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Does strengthening Collective Action Clauses (CACs) help?*

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Abstract

Does improving creditor coordination by strengthening CACs lead to efficiency gains in the functioning of sovereign bond markets? We address this question in a model featuring both debtor moral hazard and creditor coordination under incomplete information. Conditional on default, we characterize the interim efficient CAC threshold and show that strengthening CACs away from unanimity results in interim welfare gains. However, once the impact of strengthening CACs on debtor's incentives are taken into account, we demonstrate the robust possibility of a conflict between ex ante and interim efficiency. We calibrate our model to quantify such a welfare trade-off and discuss the policy implications of our results.

Keywords: Sovereign Debt, Coordination, Moral Hazard, Collective Action Clauses, Ex Ante, Ex Post, Efficiency

JEL classification: C72, C78, D82, F34.

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1 Introduction

Given the large costs[1] associated with defaults and sovereign debt crises, a key policy issue in relation to the functioning of the sovereign debt markets is the efficient design of mechanisms used in the restructuring of sovereign debts. Potential reforms range from the market-based approaches aimed at improving creditor coordination such as inserting CACs into the sovereign bond contracts[2] (Taylor, 2002) to a statutory approach such as an establishment of an international bankruptcy procedure (SDRM) (Krueger, 2001, 2002).

In this paper, we investigate the efficiency gains of strengthening Collective Action Clauses (CACs) whereby a qualified majority of bondholders can bind all bondholders (within the same issuance) to the financial terms of a sovereign debt restructuring[3]. By removing the threat of an individual creditor holdout, strengthening CACs away from unanimity ought to result in improved creditor coordination and reduce the cost associated with protracted sovereign debt restructuring driven by creditor coordination failure (Liu, 2002).

But would improved creditor coordination (conditional on default) lead to efficiency gains in the functioning of sovereign debt markets once debtor incentives are taken into account? How would strengthening CACs affect the probability of serial sovereign default and debt crises in the first place? Note that a positive probability of sovereign debt crises linked to short-term sovereign debt allows the creditors to discipline sovereign borrowers (Barro,

[1] Sovereign debt crises are typically costly to the debtor, creditor countries and international lending institutions. On the part of debtor, costs include output losses, discontinued international capital market access (Eaton and Gersovitz, 1981), contamination of the debtor's banking system, large falls in domestic currency value, triggering payment problems for many domestic firms (Roubini and Setser (2004b), Reinhart and Rogoff (2009)). For the creditors, costs include reduction of interest rates (if not principal), being saddled with illiquid and risky assets that may not pay off for decades with compensation set far below the market price of risk.

[2] The issuance of sovereign bonds containing CACs has been common in bonds governed by English Law issued in the Euro market and indeed some New York law bonds issued in the Euro market have also contained CACs.

[3] CACs consist of two main provisions: majority restructuring provisions (hereafter, qualified majority restructuring clauses) and majority enforcement provisions. While the former allows the qualified majority of bondholders to bind all bondholders within the same issuance to the financial terms of a debt restructuring, the latter enables the qualified majority of bondholders to limit the ability of minority of bondholders to accelerate their claims after a default (International Monetary Fund, 2002, p.14). In this paper, we focus on the former aspect of CACs.

1998; Diamond and Rajan, 2001; Ghosal and Miller 2003).

We address the above issues in a two-stage model of both debtor moral hazard and creditor coordination under incomplete information. At the second stage, after the occurrence of a negative shock leading to default on the part of sovereign debtor, creditors have to decide whether or not to rollover the restructured debt. Creditors are differentiated on the basis of private information about the degree of persistence of the negative shock. We study the Bayesian equilibria of the creditor coordination game. We show that strengthening CACs away from unanimity always results in interim[4] efficiency gains by improving creditor coordination. We characterize the interim efficient CAC threshold.

Next, we analyze how creditor coordination at the interim stage affects the incentives of the sovereign debtor to undertake costly actions that lower the probability of default. Strengthening CACs away from unanimity to the interim optimal threshold lowers default costs to both the debtor and creditors. As a result, the debtor's ex ante incentives may be adversely affected to the point that ex ante efficiency gains may be forfeited.

Under what conditions is there a trade-off between ex ante and interim optimality? Such a trade-off arises in a scenario where, given that the interim efficient threshold prevails in the post-default game, the debtor's incentive constraint is violated. When creditors anticipate this eventuality, the interest rate on sovereign debt will adjust upwards (to satisfy creditor participation constraints) so that it becomes too costly for the debtor to undertake the project. Therefore, the project is not undertaken even when it is ex ante Pareto improving to do so.

Clearly such a conflict is not inevitable and we provide a characterization of the case where the benefit to the debtor from project completion is high enough to ensure that interim and ex ante efficiency are compatible. Moreover, such a conflict is not inevitable even when the debtor's incentive constraint is violated especially when the impact on the interest rate on sovereign debt is limited. This can happen, for instance, when debtor's actions have a limited impact on the probability of default, or when the expected recovery rate consistent with the interim optimal threshold in the post-default

[4] The interim stage refers to the post-default stage before all uncertainty about the future values of payoff relevant variables (e.g. future value of restructured debt) has been resolved.

game is high enough to mitigate a higher probability of default. Nevertheless, we show that the conflict between ex ante and interim optimality as a consequence of strengthening CACs is a robust possibility.

Finally, we calibrate key parameters of our model to quantify the magnitude of such a trade-off. We compare two scenarios, one where the CAC threshold requires unanimity between creditors for a debt rollover to be successful and one where the CAC threshold is set at its interim optimal value. In the former case, the debtor's ex ante incentive constraint is satisfied although, in the face of adverse shock, a sovereign debt crisis occurs with probability one. In the latter case, however, the debtor's ex ante incentive constraint is violated. However, the resulting impact on interest rates in two cases ensures that although the project is undertaken in the former scenario, it is not in the latter case even when is ex ante Pareto improving to do so[5].

Our analysis captures two main concerns which have been frequently raised in the policy debate over the reform of international financial architecture: whether CACs actually helps reduce the cost of protracted sovereign debt restructuring and whether it would induce the problem of debtor moral hazard (Kletzer, 2004a). Our key contribution to the literature is to show that when both issues of sovereign debtor moral hazard and creditor coordination under incomplete information matter, the resulting conflict between interim and ex ante efficiency could limit the welfare impact of strengthening CACs. In Section 6, we provide a brief policy discussion of interventions designed to improve sovereign debt restructuring in light of our results.

The remainder of this paper is structured as follows. The next section discusses related literature. In Section 3, we then present the basic model, which is used to study creditor coordination and interim efficiency in Section 4. In Section 5, we extend the basic model to allow for ex ante sovereign debtor moral hazard and analyze and quantify the trade-off between interim and ex ante efficiency. Section 6 contains a policy discussion and Section 7 concludes the paper.

[5] For completeness, we also calibrate our model to study the case where there is no such conflict between interim and ex ante efficiency.

2 Related Literature

A number of existing papers model how strengthening CACs might reduce the costs of debt restructuring and affect sovereign debtor incentives. In general, they find that incorporating CACs into debt renegotiation raises welfare; however, these papers do not attempt to study, as we do here, the conflict between ex ante and interim welfare.

