Renegotiations on Sovereign Debt: 
Reduce or Reschedule?

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Abstract

We present a continuous time model of sovereign debt with the possibility to renegotiate once the terms of the contract. Renegotiations consist of a debt reduction or a debt rescheduling. The model provides closed-form solutions for debt values with endogenous default policy and renegotiations terms. Simulations indicate that both reduction and rescheduling deals allow the lender and the sovereign to move away from the wrong side of the debt Laffer curve well before the sovereign is highly indebted. The model also allows for a direct comparison of the benefits of debt reduction and debt rescheduling schemes. In most cases debt reduction deals appear most efficient in lowering sovereign default risk, thereby validating the historical move from the Baker plan to the Brady plan. However, debt rescheduling deals imply higher sovereign debt value in two cases: (i) when sovereign exports are very volatile, and (ii) when debt recovery value is particularly high. The model therefore advocates for a case by case approach since debt reductions may not always be the most value enhancing deals in sovereign lending.

JEL Classification: F34, G13.
1 Introduction

Over the last twenty years the market for sovereign debt has rapidly expanded. Financial liberalization has favored the emergence of private lenders. From 1990 to 1999 for example, the total amount of debt outstanding in developing countries has increased from 1,183 to 1,865 billions of US dollars (source: IMF). In the meantime, the market for sovereign debt has also experienced serious crises. The unilateral moratorium on debt service declared by Mexico in 1982 was followed by several defaults in Latin America during the 1980’s. More recently, the Russian default in 1998 provided additional evidence that lending to sovereign states requires further advances in sovereign debt modelling and country risk management.

Key to the sovereign credit relationship is the lack of enforcement mechanism for the debt contract. Lenders to sovereigns cannot take legal action to seize the borrower’s assets in case of default. In particular, securing debt has less coercive power than with corporate credit relationship. Consequently, it has been argued (see e.g. Eaton, Gersovitz and Stiglitz (1986)) that sovereign debt service depends much less on her ability to pay than on her willingness to pay. This strategic dimension complicates the sovereign debt pricing problem. It places renegotiations as a central element in sovereign credit relationship. The economic literature, surveyed in particular by Eaton and Fernandez (1995), has identified several rationales for the sovereign to accept entering into renegotiations. Eaton and Gersovitz (1981), Atkeson (1991) or Cole and Kehoe (1998) argue the sovereign needs to maintain her reputation on international debt market to preserve future financing. Bulow and Rogoff (1989a) and Rosenthal (1991) claim however that the reputation
argument alone cannot sustain positive lending if the sovereign has alternative sources of financing (such as cash-in-advance contracts). For that reason, Bulow and Rogoff (1989b) advocate for the threat of economic sanctions as an incentive for repayment (should the creditor keep this threat credible). Alternatively, Fernandez and Rosenthal (1990) propose to reward the borrowers that actually pay out their debt.

It is also clearly in the interest of the lender to enter into renegotiations. If an agreement cannot be reached, the sovereign default leads to what Froot, Scharfstein and Stein (1989) define as “stonewalling”: The creditor refuses to grant relief and the debtor refuses to impose austerity in her country. Over the 1990’s several countries including Bolivia, Costa Rica, Niger and Uganda among others got out of this deadlock with an “exit plan”. Part of the debt was bought back with the help of international organizations and the credit relationship with the lender was terminated. Empirical evidence shows that debt forgiveness following exit deals is by large amounts.

The purpose of this paper is to provide a framework for pricing sovereign debt incorporating all commonly used types of renegotiations that avoid the exit deal. Beyond serving as a debt pricing and a risk management tool, the model aims at bringing additional insight on the impact of the type of renegotiations on sovereign debt value and default risk. In particular, it determines sovereign debt capacity for various types of contracts.

In this paper we examine reduction and rescheduling deals as they represent two different approaches to resolve default on sovereign debt. Historically, the response to the Mexican crisis in 1982 was the Baker Plan set up in 1985. The plan was grounded on the analysis that sovereigns face illiquidity
problems. It therefore called for rescheduling debt while asking sovereigns to commit to foster growth in their economies. In the 1990’s the U.S. policy shifted from debt rescheduling to debt reduction deals with the Brady Plan. This plan was grounded on the analysis that sovereigns face debt overhang. Debt reductions are organized through the conversion of private loans into so-called Brady bonds. Thus, both the lender and the sovereign should benefit from debt relief. This view has received support from economic theory. Sachs (1986) or Krugman (1988) argue that debt overhang (i) results in credit rationing which prevents the sovereign from financing profitable investment opportunities and (ii) discourages the sovereign to increase her output as the accruing benefits would be captured by foreign lenders through higher debt service. Froot (1989) develops a formal model where debt overhang places the sovereign on the “wrong” side of the debt Laffer curve, thereby measuring the benefits of debt relief. Furthermore, Husain (1993) claims that debt reduction may be welfare-improving even when debt overhang is not so compelling.

These last two authors however also examine the possibility to mix reduction with rescheduling (see also Boot and Kanatas (1995) and Fernandez-Ruiz (2000)). As a matter of fact, these “debt packages” are the rule rather than the exception.¹ As noticed by D. Beers in Fabozzi (1997), debt rescheduling

¹For instance, the Mexican deal in 1989 offered lenders three options: (i) to swap existing loans with Libor-indexed debt-reduction bonds, (ii) to swap existing loans with fixed interest rate debt-reduction bonds, or (iii) to reschedule existing loans by providing new money. Each of these options was accepted by banks accounting for respectively 49%, 41% and 10% of the loans (see Unal, Demirgüç-Kunt and Leung (1993) for a thorough analysis of the Mexican deal).
occurred in 68 cases among the 69 defaults on sovereign debts recorded by Standard and Poor’s since 1970.

