovereign bonds, plummeting confidence in the state of their public finances, and large output drops. Such a sudden turnaround in market assessment of country risk has been no less dramatic in Greece and Portugal and much of central Europe – once again countries deemed mostly advanced and which have been long declared as graduated from "debt intolerance" (Reinhart, Savastano, and Rogoff, 2004).

Three main features of these recent debt crises stand out. One is the seemingly pervasive uncertainty on the part of investors about the state of national public finances. As a matter of fact, acknowledgement of this uncertainty has not been pervasive in the investment community and policy circles but also widely noted in the general press. For instance, the New York Times reported not earlier this year that "tax revenues in Greece fell 5.4 billion short of its budgeted revenues last year through a combination of unpaid taxes and an slowing economy.(...) In fact, tax collection was so poor that the Greek government decided last September to offer an amnesty program, allowing tax payers to settle their outstanding debt by paying just 55% of the bill... Some tightening of controls to collect taxes also observed."[1] Such uncertainty is clearly underscored by a spate of major revisions in national budget figures (typically in downward direction), often announced by the respective authorities with substantial lags, all of which have been accompanied by large swings in sovereign spreads.[2] Prima facie, this is suggestive of successful real time obfuscation of the true state of economic fundamentals, since if fully information on the latter were promptly available to investors, it would be immediately arbitraged away, obviating any sharp correction in bond prices upon its public announcement. These facts seem quite indicative of non-trivial information asymmetries between government, investors and the general public.

The second main feature of recent crises is that countries have been able to tap markets for the most part throughout the turmoil, albeit at a much higher

[1]New York Times, Feb 21th, 2011, p. A4.

[2]For instance, at the early stages of the crisis on April 22, 2009, the European Union statistical service (EUROSTAT) announced that Greece's budget deficit in 2008 was revised up by nearly 1% of GDP from the previous official figure of 12.9% which was itself revised up from a string of previous estimates of under 10% in the course of 2009. Spreads went by some 60 basis points upon the announcement.

spread.[3] Even in the Greek case, where fiscal fundamentals are believed to be far weaker than in other EU peers, the government's need for fresh cash were met not only by bond purchases from the European Central Bank and fresh multilateral lending (by the EU and the IMF), but also by concomitant tapping from private capital markets. In contrast with other major debt crisis episodes, like in the 1930s, access to private capital markets was never lost. Indeed, as became apparent that the underlying economic contraction and shortfall in public revenues was persistent enough, tapping from private capital markets by affected countries (and regions therein) often intensified.[4]

A third noteworthy feature of the recent debt crises is that, unlike many emerging market crisis of the past, the countries involved were mostly advanced, with ample market access, including for debt denominated in their own currency and issued within national borders - even if much of it was purchased by foreign investors. In other words, there was no "original sin": debt for the most part was issued in domestic currency and in the form of long-term bonds, at least through the onset of the crisis.[5] This underscores the point that other factors, such asymmetric information and the nature of the shock, are likely to be more central to plausible explainations

[3]For example, as the crisis continued exacerbate, the Financial Times reported on November 9, 2010 that: "The next test to Athens comes next month as the country needs to refinance EU 480 millions of debt maturing on December 24 (while) Greek 10-year bond spreads have risen to 11.30 percent from 8.77 percent since October 13". In the event, in that very same month, and amidst such a sharp rise in spreads, Athens sold EU390m worth of fresh debt.

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[5]As discussed below, both in reality and in the model, debt maturity is shortened only once the crisis is underway. This is consistent with evidence from previous crises documented in Broner, Lorenzoni, and Schmukler (2010).

for these developments.

The aim of this paper is to develop a model that can account for these stylized facts. In particular, we study an economy where asymmetric information about fiscal shocks and the high persistence thereof can bring about sudden and large shifts in country risk amidst continuing market access, and where default is a possible – but not necessarily inevitable – equilibrium outcome of large fiscal shocks. The postulated mechanism is as follows. A sizeable tax revenue shock, which is unobservable to investors but observable to the sovereign government and known to be (likely) very persistent, strikes the country that has a non-trivial net debt to GDP ratio to begin with. To the extent that spending cuts are sufficiently costly, this forces the sovereign to demand fresh cash ahead of the "normal" debt roll-over once the previously contracted (long-term) debt matures. Under asymmetric information, the incipient market tapping signals to investors that the sovereign has been hit by a large and likely persistent revenue shock. So, even if the tapping is successful and net borrowing goes up, this indicates that debt repayment capacity has been compromised relative to the no-shock baseline. Hence the future expected ratio of debt to revenue ratio goes up, raising country risk. In response, risk neutral investors raise spreads. By increasing the cost of future repayment and hence lowering the cost of a subsequent default, this increase in spread increases default risk. Default may in fact materialize if the country is hit by a subsequent round of adverse revenue shocks.

In this setting, we show that there are two possible equilibria. One in which the sovereign, when faced with the unexpected revenue shortfall, reveals itself by going to the market (separating equilibrium). This is more likely the higher cost of cutting government spending in response to the revenue shortfall.The other equilibrium is that where she "fakes": despite being hit by a bad shock, there is no middle-of-the-way market tapping (pooling equilibrium). Instead, the sovereign just adjusts by cutting spending. However, to the extent that such spending cuts subsequently depress output and hence tax revenues, they will undermine future repayment capacity and thus also raise default risk.

There are important attractive features of this setting that make it capable to account not only for key stylized features of recent debt crises but also, as we discuss later, many previous episodes of sovereign defaults as well. One is that the model can account for both sudden stops and sovereign defaults, as two faces of the same coin (country risk). This is important since it unifies in a single and reasonably parsimonious model the two phenomena, which have been examined by two distinct theoretical literatures, as if having distinct etiologies.

Another attractive feature of our model is that it can account for distinct relationships between sudden stops and sovereign defaults are glossed over by previous contributions to both literatures. This becomes clearer once one defines - as arguably should - a "sudden stop" as an abrupt inward shift in the lending supply schedule faced by any given country. In this case, the "sudden stop" can materialize in terms of either prices (spread shifts), quantities (variations in gross and/or net borrowing), or a combination of both. As such, in a separating equilibrium, sudden stops typically preceed sovereign defaults: once the sovereign is hit by a bad fiscal shock leading to higher demand for borrowing, a sudden stop materializes through prices only; spreads go up but there is actually an increase in fresh borrowing and net debt. So, the quantity flow alone will be a very misleading indicator of a SS.

At the same time, the model contemplates another possible equilibrium. For some parametrizations, the country will find optimal to "fake", i.e., to forego market tapping as if not hit a bad shock when she in fact was. In this case, there won't be a negative revision of country risk by investors, and so no bond repricing and no SS. Yet, because reality eventually bites, the probability of default following the adverse shock will be higher due to shock persistence, and again as is well-known, large fiscal shocks tend to be very persistent, as we also illustrate with ample historical data below. In this "faking" or "pooling" equilibrium case, a rise in underlying country risk and possible eventual default will not be preceded by a SS. In short, the model encompasses cases in which a SD is preceded or not by a SS. In fact, in a pooling equilibrium, the SS would take place at the same time as the SD.

In nesting possible equilibria where a SS and a SD both take place, this paper relates to two main strands of the literature. One major strand is the work on sudden stops in capital flows pioneered by Calvo (1998) and further developed, both theoretically and empirically, by Caballero and Krishnamurty (2001), Calvo, Izquierdo and Mejia (2004), Calvo, Izquierdo and Talvi (2006), Kehoe et al (2005), Mendoza (2006, 2009). Much like in Calvo (1998), there is an association between output drops and SSs in our model. In Calvo (1998), the SSs arises from an un-antecipated shock to relative prices that drives the unhedged domestic producer with a short foreign currency position insolvent. As this makes her unable to borrow and produce further, an output drop immediately follows. In contrast, in our model there is no relative price shock and unhedged currency positions (due for instance externalities that lead to the underpricing of risk as in Caballero and Krishnamurty) leading to the SS and the subsequent output collapse. In fact, in the separating equilibrium case, the causality is as suggested by Kehoe et al (2005): a bad shock leads to the SS. But since there is also a pooling equilibrium, this will not be necessarily so in all cases as mentioned above. More broadly, information asymmetries are not present in these previous contributions and SSs are gauged as quantity shocks. In contrast, the SS in our model often manifest first and foremost through price adjustments (shifts in spreads). Once SSs are defined as inward shifts in the investors' loan supply curve, whether price or output effects dominate will depend on what happens to sovereign demand and ancillary model parameters. Finally, it is important to notice that the mechanism we focus on is not incompatible with financial friction models of SSs, but rather complementary. In our model, output and tax revenue volatility are exogenously given, as is their persistences, and these may result from the combination of financial frictions and the menu of shocks (such as to the world interest rate) analyzed in previous models (e.g. Perri and Neumeyer, 2005; Mendoza, 2009). In neither of these models, however, is there default in equilibrium.

In allowing for default as a possible equilibrium outcome, our model is also closely related to a rich literature on sovereign risk. As in Aguiar and Gopinath (2006), Arellano (2008), our model builds on the volatility and persistence of output shocks (in our case translating into tax revenue shocks) as drivers of fluctuations in country risk. Aguiar and Gopinath (2006) find that greater output persistence tends to raise sovereign default risk in a model with complete symmetry of information between borrowers and lenders, where default is punished by market exclusion, with exogenous re-entry probability rather than an endogenous effect through prices. A key prediction of their model is that countries with higher underlying persistence of output shocks are more prone to default. In a model also featuring symmetric information and full market exclusion as punishment device, Arellano (2008) shows that higher output volatility raises sovereign spreads. Yet, by virtue of the symmetric information assumption, none of these models can explain sharp hikes in spreads upon fiscal news announcements, nor why country risk can fluctuate as sharply under continuous market access. Allowing for the presence of information asymmetries between borrowers and lenders buys us precisely the capacity to explain these phenomena in a way that is consistent with the stylized facts mentioned above. In this regard, o, ur setting is more closely Eaton (1996), Alfaro and Kanuzck (2005), Sandlieris (2008), and Catao, Fostel, and Kapur (2009) in that information asymmetries associated with investors's uncertainty about either the country's type or the persistence of output shocks are a key determinant of fluctuations in sovereign spreads. In these papers, as well as ours, investors learn from the country's action, updating their beliefs about future fundamentals along the way which are then reflected in the re-pricing of sovereign bonds. The main departure of our setting relative to these latter contributions is to highlight the role of fiscal shocks and market tapping mechanism as a signaling device. Also unlike these previous studies, our model thus allows for the possibility of a pooling equilibria where the country successfully "fakes" the true state of fiscal fundamentals: investors either never learn about them or only do so much later, when outright default materializes.