In a bargaining model, Kletzer (2003) has shown that CACs lead to welfare gains in post-default scenarios. Kletzer (2004b)[6], building on the analysis of Kletzer and Wright (2000) (see also Bulow and Rogoff, 1989) studies a model of debtor-creditor bargaining where strengthening CACs eliminates the inefficiency of creditor holdout. In Kletzer and Wright (2000), a higher probability of disagreement has a higher impact on the debtor's willingness to pay. In a very different setting from the one studied by us, Weinschelbaum and Wynne (2005) show that CACs are useful in coordinating creditors within the same jurisdiction thus this mechanism could lower the cost of debt restructuring although they find that CACs could have an adverse impact on the sovereign debtor's incentive to run reckless fiscal policies that increase the possibility of crisis. However, they do not carry out an explicit welfare analysis (and do not distinguish, or study the trade-off, between ex ante and interim welfare) as we do here.

The welfare analysis of the consequences of strengthening CACs goes beyond the complete information creditor coordination case with liquidity shocks studied in Ghosal and Miller (2003). The model studied by us here allows for a potential insolvency but also combines, in a single framework, both interim creditor heterogeneity under incomplete information and debtor moral hazard to study the impact of strengthening CACs on ex ante and interim efficiency.

Pitchford and Wright (2007) develop an incomplete markets model of sovereign debt default under complete information coupled with an explicit model of sovereign debt restructuring process in which delay arises due to both creditor holdout and free-riding on negotiation effort and argue that

[6] As in our paper, Kletzer (2004a) notes a potential drawback with strengthening CACs: interest rate premiums may actually rise with the inclusion of CACs in sovereign bond contract if creditors expect debtor moral hazard to dominate the benefits of easier, less costly restructuring. However no attempt at the resulting welfare consequences is attempted in his paper.

strengthening CACs enhances welfare in the post-default scenarios and in the net[7], even after debtor incentive issues are taken into account. In addition to modelling the costs of default differently, our focus here is different: establishing, and quantifying, the robust possibility of a trade-off between ex ante and interim efficiency as a consequence of strengthening CACs although we also study the case where such a conflict need not arise.

Empirical studies in this area provide a mixed results for the impact of CACs on interest rate premium. Eichengreen et al. (2003) include both primary and secondary market premiums in their study and also find that the credit rating of the issuer plays a crucial role. They predict that CACs will be able to price ex ante debtor moral hazard by lowering the borrowing cost for a creditworthy issuer but increasing the borrowing cost for less creditworthy issuer. Eichengreen and Mody (2000, 2004) study the launch spreads on emerging market bonds – both bonds subject to UK governing law and those subject to New York law – and find that CACs reduce the borrowing cost for more creditworthy issuers, while the less creditworthy issuers need to pay higher spreads for issuing bonds that contain CACs. On the contrary, Becker et al. (2003) and Richards and Gugiatti (2003) find that, by considering the yields in the secondary markets, the inclusion of CACs in a bond issue did not increase the interest rate premium (and not change the bond prices) for that particular bond. Their results seem to support the ambiguous impact of CACs on cost of borrowing and bond prices. Weinschelbaum and Wynne (2005) challenge the conclusions from previous empirical results and argue that the results obtained by the previous empirical studies do not account for (endogenous) IMF intervention and compositional effects in the markets for sovereign debt. They argue that CACs could be irrelevant in the sovereign debt markets and therefore yield spreads with and without CACs are uninformative about moral hazard problems.

Although we do not conduct an empirical analysis on the impact of inserting CACs into the sovereign bond contracts on borrowing costs and bond prices, an implication of the results reported here is that strengthening CACs will reduce borrowing costs for issuer whose incentives are not adversely affected by lowering interim crisis risk. In other cases, where the

[7] The distinction we draw here between ex ante and interim efficiency was made independently of Pitchford and Wright (2007): it was already stated in an earlier version of our paper (Ghosal and Thampanishvong, 2005).

debtor incentives are adversely affected, lowering interim crisis risk could actually raise borrowing costs. This point is quantified in our calibration exercise: we calculate the impact of strengthening CACs away from unanimity to the interim efficient threshold on the interest rate on sovereign debt and show that the interest rate will rise when debtor incentives are adversely affected.

While in Gai et al. (2004), Roubini and Setser (2004a) and Tanaka (2006), the crisis cost is exogenous to the mechanism of debt restructuring, in our model, the crisis cost is endogenous through the threat of having an endogenously generated crisis risk. Our analysis complements Tirole (2003) who provides a rationale for debt finance, short maturities and foreign currency denomination of liabilities by adopting a 'dual- and common agency' perspective. His formal analysis takes as exogenous both the probability of default conditional on the adverse shock and the probability of debt crisis. In contrast, here while the maturity structure of debt is taken as given, both the probability of default and the probability of a debt crisis, conditional on default, are endogenous.

Our analysis of the efficacy of various policy interventions such as CACs and sovereign bankruptcy procedures is related to Rodrik (1998) who suggests that there is a case for limiting the use of sovereign bonds to finance development as the unrestricted use of such debt instruments could expose a country to excessive crises.

Finally, in contrast to the unique equilibrium obtained in the literature on global games which study coordination games with asymmetric information (Carlsson and van Damme, 1993; Morris and Shin, 1998), here, conditional on default, we obtain multiple Bayesian equilibria. In our paper, the way payoffs to creditors are indexed by the underlying fundamentals ensures that an extreme form of coordination failure between creditors always exists for all values of the fundamentals. In the global games literature, the way payoffs to creditors are indexed by the underlying fundamentals ensures that there are always two extreme regions in the space of fundamentals with a strongly dominant action[8].

[8] There are, of course, other technical differences: in our model there are a finite number of creditors and the (privately observed) signal has a finite support.

3 The Basic Model

There are three time periods, $t = 0, 1, 2$. We consider a sovereign debtor who has embarked on a bond-financed project $t = 0$ by issuing two-period bonds, each with a face value of b, denominated in US dollars. These bonds are sold to n ex ante identical private creditors who will be heterogenous later after observing private signals. The promised return for each private creditor is r at $t = 1$ and $(1 + r)$ at $t = 2$. Throughout the paper, all payoffs will be denoted in $t = 1$ units.

The debtor obtains a non-contractible payoff Z[9] conditional on the project being completed, at $t = 2$. The assumption that Z is non-contractible means that Z cannot be attached by the private creditors in the settlement of their claims – nor can the sovereign debtor, at $t = 1$, make a credible commitment to make conditional transfers of Z to the private creditors at $t = 2$. At this stage of the analysis, we will assume that Z is exogenous and positive although in Section 5 below we will explicitly determine the value of Z.

Consider what happens if a negative exogenous shock ("bad luck", a sudden loss in export revenues) occurs at $t = 1$ which lowers the debtor's capacity to pay at $t = 1$ below nrb the amount owed to creditors. Let Q_t denote the amount exogenously available for repayment at period t for $t = 1, 2$. Conditional on the adverse shock, $Q_1 < nrb$ at $t = 1$. The sovereign debtor's failure to comply with the terms of the debt contract constitutes a 'technical default' at $t = 1$. Following a technical default, each creditor is entitled to accelerate her claim, demanding the capital sum as well as the current coupon owed in the first period. In other words, a technical default makes the sovereign debt callable at $t = 1$.