However, to the best of our knowledge, there is no contingent claim model (CCM) that values sovereign debt subject to reduction or rescheduling in a unified framework. Early CCMs of sovereign debt coincide with the beginning of the failure of the Baker Plan and its rescheduling strategy. Kulatilaka and Marcus (1987) model the timing of sovereign strategic default as a first hitting time problem using sovereign GDP as state variable. They do not examine the possibility to renegotiate debt terms upon default. Grossman and Van Huyck (1988) build a reputational equilibrium model in discrete time where sovereign debt service trades off with the reputational costs of debt repudiation. Although they do not refer to debt renegotiations, these authors use the concept of excusable default upon which the lender understands the sovereign behaviour and agrees with extending the credit relationship. The model by Cohen (1993) examines the value of a debt write-off. The state variable is the sovereign capacity to pay, expressed as a fraction of GDP. By explicitly deriving the marginal price of debt, Cohen (1993) concludes that theoretical buy-back prices are much lower than observed ones. Hayri (2000) also develops a contingent claims model in continuous time to study debt reduction agreements. The model shows that there exists a value of waiting to default, which may explain the evidence of many sovereigns being deeply on the “wrong” side of the debt Laffer curve. Finally, Gibson and Sundaresan (2000) price sovereign debt in a contingent claims model where

\[^2\] Apart from contingent claims models, Duffie, Pedersen and Singleton (2003) provide a reduced-form model for sovereign yield spreads with an application to Russian debt.
the defaulting sovereign is exposed to sanctions in the spirit of Bulow and Rogoff (1989). Renegotiations can only take the form of debt reduction and help mitigate the debt overhang problem. Westphalen (2001) also presents a debt reduction contingent claims model of sovereign debt where renegotiation leads to an exchange of bonds. By contrast to Gibson and Sundaresan (2000), recovery value is defined as the principal minus litigation costs and does not depend on the sovereign’s wealth.

With respect to the existing literature, our paper provides a unified analytical framework with closed-form formulae for the value of sovereign debt contracts subject to reduction and rescheduling renegotiations. Analysis of the model implications allows for a comparison between Baker-style and Brady-style deals, and brings new insight on the relative efficiency of these two sovereign debt relief strategies. The remainder of the paper is organized as follows. Section 2 presents the formal model for non-renegotiable sovereign debt. Sections 3 and 4 extend the basic model to the debt reduction and the debt rescheduling cases respectively. Section 5 compares sovereign debt value within the two different renegotiations framework. Section 6 concludes. Technical developments and figures are gathered in the appendix.

2 Sovereign default and exit deal

In the spirit of Bartolini and Dixit (1991) or Cohen (1993), we employ a contingent claims model of sovereign debt in continuous time. This type of model provides analytical solutions with economic interpretation. Also, input parameters are observable which makes the model easy to calibrate.
The model relies on the state variable $q$ that determines sovereign debt value. This state variable is driven by a geometric Brownian motion

$$\frac{dq_t}{q_t} = \mu dt + \sigma dz_t$$

where $(z_t)_{t \geq 0}$ is a standard Brownian motion and $\mu$ and $\sigma$ are two constants. In this set-up, the stochastic process $(q_t)_{t \geq 0}$ follows a log-normal distribution. Parameters $\mu$ and $\sigma$ respectively stand for the mean and the standard deviation of the returns on $q$. The explicit characterization of $q$ is question open to debate. Some contingent claims models of sovereign debt refer to $q$ as the sovereign willingness to pay. For the model to be easily implemented however, we find it more convenient that the process $(q_t, t \geq 0)$ is observable and common knowledge. Other contingent claims models of debt view $q$ as the fraction of the sovereign resources that the lender may oblige her to pay (see e.g. Bartolini and Dixit (1991) or Cohen (1993)).\(^3\) More specifically, several authors including Cohen and Sachs (1986), Diwan (1990) or Boot and Kanatas (1995) view exports as a significant determinant of sovereign debt repayment. To simplify the exposition and the implementation of the model, we will refer to $q$ as the sovereign’s exports.

### 2.1 Sovereign debt value

The debt contract value depends on the reimbursement schedule and is contingent to the process $(q_t, t \geq 0)$ and to the sovereign default policy. For\(^3\)

\(^3\)This view is supported by the empirical work of Boehmer and Megginson (1990) who document that market prices for syndicated sovereign loans are significantly impacted by solvency indicators such as long-term debt to GNP and long-term debt to total exports. Similar conclusions are obtained by Edwards (1984).
simplicity, we use the terms “lender” and “bank” interchangeably.\textsuperscript{4} The bank and the sovereign commit to a long term credit relationship, which justifies the infinite horizon of the model. The sovereign must pay a continuous debt service $s$ unless she unilaterally defaults. In this case, an exit deal solves the crisis: The bank incurs a debt forgiveness and the sovereign is exposed to economic sanctions on her exports.\textsuperscript{5} The sanctions consist in reducing the trend of exports from $\mu$ to $m < \mu$. This specification is equivalent to a dollar sanction that amounts to the present value of the reduced future cash flows.

The sovereign opts for the exit deal when her exports reach the endogenous threshold $H < q$. The sovereign and the bank agree on the payment of a fraction $\alpha$ of the nominal $s/r$ that puts an end to the contract. The fraction $\alpha$ may be interpreted as the collateral of the loan. In some cases, it may represent the value of sovereign assets abroad that the lender can seize. We call $\alpha s/r$ the recovery value of debt. We note $\tau_H$ as the first time the state variable $q_t$ hits the level $H$. Thus, $\tau_H$ represents the default time and is defined by

$$\tau_H = \inf \{t \geq 0 : q_t = H\}$$

Assuming the bank is risk neutral\textsuperscript{6} and denoting $r$ the world safe interest

\textsuperscript{4}Banks are the main lenders to sovereigns but not the only ones. From 1990 to 1999, the proportion of external debt to developing countries held by private lenders has moved from 52\% to 60\% (source: IMF).

\textsuperscript{5}Rose (2002) documents that renegotiation on sovereign debt is associated with an economically and statistically significant decline in bilateral trade between a debtor and its creditors. This evidence supports the view that creditors target sovereign exports for sanctions.

\textsuperscript{6}Replicating pay-offs that are perfectly correlated with sovereign exports could be difficult, unless maybe for economies with a single output traded on international markets (e.g.
rate (with \( r > \mu \)), we may write sovereign debt value as

\[
D(q, H) = \alpha \frac{s}{r} \mathbb{E}\left( e^{-\tau H} \right) + s \mathbb{E}\left( \int_0^{\tau H} e^{-rt} \, dt \right)
\]

where the first term represents the recovery value of debt multiplied by the corresponding stochastic discount factor, and the second term stands for the continuous debt service discounted until the default time. Using the Laplace transform of the first hitting time of a Brownian motion with drift (see e.g. Karatzas and Shreve (1991) p.197), we get

\[
\mathbb{E}\left( e^{-\tau H} \right) = \left( \frac{H}{q} \right)^{\lambda}
\]

with

\[
\lambda = \frac{1}{\sigma} \left( \frac{\mu}{\sigma} - \frac{\sigma}{2} + \sqrt{\left( \frac{\mu}{\sigma} - \frac{\sigma}{2} \right)^2 + 2r} \right),
\]

it follows that

\[
D(q, H) = \frac{s}{r} \left( 1 - (1 - \alpha) \left( \frac{H}{q} \right)^{\lambda} \right)
\]