Finally, and also relative to both literatures, one extra contribution of this paper is to review the main stylized facts surrounding SSs and debt crises using a very long cross-country dataset. While most salient features of historical patterns of borrowing and defaulting have been nicely summarized in Reinhart and Rogoff (2009), we zoom in on the dynamics around sovereign defaults and debt crisis events more broadly, focusing in particular on the timing of price and quantity responses and the dynamics of critical fiscal variables, notably tax revenues. Two main novelties in this exercise are the use of newly revised and updated estimates of countries' external debt positions pioneered in the work of Milesi-Ferretti and Lane (2007) as well as the construction of a long database on general government revenues and expenditures spanning over 60 countries over a 40 year period. While an extensive empirical test of alternative theories is beyond the scope of this paper, we use this newly constructed database to show that the proposed model does a very good job in accounting for the main stylized facts not only of the recent debt crises but several past episodes as well.

The plan of the paper is as follows. Section 2 below reviews the empirical evidence on debt crises, highlighting some key similarities between the recent (2008-09) ones and past episodes, which corroborate as well as offer some further insights into the stylized facts about debt crises discussed above. Section 3 lays out the model and its predictions on the relationships between SSs and SDs under the distinct equilibria - pooling and separating. Section 4 presents the respective simulations results. Section 5 concludes. Specifics of the proofs and the data are provided in Appendices 1 and 2 respectively.

2 Stylized Facts

As a illustration of whether and how far our model can rationale the main stylized facts surrounding SSs and SDs (or sovereign debt crises more broadly defined), we look at a very broad sample of sovereign crisis events, both across countries and over time. Since the main crisis mechanism highlighted in the model are largely motivated by recent episodes, we separate between defaults and near-default events over the past couple of years (largely but not exclusively the European debt crises) and events (largely confined to emerging markets) over 1970-2006. One advantage of separating the two periods is that of highlighting the robustness of the main stylized facts to period breakdowns. The other is that pre-2007 events allow us to study both the pre-crisis dynamics as well as the post-crisis one, as data is available for both pre- and post-crisis period. This is not possible for the 2008-09 events since our sample finishes in 2009.

We define a debt crisis as episodes of either an outright default or a near-default. We define outright defaults as per the Standard & Poor classification of sovereign defaults, combined with that in Beim and Calomiris (2002), both compiled by Borenzstein and Pannizza (2009). We define "near-defaults" episodes of large IMF support (such as during the Argentine and Mexican crises of 1995, the Asian crises of 1997-98), where "large" is taken of at least twice as large as the respective country's quota in the IMF, when all net disbursements are computed from program's inception to end. Further specifics of this definition and its robustness in identifying main external crisis events relative to alternative definitions that also take into account major exchange rate realignments and recessions are discussed in Catao and Milesi-Ferretti (2011). In addition, and consistent with the discussion in the introduction, we also classify as near-defaults (or more accurately "debt crises") the crisis episodes in much of peripheral europe even if not supported by an IMF program before 2010, such as Greece, Ireland, Portugal and Spain. In the case of Greece and Portugal, they received some sort of multilateral support through ECB bond purchases and then direct IMF support from 2011. In all four cases, spreads skyrocketed in 2009 (well above 2 standard deviations) making it straighforward to deem such episodes as debt crises.[6] Finally, because the causal mechanisms we are concerned in

[6] One might contend that since large multilateral support to these countries took place in 2010 or 2011, these should be considered the years in which the crises peaked. However, our sample finishes in 2009, so for the purposes of event analysis we set 2009 as the peak crisis or "near default" year. If we were to choose 2010 or 2011 the event analysis below would make even clearly that bad news

this paper require some reasonable degree of country integration with international capital markets, our sample comprises emerging markets and advance countries, excluding countries where most borrowing through the sample period has been on concessional/multilateral basis. The resulting sample of events by country/year is reported in Appendix 2. We report below the cross-country means of these various country/year events centered within a eight-year window for each of the variables of interest.[7]

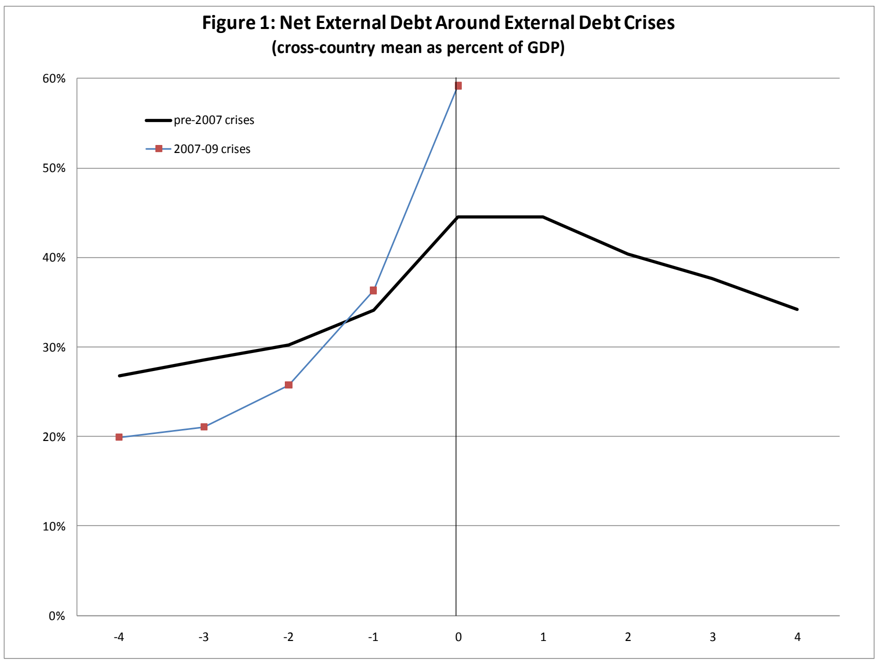

Figure 1: Net Foreign Debt

Figure 1 depicts the cross-country mean of net foreign debt (encompassing public and private debt) in countries that experienced a debt crisis defined as above. As standard, net foreign debt is scaled by the respective countries' GDP. Figure 1 shows that there is no SSs in net borrowing prior to the default (or near default) event at t=0. Debt crises are typically associated with a major rise of net external borrowing

(specially on the tax revenue side) began to mount well before the peak year (what we call $t = 0$ in the figures below).

[7]The only variable which has substantial gaps in our sample is spreads. Even though we were able to compile some spread data for a few countries from the late 1970s, the overwhelming majority of spread data covers the 1992-2009 period.

all the way through default. Thus, there is no SSs in quantities. That, if anything, takes place only after the default. Note that two sets of crises - pre-2007 and post-2007 - display very similar pre-default dynamics, a sharp rise, and not a drop, in net borrowing in the run-up to the default.

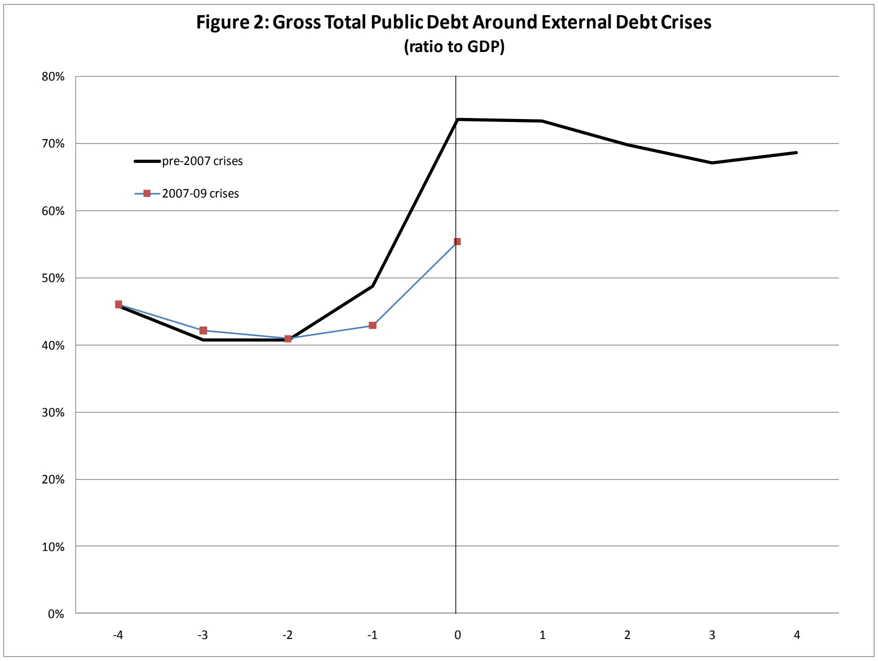

Figure 2: Gross General Borrowing.

Figure 2 reinforces this point about the continuing rise in external borrowing in the run-up to defaults or "near defaults" by depicting the path of gross general government borrowing. Both pre- and post-2007 crises have been associated with rising gross public indebtedness relative to national income. A main difference between the two crisis relative to what is shown in Figure 1 is that latter includes both private and public debt and much of the rapid rise in external indebtedness in the 2007-09 crises have been associated with private sector external debt. Yet, both figures together show that the rise in external debt has been key and that much of it – in both recent and past crises – have been associated with rising public, sovereign debt.