The negative shock not only affects the debtor's capacity to repay at $t = 1$ but also affects the project net worth and therefore, the debtor's capacity to pay at $t = 2$ i.e. the adverse shock is persistent. It will be assumed that conditional on default, at $t = 1$, creditors have incomplete information about the degree of persistence of the negative shock (specified in greater detail below).

In the absence of the negative shock, we assume that the debtor has

[9] Following Eaton and Gersovitz (1981), one possible interpretation of this non-contractible payoff is that it is the benefit at $t = 1$ of a gain in national output at $t = 2$ when the debt is successfully rolled over consistent with the analysis and the calibration exercise presented in Section 5 below.

enough funds to cover bond payments at both time periods so that the project is completed.

Figure 1 shows the time line of events.

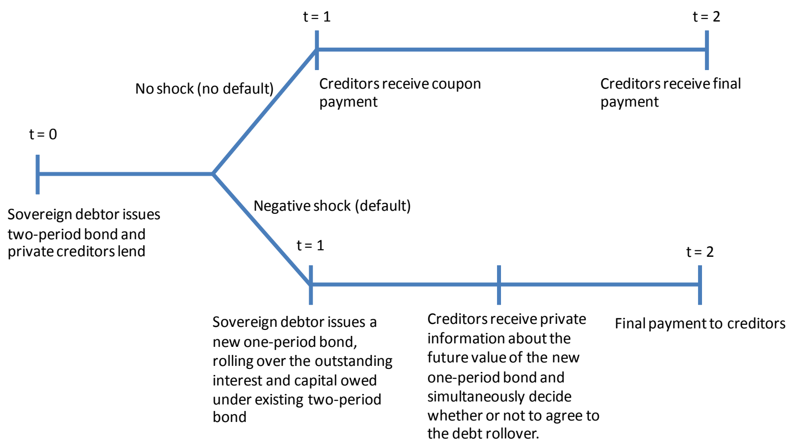

Figure 1: *Timeline of Events*

Conditional on default, the sovereign debtor issues a new one-period bond rolling over the outstanding interest and capital owed in the existing two-period bond. The new one-period bond has a face value of rb and promises a return of $(1+r)$. Therefore, a successful debt rollover implies that, at $t = 2$, the amount falling due becomes $rb\,(1+r) + (1+r)\,b = (1+r)^2\,b$ which at $t = 1$ (using $\frac{1}{(1+r)}$ as the discount factor) is worth $(1+r)\,b$. We find it convenient to work with normalized per capita creditor payoffs, which are obtained by dividing the gross creditor payoffs by $(1+r)nb$. Thus, in a normalized per capita payoff term, the amount owed by the debtor to each creditor at $t = 2$ is 1.

The amount that is actually paid out by the debtor at $t = 2$ is $min\left\{Q_2, n\,(1+r)^2\,b\right\}$ which, at $t = 1$, worth $\min\left\{\frac{Q_2}{(1+r)}, n\,(1+r)\,b\right\}$ (again using $\frac{1}{(1+r)}$ as the discount factor). Let $\gamma = \min\left\{\frac{Q_2}{n(1+r)^2 b}, 1\right\}$. Then, conditional on default at $t = 1$, the degree of persistence of the exogenous adverse shock is captured by the parameter γ that determines the value of the new one-period bond issued by the debtor if the project continues to completion at period $t = 2$. Note that there is an element of debt restructuring involved whenever $\gamma < 1$.

In our model, conditional on default, each creditor decides whether to accept the debt rollover (the new one-period bond issued by the sovereign debtor at $t = 1$). A *sovereign debt crisis* only occurs when a sufficiently large number of creditors decide not to roll over the debts.

We label an individual private creditor by i, where $i = 1, ..., n$.

We assume that creditors have to decide whether or not to accept the debt rollover conditional on default but before all uncertainty about future payoffs has been fully revealed. The information that creditors have about γ (equivalently, Q_2) at $t = 1$ is specified as follows. There is a common prior probability over $\gamma \in [0, 1]$ given by some continuous probability density function $p(.)$ (with $P(.)$ being the associated cumulative probability distribution). Conditional on default at $t = 1$, each private creditor i receives a privately observed signal $\sigma \in \{\gamma - \varepsilon, \gamma + \varepsilon\}$ of the true value of γ, $\varepsilon > 0$[10] and for each i, σ is i.i.d. over $\{\gamma - \varepsilon, \gamma + \varepsilon\}$ according to the distribution $\left\{\frac{1}{2}, \frac{1}{2}\right\}$[11].

The interpretation is that each creditor observes a noisy private signal of the true value of γ. Therefore, although creditors are identical ex ante, conditional on default at $t = 1$, creditors are differentiated on the basis of the information, and hence, beliefs about the degree of persistence of the adverse shock. Conditional on default, creditors disagree on the future payoff once debt is rolled over and this, in turn, affect their incentives to agree to the debt rollover in the first place.

Each private creditor privately observes a signal[12] σ. Conditional on σ, each private creditor simultaneously chooses an action $d^i(\sigma) \in \{\text{Accept } (A), \text{ Reject } (R)\}$, where A denotes accepting the debt rollover (the new one-period bond issued by the sovereign debtor, conditional on default at $t = 1$) and R denotes rejecting the debt rollover. A strategy of the creditor i is a map that specifies an action for each σ. Conditional on $\boldsymbol{\sigma} = (\sigma^1, ..., \sigma^n)$, let $d(\boldsymbol{\sigma}) = (d^1(\sigma^1), ..., d^n(\sigma^n))$. For each σ, let $\tilde{n}_d(\sigma) = \#\{i : d^i(\sigma) = R\}$ denote the number of private creditors who choose to reject the debt rollover when the value of the signal is σ. Given γ, let $n_d(\gamma) = \tilde{n}_d(\gamma - \varepsilon) + \tilde{n}_d(\gamma + \varepsilon)$ denote the number of creditors who reject the debt rollover.

Collective action clauses (CACs) in the original two-period bond contract

[10] It will be assumed that ε is small i.e. $\varepsilon < \bar{\varepsilon}$, $\bar{\varepsilon} > 0$ and $\bar{\varepsilon} < \frac{1}{H}$ for large but finite $H > 2$.

[11] When $\gamma = 0$, $\sigma^i = \varepsilon$ for all i and when $\gamma = 1$, $\sigma^i = 1 - \varepsilon$ for all i. Appropriate adjustments to all expressions involving signals need to be made at the boundary: these are not explicitly stated in the text.

[12] It is important to note that, even though the creditors are identical ex ante, after there is a default at $t = 1$, creditors receive different signals and are heterogenous.

aggregate the choices of individual creditors to determine whether or not a successful debt rollover occurs. Formally, we assume that the original two-period bond contract has a built in critical threshold $m \in \left[\frac{1}{n}, 1\right]$, where m denotes the proportion of private creditors that are needed to block a successful debt rollover at $t = 1$ i.e. m represents the critical CAC threshold. If $m = \frac{1}{n}$, a decision of only one private creditor not to roll over the short-term debts is sufficient to prevent a successful debt rollover: this is equivalent to requiring unanimity in the debt rollover decision. If $m = \frac{1}{4}$ then 25 percent of creditors can act to prevent a debt rollover. When the proportion of private creditors who reject the debt rollover exceeds the critical CAC threshold, m, a 'sovereign debt crisis' occurs.

