Sovereign Debt Crises[1]

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ABSTRACT

Sovereign debt crises can be triggered by high default probabilities induced by high interest rates. This is more likely if debt is relatively large. In this context, the intervention of a large lender with deep pockets, such as the European Central Bank (ECB), can help coordinate on low interest rates. The article is based on the work of Navarro, Nicolini and Teles (2014).

Introduction

The European debt crisis has motivated new research on the origins of sovereign debt crises. Are crises caused by fundamentals, alone, or is it the case that beliefs play an important role? The answer to this question is crucial in justifying policies such as the massive debt purchases announced by the ECB, back in the Summer of 2012. Those Outright Monetary Purchases (OMTs) were not undertaken, but they are still overwhelmingly credited for the drop in sovereign debt spreads that followed.

Spreads on sovereign bonds, that were nonexistent since the introduction of the Euro until the end of 2009, were by the Summer of 2012 higher than 5 per cent for Spain and Italy, and 11 per cent for Portugal. After the announcement of debt purchases by the ECB in July of 2012, they came down to the current levels of 1.5 to 2 per cent. These were countries that had very fast, and massive, accumulation of sovereign debt. In that, they were not alone. Average debt accumulation for advanced economies, between 2008 and 2011, was 25 per cent of GDP. For Portugal, sovereign debt as a share of GDP went up from 72 per cent in 2008 to 108 per cent in 2011. The corresponding figures for Spain and Italy were 40 per cent to 70 per cent, and 106 per cent to 120 per cent, respectively. For Portugal, the unprecedented debt accumulation coincided with a period of stagnation that was more than a decade long. Are the sovereign debt crises in these countries to be explained by these bad fundamentals, or, instead, was it caused, by, equally bad, expectations? Or rather, do both fundamentals and expectations play a role?

The literature on sovereign debt crises is ambiguous on whether equilibria can be driven by expectations alone. In the more standard quantitative model of sovereign debt crises, as in Eaton and Gersovitz (1981), Aguiar and Gopinath (2006) or Arellano (2008), a single equilibrium is computed in which only fundamentals play a role. Instead, in Calvo (1988) and, more recently, Lorenzoni and Werning (2013), there are also high interest rate equilibria that are driven by expectations. Navarro, Nicolini and Teles (2014) argue that the reasons for the different results are the assumptions on the timing of moves of the debtor and creditors and the actions they take. In Aguiar and Gopinath (2006) or Arellano (2008), the debtor moves first and chooses debt at maturity. The debtor faces an interest rate schedule as a function of the choice of debt. By choosing the level of debt at maturity, the debtor determines the probability of default, and hence the interest rate. In Calvo (1988) and Lorenzoni and Werning (2013), the debtor faces a schedule for current debt rather than debt at maturity. For the same level of current debt, if the interest rate is high, so will debt at maturity. If debt at maturity is high, the debtor is more likely to default which confirms the high interest rate. Similarly, if the interest rate is low, the probability of default will also be low, which is consistent with the low interest.

The timing of moves in Navarro *et al.* (2014) has the creditors move first and offer funds at some interest rate. The debtor moves next and chooses the debt level. There is nothing the debtor can do to prevent the creditors from coordinating on high interest rates. Whether the choice of debt is for current debt or debt at maturity does not make a difference. There are multiple equilibria in either case. There are equilibria with low interest rates and low default probabilities, and equilibria in which both interest rates and default probabilities are high.

In Navarro *et al.* (2014), even if the debtor takes the current interest rate as given, the impact of the decisions on aggregate outcomes is still taken into account. The debtor is a large agent, it is just the first mover advantage that is assumed away. That first mover advantage is what permits the coordination on a low interest rate equilibrium in Aguiar and Gopinath (2006) or Arellano (2008).

The reason for expectations-driven, high interest rate equilibria, in these models is different from the one in the model with rollover risk of Cole and Kehoe (2000). Still, one thing these models have in common is that the timing of moves is crucial to generate multiplicity. In Cole and Kehoe, there is multiplicity when the issuance of debt takes place before the decision to default. In that case, it may be individually optimal for the creditors not to roll over the debt, which amounts to charging very high rates. This may induce default, confirming the high interest rates.