How these developments relate to country risk is a key feature of our model and Figure 3 provides cornstone evidence in this regard. Once again, both pre- and post-2007 crises have been quite similar in that defaults or near-defaults have been

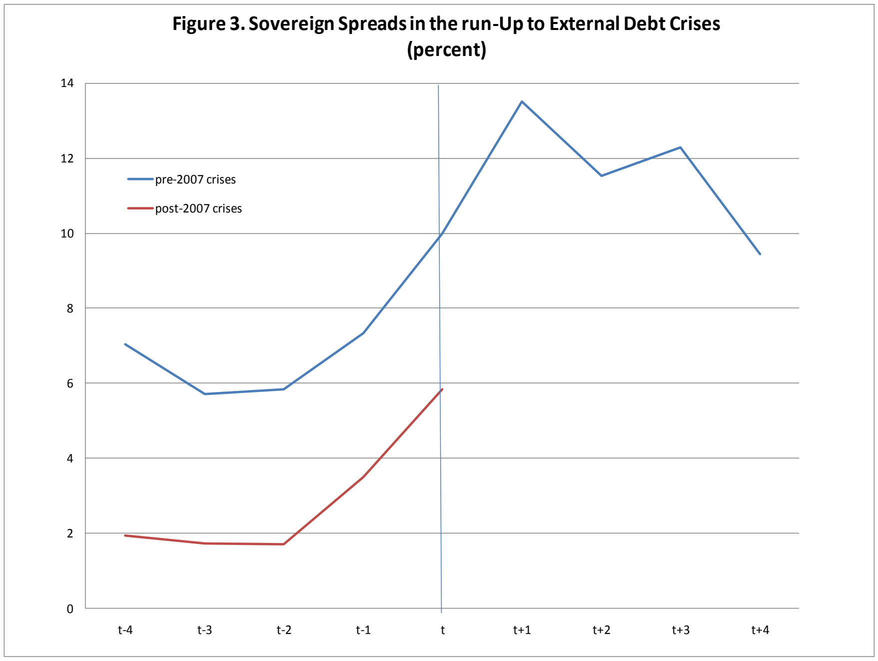

Figure 3: Sovereign Spreads.

preceded by a sharp rise in sovereign spreads (all measured relative to a benchmark "risk-free" bond which can be the US and German bond of similarly long maturity).[8] Thus, while gross and net borrowing increases, what happens to bond prices is very different from what happens to quantities. Bond prices sharply fall, and hence country spreads rise. Thus, as discussed in the introduction, the early manifestation of the SS shows up in prices rather than quantities. The turnaround is rather abrupt in both pre- and post-2007 crises, but because the latter hit mostly advanced countries that were considered low risk relative to emerging markets and hence that had a low initial level of spreads two to three years before the crisis outbreak, the turnaround was particularly dramatic.

Figure 4 provides evidence on a key variable in the model: the fiscal (general government) balance. Figure 4 clearly highlights that the overwhelming majority of external debt crises (the Asian crisis being one exception) have typically associated

[8]For emerging countries, we use the EMBI spread, whereas for Euroarea bonds we compute spreads relative to the German 10-year bond. If anything, the latter tends to under-estimate the spread since peripheral euro area countries have witnessed a gradual shortening of the maturity structure as the crisis intensified in 2009 and 2010.

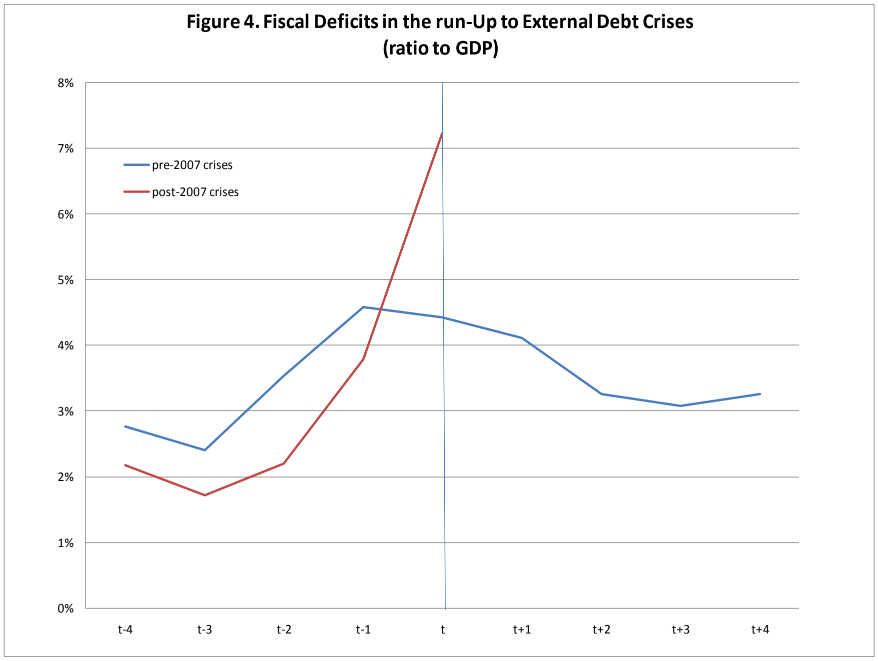

Figure 4: Fiscal Balance.

with government financing problems: consistent with what is shown in Figures 1 and 2 above, much of the increase in country's net foreign liabilities in the run-up to the crisis have been associated with rising fiscal gaps. These begin to widen two to three years before the default or near-default and, once again, this pattern has been particularly dramatic in recent crisis. Only once default or an averted default through large multilateral materializes, does fiscal adjustment begin to take place. In the case of default, the reason is clear: upon announcing default countries are usually shut off from any fresh borrowing and so have to tighten their fiscal stance to the SS in quantities. In the case of multilateral support (under say an IMF program), some access to external borrowing is preserved (so that the SS in quantities is milder or even altogether avoided) but conditionality kicks in and countries have to adjust fiscally. So, either way defaults or near defaults are typically associated with a widening fiscal gap and subsequent tightening.

Also critical to the "bite" of the proposed model is what lurks behind such widening of the fiscal gap in the run-up to the crisis. Figure 5 points to the key driver: the downturn in real fiscal revenues (nominal revenues deflated by the respective

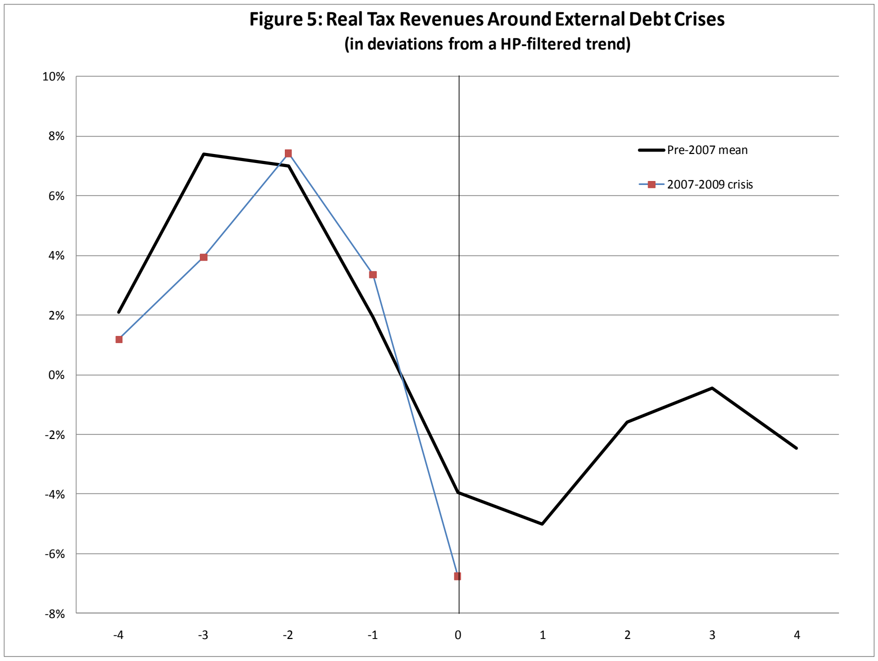

Figure 5: Real Fiscal Revenues.

country's CPI), all measured relative to (an HP-filtered) trend. In both pre- and post-2007 the drop is spectacular and in fact of a somewhat similar magnitude – with some apparent difference regarding the onset of the drop, with pre-2007 crisis being marked by a slightly more protracted tax revenue slowdown, but this is largely due to having set 2009 as the peak crisis year for some of peripheral Europe (i.e., if we had set t0=2010 in these cases, the tax revenue slowdown would have started earlier). Figure 6 suggests that this deterioration in real tax revenues results from a concomitant slowdown and eventual collapse of the tax base. Clearly a declining and later negative output growth precedes both the default and the SS in quantities. Note, however, that the amplitude in real tax revenues drop is larger (relative to its). This indicates that part of the revenue shortage relative to its trend is also due to a tax collection slowdown beyond what is warranted by the GDP drop. This is particularly true for some countries in recent and past crises, where the ratio of tax revenues to GDP clearly drops in the two to three year window preceding the default and/or multilateral bail-out.