In our model, increasing m is equivalent to strengthening CACs. Note that our model abstracts from issues relating to aggregation across creditor classes. One possible way to handle aggregation issues would be to have a two-stage bond swap where the first step is designed to achieve uniformity and the second step is actual restructuring (Bartholomew et. al (2002)). Our formal model will, then, correspond to the second step of such a two-stage procedure.

Conditional on γ, next, we specify how creditor payoffs are determined. There are two scenarios of interest.

First, $n_d(\gamma) \geq mn$: this scenario captures a situation where there is no debt rollover. In this contingency, we assume that creditors enter into the asset grab race as follows. Each private creditor who chooses to reject the debt rollover is a first mover in the asset grab race, while the private creditor who chooses to accept the debt rollover is a second mover. The payoff of each creditor i depends on whether she is the first- or the second mover in the asset grab race. A first mover recovers either her initial investment, b, plus interest, rb, or $\frac{Q_1}{n_d}$ (the liquidation value of the project at $t = 1$) minus the privately borne legal costs, L, leaving the second mover with the residual resources. In other words, litigation allows the first mover to exit without much loss of value but it is potentially costly for the second mover. Formally, the payoff to the first mover is determined by the function g such that $g(n_d) = \min\left\{1, \frac{Q_1}{n_d(1+r)b}\right\} - \frac{L}{(1+r)b}$, where $n_d < n$, $g(n) = \frac{Q_1}{n(1+r)b} - \frac{L}{(1+r)b}$. Note that the normalization is done by dividing the creditor's payoffs by $(1 + r)b$. For internal consistency, we assume that $\frac{Q_1}{n} - L > 0$ and by assumption, $\frac{Q_1}{n} - L < \frac{Q_1}{n} < (1 + r)b$, so that $0 < g(n) < 1$. The payoff to a second mover is determined by the function $l\left(n-n_d\right)$ such that $l\left(n-n_d\right)=\max\left\{\frac{\left[Q_1-(1+r)bn_d\right]}{(n-n_d)(1+r)b},0\right\}$, where $n_d<n$ and again the normalized payoff is obtained by dividing the creditor's payoff by $(1+r)b$. Note that the function $l(n-n_d)$ is well-defined for all n_d as, by assumption, $(1+r)\,bn>Q_1$.

To summarize, the payoff to creditor i when $n_d\left(\gamma\right)\geq mn$ are: if $d^i\left(\sigma\right)=R$, the per capita normalized payoff for creditor i is $g\left(n_d\right)$, while if $d^i\left(\sigma\right)=A$, the per capita normalized payoff to creditor i is $l(n-n_d)$.

Second $n_d\left(\gamma\right)<mn$: the debt rollover is successful. If $d^i\left(\sigma\right)=R$, the per capita payoff for creditor i is $\gamma\left(1+r\right)b-L'$, while if $d^i\left(\sigma\right)=A$, the per capita payoff to creditor i is $\gamma\left(1+r\right)b$, where $L'>0$ reflects the fact that an individual creditor, who unsuccessfully tries to accelerate the project, pays a small legal fee, L', for doing so but as the debt rollover is successful, obtains her continuation payoff $\gamma\left(1+r\right)b$.

After normalizing the payoffs by dividing the creditor i's payoffs by $(1+r)b$, we obtain the following: if $d^i\left(\sigma\right)=R$, the per capita normalized payoff for creditor i is $\gamma-\varphi$ where $\varphi\equiv\frac{L'}{(1+r)b}$, while if $d^i\left(\sigma\right)=A$, the per capita normalized payoff to creditor i is γ.

The above specification of actions and payoffs results in an incomplete information creditor coordination game where at $t=1$ each creditor has to decide whether or not to rollover outstanding debt.

We end this section by specifying the welfare benchmark used to evaluate Bayesian equilibrium outcomes. In our model, the private creditors have to decide whether or not to accept the debt rollover conditional on default but before all payoff-relevant uncertainty has been fully revealed. Accordingly, we ask whether relative to a first-best benchmark, which corresponds to the case with complete information about the value of the new one-period bond issued by the debtor, the equilibrium crisis risk is interim efficient[13].

Note that it is interim efficient to rollover outstanding debt if and only if the (per capita) payoff from debt rollover exceeds the (per capita) payoff when all available cash is equally shared between existing creditors. Formally, interim efficiency requires that whenever $\gamma\geq g\left(n\right)$ the debt should be rolled over to $t=2$, while if $\gamma<g\left(n\right)$, termination should occur at $t=1$.

In the following section, we study the welfare properties of the Bayesian

[13] From an ex ante viewpoint, the relevant welfare comparison would have to take into account both states of the world where the debt is rolled over and states of the world where the debt is not rolled over. Section 5 examines the link between ex ante and interim efficiency.

equilibria of this game.

4 Creditor Coordination, CACs and Interim Efficiency

In this section, for each fixed value of the CAC threshold m, we study the Bayesian equilibria of the incomplete information creditor coordination game. We show that a Bayesian equilibrium in symmetric threshold strategies exists. We characterize how conditional on default, creditor coordination is altered by strengthening CACs. We characterize the CAC threshold which ensures that the crisis risk at a Bayesian equilibrium threshold is interim efficient.

Clearly, a necessary condition for a Bayesian equilibrium to be interim efficient is that the actions chosen by individual creditors vary with their privately observed signals. To this end, we assume that creditors use symmetric threshold strategies i.e. strategies where for some value $\bar{\gamma} \in [0, 1]$, whenever $\sigma^i \geq \bar{\gamma}$, creditor i agrees to a debt rollover but whenever $\sigma^i < \bar{\gamma}$, creditor i rejects the debt rollover.

Clearly, when creditors use threshold strategies, the outcomes of the creditor coordination game depend on the payoff relevant uncertainty. Whether or not a creditor agrees to the debt rollover is a function of her assessment (based on her privately observed signal) of future payoffs following a debt rollover.

Denote a symmetric threshold strategy profile by $d_{\bar{\gamma}}$. Given $d_{\bar{\gamma}}$, conditional on σ, let E_R^m denote creditor i's expected payoff from not agreeing to the debt rollover and E_A^m denote creditor i's expected payoff from agreeing to the debt rollover.

Given $d_{\bar{\gamma}}$, conditional on observing a signal σ, from the perspective of any one creditor, in general, the number of other creditors not agreeing to the debt rollover is a random variable.

For each creditor who observes a signal $\sigma = \bar{\gamma}$, given that all other private creditors are choosing actions according to $d_{\bar{\gamma}}$,let $p_j(\bar{\gamma})$ denote the probability that exactly j other creditors (from a population of $n-1$ other private creditors) do not agree to the debt rollover[14]. Given a symmetric

[14] Recall from Section 3 that $p(.)$ is the continuous probability density function, which gives the (prior) probability over γ.

threshold strategy profile $d_{\bar{\gamma}}$, notice that $\{p_j(\bar{\gamma})\}_{j=0}^{n-1}$ is a symmetric binomial distribution. For the two different threshold strategies $d_{\bar{\gamma}}$ and $d_{\bar{\gamma}'}$, by computation, for each j, $j = 0, ..., n-1$,

$$p_j(\bar{\gamma}) = p_j(\bar{\gamma}') = \binom{n-1}{j}\left(\frac{1}{2}\right)^n = p_j.$$

so that the two distributions, $\{p_j(\bar{\gamma})\}_{j=0}^{n-1}$ and $\{p_j(\bar{\gamma}')\}_{j=0}^{n-1}$, are identical.