From equation (1), sovereign debt value is a riskless perpetuity with continuous coupon \( s \) minus a default premium. This default premium is the present value of 1 dollar contingent on default multiplied by the unrecovered fraction of debt.

oil). As a consequence, the contingent claims pricing based on sovereign exports might require a risk premium. Nevertheless, the bank risk neutrality may be justified by the high capitalization of banks and the stringent regulation on their balance sheet structure.
2.2 Sovereign default policy

Sovereign resources stem from domestic product \(I\) and exportations. The total wealth writes

\[
W(q, H) = I + \mathbb{E} \left( \int_{0}^{\tau_H} e^{-rt}q_t dt \right) + \mathbb{E} \left( \int_{\tau_H}^{\infty} e^{-rt}q_t dt \right)
\]

keeping in mind that after \(\tau_H\), the drift of \(q_t\) is \(m\). Which yields (see Appendix A for a proof)

\[
W(q, H) = I + \frac{q}{r - \mu} + \left( \frac{H}{q} \right)^\kappa \left( \frac{H}{r - m} - \frac{H}{r - \mu} \right)
\]  

(2)

with

\[
\kappa = \frac{1}{\sigma} \left( \frac{\mu}{\sigma} - \frac{\sigma}{2} + \sqrt{\left( \frac{\mu}{\sigma} - \frac{\sigma}{2} \right)^2 + 2 (r - \mu)} \right)
\]

From equation (2) we see sovereign wealth consists in the domestic product plus the present value of a perpetual stream of exports starting from \(q\) and growing at rate \(\mu\) minus the expected loss due to economic sanctions. This loss is the difference in perpetuities starting from \(H\) with corresponding growth rates times the present value of one dollar contingent on default. In the absence of renegotiations, the default threshold \(H^*\) maximizing sovereign equity \(e\) is given by the smooth pasting condition

\[
\frac{\partial e(q, H)}{\partial q} \bigg|_{q=H} = 0
\]

where

\[
e(q, H) = W(q, H) - D(q, H)
\]

We therefore obtain

\[
H^* = \frac{s \lambda (1 - \alpha) (r - \mu) (r - m)}{r - m + \kappa (\mu - m)}
\]  

(3)
In the subsequent cases where debt is renegotiable, sovereign wealth as well as debt value given by equations (1) and (2) are to be reinterpreted as post-renegotiations values. Thus, the optimal exit threshold is \( xH^* \) where \( x \) stands for the post-renegotiations debt service. Since the default threshold is proportional to debt service, the value of \( H^* \) given by equation (3) also stands for the renegotiations threshold.

The comparative statics of the sovereign default policy are summarized in the following table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( s )</th>
<th>( r )</th>
<th>( \alpha )</th>
<th>( \sigma )</th>
<th>( \mu )</th>
<th>( m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign of ( \frac{dH^*}{dx} )</td>
<td>+</td>
<td>+</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
</tbody>
</table>

The optimal default threshold of the sovereign trades off the expected cost of servicing the debt and the expected economic sanctions when not servicing the debt (including the payment upon the exit deal). Thus, a higher debt service as well as a higher interest rate increase \( H^* \). Also, a higher \( \alpha \) implies a higher cost of defaulting. For a given \( \mu \), a higher \( m \) implies more lenient sanctions, so the sovereign raises her default threshold. Conversely, for a given \( m \), a higher \( \mu \) means tougher sanctions.\(^7\) Finally, uncertainty in our model surrounds the level of sovereign exports and gives the sovereign the option of waiting to default. A higher exports volatility increases the value of this option and therefore lowers the optimal threshold.

\(^7\)Note that we are only interested in the sensitivity of \( \mu \) over the region where this parameter has an economic sense, that is where \( \mu \in ]m,r[ \).
3 The debt reduction deal

In our rational expectations model, the bank anticipates to lose $\alpha s/r$ during the exit deal following default. We now examine the case where the bank and the sovereign may avoid the exit deal by setting up renegotiations. In this case, the default of the sovereign is the starting point of a bargaining process. We assume renegotiations may occur only once.\(^8\) In this section, we focus on a debt reduction proposal. Next, we will consider renegotiations on rescheduling debt.

3.1 Sovereign debt value

Following the terminology defined by Sachs (1990), the debt reduction deal consists in reducing the net present value of due payments. The sovereign and the bank agree on reducing the amount of debt, i.e. the sovereign must then pay the continuous debt service $\beta s$. Parameter $\beta$ is interpreted as a recovery rate or alternatively $(1 - \beta)$ stands for the debt write-off in case of a debt reduction deal. Consequently, the sovereign adopts the exit threshold

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\(^8\)If renegotiations are unlimited in number and costless, debt is virtually risk-free. One-shot renegotiations or costly renegotiations are therefore alternative assumptions. We opt for the former for two reasons. First, at least part of the cost of setting up renegotiation deals involving private lenders is borne by official lending organizations. It is therefore particularly hard to correctly allocate the real costs borne by each party. Second, there is empirical evidence supporting that sovereign debt restructuring is a somewhat rare event. For instance, among the 27 countries that agreed on a debt reduction deal between 1989 and 1995, none of them have declared another default ever since (Source: World Bank). One reason is that the outcome of renegotiations is the issuance of publicly traded bonds, which makes future debt renegotiations particularly difficult.
$\beta H^\star$.

There is room for renegotiation since debt reduction lowers the present value of due payments (which is unfavorable to the bank), but it also lowers the probability of an exit deal (which is favorable to the bank). Note that upon the exit deal, the lender gets a fraction $\alpha$ of the renegotiated amount of debt, that is $\alpha \beta s/r$.\footnote{This specification is of course flexible. It is consistent with a constant degree of collateralization before and after renegotiation.} Sovereign debt initial value is given by

$$D_{\text{red}}(q, H) = s\mathbb{E}\left(\int_0^{\tau_H} e^{-rt} dt\right) + \beta s\mathbb{E}\left(\int_{\tau_H}^{\tau_B} e^{-rt} dt\right) + \frac{\beta s}{r}\mathbb{E}\left(e^{-r\tau_B}\right)$$

The first term represents the continuous debt service until the renegotiation time. The second term represents the reduced continuous debt service from the renegotiation time until the exit time. And the third term represents the recovery value upon the exit time. All three components are multiplied by their corresponding stochastic discount factors. Computing this expression leads to the following proposition.