As we shall discuss below, this is consistent with the genesis and attendant time-

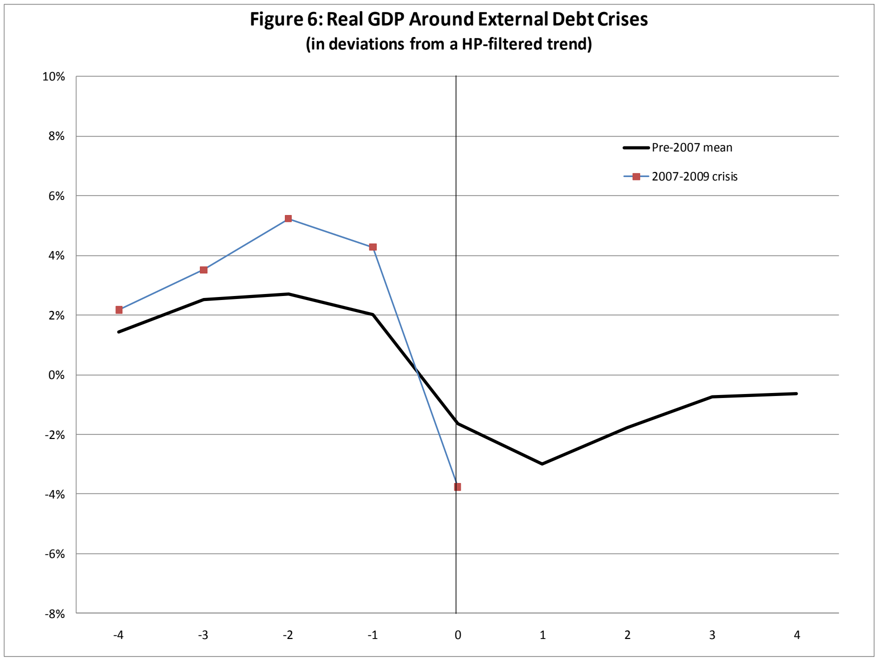

Figure 6: Output Growth.

line of debt crisis-sudden stop phenomena in our model: the country is first hit by a bad shock to its output (i.e., its main tax base) and hence to tax revenues; to the extent that the country taps the market, seeking to smooth the revenue shock (so as to preserve real spending), external debt mounts and country risk (spreads) rises. In other words, there is a potentially veiled SS that manifests typically in bond prices rather than quantity. As more costly borrowing tends to lower the cost of a future default, the latter may follow once the country is once again hit by sufficiently bad shock that makes repayment undesirable.

3 Model

3.1 Fiscal Shocks and Sovereign Debt.

A government issues bonds in international capital markets to finance investment in a long-term project which can be related to physical infrastructure and/or human capital development (e.g. education and health). We develop our argument in the simplest setting, which involves three periods, $t = 0, 1$, and 2. The project's investment requirement in period 0 (which we consider exogenous) generates fiscal revenues τ_0, τ_1 and τ_2 in periods $0, 1$ and 2 respectively.

To finance this requirement, the sovereign issues long-term debt to be paid in period 2. It issues $D_0 = \tau_0$ at time $t = 0$, it pays interest $r_0\tau_0$ in $t = 1$ and it promises to pay $(1 + r_0)\tau_0$ in $t = 2$.

In period $t = 1$ government's fiscal revenue is subject to a shock $\tilde{\epsilon_1}$ which assumes two values: $\epsilon_1^H = \alpha\tau_1$ and $\epsilon_1^L = -\alpha\tau_1$, with probability p and $1 - p$ respectively, where $\alpha < 1$. A key assumption throughout the model is that the shock in period 1 is persistent, so that $\rho\epsilon_1$ still affects the fiscal revenues in the final period.

Upon receiving the shock in the middle period, the borrower has two options:

1. "Renegotiate" (R).

   In this case the borrower can buy back its debt paying $(1 + r_0)\tau_0$ at $t = 1$ and re-issue the same debt $D_1 = \tau_0$ at $t = 1$ promising $(1 + r_1^R)\tau_0$ at $t = 2$. Notice that total outstanding debt at the end of the middle period is τ_0. Hence, after renegotiation there is no fresh debt issuance, i.e total outstanding debt at $t = 1$ is the same as in $t = 0$.[9]

2. "New Fresh Issuance" (I).

   In this case the borrower can issue new fresh debt D_1 to cover fiscal downfalls, $D_1 = \alpha\tau_1$, and promise to pay $(1 + r_1^I)\alpha\tau_1$ at $t = 2$. Notice that in this case total outstanding debt at the end of the middle period is $\alpha\tau_1 + \tau_0$.

At the final period, the government is subjected to another fiscal shock $\tilde{\epsilon_2}$ which can assume two values, ϵ_2^H or ϵ_2^L with probability q and $1 - q$ respectively. After the realization of the shock, the government decides whether to pay or default in all outstanding debt. Default only happens at the end. Without loss of generality, we assume there is no default on interest payments in the middle period.[10]

[9] Another way of interpreting this "buy back" option is that we have in mind a "callable" bond. Although no (or very few countries) issue bonds with a "callable clause", sovereigns (even if legally forbidden to buy-back) may use other agents to do so (paying say a trivial commission), and hence, effectively the bond becomes callable.

[10] Not only this assumption will not change the results in the model, but it is also a very easy

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, allow 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 riskless interest rate r_f, which in the model is taken as exogenous.

There are two debt markets, at $t = 0$ and at $t = 1$.[11] We will assume that there is no seniority of debt at $t = 2$ and when the borrower defaults, it defaults on all its outstanding debt at the same time.

In the case of default, creditors receive a portion c of the final promise. This would correspond to a haircut of $1 - c$. 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. This cost applies to all debt since we are assuming no seniority in the baseline model.

Hence, the total confiscation cost in the final period for a borrower that decided to issue fresh debt in the middle period is given by $\eta^I = \eta\tau_0 + \eta\alpha\tau_1$. This is, $\eta\tau_0$ goes to $t = 0$ creditors and $\eta\alpha\tau_1$ goes to $t = 1$ creditors. On the other hand, the total confiscation costs for a borrower that decided to refinance in the middle period is given by $\eta^R = \eta\tau_0$.

Now we are ready to completely describe the lender's cash flows. Figure 7 shows the cash flow associated to lending at $t = 0$. With some probability π the debt gets bought back in period 1. In this case, the principal plus interest gets re-invested in the risk-free technology. With probability $(1 - \pi)$, the lender receives interest payment in period 1, which are re-invested in the risk free technology. In period 2, with some probability $1 - \pi'$ the creditor is paid back interest plus principal, a

assumption to justify. For example, suppose $r = 5\%$ and $\tau_0 = 100\%$, this means that repayment of interest would amount only to 5% of revenues. Clearly, this payment would be easily met given that a very bad shock still leaves you with 40 or 50% of revenues, ie. an amount 10 times higher than what you need to pay.

[11]We will treat creditors at $t = 0$ as different from creditors at $t = 1$. Basically, we are treating both credit markets as segmented. The exposition in the appendix shows very clearly that assuming this segmentation will not alter the results, and simplify tremendously equilibrium characterization.

total revenue of $(1+r_f)r_0\tau_0+(1+r_0)\tau_0$. With some probability π' the creditor faces sovereign default in which case she receives $(1+r_f)r_0\tau_0+c(1+r_0)\tau_0+\eta\tau_0F_2$, where F_2 is defined as fiscal revenues in period 2.

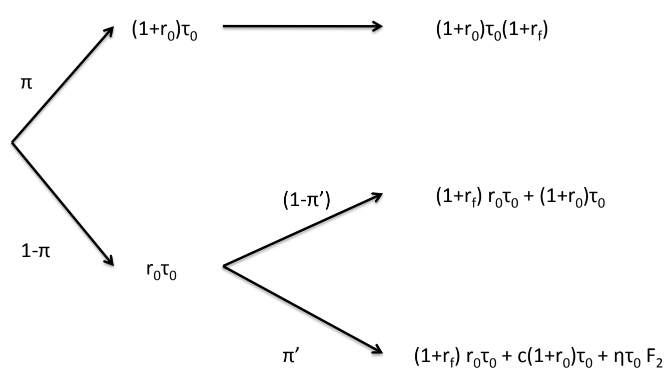

Figure 7: Lending at $t = 0$.

Figure 8 shows the cash flow associated to lending at $t = 1$ to a borrower that decided to renegotiate. In period 2, with probability $1 - \pi$ the creditor is paid back interest plus principal, $(1 + r_1^R)\tau_0$, where r_1^R is the interest rate charged in period 1 to borrowers after renegotiation. On the other hand, with probability π' the creditor faces sovereign default and in which case she receives $c(1 + r_1^R)\tau_0 + \eta\tau_0F_2$.

Finally figure 9 shows the cash flow associated to lending at $t = 1$ to a borrower that decided to issue fresh debt. In period 2, with probability $1 - \pi$ the creditor is paid back interest plus principal, $(1 + r_1^I)\alpha\tau_1$, where r_1^I is the interest rate charged in period 1 to borrowers after fresh issuance. On the other hand, with probability π' the creditor faces sovereign default and On the other hand, with probability π' the creditor faces sovereign default and in which case she receives $c(1+r_1^I)\alpha\tau_1+\eta\alpha\tau_1F_2$.

Finally, notice that r_1^R and r_1^I may or may not be the same. We will discuss

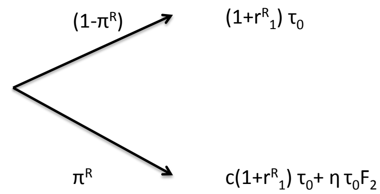

Figure 8: Lending at $t = 1$ to borrowers after renegotiation.

extensively this issue at the end of this section.

3.3 Sovereign Payoffs.

The government maximizes social welfare. Without getting into the details of a particular social welfare function, we will assume that the government is risk neutral, have a discount factor of β and maximizes expenditure G. The payoffs are:

In period $t = 0$:

$$G_0 = \tau_0 \tag{1}$$

In period $t = 1$ there are two possibilities. If the borrower re-negotiates (R), we have that

$$G_1 = \tau_1 + \tilde{\epsilon_1} - (1 + r_0)\tau_0 + \tau_0 \tag{2}$$

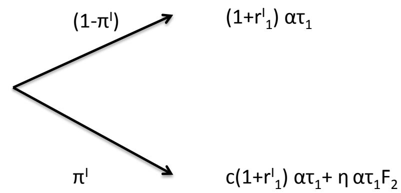

Figure 9: Lending at $t = 1$ to borrowers after fresh new issuance.

so, expenditures equals fiscal revenues $F_1 = \tau_1 + \tilde{\epsilon_1}$ minus debt buy back plus new debt issuance.