For each creditor who observes a signal $\sigma = \bar{\gamma}$, given that all other private creditors are choosing actions according to $d_{\bar{\gamma}}$, the expected payoff from not agreeing to a debt rollover, E_R^m, is given by the expression

$$E_R^m = \sum_{j=mn-1}^{n-1} g(j)p_j + (\bar{\gamma} - \varphi)\sum_{j=0}^{n(m)} p_j, \tag{1}$$

where $n(m) = \max\{0, mn-2\}$.[15] The first term in equation (1) can be interpreted as follows. Given that at least $(mn-1)$ other creditors have chosen to reject the debt rollover (which occurs with probability $\sum_{j=mn-1}^{n-1} p_j$), if creditor i chooses to reject the debt rollover, this is sufficient to render the debt rollover at $t = 1$ unsuccessful and ensure that the asset grab race ensues. When this is the case, since the creditor i's action is rejecting the debt rollover, the creditor i and each of the other $(mn-1)$ creditors are entitled to receive $g(j)$, $mn-1 \leq j \leq n$, the payoff to creditor i is the payoff to a first mover in the asset grab race. The second term in equation (1) shows the expected payoff of creditor i under the case in which $n(m)$ other private creditors already decided to reject the debt rollover. Despite the fact that creditor i chooses to reject the debt rollover, this is not sufficient to block a debt rollover. Therefore, each of the $n(m)$ creditors as well as creditor i receives the continuation value, $\bar{\gamma}$, net of a small legal fee, φ, (with probability $\sum_{j=0}^{n(m)} p_j$) for unsuccessfully trying to prevent the debt rollover.

For each creditor who observes a signal $\sigma = \bar{\gamma}$, given that all other private creditors are choosing actions according to $d_{\bar{\gamma}}$, the expected payoff

[15] In what follows, we assume, for ease of exposition, that mn is an integer.

from agreeing to the debt rollover, E_A^m, is given by the expression

$$E_A^m = \sum_{j=mn}^{n-1} l(n-j)p_j + \bar{\gamma} \sum_{j=0}^{mn-1} p_j. \tag{2}$$

The first term in equation (2) is creditor i's expected payoff when there are already mn private creditors chosen to reject the debt rollover; thus, even though creditor i chooses to accept the debt rollover, the debt rollover is unsuccessful and the asset grab race occurs (with probability $\sum_{j=mn}^{n-1} p_j$). Since creditor i chooses to accept the debt rollover and did not join the queue in the asset grab race, she is classified as the second mover and is entitled to receive $l(n-j)$, $mn-1 \leq j \leq n$, the payoff to a second mover in the asset grab race. The second term in equation (2) captures the expected payoff to creditor i under the scenario in which the debt rollover is successful so that each of the $(mn-1)$ private creditors and creditor i receives the continuation payoff, $\bar{\gamma}$ (with probability $\sum_{j=0}^{mn-1} p_j$).

The following proposition characterizes the nature of creditor coordination when all creditors use threshold strategies. We show that a Bayesian equilibrium in symmetric threshold strategies exists where, with positive probability, successful debt rollover occurs. It follows that each creditor will agree to a debt rollover if and only if their privately observed signal is greater than a common (across all creditors) positive threshold value. Second, we show that the Bayesian equilibrium threshold is decreasing in m so that strengthening CACs increases the probability of a successful debt rollover and decreases interim crisis risk conditional on default. Third, we show that strengthening CACs away from unanimity leads to efficiency gains and we characterize the interim efficient CAC threshold.

Proposition 1 *A Bayesian equilibrium in symmetric threshold strategies exists. The equilibrium threshold value, $\bar{\gamma}_m^*$, is positive and decreasing in the CAC threshold m. Strengthening CACs away from unanimity leads to interim efficiency gains and the interim optimal CAC threshold, $\hat{m}$, satisfies the condition that $\bar{\gamma}_{\hat{m}}^* = g(n)$.*

Proof. We begin by proving the existence of an positive Bayesian equilibrium threshold value. Conditional on observing the signal $\sigma = \bar{\gamma}$, creditor

i's expected payoffs from not agreeing to the debt rollover, E_R^m, and her expected payoffs from agreeing to the debt rollover, E_A^m, are given by the expressions in (1) and (2), respectively. Therefore, (a) whenever $E_R^m - E_A^m > 0$, creditor i does not agree to the debt rollover, and (b) whenever $E_R^m - E_A^m \leq 0$, creditor i agrees to the debt rollover. Notice that both E_R^m and E_A^m are increasing linear functions of $\bar{\gamma}$. By computation, we have

$$\begin{aligned} E_R^m - E_A^m &= \sum_{j=mn-1}^{n-1} g(j) p_j + (\bar{\gamma} - \varphi) \sum_{j=0}^{n(m)} p_j - \sum_{j=mn}^{n-1} l(n-j) p_j - \bar{\gamma} \sum_{j=0}^{mn-1} p_j \\ &= \sum_{j=mn}^{n-1} [g(j) - l(n-j)] \, p_j + [g(mn-1) - \bar{\gamma}] \, p_{(mn-1)} - \varphi \sum_{j=0}^{n(m)} p_j. \end{aligned}$$

Therefore, viewed as functions of $\bar{\gamma}$, the intercept of E_A^m is lower than the intercept of E_R^m. The slope of E_A^m is higher than the slope of E_R^m as $l(n-j)$ is strictly less than $g(j)$ for all j, $l(n-j)$ is decreasing in j, and $g(j)$ is increasing in j. It follows that there exists a $\bar{\gamma}_m^{'}$ such that $E_R^m - E_A^m = 0$, where

$$\bar{\gamma}_m^{'} = g\,(mn-1) + \frac{\sum_{j=mn}^{n-1} [g(j) - l(n-j)] \, p_j - \varphi \sum_{j=0}^{n(m)} p_j}{p_{(mn-1)}},$$

and $p_{(mn-1)} = \binom{n-1}{mn-1} \left(\frac{1}{2}\right)^n$. Therefore, a positive Bayesian equilibrium threshold value, $\bar{\gamma}_m^*$, exists, where $\bar{\gamma}_m^* = \min \left\{ \bar{\gamma}_m^{'}, 1 \right\} > 0$ and it is interior whenever $\bar{\gamma}_m' < 1$.

For $m < m'$, relative to m, at m', the action profiles where there is a successful debt rollover have a higher probability so that by first-order stochastic dominance, it follows that $E_R^{m'}(\bar{\gamma}_m^*) - E_A^{m'}(\bar{\gamma}_m^*) < 0$ and therefore, $\bar{\gamma}_{m'}^* \leq \bar{\gamma}_m^*$ with strict inequality whenever $\bar{\gamma}_m^* < 1$.