\textbf{Proposition 1} (Debt reduction) Consider a sovereign who is contractually liable to reimburse a continuous debt service $s$. She decides to unilaterally default if her exports fall below the level $H$. This default leads to a debt reduction deal where the debt service is reduced to $\beta s$. After this renegotiation, the sovereign unilaterally defaults if her exports fall below the level $\beta H$. This default then leads to an exit deal where the sovereign leaves the amount $\alpha \beta s/r$ to the bank. The initial value of the debt contract is given by

$$D_{\text{red}}(q, H) = \frac{s}{r} \left(1 - \left(\frac{H}{q}\right)^{\lambda} + (1 - \alpha) \beta^{\lambda+1}\right)$$
3.2 Endogenous debt reduction

We determine the debt recovery rate $\beta$ as the solution of a Nash bargaining game. When $q$ reaches $H^*$, successful renegotiations mean that the lender does not receive the recovery value $\alpha s/r$ but instead holds a non-renegotiable debt with coupon $\beta s$ and exit threshold $\beta H^*$. Hence, the incremental value accruing to the lender is

$$\Delta_{bk} = D_{red} (H^*, H^*) - D (H^*, H^*)$$

Which yields

$$\Delta_{bk} = \frac{s}{r} [\beta - \alpha - (1 - \alpha) \beta^{\lambda+1}]$$

Similarly, the incremental value accruing to the sovereign at the time of default ($q = H^*$) is

$$\Delta_{sov} = W_{red} (H^*, H^*) - W (H^*, H^*) - \Delta_{bk}$$

Since sovereign wealth given by equation (1) may be reinterpreted as a post-renegotiations value, we have that

$$W_{red} (H^*, H^*) = W (H^*, \beta H^*)$$

Thus

$$\Delta_{sov} = \left( \frac{H^*}{r - \mu} - \frac{H^*}{r - m} \right) (1 - \beta^{\kappa+1}) - \Delta_{bk}$$

Let $\eta$ denote the bargaining power of the bank. The debt reduction $\beta$ satisfies

$$\beta^* = \arg \max \left[ (\Delta_{bk})^\eta (\Delta_{sov})^{1-\eta} \right]$$

(5)

and is solved numerically. Figure 1 plots the renegotiations total surplus (defined as $(\Delta_{bk})^\eta (\Delta_{sov})^{1-\eta}$) as a function of the debt write-off for various
balances of power.\textsuperscript{10} As the bank bargaining power increases, total surplus decreases and recovery rate $\beta^*$ increases.

The other comparative statics of optimal recovery rate are summarized in the following table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$s$</th>
<th>$r$</th>
<th>$\alpha$</th>
<th>$\sigma$</th>
<th>$\mu$</th>
<th>$m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign of $\frac{d\beta^*}{dx}$</td>
<td>0</td>
<td>$-$</td>
<td>$+$</td>
<td>$-$</td>
<td>$+$</td>
<td>$-$</td>
</tr>
</tbody>
</table>

Since $\beta^*$ is defined as a recovery rate, it is independent of $s$. Both lowering $r$ or raising $\alpha$ amount to increasing debt recovery value, which makes room for renegotiation (that is, the potential debt reduction) shrink. As a result, the recovery rate $\beta^*$ increases. In addition, both lowering $m$ or raising $\mu$ amount to increasing the sovereign exposure to sanctions in case of failing renegotiations. Again, this places the lender in a better position to obtain a low debt reduction (i.e. a high recovery rate $\beta^*$) when renegotiating with the sovereign.

Most interesting is the U-shaped behavior of $\beta^*$ as a function of sovereign risk ($\sigma$). On one hand, the optimal renegotiation threshold $H^*$ decreases with $\sigma$. This reduces the potential gain from renegotiations (i.e. both $\Delta_{bk}$ and $\Delta_{sover}$) and therefore increases $\beta^*$. On the other hand, a higher $\sigma$ implies a higher probability of sovereign default, which makes it worthwhile for the lender and the sovereign to agree on a significant debt write-off. This effect dominates for low levels of $\sigma$ and is then more than offset by the first effect on the optimal renegotiation threshold. An implication of this result is that, all other things equal, we should observe the highest debt reductions for moderately risky sovereigns. For sovereigns with a low level of risk, the

\textsuperscript{10} All Figures are reported in Appendix D.
likelihood of default is insufficient to justify a significant debt write-off. And as for very risky sovereigns, they have an incentive to delay renegotiations to a point where significant debt reduction can no longer be profitable to both parties.

### 3.3 The value of renegotiable debt

Simulations are calibrated for several representative borrowing countries according to the standards of international organizations such as IMF or the World Bank. Input parameters are summarized in Figure 2. Unless otherwise indicated, they serve as our base case for simulations. In a sample of ten exit deals, Hayri (2000) reports debt write-offs from 50% to 92% of the face value with an average of 74.31%. We therefore set $\alpha = 0.25$. Other parameter values define representative countries along the following two dimensions:

1. **Sovereign indebtedness**: Following the terminology of the World Bank, a sovereign is "severely indebted" when her debt is more than 275% of exports. For example, Fabozzi (1997) reports a ratio of debt to exports for South American countries lying between 165% (Chile) and 550% (Peru) over the 1989-1994 period. In our model, the debt-to-exports ratio (regardless of possible future sanctions) is given by

$$\frac{s/r}{q/(r-\mu)} = \frac{s}{q} \frac{r-\mu}{r}$$

2. **Exposure to trade sanctions**: For a given growth rate of exports ($\mu$), parameter $m$ measures the extent to which the sovereign access to international trade may be restricted as a consequence of economic sanctions after default.
For each simulation, the default threshold $H^*$ and the new debt service after renegotiations $\beta^* s$ are determined endogenously. Figure 3 plots the value of sovereign debt as given by equation (3) as a function of debt service $s$ for various levels of sovereign exports. Figure 3 is known as the debt Laffer curve. When indebtedness is very small, default risk is absent, so that a dollar increase in present debt value $(s/r)$ results in a dollar increase in debt market value. Graphically, the slope of the debt Laffer curve starts at 45° (which is equivalent to the slope of $1/r = 20$ in our Figure 3). However, as indebtedness increases, debt market value is reduced by a default risk premium. Moreover, the humped shape of the debt Laffer curve represents the benefits of debt reduction. If debt service is set above the level that maximizes debt value, the sovereign is said to be on the wrong side of the debt Laffer curve. In this region, a debt reduction increases debt value and is therefore beneficial to both parties (see e.g. Krugman (1988) or Bowe and Dean (1997) for a related analysis).