It is not clear how direct evidence could be used to assess the alternative timing assumptions, on who moves first, whether debtors or creditors, and on which actions they take. But it is not easy to dismiss the indirect evidence on these assumptions, from the large and abrupt movements in spreads during sovereign debt crises, the recent European crisis being of particular interest.

Focusing on Navarro *et al.* (2014), this article explains how sovereign debt crises can be driven by expectations of high default probabilities that are induced by high interest rates. Those expectation-driven, high interest rate equilibria are more likely for relatively high debt levels. There is a role for a creditor, with deep pockets, that can achieve coordination on the low interest rate equilibrium, at zero cost.

The model

The model is borrowed from Navarro *et al.* (2014). It is of a small open economy populated by a representative agent that lives for two periods. There is a low endowment in period one (normalized to 1) and a random endowment $y \in [1, Y]$ in the second period. y has density $f(y)$ and cumulative distribution $F(y)$. The agent can borrow in a noncontingent bond, but cannot commit to repay. Default is penalized with the lowest endowment in the support of the distribution, 1. There is a continuum of risk neutral foreign creditors that require an average return equal to the risk-free rate.

The timing of moves is as follows. In the first period, each creditor $i \in [0,1]$ offers limited funds at gross interest rate R_i. In equilibrium, $R_i = R$ for all i. The borrower moves next and borrows b from the low rate creditors. In the second period, the borrower decides whether to default fully or to pay the debt in full.

Second period utility is $U(y - Rb)$ if the debt is repaid, or $U(1)$ if there is default. Default occurs whenever the endowment is below the threshold $1 + bR$. It follows that $F(1 + bR)$ is the probability of default. In the first period, the borrower chooses debt b to maximize

$$U(1+b) + \beta\left[F(1+bR)U(1) + \int_{1+bR}^{Y} U(y - bR)f(y)dy\right].$$

The solution of this problem defines a demand curve for b as a function of R.

The other equilibrium condition, defining a supply curve for b as a function of R, is obtained from the requirement that the average return on the debt that is subject to default, $R\left[1-F\left(1+bR\right)\right]$, be equal to the risk free rate, R^*,

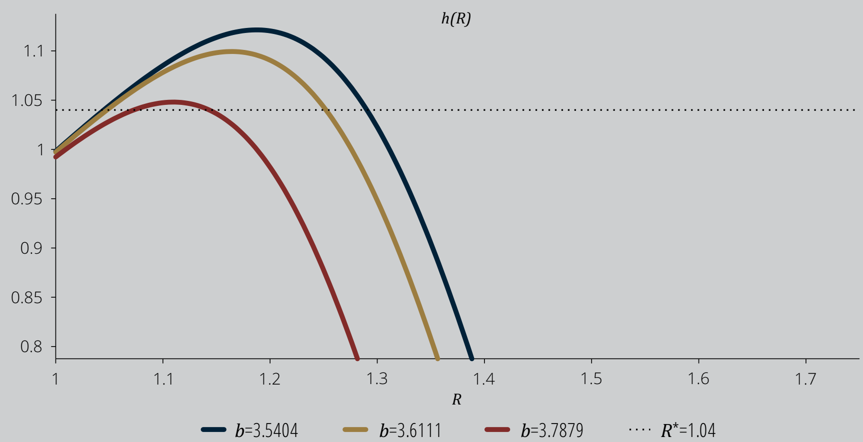
$$R^* = R\left[1-F\left(1+bR\right)\right]. \tag{1}$$

It is useful to represent the supply curve defined in (1). To do this, consider first the function for the expected return on the debt, $h\left(R;b\right)=R\left[1-F\left(1+bR\right)\right]$.

For a very low R, the expected return must be below R^*. In particular, for $R=0$, $h\left(0;b\right)=0$. For R high enough, the debt gross of interest is such that default is very likely, so that for most distributions, the expected return will also be zero. For standard distributions, the function $h\left(R;b\right)$ is concave. Chart 1 depicts the curves of the expected return as a function of R, for different levels of b, for the normal distribution. The higher is b, the closer is the curve to x-axis. The horizontal dotted line is the risk free rate. There are two solutions of equation (1) for the interest rate, a low and a high rate. When the level of debt b goes up, the low rate also goes up, but the high rate goes down.