When creditors use threshold strategies, at the Bayesian equilibrium threshold, $\bar{\gamma}_m^*$, the expected payoff to the creditor from a successful debt rollover $E(\gamma | \bar{\gamma}_m^*) = \bar{\gamma}_m^*$. It follows that the interim efficient CAC threshold, $\hat{m}$, satisfies the equation $E(\gamma | \bar{\gamma}_{\hat{m}}^*) = \bar{\gamma}_{\hat{m}}^* = g(n)$. By computation, observe that when $m = 1$, $\bar{\gamma}_1^* = 0 < g(n)$; however, when $m = \frac{1}{n}$, $\bar{\gamma}_{\frac{1}{n}}^* = 1 > g(n)$. Therefore, correcting for integer effects an interim efficient CAC threshold exists and as $\bar{\gamma}_m^*$ is decreasing in m, strengthening CACs away from unanimity always leads to interim efficiency gains. ■

It is useful to depict the interior Bayesian equilibrium threshold in Figure 2.

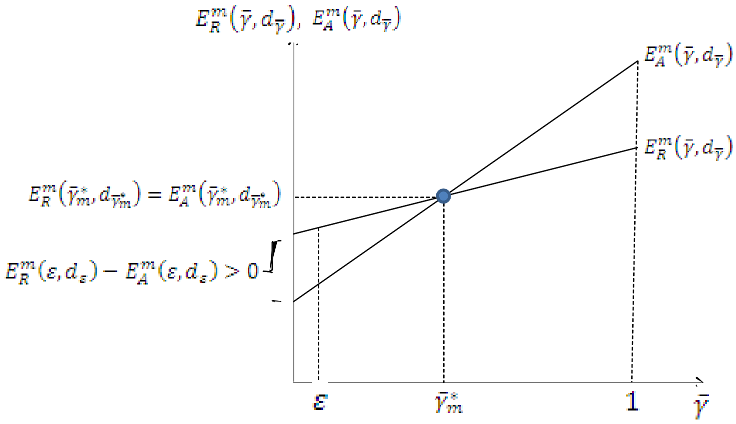

Figure 2: *Interior Bayesian equilibrium threshold*

Proposition 1 implies that, in general, strengthening CACs lowers $\bar{\gamma}_m^*$ and thus reduces interim crisis risk, conditional on default. An increase in the value of m reduces the number of different scenarios in which any one creditor can prevent a successful debt rollover thus lowering the expected payoff to an individual creditor from rejecting the debt rollover and increasing the expected payoff to an individual creditor from accepting the debt rollover. Therefore, by choosing the CAC threshold appropriately, it is possible to ensure that interim efficient creditor coordination is achieved in the post-default creditor coordination game[16].

It is of some interest to note that there are other Bayesian equilibrium scenarios where the outcomes of creditor coordination does not depend on payoff relevant uncertainty and are invariant to the signals privately observed by creditors. As long as $\frac{1}{n} < m < \frac{n-1}{n}$, both action profiles, one where each creditor agrees to a debt rollover and the other where each creditor rejects the debt rollover, are Bayesian equilibria. Indeed, (i) if $m \leq \frac{n-1}{n}$ and $n-1$ creditors reject the debt rollover, then it is a best-response for

[16] By using a theoretical model of grey-zone financial crisis, which allows for the interaction of liquidity problems with solvency problems, Haldane et al. (2004) find that the sovereign debtors' optimal choice of CAC threshold could vary because of their different risk preferences and creditworthiness.

the remaining creditor (who cannot force a debt rollover by an individual deviation) to also reject the debt rollover, and (ii) if $m > \frac{1}{n}$, if all other creditors agree to a debt rollover it is a best-response for the remaining creditor (who cannot force a debt rollover by an individual deviation) to agree to the debt rollover. Note that the action profile in scenario (i) remains an equilibrium even when γ is close to 1 and the action profile in scenario (ii) remains an equilibrium even when γ is close to 0. Therefore, either of the above Bayesian equilibrium scenarios cannot, in general, be interim efficient. Evidently, in such scenarios, strengthening CACs within the bounds $\frac{1}{n} < m < \frac{n-1}{n}$will have no effect on the debt rollover[17]. Given that there are multiple Bayesian equilibria, even when the CAC threshold is set at the interim efficient level $\hat{m}$, in order to ensure that creditors coordinate on the interim efficient Bayesian equilibrium threshold, there could be a role for third parties like the bondholder committee[18].

5 Debtor Moral Hazard: Interim vs. Ex Ante Efficiency

In this section, we study whether interim efficient creditor coordination is compatible with ex ante efficiency in the presence of debtor moral hazard. The source of ex ante debtor moral hazard in our model is the misalignment between the incentives of private creditors and the incentives of sovereign debtor. Debtor effort will determine the probability of default and we shall show that debtor effort, and therefore, the probability of default, will depend on anticipated payoffs in the post-default bargaining game. This, in turn, will determine the interest rate on sovereign debt (via creditor participation constraints) and hence whether the project is undertaken in the first place leading to the potential trade-off between ex ante and interim efficiency. We

[17] A case of interest is one where $m = \frac{1}{n}$. Suppose $\sigma^i < g(1)$ for some creditor i. Given the signalling structure, conditional on $E(\gamma|\sigma^i) = \sigma^i < g(1)$. Therefore, even if all other creditors agree to a debt rollover, player i will stop the debt rollover from occurring. Note that by strengthening CACs (increasing m away from unanimity) there will be a new equilibrium where the debt rollover occurs with a probability one. Note that even when it is interim efficient to do so, there is no guarantee that strengthening CACs alone will ensure that creditors coordinate on the new equilibrium.

[18] According to Mauro and Yafeh (2003), the Corporation of Foreign Bondholders (an association of British investors holding bonds issued by foreign governments) played a key role between 1870-1913 and in the aftermath of the defaults in the 1930s by ensuring that creditors would base their decisions on a common strategy using similar data and analysis.

will then calibrate our model to quantify the trade-off.

5.1 Model

We assume that the sovereign debtor issues two-period bond at $t = 0$, which promises an interest coupon at $t = 1$ and repayment of the capital sum together with the second interest coupon at $t = 2$. With debtor moral hazard, we show below that positive crisis risk, conditional on default, is a necessary condition for resolving debtor's ex ante incentives[19] a possibility that requires the use of short-term debt contracts with payments to be made at both $t = 1$ and at $t = 2$.

The timing at $t = 0$ is as follows:

1. First, the debtor has to choose whether or not to undertake the project.

2. Second, the debtor has to mobilize the required finance (assumed to be exactly equal to nb) by issuing sovereign debt at an interest rate determined by the participation constraints of private creditors.

3. Finally, the debtor will choose an action (effort) $a \in \{G, B\}$ .where G and B denote good and bad effort respectively which determines the probability of default at $t = 1$.

Good effort can be interpreted as any policy choice (such as prudent fiscal policy) which makes the sovereign debtor less vulnerable to a negative external shock, while the bad effort corresponds to policy choices (fiscal indiscipline) which makes the sovereign debtor more vulnerable to adverse external shock[20].

Let $c^a \in \left\{c^G, c^B\right\}$ denote the cost of effort, measured in $t = 1$ payoff units. We assume that it is more costly for the debtor to exert good effort than to choose bad effort so $c^G > c^B$. We will normalize the cost of bad effort so that $c^B = 0$. Let $q^a \in \left\{q^G, q^B\right\}$ denote the ex ante probability

[19] A number of authors (Barro (1998), Ghosal and Miller (2003)) have pointed out that if the probability of early debt liquidation were reduced to zero, the sovereign debtor could have an incentive to use the borrowed money unwisely. Short-term debt contracts thus allow for the possibility of at least partially aligning creditor's and debtor's incentives a point made by Diamond and Rajan (2001) and Jeanne (2009).