The humped shape of the debt Laffer curve also refers to the notion of sovereign debt capacity. The top of the curve represents the maximum amount of debt (in value) that the sovereign can take on. From Figure 3, we see that the top of the debt Laffer curve corresponds to a debt-to-exports ratio of around 90%. This means debt reduction deals should be implemented well before the sovereign country is considered as “severely indebted” by World Bank standards. Also, we note that debt capacity increases with the sovereign exports level. Banks have an incentive to lend more to sovereigns who can be significantly punished for defaulting and who lower their exit threshold accordingly.
Figure 4 plots debt value as given by equation (3) as a function of debt service $s$ for various exposures to sanctions. Note that tougher sanctions increase debt capacity. This reflects the impact of the threat of sanctions on the sovereign willingness to pay as put forward by Bulow and Rogoff (1989). Figure 5 indicates that debt value increases in a non-proportional way with recovery value. This underlines the importance of collateral in enhancing sovereign debt capacity and reducing default risk. However, debt Laffer curves are homothetic in Figure 5, which indicates that collateral does not increase the potential gains from renegotiations. Finally, debt value increases with the bank bargaining power as the lender extracts a bigger portion of the renegotiations surplus (see Figure 6).

4 The debt rescheduling deal

In this section we examine the debt rescheduling deal. This deal consists in delaying interest payments to allow the sovereign to recover from her temporary financial distress. To simplify the exposition, we consider a deal where the entire debt service is postponed for a time period $T$ (that is from $\tau_H$ to $T + \tau_H$). Afterwards, the sovereign resumes interests payments. We call the period $T$ the moratorium.

4.1 Sovereign debt value

By contrast with the debt reduction deal, the debt rescheduling deal maintains the present value of debt in the actuarial sense upon renegotiations (these definitions are standard in the public policy debate, see e.g. Sachs
(1990)). This implies that the new debt service $x$ after the moratorium is such that

$$\frac{s}{r} = \int_T^\infty x e^{-ru} du$$

which yields

$$x = se^{rT}$$

Following this deal, the sovereign will not default until $T + \tau_H$. Then, the exit threshold is $H^* e^{rT}$. If the state variable is below this value at date $T + \tau_H$, the sovereign will immediately exit. Otherwise, the exit time will be the first hitting time to this threshold. Consequently, sovereign debt initial value is now given by

$$D_{res} (q, H) = sE \left( \int_0^T e^{-rt} dt \right) + se^{rT}E \left( 1_{q_{T+\tau_H} \geq He^{rT}} \int_{T+\tau_H}^{T+\tau_H} e^{-rt} dt \right)$$

$$+ \alpha \frac{se^{rT}}{r} E \left( e^{-r\theta_{H^*T}} 1_{q_{T+\tau_H} > He^{rT}} \right)$$

$$+ \alpha \frac{se^{rT}}{r} E \left( e^{-r(T+\tau_H)} 1_{q_{T+\tau_H} \leq He^{rT}} \right)$$

where

$$\theta_x = \inf \{ t \geq T + \tau_H : q_t = x \}$$

The first term represents the continuous debt service until the renegotiation time. The second term represents the rescheduled continuous debt service from the end of the moratorium until the exit time and is subject to the no-default condition at the end of the moratorium. The third term represents the recovery value upon the exit time and is also subject to the no-default condition at the end of the moratorium. The fourth term represents the recovery value upon the end of the moratorium in the case of default at this time. All four components are multiplied by their corresponding stochastic
Proposition 2 (Debt rescheduling) Consider a sovereign who is contractually liable to reimburse a continuous debt service $s$. She decides to unilaterally default if her exports fall below the level $H$. This default leads to a debt rescheduling deal where the debt service is postponed for $T$ units of time and then set at $se^{rT}$ to preserve the actuarial present value of debt. After this renegotiation and the period of moratorium, the sovereign unilaterally defaults if her exports fall below the level $He^{rT}$. This default then leads to an exit deal where the sovereign leaves the amount $\alpha se^{rT}/r$ to the bank. The initial value of the debt contract is given by

$$D_{res}(q, H) = \frac{s}{r} \left\{ 1 - (1 - \alpha) \left( \frac{H}{q} \right)^{\lambda} \left[ N \left( \xi \sqrt{T} \right) + X \eta N \left( - (\xi + \sigma \lambda) \sqrt{T} \right) \right] \right\}$$

with

$$\xi = \frac{r - \mu}{\sigma} + \frac{\sigma}{2}$$

and

$$X_x = \exp \left( \frac{x^2 \sigma^2 T}{2} + \xi x \sigma T \right)$$

and $N(.)$ stands for the normal cumulative distribution function.

4.2 Endogenous moratorium

The moratorium on which both parties agree is determined as the solution of a Nash bargaining game. When $q$ reaches $H^*$, the bank will forsake the recovery value $\alpha s/r$ in exchange of a non-renegotiable debt that starts paying
$se^{rT}$ after $T$ units of time provided $q_T > H^*e^{rT}$. Hence, the incremental value accruing to the lender is

$$
\Delta_{bk} = D_{res} (H^*, H^*) - D (H^*, H^*)
$$

Which yields

$$
\Delta_{bk} = \frac{s}{r} (1 - \alpha) \left[ \mathcal{N} \left( -\xi \sqrt{T} \right) - X_\lambda \mathcal{N} \left( - (\xi + \sigma \lambda) \sqrt{T} \right) \right]
$$