Chart 2 depicts the solutions of the arbitrage condition (1) for the interest rate. There is an increasing schedule, with the interest rate going up with the level of debt, and a decreasing schedule in which strikingly the interest rate goes down with the level of debt. In a sense, along the increasing schedule, default probabilities are high because debt is high, while in the decreasing schedule, default probabilities are high because interest rates are high.

That interest rates go down with the level of debt is not the only surprising feature of the decreasing schedule. As it turns out, the gross service of debt also goes down with the level of debt. This means that along that schedule the borrower can increase the borrowed amount, b, and pay less for it, bR. To see this, notice that from (1), bR is increasing in R. Since R decreases with b, it must be that bR decreases with b.



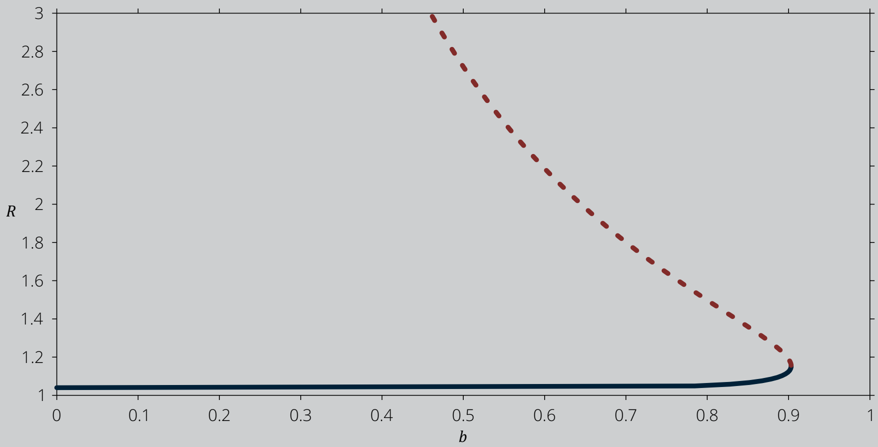
Source: Author's calculations.

Chart 1 •
Expected return
h(R;b)

There is one more disturbing feature of the decreasing schedule. Notice that for each point in the area comprised between the two schedules it is possible to find a point on either the decreasing or the increasing schedule with the same interest rate and higher debt, and therefore with higher default probability. This means that profits are positive in that area. If creditors were to jointly deviate from the points on the decreasing schedule and lower interest rates, they would in general be able to increase profits. It also means that there is a big enough coalition of creditors that can do that.[3] The role played by the coalition of creditors that can lower rates and make profits could be played by a larger creditor with deeper pockets, such as the IMF or the ECB.

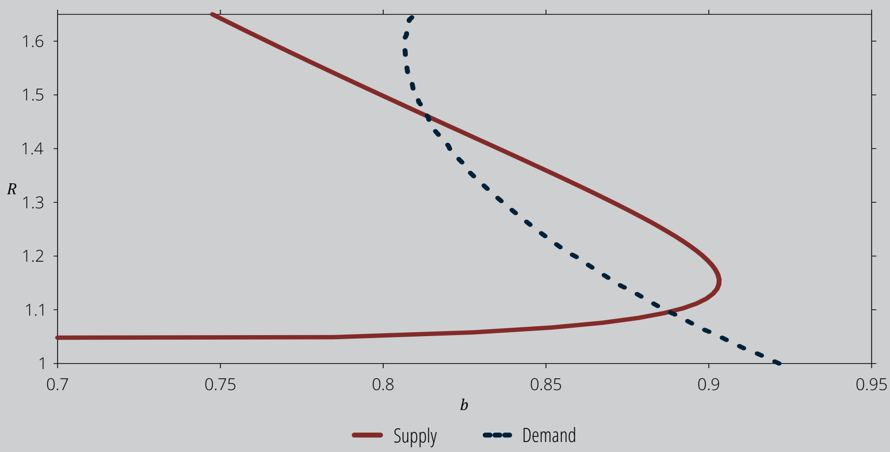
An equilibrium will have to satisfy both the supply curve in chart 2 and a demand curve obtained from the solution of the problem of the optimal debt for the borrower, as depicted in chart 3. As can be seen, there are two intersections, two potential equilibria, one with high interest and relatively low debt. Because of the fragility associated with the decreasing schedule discussed above, the high rate equilibrium can easily be dismissed. However, there are high interest rate equilibria that do not share the same fragility.