[20] In this context, good effort could correspond to a situation where the money borrowed is used to promote R&D in the export sector, invest in infrastructure and build up foreign exchange reserves while bad effort could correspond to squandering borrowed money on a wasteful project that yields low returns or transferring the borrowed money either directly, or indirectly via tax breaks, to local elites.

of default. We assume that the probability of default conditional on the adverse shock is higher if the debtor chooses bad effort so $q^B > q^G$.

As already pointed out in Section 3, we assume that, if there is no adverse shock at $t = 1$ or if there is a successful debt rollover at $t = 1$, the project continues to completion in the second period, the debtor obtains a non-contractible payoff Z at $t = 2$.

At this stage, it is convenient to be explicit about the interpretation we attach to the non-contractible debtor's payoff from a successful debt rollover at this stage of the analysis. Suppose the funds borrowed by the sovereign debtor are used to finance a publicly operated infrastructure project. If the infrastructure project succeeds, the government enjoys the prospect of higher national output as more domestic and foreign firms invest and employment is generated. No private creditor can attach the future higher national output generated by the infrastructure project. Moreover, this additional output would be lost if the project was terminated early. Let Y denote the additional national output generated upon successful completion of the project. Then $Z = Y - (1 + r)nb$. Note that the project is undertaken if and only if $Z > 0$, consistent with the assumption made in Section 3 above.

We will assume that conditional on default, creditors have to decide whether or not to roll over the debt before observing the ex ante choice of action by the debtor: it takes time for all the debtor's action to be revealed and creditors have to decide whether or not to agree to the debt rollover before the action of the debtor is revealed. This rules out the possibility that equilibrium outcomes in the post-default creditor coordination game can be conditioned on the action chosen by the debtor making the debtor's ex ante incentive constraint easier to satisfy[21].

Let P^* denote the equilibrium probability of a successful debt rollover in the post-default creditor coordination game. Let β^* denote the debtor's expected payoff conditional on default, measured in $t = 1$ payoff units. By computation,

[21] Evidently, if the equilibrium in the post-default game could be made conditional on the action chosen by the debtor, the debtor's incentive compatibility constraint will be easier to satisfy. In particular, the potentially adverse impact of strengthening CACs on ex ante incentive could be mitigated. We will come back to this point in the calibration exercise reported below.

$$\beta^* = P^* \left(Y - (1+r)nb\right). \tag{3}$$

It follows that

(i) If the equilibrium prevailing in the post-default creditor coordination game is the one where all creditors agree to a debt rollover, as $P^* = 1$, $\beta^* = (Y - (1+r)nb)$;

(ii) If the equilibrium prevailing in the post-default creditor coordination game is the one where no creditor agrees to a debt rollover, as $P^* = 0$, $\beta^* = 0$;

(iii) If the equilibrium prevailing in the post-default creditor coordination game is the one where all creditors use threshold strategies, $P^* = \Pr(\bar{\gamma}_m^*)$ (i.e. a function of the equilibrium threshold $\bar{\gamma}_m^*$) and $\beta_m^* = \Pr(\bar{\gamma}_m^*)\left(Y - (1+r)nb\right)$. By first-order stochastic dominance, as a higher value of $\bar{\gamma}_m^*$ implies a lower $\Pr(\bar{\gamma}_m^*)$, β_m^* is decreasing in $\bar{\gamma}_m^*$ and hence, by Proposition 1, increasing in m.

The debtor's payoff from choosing good effort is given by the expression $(1-q^G)Z + q^G\beta^* - c^G$, while the debtor's payoff from choosing a bad effort is given by the expression $(1-q^B)Z + q^B\beta^*$. The incentive compatibility constraint, which ensures that the sovereign debtor chooses good effort, is

$$(1-q^G)Z + q^G\beta^* - c^G \geq (1-q^B)Z + q^B\beta^*. \tag{4}$$

If $P^* = 1$ as $\beta^* = Z$, the incentive constraint (4) can never hold. This confirms, in our set-up, the intuition that a positive probability of a crisis is a necessary condition for the debtor to undertake the costly good action.

Next, we examine how creditor participation constraint generates an endogenous interest rate for sovereign debt. We assume that the n creditors who actually participate in the project are drawn from randomly from a pool of identical potential creditors under two constraints: (i) no creditor who is chosen refuses to participate, and (ii) no creditor who is not chosen has an incentive to undercut (by offering a lower interest rate on the loan made to the sovereign debtor).

It follows that the interest rate on sovereign debt adjusts to ensure that each creditor who participates is indifferent between holding the sovereign debt and investing in a risk-free bond (e.g. US Treasury bill). Let K^* denote the expected recovery rate for each creditor as a function of the equilibrium prevailing in the creditor coordination game. Even if a creditor has a first mover advantage and is able to recover the full amount owed, as there is a positive legal cost involved in doing so $K^* < 1$. Let r_f denote the risk free interest rate. If creditors anticipate that the debtor will choose G, the interest rate charged on sovereign debt is determined by the equation

$$q^G(1+r)b + (1-q^G)K^*(1+r)b = (1+r_f)b$$

$\Leftrightarrow$

$$\frac{r^G - r_f}{(1+r_f)} = \frac{q^G(1-K^*)}{1-q^G(1-K^*)} \tag{5}$$

By a symmetric argument, if creditors anticipate that the debtor will choose the bad action, the interest rate charged on sovereign debt will be

$$\frac{r^B - r_f}{(1+r_f)} = \frac{q^B(1-K^*)}{1-q^B(1-K^*)}. \tag{6}$$

Note that $r^B > r^G$ as $q^B > q^G$ implies that $\frac{q^B(1-K^*)}{1-q^B(1-K^*)} > \frac{q^G(1-K^*)}{1-q^G(1-K^*)}$: the interest rate charged will be lower if creditors anticipate that the debtor will choose the good action.

The following proposition provides a set of sufficient conditions under which a trade-off between ex ante and interim efficiency is a robust possibility.

Proposition 2 *There exists $\bar{\varepsilon} > 0$, $K > 0$, $\bar{Y} > \underline{Y} > 0$ such that if $q^B \geq 1-\bar{\varepsilon}$, $q^G \leq \bar{\varepsilon}$, $K > c^G$ and $\bar{Y} > Y > \underline{Y}$, ex ante efficiency and interim efficiency cannot be simultaneously satisfied.*

Proof. There is conflict between ex ante efficiency and interim efficiency if and only if the following three inequalities are simultaneously satisfied:

(i) The debtor's incentive constraint is never satisfied if he anticipates that the interim optimal threshold prevails in the post-default game i.e.

$$\frac{c^G}{(q^B - q^G)(Y - (1+r^G)nb)} > 1 - \hat{P} \tag{7}$$

where $\hat{P}$ is the probability of a successful debt rollover at the interim optimal threshold.