In case of a successful rescheduling deal, the surplus accruing to the sovereign is formally given by

$$
\Delta_{sov} = W_{res} (H^*, H^*) - W (H^*, H^*) - \Delta_{bk}
$$

The term $W_{res} (H^*, H^*)$ requires further development. Upon debt rescheduling, the sovereign is guaranteed to avoid sanctions for the next $T$ units of time. Afterwards, exports drift will be set to $m$ at date $T$ if $q_T \leq He^{rT}$. Otherwise, sanctions will occur at date $\theta_{He^{rT}}$. We therefore have that

$$
W_{res} (H^*, H^*) = I + \mathbb{E} \left( \int_0^T e^{-rt} q_t^{(\mu)} dt \right) + \mathbb{E} \left( 1_{q_T > He^{rT}} \int_{\theta_{He^{rT}}}^T e^{-rt} q_t^{(\mu)} dt \right)
$$

$$
+ \mathbb{E} \left( 1_{q_T > He^{rT}} \int_{\theta_{He^{rT}}}^\infty e^{-rt} q_t^{(m)} dt \right)
$$

$$
+ \mathbb{E} \left( 1_{q_T \leq He^{rT}} \int_T^\infty e^{-rt} q_t^{(m)} dt \right)
$$

where $q_t^{(x)}$ indicates that exports have drift $x$. Which yields (see Appendix C for details)

$$
\Delta_{sov} = \left[ 1 - e^{-(r-\mu)T} \mathcal{N} \left( -\phi \sqrt{T} \right) - X_\kappa \mathcal{N} \left( - (\xi + \sigma \kappa) \sqrt{T} \right) \right]
$$

$$
\times \left( \frac{H^*}{r - \mu} - \frac{H^*}{r - m} \right) - \Delta_{bk}
$$

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with
\[ \phi = \frac{\mu - r}{\sigma} + \frac{\sigma}{2} \]

The debt rescheduling horizon \( T \) satisfies
\[ T^* = \arg \max \left[ (\Delta_{bk})^\eta (\Delta_{sov})^{1-\eta} \right] \tag{7} \]

and is solved numerically. Figure 7 plots the renegotiations total surplus as a function of the debt rescheduling horizon for various balances of power. As the bank bargaining power increases, total surplus decreases and the horizon \( T^* \) decreases.

The other comparative statics of optimal debt moratorium are summarized in the following table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( s )</th>
<th>( r )</th>
<th>( \alpha )</th>
<th>( \sigma )</th>
<th>( \mu )</th>
<th>( m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign of ( \frac{d\tau^*}{dx} )</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>+ then -</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Because the debt rescheduling involves no debt write-off, the optimal moratorium does not depend on the recovery value. Moreover, since the length of the moratorium is positively associated with the gain from renegotiation, the comparative statics of \( T^* \) should be opposite to those of \( \beta^* \). Notable exceptions are the sensitivities with respect to \( r \) and \( \mu \). Debt rescheduling means leaving the sovereign generating revenues discounted at rate \( r - \mu \) without being exposed to sanctions at least until \( T^* \). Increasing this discount rate (by raising \( r \) or lowering \( \mu \)) reduces the potential gain from renegotiation, which shortens the optimal \( T^* \).
4.3 The value of renegotiable debt

We conduct the same analysis as for the debt reduction deal using base case parameters defined in Figure 2. Simulations are reported in Figure 8. For each simulation, the default threshold $H^*$ and the rescheduling horizon $T^*$ are derived endogenously.

In case of a debt rescheduling deal, we still obtain the humped debt Laffer curve (see Figure 8). Although the debt Laffer curve seems to be of same magnitude as that of debt subject to reduction deal, we shall investigate the difference in debt values in the next section. From Figure 8, we see that the top of the debt Laffer curve corresponds to a debt-to-exports ratio of around 90% as for the debt reduction case. The fact that renegotiations are beneficial to lenders long before the sovereign is “severely indebted” holds for different types of renegotiations and is not specific to debt reduction schemes. Other behaviours of debt value are similar to those in the case of debt reduction, so we do not report them.

5 Comparing reduction and rescheduling deals

In this section, we investigate the renegotiations policy that lenders should implement in order to minimize sovereign default risk. Historically, the Baker plan based on a debt rescheduling logic was replaced by the Brady plan which favors debt reduction agreements. Still, some recent deals mixed debt reduction with debt rescheduling schemes. We show in this section that, although debt reduction plans induce higher debt values in most situations, some exceptions exist and the case by case approach should be favored. To
motivate this, we analyze the difference in value between debt that may be reduced and debt that may be rescheduled. Figures 9 to 11 report these values.

Figure 9 indicates that the debt Laffer curve for debt subject to rescheduling is below that of debt subject to debt reduction. On the “good” side of the curve, the two debt values are equal. On the top of the curve, default risk affects most debt subject to rescheduling. Then, on the “wrong” side, the difference in debt value remains constant. This difference arises from the rescheduling mechanism. If at the end of the moratorium, the sovereign exits, then renegotiations will have been useless \textit{ex post} and the lender loses the discounting of the recovery value.

We then set \( s = 15 \), i.e. near the top of the debt Laffer curve, and examine the difference in debt values as a function of the model input parameters. As expected, this difference tends to zero as \( r \to 0 \) (the lender no longer loses the discounting of the recovery value), as \( \mu \to r \) and \( q \to \infty \) (both debts become riskless), and as \( \eta \to 0 \) (with no bargaining power, the type of deal does not matter to the bank anymore). Also this difference remains unchanged for various \( m \) since the exposure to sanctions modifies the sovereign default policy in the same way for both debts. Most interesting cases are reported in Figures 10 and 11. Debt subject to rescheduling may become most valuable when exports volatility or recovery value get high and we now discuss these two cases.

First, both types of renegotiable debt contain the option to avoid the exit deal. The value of this option increases with exports volatility. In the long run however, exports volatility also raises the chances to default once
renegotiations have occurred. This explains the humped shape of Figure 10. But the long run effect is less pronounced for debt subject to rescheduling. Indeed, after renegotiations, the lender has to wait during the moratorium to know if the sovereign resumes paying or not. Increasing volatility raises the chances that exports will be above the new exit threshold. Our model therefore implies that debt rescheduling deals should be favored by banks when the sovereign access to international trade is very volatile.

Second, as the recovery value increases, the benefits of the reduction deal tend to disappear. On the other hand, those of the rescheduling deal also shrink since the lender is likely to lose the discounting of the recovery value. However, the first effect dominates: as \( \alpha \) increases, both debts converge to the riskless equivalent debt, but debt subject to rescheduling converges faster. Our model therefore implies that debt rescheduling deals should be favored by banks when they are able to recover a substantial proportion of debt in case of sovereign default.

6 Conclusion

We have presented a contingent claims model of sovereign debt that incorporates the possibility to renegotiate once the terms of the contract. Renegotiations take the form of a debt reduction (as implemented by the Brady plan) or of a debt rescheduling (as used to be fostered by the Baker plan). The model quantifies the benefits of renegotiations. Simulation results indicate that both reduction and rescheduling deals allow the lender and the sovereign to move away from the wrong side of the debt Laffer curve well before the
sovereign is highly indebted according to international lending organizations standards.