Chart 2 • Supply cuve



Source: Author's calculations.

Chart 3 • Demand and suply



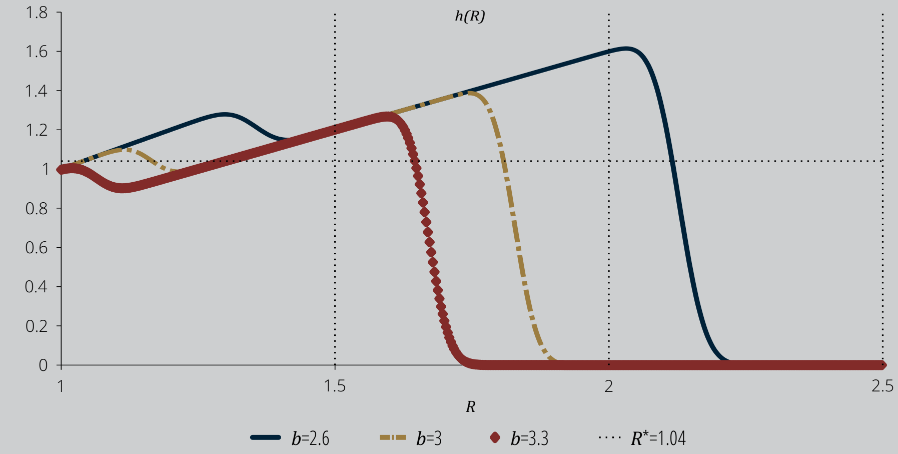
Source: Author's calculations.

High interest rate equilibria

The function for the expected return, $h\left(R;b\right)$, does not have to be everywhere concave. For a bimodal distribution, with good and bad times, it is not. Suppose the endowment is drawn from one of two independent random variables, y^1 and y^2, both normal with means μ^1 and μ^2, and standard deviation σ. The endowment is y^1 or y^2 with some probability. If μ^1 and μ^2 are sufficiently apart, the arbitrage condition (1) has four solutions, as shown in chart 4. The larger is b the more likely it is that there will be more than two solutions, up to the point where there will be again two solutions, and finally none.

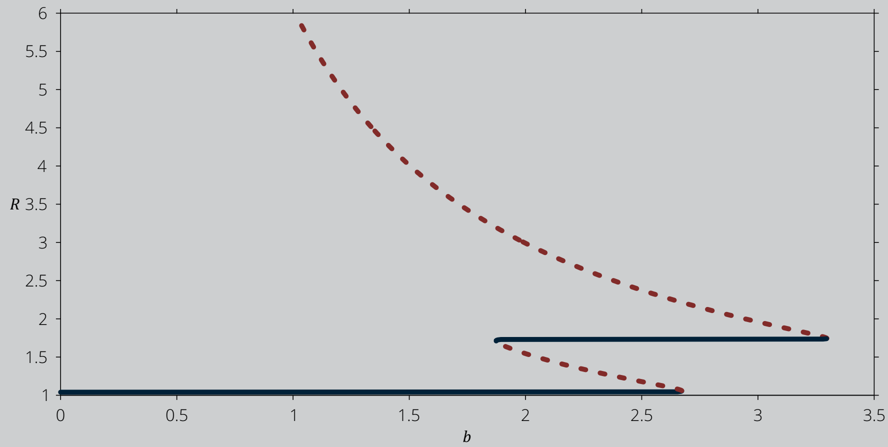
Plotting the solutions for R of the arbitrage condition (1), for different debt levels, the supply curve depicted in chart 5 is obtained. There are now two increasing schedules. For relatively high levels of debt, there is a high rate and a low rate that both give zero profits to the creditors, and neither can be easily dismissed.

Chart 6 depicts both the supply and the demand curve, that is discontinuous for the bimodal distribution that was considered.



Source: Author's calculations.

Chart 4 • *h(R;b)* for the bimodal distribution



Source: Author's calculations.