In case the borrower issues new fresh debt (I), we have that

$$G_1 = \tau_1 + \tilde{\epsilon_1} - r_0\tau_0 + \alpha\tau_1 \tag{3}$$

so, expenditures equals fiscal revenues $F_1 = \tau_1 + \tilde{\epsilon_1}$ minus interest payments plus new debt issuance.

In the last period there are four possibilities. After renegotiation (R) the sovereign could repay or default. If it repays, we have that

$$G_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2} - (1 + r_1^R)\tau_0 \tag{4}$$

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

If it defaults

$$G_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2} - c(1 + r_1R)\tau_0 - \eta^R(\tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2}) \tag{5}$$

expenditure equals fiscal revenues $F_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2}$ minus debt haircuts minus fiscal confiscation losses.

On the other hand, after new debt issuance (I), the sovereign could again either repay or default. If it repays

$$G_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2} - (1 + r_0)\tau_0 - (1 + r_1^I)\alpha\tau_1 \tag{6}$$

expenditure equals fiscal revenues $F_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2}$ minus debt re-payments of debt issued at $t = 0$ and $t = 1$.

If it defaults

$$G_2 = \tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2} - c(1 + r_0)\tau_0 - c(1 + r_1^I)\alpha\tau_1 - \eta^I(\tau_2 + \rho\epsilon_1 + \tilde{\epsilon_2}) \tag{7}$$

expenditure equals fiscal revenues minus debt haircuts of all outstanding debt, minus fiscal confiscation losses.

3.4 Asymmetric Information and Sudden Stops

We assume that there is asymmetric information between the sovereign borrower and investors. While the borrower can perfectly observe the realization of the middle period shock $\tilde{\epsilon_1}$, lenders cannot.

The only way lenders can infer some information about the realization of the shock is through the borrower's action in the middle period: to issue new debt (I) or to re-negotiate (R).

Lenders at $t = 1$, after observing the borrower action (issue or re-negotiate) update their beliefs of future default and re-price debt accordingly. In the next section we show that there are situations in which the interest rate charged in the middle period is sensitive to the borrower's action. So $r_1^I \neq r_1^R$, this is, borrowers' action alter credit market conditions.

We define a sudden stop (SS) as the shift in the supply curve of funds. As explained before, in order to keep the model tractable, we are not modeling the quantity choice, so issuance is taken exogenous. This also serves the purpose of studying the opposite extreme case from the one studied in the standard Sudden Stops literature. This literature defines a sudden stop as a sudden drop in the quantities issued without paying attention to prices. Our model will focus on endogenous and sudden changes in prices as opposed to quantities. Hence, it will be characterized by the difference in rates charged by lenders in period 1: $r_1^I - r_1^R$.

3.5 Sudden Stops and Sovereign Defaults

We model the borrower and lender interaction as a game. The borrower's strategy is to issue (I) or re-negotiate (R) in period 1 and to pay or not in period 2. The lender's strategy is to set a break-even price. Lenders will have beliefs about borrower's type (shock realization in period 1). A Perfect Bayesian equilibrium (PBE) is an equilibrium in which everybody's response is optimal given everybody's else response and beliefs, and beliefs are consistent with strategies and updates using Bayes' (whenever possible).

There are potentially to types of equilibria: Separating and Pooling.[12] In a separating equilibrium actions following each shock realization will be different (say issuing fresh debt only when a bad shock) and hence completely revealing. In a pooling equilibrium actions following different shock realizations are the same (say country never issues).

A Sudden Stop, as defined in section 3.4, will arise in the model only in a separating equilibrium in which R follows a good shock and I follows a bad shock in the middle period. The main result of the paper is the following.

Theorem: *There exists a separating perfect bayesian equilibrium in this economy in which Sudden Stop associated with hiking spreads but positive net borrowing precedes a Sovereign Default.*

Proof: See Appendix.

4 Numerical Simulations

In this section, we calibrate our model, using plausible parameters of the economy and discuss the type of equilibrium outcome - pooling equilibrium or different type of separating equilibria - and the resulting consequences for debt pricing and capital flows. Each calibration exercise contrasts the experience of two countries: one

[12]In pure strategies. We are not considering mixed strategies in the model.

country experiencing a positive fiscal shocks in the first period and and an other country experiencing a good fiscal shock. Recall that in a separating equilibrium, the country with a good shock will find profitable to refinance its long term debt by issuing fresh one-period bond while in a pooling equilibrium both country will follow the same course of action. We define the size of a sudden stop as the difference in interest-rate pricing on new debt between re-issuers and re-financers.

4.1 Calibration

We consider three sets of calibrations. The first two set of calibrations allow us to analyze different types of separating equilibria while the third one describes parametric conditions for a pooling equilibrium to exist. In the baseline calibration, the haircut is set equal to 30% ($c = 0.70$)- a standard "average" value in the literature - and the share of fiscal revenues that can be confiscated by creditors is equal to 25%. There is equal probability of good and bad realization of the i.i.d shocks - $(\varepsilon_1, \varepsilon_2)$ - in both periods and the absolute value of the shocks is equal across period. The discount rate, β is set equal to 0.96 implying a risk-free rate $r_f = 4.17\%$. In the two alternative scenario, the haircut is reduced with $c = 0.75$ (alternative scenario 1) or $c = 0.8$ (alternative scenario 2).

Given the initial level borrowing, τ_0 , the fiscal shock structure in period 1 and period 2 is defined as follows:

$$\begin{aligned}\varepsilon_1 &= +/- \ \alpha_1 \tau_0 \\ \varepsilon_2 &= +/- \ \alpha_2 \tau_0 \\ \eta_2 &= \rho\varepsilon_1 + \varepsilon_2\end{aligned}$$

where $\varepsilon_1, \varepsilon_2$ are the i.i.d shocks and η_2 is the sum of the persistent shock and the i.i.d shock in period 2. In the baseline scenario and in the first alternative scenario, we set $\alpha = \alpha_1 = \alpha_2$ while in the second alternative scenario we set $\alpha_2 = 0$ so that all the uncertainty is resolved at the end of the first period. Each simulation is repeated for different values of α ranging from 0.10 to 0.3 an different values of ρ, the persistence of the first period shock, ranging from 0.5 to 0.95. The table below summarize the parameters of the simulated economy.

parameter	parameter name	Baseline	Alternative 1	Alternative 2
β	Discount Factor ($\beta = 1/(1+r)$)	0.975	--	--
τ_0	Initial Borrowing	100	--	--
c	Recovery (1-Haircut)	0.70	0.75	0.8
η	Confiscated Share of Fiscal Revenues	0.26	--	--
p	Probability of a good shock ($t = 1$)	0.5	--	--
q	Probability of a good shock ($t = 2$)	0.5	--	--
ρ	Persistence of Shock	$[0.5, 0.95]$	--	
α_1	First Period i.i.d Fiscal Shock	$[0, 0.3]$	--	--
α_2	Second Period i.i.d Fiscal Shock	$[0, 0.3]$	--	0

4.2 Baseline Scenario.

Figure 10 details the baseline scenario for different combinations of the size of the shock (α) and the persistence of the first period shock (ρ). Panel (a) plots the index of the equilibrium outcome according to the classification provided in the appendix. If the shock is both too small and not enough persistent, there is not equilibrium that allows positive borrowing. The same is true is the shock is both highly persistent and very large. For interim values of shock size and persistence a separating equilibrium exists however and for most of the range it features an equilibrium - indexed by 5 - where a country experiencing a bad shock re-issue and default in subsequent period while a country experiencing a good shock refinance and default in second period only if it experiences a bad shock.

Panel (b) plots the sudden stop size, that is the difference in the interest rate at which a country with a bad shock re-issues and a country with a good shock refinances. As expected, the spread increases with the size of the shock and with its persistence. It varies between 6.7% and 12%, a reasonable order of magnitude based on the evidence of interest rate hikes experienced by countries suffering large negative fiscal shocks and negative default outlook.

Panel (c) and Panel (d) plot the net inflows experienced by a country with a negative shock and and the net outflows for a country with a positive shocks. Net inflows for re-issuers (c) correspond to the difference between the amount of debt re-issued ($\alpha\tau$) and the interest rate payment ($r_0\tau$). Net outflows for re-financers (d) correspond to the interest rate payment.. Notice that the first period interest rate is relatively insensitive to an increase in the persistence and in the size of the shock.

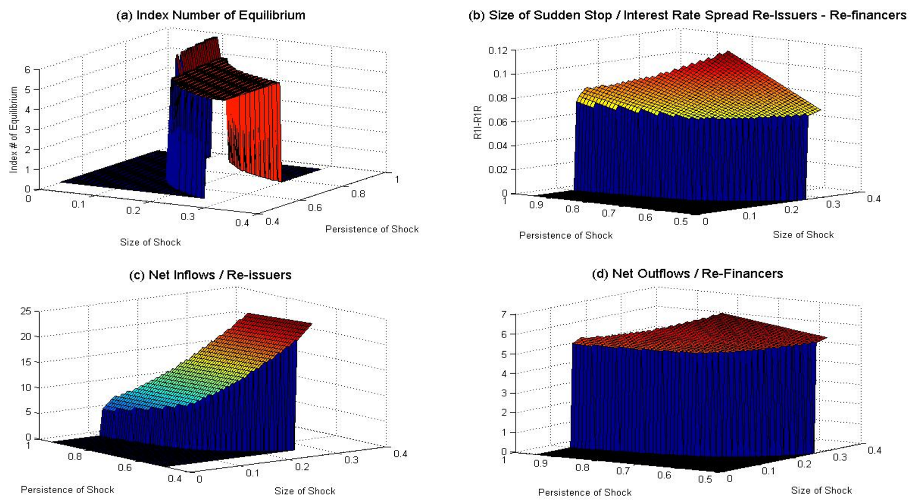

Figure 10: Simulations: Baseline Scenario of Separating Equilibrium.