In addition, the model allows for a direct comparison of the benefits of debt reduction and debt rescheduling schemes. We find that in most cases debt reduction deals are most efficient in lowering sovereign default risk, thereby validating the historical move from the Baker plan to the Brady plan. This result holds in our model because the moratorium associated with the rescheduling strategy corresponds to a free option given to the sovereign. However, debt rescheduling deals imply higher sovereign debt value in two cases: (i) when sovereign exports are very volatile, and (ii) when debt recovery value is particularly high. The model therefore advocates for a case by case approach since debt reductions may not always be the most value enhancing deals in sovereign lending.
Appendix

A. Sovereign wealth

The strong Markov property for Brownian motion yields

\[ \mathbb{E} \left( \int_{\tau_H}^{\infty} e^{-rt} q_t dt \right) = \mathbb{E} \left( e^{-(r-\mu)\tau_H} q_{\tau_H} \int_0^{\infty} e^{-(r-m)u} e^{\sigma z_u - \frac{\sigma^2}{2} u} du \right) \]

Since \( q_{\tau_H} = H \), we get

\[ \mathbb{E} \left( \int_{\tau_H}^{\infty} e^{-rt} q_t dt \right) = \frac{H}{r - m} \left( \frac{H}{q} \right)^\kappa \]

In addition,

\[ \mathbb{E} \left( \int_{0}^{\tau_H} e^{-rt} q_t dt \right) = \mathbb{E} \left( \int_0^{\infty} e^{-rt} q_t dt \right) - \mathbb{E} \left( \int_{\tau_H}^{\infty} e^{-rt} q_t dt \right) \]
\[ = \frac{q}{r - \mu} - \frac{H}{r - \mu} \left( \frac{H}{q} \right)^\kappa \]

B. Debt value with rescheduling deal

Developing and rearranging terms, we get

\[ D_{res}(q, H) = \frac{s}{r} \left( 1 - \left( \frac{H}{q} \right)^\lambda \right) \]
\[ + \frac{s}{r} \mathbb{E} \left( e^{-\tau_H} 1_{q_{\tau_H} > He^{-T}} \right) \]
\[ - (1 - \alpha) \frac{sc^T}{r} \mathbb{E} \left( e^{-\tau_H c^T} 1_{q_{\tau_H} > He^{-T}} \right) \]
\[ + \alpha \frac{s}{r} \mathbb{E} \left( e^{-\tau_H} 1_{q_{\tau_H} \leq He^{-T}} \right) \]

Using the strong Markov property for Brownian motion, we have that

\[ q_{T+\tau_H} = H \exp \left[ \left( \mu - \frac{\sigma^2}{2} \right) T + \sigma w_T \right] \]
where \((w_t)_{t \geq 0}\) is a standard Brownian motion starting from zero at date \(\tau_H\). Hence the function \(1_{q_{T+\tau_H} \leq He^{rT}}\) is independent of the stopping time \(\tau_H\). Thus

\[
\mathbb{E}\left(e^{-r\tau_H} 1_{q_{T+\tau_H} \leq He^{rT}}\right) = \mathbb{E}\left(e^{-r\tau_H}\right) \mathbb{P}\left(q_{T+\tau_H} \leq He^{rT}\right) = \left(\frac{H}{q}\right)^\lambda \mathcal{N}\left(\left(\frac{r - \mu}{\sigma} + \frac{\sigma}{2}\right) \sqrt{T}\right)
\]

Similarly

\[
\mathbb{E}\left(e^{-r\tau_H} 1_{q_{T+\tau_H} > He^{rT}}\right) = \left(\frac{H}{q}\right)^\lambda \mathcal{N}\left(\left(\frac{\mu - r}{\sigma} - \frac{\sigma}{2}\right) \sqrt{T}\right)
\]

The remaining term, \(\mathbb{E}\left(e^{-\tau_H} 1_{q_{T+\tau_H} > He^{rT}}\right)\), may be decomposed as follows

\[
\mathbb{E}\left(e^{-\tau_H} 1_{q_{T+\tau_H} > He^{rT}}\right) = \mathbb{E}\left(e^{-\tau(H+\tau_H)}\right) \int_{He^{rT}}^{+\infty} \mathbb{P}\left(q_{T+\tau_H} \in dx\right) \mathbb{E}_x\left(e^{-r\tau_H}\right)
\]

Let us focus on the latter integral. Since \(q_{T+\tau_H}\) is log-normal, we obtain

\[
\int_{He^{rT}}^{+\infty} \frac{1}{\sqrt{2\pi}\sigma\sqrt{T}} \exp\left(-\frac{\ln H - (\mu - \frac{\sigma^2}{2}) T}{2\sigma^2 T}\right) \left(\frac{He^{rT}}{x}\right)^\lambda \, dx
\]

With the change of variable \(y = \ln x\), we get

\[
H^\lambda e^{\lambda r T} \int_{\ln(H+\tau_H)}^{+\infty} \frac{1}{\sqrt{2\pi}\sigma\sqrt{T}} \exp\left(-\frac{(y-A)^2 + 2\sigma^2 T \lambda y}{2\sigma^2 T}\right) \, dy
\]

with \(A = \ln H + (\mu - \frac{\sigma^2}{2}) T\). Or, equivalently

\[
H^\lambda e^{\lambda r T} e^{-\frac{\sigma^2}{2\sigma^2 T}} \int_{\ln(H+\tau_H)}^{+\infty} \frac{1}{\sqrt{2\pi}\sigma\sqrt{T}} \exp\left(-\frac{y^2 - 2y(A-\sigma^2 T \lambda)}{2\sigma^2 T}\right) \, dy
\]

After rearranging terms and another change of variable \(u = \frac{y-(A-\sigma^2 T \lambda)}{\sigma\sqrt{T}}\), we finally obtain

\[
H^\lambda \exp\left(\frac{\sigma^2 T \lambda^2}{2} - A\lambda + \lambda r T\right) \mathcal{N}\left(-G\right)
\]

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with

\[ G = \ln H + rT - (A - \sigma^2T\lambda) \]

Simplifying this expression yields equation (6).