Chart 5 • Supply curve for the bimodal distribution

Policy

Consider now that the model also included a large lender that could lend to the borrower, at rate R^P, any amount lower than or equal to a maximum level b^P. If R^P and b^P were the maximum levels of interest rate and debt level along the low increasing schedule of chart 5, then points along the higher increasing schedule up to b^P would not be equilibrium points. Furthermore, since at that rate, and for those debt levels, creditors would be making positive profits, they would compete those profits away and, in equilibrium the amount borrowed from the large lender would be zero.

Multiplicity of equilibria in the literature

Does it matter for multiplicity whether the choice for the borrower is current debt, b, or debt at maturity, $a = Rb$? Not, in this set up. Instead of writing the supply and demand[4] conditions from

$$R^* = R\left[1 - F\left(1 + bR\right)\right]$$

and

$$U'(1+b) = R\beta\int_{1+bR}^{Y} U'(y - bR) f\left(y\right) dy,$$

those conditions would be written as

$$R^* = R\left[1 - F\left(1 + a\right)\right]$$

and

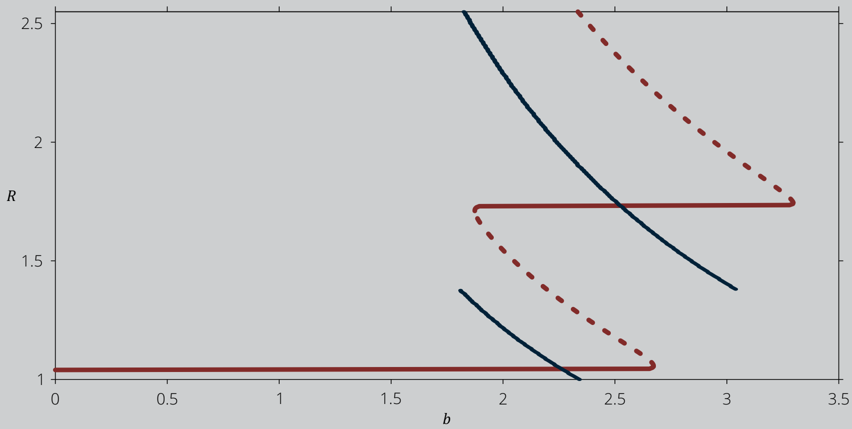
$$U'(1+\frac{a}{R}) = R\beta\int_{1+a}^{Y} U'(y - a) f(y) dy.$$

They are the same two equations with the change of variable $a = Rb$. The solution must be the same. Indeed, chart 7 depicts those same solutions in R and b, and R and a.

Alternative timing assumptions

The related literature has considered a different timing assumption from the one in Navarro *et al.* (2014), in which the borrower moves first and is offered a schedule of interest rates as a function

Chart 6 • Demand and supply, bimodal distribution



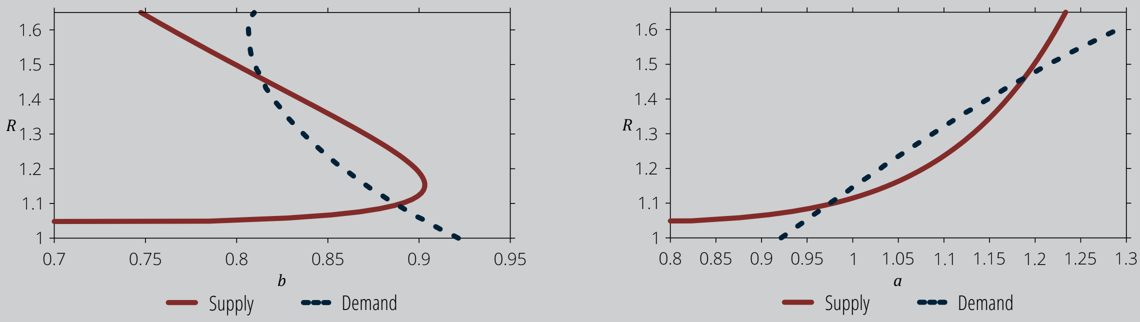
Source: Author's calculations.

of debt levels, b, or a. In that case whether the schedule is for current debt or debt at maturity matters.