This is a consequence of having a fully revealing equilibrium outcome at the end for the first period that allows to charge a high risk-premium to the country that will eventually default and a lower to the other country.

4.3 Alternative Scenario: Separating Equilibrium.

Figure 11 presents an alternative scenario with a smaller haircut ($c = 0.75$). The rest of the parameters are the same as in the baseline. The equilibrium indexed by 5 featured in the baseline scenario still exists for some range of parameters. In addition, an other equilibrium - indexed by 3 - occurs when shocks are large enough but not very persistent. While this equilibrium is separating and fully revealing, both types of countries are defaulting for a bad shock and repaying for a good shock. As a consequence when the equilibrium switched from 5 to 3, the gains from re-financing compared to re-issuing shrink. They remain however positive and rise with the persistence and size of shock. The reason is that while both countries take similar action in the second period with respect to repaying or defaulting, they strongly differ by the *size of the liabilities* at the end of the first period and by the amount

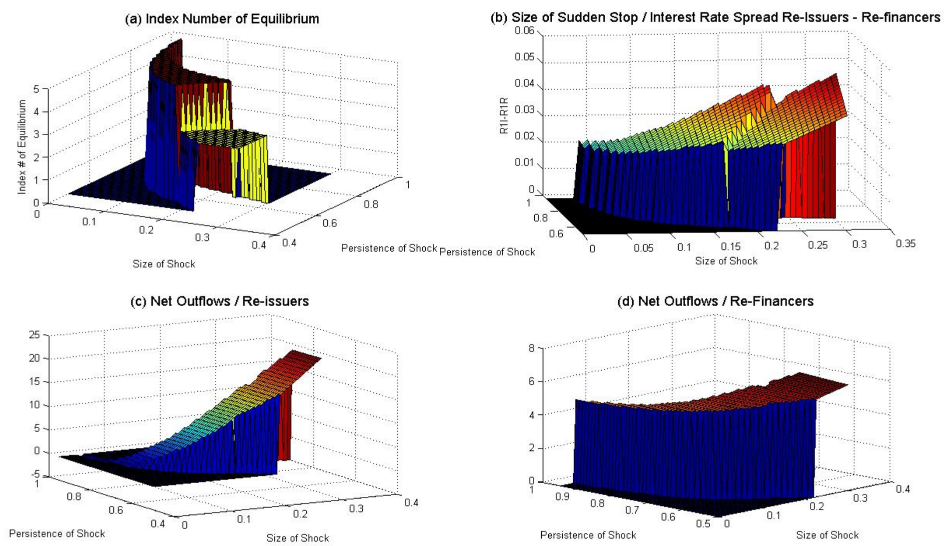

Figure 11: Simulations: Alternative Scenario of Separating Equilibrium

of *future collateral* available to creditors.. The country which is hit by a bad shock and choose to re-issue has now a stock of outstanding debt of $(1+\alpha)\tau_0$ while the country that choose to refinance maintains a debt equal to τ_0. Meanwhile, creditors can seize a fraction of tax revenues upon default. For a country with a good shock in the first period, this fraction is more important than for a country hit by a bad shock although the debt liabilities of the former are much smaller. In a sense, the debt of the re-financers is more collateralized than the debt of the re-issuers which explains the difference in pricing even if there are no difference in second period decision.

4.4 Alternative Scenario: Pooling Equilibrium

Figure 12 illustrates combinations of parameters for which a pooling equilibrium exists in which the country hit by a bad shock imitates the country hit by a good shock and choose to re-finance instead of re-issuing. By doing so this country sac-

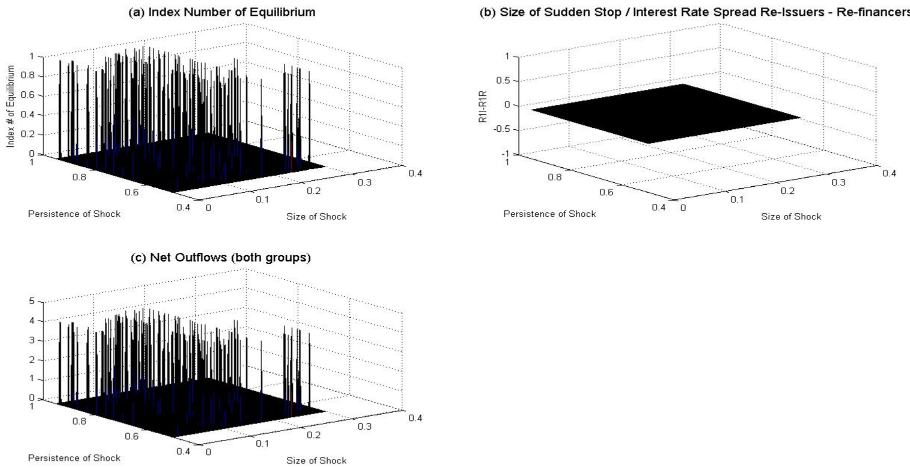

Figure 12: Simulations: Alternative Scenario of a Pooling Equilibrium.

rifices current public spending in order to maintain a low cost of financing for the second period. No sudden stop occurs and debt pricing is independent of the first period shock. It turns out that for a pooling equilibrium to exists, the second period i.i.d shock should be close to zero, meaning that all the uncertainty has been resolved in the first period. When this is the case, the country hit by a bad shock has no prospect of recovering thanks to a good shock in the second period. In this case, re-issuing would be prohibitive as it would reveal a bad state of public finance with no hope to be lucky enough in the second period to ameliorate the fiscal situation. The optimal strategy in this case is to “hide” the true state of public finance by pretending the absence of any need to re-issue more debt to cover fiscal shortfall. The tax shortfall cannot be offset but the cost of funding remains low for one more period. Notice that “pooling” equilibria are more fragile, they exist over a non-compact set of parameters and therefore can be “destroyed” by very small change in the parameters of the economy.

5 Conclusion

This paper has examined how sharp fluctuations in sovereign spreads amidst continuous market access cum net borrowing can arise in an environment characterized by substantive information asymmetries about fiscal fundamentals and where tax revenue shocks can be large and persistent. In this setting, we show that there two types of equilibria. In a separating equilibrium, unexpected market tapping by the sovereign signals to investors that it has been hit by a large and likely persistent revenue shock. So, even if the tapping is successful in the sense that net borrowing goes up, this signals to investors that debt repayment capacity has been compromised relative to baseline. Hence the future expected ratio of debt to revenue ratio goes up, raising repayment risk. In response, risk neutral investors hike up spreads which, in turn, increases the cost of future repayment and thus lowers the cost of a subsequent default. In this separating equilibrium, the SS (defined as an inward shift in lenders' supply schedule) preceeds the sovereign default or debt crisis broadly speaking. The novelty of this equilibrium relative to previous SS models is that the drop in net capital flows may take place only long after a large drop in output and tax revenues; capital inflows (both gross and net) only dry up later - and potentially much later - once default materializes.

Yet, we also establish the existence of another equilibrium in which the country "fakes": despite being hit by a bad fiscal shock, there is no middle-of-the-way market tapping. In this pooling equilibrium, the sovereign instead adjusts by cutting spending, not revealing to investors the "bad news". Hence spreads stay put and there is no SS, measure either in price or quantity (flow) terms. However, to the extent that the deterioration is persistent and insofar as public spending cuts further depress output and hence tax revenues, future repayment capacity is undermined. Thus default risk will rise nevertheless. We illustrate circumstances in which each equilibria will occur under various model calibrations. In the case of separating equilibrium, we also illustrate using a comprehensive cross-country database that the model predictions regarding tight and roughly contemporary correlation between spreads, output and tax revenues, as well as lags in capital inflow adjustment, have been remarkably consistent with main stylized facts of recent and also several past debt crises.

It is important to note that the postulated crisis mechanism and attendant equilibria are potentially complementary, rather than substitutes, to those featuring in many previous models of SSs and SDs. By developing our argument in a simple one-good setting, where unhedged currency positions are not present, complicated coordination issues between junior and senior investors are schewed away, and the persistence of output and tax shocks is taken as given rather than modeled from the supply-side of the economy, our aim has been to isolate the role of asymmetric information on bond pricing in an environment where fiscal can be large and highly persistent. Insofar as this simple setting can rationalize salient correlations and lags observed in real world data, as we argue to be the case, we regard this as a non-trivial plus in favor of our model. A more comprehensive model of SSs and SDs would of course need to incorporate the supply side of these economies, as well as the role of financial frictions such as leverage constraints on the private sector, given evidence of its importance in shock amplification and persistence, along the lines of a recent DSGE literature (see, e.g., Gertler and Kiyotaki, 2009; Mendoza, 2010; and various reference therein). Once again, however, given the seemingly central importance of fiscal shocks and asymmetric information about them in the anatomy of the recent debt crises, these seem important to incorporate in the menu of frictions purporting to explain such events.

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7 Appendix

7.1 Appendix 1

Proof of Theorem:

The proof establishes that the strategies are optimal given beliefs and other player's strategies and beliefs are consistent with observed choices. Step 1 begins by assuming that the borrowers renegotiates after a good shock and issues new 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 (R) and after receiving $\epsilon_1^L = -\alpha\tau_1$ decides to follow strategy (I). We also assume without loss of generality that $\tau_0 = \tau_1 = \tau_2 = \tau$. Hence, confiscation losses are given by $\eta^I = (1+\alpha)\eta\tau$ and $\eta^R = \eta\tau$.

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

   Clearly, lender's beliefs are given by $\mu(H/R) = 1$ and $\mu(L/I) = 1$.