**C. Sovereign surplus**

At the time of renegotiations, sovereign wealth upon a debt rescheduling deal may be written as

\[
W_{\text{res}}(H^*, H^*) = I + \mathbb{E}\left( \int_0^T e^{-rt} q_t^{(\mu)} dt \right) + \mathbb{E}\left( 1_{q_T > He^{rT}} \int_0^T e^{-rt} q_t^{(\mu)} dt \right) \\
+ \mathbb{E}\left( 1_{q_T > He^{rT}} \int_{H e^{rT}}^{\infty} e^{-rt} q_t^{(m)} dt \right) \\
+ \mathbb{E}\left( 1_{q_T \leq He^{rT}} \int_{H e^{rT}}^{\infty} e^{-rt} q_t^{(m)} dt \right)
\]

The first expectation is straightforward and the others are decomposed as in Appendix B

\[
W_{\text{res}}(H^*, H^*) = I + \frac{H^*}{r - \mu} \left( 1 - e^{-(r-\mu)T} \right) \\
+ e^{-rT} \int_{H e^{rT}}^{+\infty} \mathbb{P}(q_T \in dx) \mathbb{E}_x \left( \int_0^{H e^{rT}} e^{-rt} q_t^{(\mu)} dt \right) \\
+ e^{-rT} \int_{H e^{rT}}^{+\infty} \mathbb{P}(q_T \in dx) \mathbb{E}_x \left( \int_{H e^{rT}}^{\infty} e^{-rt} q_t^{(m)} dt \right) \\
+ e^{-rT} \int_0^{H e^{rT}} \mathbb{P}(q_T \in dx) \mathbb{E}_x \left( \int_0^{H e^{rT}} e^{-rt} q_t^{(m)} dt \right)
\]

Using results from Appendix A, we get

\[
W_{\text{res}}(H^*, H^*) = I + \frac{H^*}{r - \mu} \left( 1 - e^{-(r-\mu)T} \right)
\]
\[ + e^{-rT} \int_{He^{rT}}^{+\infty} \mathbb{P}(q \in dx) \left( \frac{x}{r - \mu} - \frac{H*e^{rT}}{r - \mu} \left( \frac{H*e^{rT}}{x} \right)^\kappa \right) \]

\[ + e^{-rT} \int_{He^{rT}}^{+\infty} \mathbb{P}(q \in dx) \frac{H*e^{rT}}{r - m} \left( \frac{H*e^{rT}}{x} \right)^\kappa \]

\[ + e^{-rT} \int_{0}^{He^{rT}} \mathbb{P}(q \in dx) \frac{x}{r - m} \]

Using results from Appendix B, we get

\[ W_{\text{res}}(H^*, H^*) = I + \frac{H^*}{r - \mu} \left( 1 - e^{-(r-\mu)T} \right) \]

\[ + \frac{H^*}{r - \mu} e^{-(r-\mu)T} N \left( \phi \sqrt{T} \right) \]

\[ + \left( \frac{H^*}{r - m} - \frac{H^*}{r - \mu} \right) X_N N \left( - (\xi + \sigma\kappa) \sqrt{T} \right) \]

\[ + \frac{H^*}{r - m} e^{-(r-\mu)T} N \left( - \phi \sqrt{T} \right) \]

with

\[ \phi = \frac{\mu - r}{\sigma} + \frac{\sigma}{2} \]
D. Figures

**Figure 1**

Renegotiations surplus and debt recovery rate

Parameters are: $\mu = 0.02$, $\sigma = 0.2$, $r = 0.05$, $s = 15$, $\alpha = 0.25$ and $m = 0$.

The bank bargaining power is $\eta = 0.3$ (thin line), $\eta = 0.5$ (short-dashed line), and $\eta = 0.7$ (long dashed-line).

The Nash equilibrium is represented by the top of each curve.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current level of exports</td>
<td>$q$</td>
<td>10</td>
</tr>
<tr>
<td>Growth rate of exports</td>
<td>$\mu$</td>
<td>0.02</td>
</tr>
<tr>
<td>Volatility of exports</td>
<td>$\sigma$</td>
<td>0.2</td>
</tr>
<tr>
<td>Debt service</td>
<td>$s$</td>
<td>varying</td>
</tr>
<tr>
<td>Growth rate of exports after default</td>
<td>$m$</td>
<td>0</td>
</tr>
<tr>
<td>Recovery rate upon default</td>
<td>$\alpha$</td>
<td>0.25</td>
</tr>
<tr>
<td>Bargaining power of the bank</td>
<td>$\eta$</td>
<td>0.5</td>
</tr>
<tr>
<td>World riskless interest rate</td>
<td>$r$</td>
<td>0.05</td>
</tr>
</tbody>
</table>

**Figure 2**

**Input parameters**
Parameters are given in Figure 2.

Other parameters are $q = 5$ (thin line), $q = 10$ (short-dashed line), $q = 15$ (long-dashed line).
Parameters are given in Figure 2.

Other parameters are $m = -0.02$ (thin line), $m = 0$ (short-dashed line), $m = 0.01$ (long-dashed line).
Parameters are given in Figure 2.

Other parameters are $\alpha = 0$ (thin line), $\alpha = 0.25$ (short-dashed line), $\alpha = 0.5$ (long-dashed line).
Parameters are given in Figure 2.

Other parameters are $\eta = 0.3$ (thin line), $\eta = 0.5$ (short-dashed line),

$\eta = 0.7$ (long-dashed line).
Parameters are: $\mu = 0.02$, $\sigma = 0.2$, $r = 0.05$, $s = 15$, $\alpha = 0.25$ and $m = 0$.

The bank bargaining power is $\eta = 0.3$ (thin line), $\eta = 0.5$ (short-dashed line), and $\eta = 0.7$ (long dashed-line).

The Nash equilibrium is represented by the top of each curve.
Figure 8
Rescheduling deal: debt Laffer curve for various levels of exports

Parameters are given in Figure 2.

Other parameters are $q = 5$ (thin line), $q = 10$ (short-dashed line), $q = 15$ (long-dashed line).
Parameters are given in Figure 2.

Debt values subject to a reduction deal or a rescheduling deal are respectively plotted with a thin line and a dashed line.
Parameters are given in Figure 2. Other parameters are \( s = 15 \).

Debt values subject to a reduction deal or a rescheduling deal are respectively plotted with a thin line and a dashed line.

**Figure 10**

Reducing vs. rescheduling deal:
Debt values and exports volatility
Debt values subject to a reduction deal or a rescheduling deal are respectively plotted with a thin line and a dashed line.

Figure 11
Reducing vs. rescheduling deal:
Debt values and recovery value

Parameters are given in Figure 2. Other parameters are $s = 15$. 

Debt values subject to a reduction deal or a rescheduling deal are respectively plotted with a thin line and a dashed line.
References