In Aguiar and Gopinath (2006) and Arellano (2008), the schedule is for the interest rate as a function of debt at maturity. Since the borrower is a first mover, that takes the schedule into account, it is able to choose a on the low interest rate part of the schedule. Chart 8 depicts the different schedules in R and b, and R and a. The dotted part of the increasing schedule in R and a corresponds to the dotted decreasing schedule in R and b. The borrower that is offered the single increasing schedule in R and a will never choose on the dotted part, where debt at maturity is high, and current debt is relatively low.

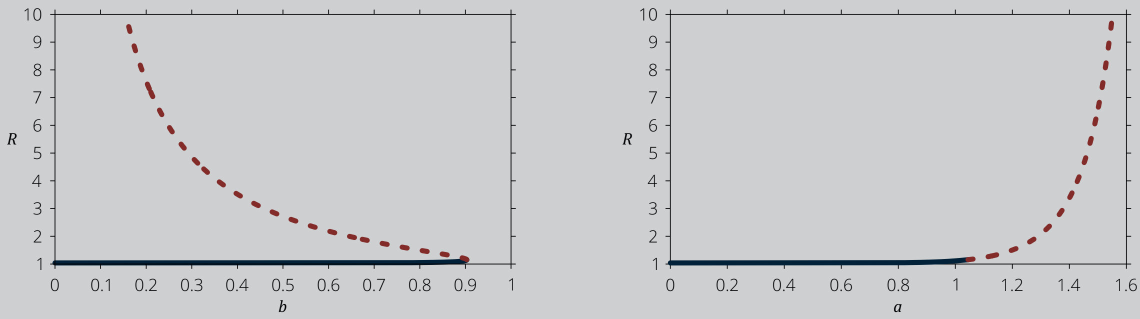
By choosing a, the borrower is able to choose the probability of default, selecting the low probability associated with a low interest rate. Instead, in Calvo (1988) or Lorenzoni and Werning (2013), the borrower is offered either the high rate decreasing schedule in R and b, or the low rate increasing schedule also in R and b. Current debt is exogenous, but even if it was not, there would be nothing that the borrower could do to avoid the high rate schedule. Even if the current debt is exogenous, debt at maturity is not. If the borrower was given the right hand schedule in R and a, it would be able to choose the relatively low a, avoiding the high interest rates.

Chart 7 • Current debt *versus* debt at maturity



Source: Author's calculations.

Chart 8 • Supply curve for current debt and for debt at maturity



Source: Author's calculations.

Lorenzoni and Werning (2013) use an interesting argument against the ability to choose debt at maturity. They build a game in which the borrower can issue debt in infinitely many subperiods within the period. Crucially there is no within period commitment. The borrower will be competing with the future self, so that in the limit the behavior will be competitive.[5] This is similar to the timing assumption in Navarro *et al.* (2014) according to which the borrower takes the interest rate as given, and therefore is not able to choose along the schedule.

Concluding remarks

Can a country be trapped in a high interest rate equilibrium, where default probabilities are high because interest rates are high, as first argued by Calvo (1988)? Even if the literature is ambiguous, the answer appears to be yes. Relative to the models that produce a single equilibrium, minor deviations on the timing and actions of agents produce multiple equilibria which have similar features to the multiple equilibria in Calvo (1988).

It is not clear how one can get direct evidence on timing assumptions. But there is indirect evidence in the large and abrupt movements in interest rates, obtained in the model with multiple schedules and a sunspot variable that helps coordinate on the different schedules.

The level of debt plays an important role. In Navarro *et al.* (2014), the high interest rate equilibria that are "expectation-driven" are more likely for relatively high levels of debt. This result can be related to the recent European experience. In fact the sovereign debt crisis in Europe, with large and abrupt movements in spreads, was preceded by a very significant accumulation of debt. The analysis in this article is also consistent with the downward movement in spreads once the intervention policies by the ECB were announced, even if not implemented.

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Notes

1. The opinions expressed in this article are those of the author and do not necessarily coincide with those of Banco de Portugal or the Eurosystem. Any errors and omissions are the sole responsibility of the author.

2. Banco de Portugal, Economics and Research Department.

3. A similar deviation from the increasing schedule would not achieve this. If all creditors were to jointly deviate and increase rates, they would use the monopoly power to increase profits, but an increase in rates by a coalition should not find demand.

4. This, provided the solution of the borrower's problem is interior.

5. The result is similar to the one in the durable good monopoly.