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

   Let us consider first the borrower that received a good shock in the middle period, from now on called H-type. His revenue after repayment is $\tau_2 + \rho\epsilon_1^H + \tilde{\epsilon_2} - (1 + r_1^R)\tau_0 = \tau(1 + \rho\alpha - (1 + r_1^R)) + \tilde{\epsilon_2}$. On the other hand, if he defaults his revenue is $\tau_2 + \rho\epsilon_1^H + \tilde{\epsilon_2} - c(1 + r_1^R)\tau_0 - \eta^R(\tau_2 + \rho\epsilon_1^H + \tilde{\epsilon_2}) = \tau((1 + \rho\alpha)(1 - \eta^R) - c(1 + r_1^R)) + (1 - \eta^R)\tilde{\epsilon_2}$. Hence an H borrower repays at the end if and only if

$$\tilde{\epsilon_2} \geq (\tau/\eta^R)(-(1 + \rho\alpha)\eta^R + (1 - c)(1 + r_1^R)) = H_2 \quad (8)$$

Now, let us consider an L type borrower. His revenue after repayment is $\tau_2+\rho\epsilon_1^L+\tilde{\epsilon_2}-(1+r_0)\tau_0-(1+r_1^I)\alpha\tau_1=\tau(1-\rho\alpha-(1+r_0)-(1+r_1^I)\alpha)+\tilde{\epsilon_2}$. On the other hand, if he defaults his revenue is $\tau_2+\rho\epsilon_1^L+\tilde{\epsilon_2}-c(1+r_0)\tau_0-c(1+r_1^I)\alpha\tau_1-\eta^I(\tau_2+\rho\epsilon_1^L+\tilde{\epsilon_2})=\tau((1-\rho\alpha)(1-\eta^I)-c(1+r_0)-c(1+r_1^I)\alpha)+(1-\eta^I)\tilde{\epsilon_2}$. Hence an L borrower repays at the end if and only if

$$\tilde{\epsilon_2}\geq(\tau/\eta^I)(-(1-\rho\alpha)\eta^I+(1-c)((1+r_0)+(1+r_1^I)\alpha))=L_2 \tag{9}$$

Note that in a genuine separating equilibrium $H_2<L_2$. We confirm this in section 4 with the numerical simulations. Before moving on to determine the pricing, notice that there are six cases from the lender's perspective:

- 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: $\epsilon_2^L<H_2<\epsilon_2^H<L_2$. L always defaults, H only for a bad shock.
- Case 6: $\epsilon_2^L<\epsilon_2^H<H_2<L_2$. Both always default.

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

We need to consider each case separately.

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

$$r_1^R=r_1^I=r_f \tag{10}$$

- Case 2: $H_2<\epsilon_2^L<L_2<\epsilon_2^H$. In this case r_1^R is given by equation (10). Break-even condition implies that $q(1+r_1^I)\alpha\tau+(1-q)(c(1+r_1^I)\alpha\tau+\eta_1F_2^{LL})=(1+r_f)\alpha\tau$, where $F_2^{LL}=\tau-\rho\alpha\tau+\epsilon_2^L$. This gives

$$(1+r_1^I)=\frac{1+r_f}{q+(1-q)c}-\frac{(1-q)\alpha\eta\tau F_2^{LL}}{(q+(1-q)c)\alpha\tau} \tag{11}$$

- Case 3: $\epsilon_2^L<H_2<L_2<\epsilon_2^H$. In this case r_1^I is given by equation (11). And by the same break-even logic we have that

$$(1+r_1^R)=\frac{1+r_f}{q+(1-q)c}-\frac{(1-q)\eta^RF_2^{HL}}{(q+(1-q)c)\tau} \tag{12}$$

where where $F_2^{HL} = \tau + \rho\alpha\tau + \epsilon_2^L$

- Case 4: $H_2 < \epsilon_2^L < \epsilon_2^H < L_2$. In this case r_1^R is given by equation (12), and r_1^I is given by

$$(1 + r_1^I) = \frac{1 + r_f}{c} - \frac{\alpha\eta\tau EF_2^L}{c\alpha\tau} \tag{13}$$

where $EF_2^L = qF_2^{LH} + (1-q)F_2^{LL}$, and $F_2^{LH} = \tau - \rho\alpha\tau + \epsilon_2^H$.

- Case 5: $\epsilon_2^L < H_2 < \epsilon_2^H < L_2$. In this case r_1^R is given by equation (12) and r_1^I by equation (13).

- Case 6: $\epsilon_2^L < \epsilon_2^H < H_2 < L_2$. In this case r_1^I is given by equation (13) and r_1^R by

$$(1 + r_1^R) = \frac{1 + r_f}{c} - \frac{\eta^R EF_2^H}{c\tau} \tag{14}$$

where $EF_2^H = qF_2^{HH} + (1-q)F_2^{HL}$ and $F_2^{HH} = \tau + \rho\alpha\tau + \epsilon_2^H$.

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

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

$$r_0 = \frac{(1 + r_f)^2\tau - (1 + r_f)\tau p - (1-p)\tau}{(1 + r_f)\tau + (1-p)\tau} \tag{15}$$

As shown in the numerical simulations in this case $r_0 = r_f$.

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

$$r_0 = \frac{(1 + r_f)^2\tau - (1 + r_f)\tau p - (1-p)(q\tau + (1-q)c\tau + (1-q)\eta F_2^{LL})}{(1 + r_f)\tau + (1-p)(q\tau + (1-q)c\tau)} \tag{16}$$

- Case 3: $\epsilon_2^L < H_2 < L_2 < \epsilon_2^H$. In this case, r_0 is given by equation (16).

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

$$r_0 = \frac{(1 + r_f)^2\tau - (1 + r_f)\tau p - (1-p)(c\tau + \eta EF_2^L)}{(1 + r_f)\tau + (1-p)c\tau} \tag{17}$$

- Case 5: $\epsilon_2^L < H_2 < \epsilon_2^H < L_2$. In this case r_0 is given by equation (17).

- Case 6: $\epsilon_2^L < \epsilon_2^H < H_2 < L_2$. In this case r_0 is given by equation (17).

Step 2:

We first describe the payoffs of each type. Let us start with the L-type. 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:

$$\tau(1-r_0)+\beta(\tau(1-\rho\alpha-(1+r_0)-(1+r_1^I)\alpha)+E\tilde{\epsilon_2}) \tag{18}$$

when it repays only for a good shock:

$$\tau(1-r_0)+\beta(q(\tau-\tau\rho\alpha+\epsilon_2^H-(1+r_0)\tau-(1+r_1^I)\alpha\tau)+(1-q)(\tau-\tau\rho\alpha+\epsilon_2^L-c(1+r_0)\tau-c(1+r_1^I)\alpha\tau-\eta^I F_2^{LL})) \tag{19}$$

and finally, when he always defaults

$$\tau(1-r_0)+\beta(\tau-\tau\rho\alpha-c(1+r_0)\tau-c(1+r_1^I)\alpha\tau+E\tilde{\epsilon_2}-\eta^I EF_2^L)) \tag{20}$$

There are two things that change when an L-type decides to deviate and play the R 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. After deviation his payoff after repayment at the end is given by $\tau(1-\rho\alpha-(1+r_1^R))+\tilde{\epsilon_2}$. After default is given by $\tau-\rho\alpha\tau+\tilde{\epsilon_2}-c(1+r_1^R)\tau-\eta^R(\tau-\rho\alpha\tau+\tilde{\epsilon_2})$. Hence, he repays if and only if

$$\tilde{\epsilon_2}\geq(\tau/\eta^R)(-(1-\rho\alpha)\eta_1+(1-c)(1+r_1^R))=L_2^d \tag{21}$$

From equations (8), (9) and (21) it follows that $H_2<L_2^d<L_2$.

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

$$\tau(2-\alpha-(1+r_0))+\beta(\tau(1-\rho\alpha-(1+r_1^R))+E\tilde{\epsilon_2}) \tag{22}$$

when it repays only for a good shock:

$$\tau(2-\alpha-(1+r_0))+\beta(q(\tau-\tau\rho\alpha+\epsilon_2^H-(1+r_1^R)\tau)+(1-q)(\tau-\tau\rho\alpha+\epsilon_2^L-c(1+r_1^R)\tau-\eta^R F_2^{LL})) \tag{23}$$

and finally, when he always defaults

$$\tau(2-\alpha-(1+r_0))+\beta(\tau-\tau\rho\alpha-c(1+r_1^R)\tau+E\tilde{\epsilon_2}-\eta^R EF_2^L)). \tag{24}$$

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

$$\tau(2+\alpha-(1+r_0))+\beta(\tau(1+\rho\alpha-(1+r_1^R))+E\tilde{\epsilon_2}) \tag{25}$$

when it repays only for a good shock:

$$\tau(2+\alpha-(1+r_0))+\beta(q(\tau+\tau\rho\alpha+\epsilon_2^H-(1+r_1^R)\tau)+(1-q)(\tau+\tau\rho\alpha+\epsilon_2^L-c(1+r_1^R)\tau-\eta^R F_2^{HL})) \tag{26}$$

and finally, when he always defaults

$$\tau(2+\alpha-(1+r_0))+\beta(\tau+\tau\rho\alpha-c(1+r_1^R)\tau+E\tilde{\epsilon_2}-\eta^R EF_2^H)). \tag{27}$$

There are two things that change when an H-type 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. After deviation his payoff after repayment at the end is given by $\tau(1+\rho\alpha-(1+r_0)-(1+r_1^I)\alpha)+\tilde{\epsilon_2}$. After default is given by $\tau+\rho\alpha\tau+\tilde{\epsilon_2}-c(1+r_0)\tau-c(1+r_1^I)\alpha\tau-\eta^I(\tau+\rho\alpha\tau+\tilde{\epsilon_2})$. Hence, he repays if and only if

$$\tilde{\epsilon_2}\geq(\tau/\eta)(-(1+\rho\alpha)\eta^I+(1-c)((1+r_0)+(1+r_1^I)\alpha))=H_2^d \tag{28}$$

From equations (8), (9) and (28) it follows that $H_2<H_2^d<L_2$.

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:

$$\tau(1+2\alpha-r_0)+\beta(\tau(1+\rho\alpha-(1+r_0)-(1+r_1^I)\alpha)+E\tilde{\epsilon_2}) \tag{29}$$

when it repays only for a good shock:

$$\tau(1+2\alpha-r_0)+\beta(q(\tau+\tau\rho\alpha+\epsilon_2^H-(1+r_0)\tau-(1+r_1^I)\alpha\tau) \tag{30}$$
$$+(1-q)(\tau+\tau\rho\alpha+\epsilon_2^L-c(1+r_0)\tau-c(1+r_1^I)\alpha\tau-\eta^I F_2^{HL})) \tag{31}$$

and finally, when he always defaults

$$\tau(1+2\alpha-r_0)+\beta(\tau+\tau\rho\alpha-c(1+r_0)\tau-c(1+r_1^I)\alpha\tau+E\tilde{\epsilon_2}-\eta^I EF_2^H)) \tag{32}$$

Finally, in order to check for the existence of a separating equilibrium, we need to check for possible deviations for each type. We have two cases: I) $H_2 < H_2^d < L_2^d < L_2$ and II) $H_2 < L_2^d < H_2^d < L_2$. Note that for pricing we still just need to consider the 6 original cases since investors cannot observe deviations. However, in order to check for deviations some of these cases may get subdivided in sub-cases. Table 1 and 2 show all the possible cases that we need to check. For example, in case 4.1) in table 1 in order to check for deviation we need to show that equation (25) is bigger than equation (29) for the H type and that equation (20) is bigger than equation (22) for the L-type using pricing according to case 4 discussed in step 1. 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.

CASE $H_2 < H^d_2 < L^d_2 < L_2$

REGION	H: CONDITION FOR NO DEVIATION	L: CONDITION FOR NO DEVIATION
1.1) $H_2 < H^d_2 < L^d_2 < L_2 < \varepsilon^L_2 < \varepsilon^H_2$	(25) ≥ (29)	(18) ≥ (22)
2.1) $H_2 < H^d_2 < L^d_2 < \varepsilon^L_2 < L_2 < \varepsilon^H_2$	(25) ≥ (29)	(19) ≥ (22)
2.2) $H_2 < H^d_2 < \varepsilon^L_2 < L^d_2 < L_2 < \varepsilon^H_2$	(25) ≥ (29)	(19) ≥ (23)
2.3) $H_2 < \varepsilon^L_2 < H^d_2 < L^d_2 < L_2 < \varepsilon^H_2$	(25) ≥ (30)	(19) ≥ (23)
3.1) $\varepsilon^L_2 < H_2 < H^d_2 < L^d_2 < L_2 < \varepsilon^H_2$	(26) ≥ (30)	(19) ≥ (23)
4.1) $H_2 < H^d_2 < L^d_2 < \varepsilon^L_2 < \varepsilon^H_2 < L_2$	(25) ≥ (29)	(20) ≥ (22)
4.2) $H_2 < H^d_2 < \varepsilon^L_2 < L^d_2 < \varepsilon^H_2 < L_2$	(25) ≥ (29)	(20) ≥ (23)
4.3) $H_2 < \varepsilon^L_2 < H^d_2 < L^d_2 < \varepsilon^H_2 < L_2$	(25) ≥ (30)	(20) ≥ (23)
4.4) $H_2 < H^d_2 < \varepsilon^L_2 < \varepsilon^H_2 < L^d_2 < L_2$	(25) ≥ (29)	(20) ≥ (24)
4.5) $H_2 < \varepsilon^L_2 < H^d_2 < \varepsilon^H_2 < L^d_2 < L_2$	(25) ≥ (30)	(20) ≥ (24)
4.6) $H_2 < \varepsilon^L_2 < \varepsilon^H_2 < H^d_2 < L^d_2 < L_2$	(25) ≥ (31)	(20) ≥ (24)
5.1) $\varepsilon^L_2 < H_2 < H^d_2 < L^d_2 < \varepsilon^H_2 < L_2$	(26) ≥ (30)	(20) ≥ (23)
5.2) $\varepsilon^L_2 < H_2 < H^d_2 < \varepsilon^H_2 < L^d_2 < L_2$	(26) ≥ (30)	(20) ≥ (24)
5.3) $\varepsilon^L_2 < H_2 < \varepsilon^H_2 < H^d_2 < L^d_2 < L_2$	(26) ≥ (31)	(20) ≥ (24)
6.1) $\varepsilon^L_2 < \varepsilon^H_2 < H_2 < H^d_2 < L^d_2 < L_2$	(27) ≥ (31)	(20) ≥ (24)

Table 1: Separating conditions Case I.

CASE $H_2 < L^d_2 < H^d_2 < L_2$

REGION	H: CONDITION FOR NO DEVIATION	L: CONDITION FOR NO DEVIATION
1.1) $H_2 < L^d_2 < H^d_2 < L_2 < \varepsilon^L_2 < \varepsilon^H_2$	(25) $\geq$ (29)	(18) $\geq$ (22)
2.1) $H_2 < L^d_2 < H^d_2 < \varepsilon^L_2 < L_2 < \varepsilon^H_2$	(25) $\geq$ (29)	(19) $\geq$ (22)
2.2) $H_2 < L^d_2 < \varepsilon^L_2 < H^d_2 < L_2 < \varepsilon^H_2$	(25) $\geq$ (30)	(19) $\geq$ (22)
2.3) $H_2 < \varepsilon^L_2 < L^d_2 < H^d_2 < L_2 < \varepsilon^H_2$	(25) $\geq$ (30)	(19) $\geq$ (23)
3.1) $\varepsilon^L_2 < H_2 < L^d_2 < H^d_2 < L_2 < \varepsilon^H_2$	(26) $\geq$ (30)	(19) $\geq$ (23)
4.1) $H_2 < L^d_2 < H^d_2 < \varepsilon^L_2 < \varepsilon^H_2 < L_2$	(25) $\geq$ (29)	(20) $\geq$ (22)
4.2) $H_2 < L^d_2 < \varepsilon^L_2 < H^d_2 < \varepsilon^H_2 < L_2$	(25) $\geq$ (30)	(20) $\geq$ (22)
4.3) $H_2 < \varepsilon^L_2 < L^d_2 < H^d_2 < \varepsilon^H_2 < L_2$	(25) $\geq$ (30)	(20) $\geq$ (23)
4.4) $H_2 < L^d_2 < \varepsilon^L_2 < \varepsilon^H_2 < H^d_2 < L_2$	(25) $\geq$ (29)	(20) $\geq$ (22)
4.5) $H_2 < \varepsilon^L_2 < L^d_2 < \varepsilon^H_2 < H^d_2 < L_2$	(25) $\geq$ (31)	(20) $\geq$ (23)
4.6) $H_2 < \varepsilon^L_2 < \varepsilon^H_2 < L^d_2 < H^d_2 < L_2$	(25) $\geq$ (31)	(20) $\geq$ (24)
5.1) $\varepsilon^L_2 < H_2 < L^d_2 < H^d_2 < \varepsilon^H_2 < L_2$	(26) $\geq$ (30)	(20) $\geq$ (23)
5.2) $\varepsilon^L_2 < H_2 < L^d_2 < \varepsilon^H_2 < H^d_2 < L_2$	(26) $\geq$ (31)	(20) $\geq$ (23)
5.3) $\varepsilon^L_2 < H_2 < \varepsilon^H_2 < L^d_2 < H^d_2 < L_2$	(26) $\geq$ (31)	(20) $\geq$ (24)
6.1) $\varepsilon^L_2 < \varepsilon^H_2 < H_2 < L^d_2 < H^d_2 < L_2$	(27) $\geq$ (31)	(20) $\geq$ (24)

Table 2: Separating conditions Case II.

7.2 Appendix 2

A. Country List From Which Crisis Events were Sampled

Argentina	Hong Kong	Pakistan
Australia	Hungary	Panama
Austria	Iceland	Peru
Belgium	India	Philippines
Brazil	Indonesia	Poland
Bulgaria	Ireland	Portugal
Canada	Israel	Romania
Chile	Italy	Russia
China	Japan	Serbia
Colombia	Jordan	Singapore
Costa Rica	Kenya	Slovak Republic
Croatia	Korea	Slovenia
Cyprus	Latvia	South Africa
Czech Republic	Lithuania	Spain
Denmark	Luxembourg	Sweden
Dominican Republic	Macedonia	Switzerland
Ecuador	Malaysia	Taiwan
Egypt	Malta	Thailand
El Salvador	Mexico	Turkey
Estonia	Moldova	Ukraine
Finland	Morocco	United Kingdom
France	Netherlands	United States
Germany	New Zealand	Uruguay
Greece	Nigeria	Venezuela
Guatemala	Norway	

B. Debt Crisis Events

1982	Argentina	2002	Moldova
1995	Argentina	1983	Morocco
2001	Argentina	1983	Nigeria
1983	Brazil	2002	Nigeria
1999	Brazil	1998	Pakistan
2009	Bulgaria	1984	Peru
1983	Chile	1983	Philippines
1981	Costa Rica	1997	Philippines
1982	Dominican Republic	1981	Poland
2003	Dominican Republic	2009	Portugal
1983	Ecuador	1982	Romania
1999	Ecuador	2009	Romania
2008	Ecuador	1998	Russia
1984	Egypt	1992	Serbia
2009	Greece	2009	Serbia
2008	Hungary	1985	South Africa
2009	Iceland	2009	Spain
1998	Indonesia	1997	Thailand
2009	Ireland	1978	Turkey
1989	Jordan	1999	Turkey
1994	Kenya	1998	Ukraine
1982	Korea	2009	Ukraine
1998	Korea	1983	Uruguay
2008	Latvia	2003	Uruguay
1998	Malaysia	1983	Venezuela
1982	Mexico		
1995	Mexico		

Table 3: Data Information