(ii) The debtor's participation constraint is never satisfied if the debtor chooses B and the interest rate on sovereign debt is r^B i.e.

$$\left((1-q^B)+q^B\hat{P}\right)(Y-(1+r^B)nb)<0. \tag{8}$$

(iii) The debtor's participation constraint is satisfied if the debtor chooses G and the interest rate on sovereign debt is r^G i.e.

$$\left((1-q^G)+q^G\hat{P}\right)(Y-(1+r^G)nb)>c^G. \tag{9}$$

Let $q^B \approx 1$ and $q^G \approx 0$. Then, by computation, it is checked that $1+r^G \approx 1+r_f$ and $1+r^B \approx \frac{1+r_f}{\hat{K}}$ where $\hat{K}$ is the expected recovery rate at the interim optimal threshold in the post-default game. Further, by computation, it follows that (9) can be rewritten as $Y > c^G - (1+r_f)nb$ while (8) can be rewritten as $Y < \frac{(1+r_f)}{\hat{K}}nb$ and (7) can be rewritten as $Y < \frac{c^G}{1-\hat{P}} - (1+r_f)nb$. It remains to check that that there are parameter configurations for which the inequalities

$$\begin{aligned}
c^G+(1+r_f)nb &< \frac{(1+r_f)}{\hat{K}}nb \\
c^G+(1+r_f)nb &< \frac{c^G}{1-\hat{P}}+(1+r_f)nb \\
0 &< c^G
\end{aligned}$$

simultaneously hold. By computation, it is easily checked that the above inequalities simultaneously hold if and only if

$$(1+r_f)nb\left(\frac{\hat{K}-1}{\hat{K}}\right) < -c^G < 0.$$

Note that $\hat{P}$ and $\hat{K}$ are fixed numbers (determined by Q_1, Q_2 and the probability distribution over γ). By setting $K = (1+r_f)nb\left(\frac{1-\hat{K}}{\hat{K}}\right)$ it follows that whenever $K > c^G$ there exists $\bar{Y} > \underline{Y} > 0$ such that if $\underline{Y} < Y < \bar{Y}$, the inequalities (7), (8) and (9) are satisfied. Moreover, the LHS of both (8) and (9) are decreasing in q^B and q^G respectively while the LHS of (7) is decreasing in q^B and increasing in q^G so that, for ε positive but close to zero, if $q^B = 1-\varepsilon$ and $q^G = \varepsilon$, all the inequalities (7), (8) and (9) continue to be satisfied. ■

Proposition 2 states that the conflict between ex ante and interim optimality arises whenever three conditions hold: (i) the debtor's incentive constraint is violated if he anticipates that the interim optimal threshold prevails in the post-default game, (ii) the debtor's participation constraint is never satisfied if the debtor chooses B and the interest rate on sovereign debt is r^B, and (iii) the debtor's participation constraint is satisfied if the debtor chooses G and the interest rate on sovereign debt is r^G. The condition on the parameters requires that (i) the difference between the probability of default resulting from the good effort q^G is close to zero while the probability of default from bad effort q^B is close to one, (ii) the difference between the cost of good effort and bad effort (the latter normalized to zero) is not too high, and (iii) that the additional benefit to the debtor from successful completion of the project is moderate i.e. falls between an upper bound and a lower bound.

Proposition 2 also shows that such a conflict is not inevitable even when the debtor's incentive constraint is violated especially when the impact on the interest rate on sovereign debt is limited. This can happen, for instance, when debtor's actions have a limited impact on the probability of default, or when the expected recovery rate consistent with the interim optimal threshold in the post-default game is high enough to mitigate a higher probability of default.

The above proposition states that when it is ex ante efficient for the sovereign debtor to choose G, achieving ex ante efficiency imposes an upper bound on the probability of a successful debt rollover conditional on default. However, as interim efficiency requires the probability of a successful debt rollover conditional on default to be a fixed number, $\hat{P}$, improved creditor coordination may lead the sovereign debtor to choose the ex ante inefficient action.

Clearly, when $m = \frac{1}{n}$ (the unanimity rule so that an individual creditor, by rejecting the debtor's offer, can prevent a successful debt rollover), by computation, it is easily checked that $\bar{\gamma}^*_m = 1$. The debtor will always choose G but in this case, interim optimality is never satisfied.

Let $\tilde{P}$ be the maximum probability of a successful debt rollover in the post-default game consistent with debtor's incentive compatibility i.e. $\tilde{P}$

solves the equation

$$\tilde{P} = \left\{1 - \frac{c^G}{(q^B - q^G)(Y - (1 + r^G)nb)}, 0\right\}.$$

If $\hat{P} > \tilde{P}$ the debtor will never choose to put in a good effort if he anticipates that the interim efficient threshold will prevail conditional on default.

Let $\tilde{m}$ be the CAC threshold compatible with debtor incentive compatibility so that $P\left(\bar{\gamma}^*_{\tilde{m}}\right) = \tilde{P}$. It follows that we must have $\bar{\gamma}^*_{\hat{m}} > \bar{\gamma}^*_{\tilde{m}}$ which implies that $\tilde{m} < \hat{m}$. Note in this case that strengthening CACs away from unanimity to $\tilde{m}$ would be efficiency enhancing as there will be gains in interim efficiency without affecting the incentive constraints of the debtor.

The following proposition studies the case where there is no conflict between interim and ex ante efficiency:

Proposition 3 *There exists $\underline{Y}' > 0$ such that if $Y > \underline{Y}'$ex ante efficiency and interim efficiency are simultaneously satisfied.*

Proof. There is no conflict between ex ante efficiency and interim efficiency if and only if the following inequalities are simultaneously satisfied:

(i) The debtor's incentive constraint is satisfied if he anticipates that the interim optimal threshold prevails in the post-default game i.e.

$$\frac{c^G}{(q^B - q^G)(Y - (1 + r^G)nb)} < 1 - \hat{P} \tag{10}$$

where $\hat{P}$ is the probability of a successful debt rollover at the interim optimal threshold.

(ii) The debtor's participation constraint is satisfied if the debtor chooses G and the interest rate on sovereign debt is r^G i.e.

$$\left(\left(1 - q^G\right) + q^G\hat{P}\right)(Y - (1 + r^G)nb) > c^G. \tag{11}$$

By computation it is easily checked that $1+r^G = \frac{1}{1-q^G(1-\hat{K})}$ a fixed number independent of Y as $\hat{K}$ is a fixed number independent of Y. Moreover, $\hat{P}$ is also a fixed number independent of Y. Therefore, the LHS of (10) is decreasing in Y while the LHS of (11) is increasing in Y. It follows that there exists $\underline{Y}' > 0$ such that if $Y > \underline{Y}'$ both (10) and (11) are simultaneously satisfied. ■

Proposition 3 states that the conflict between ex ante and interim optimality will not arise whenever two conditions hold: (i) the debtor's incentive constraint is not violated if he anticipates that the interim optimal threshold prevails in the post-default game, (ii) the debtor's participation constraint is satisfied if the debtor chooses G and the interest rate on sovereign debt is r^G. Proposition 3 requires that the additional benefit to the debtor from successful completion of the project is large enough. Under the conditions set out in Proposition 3, $\hat{P} < \tilde{P}$, the debtor will choose to put in a good effort if he anticipates that the interim efficient threshold will prevail conditional on default: in this case, strengthening CACs away from unanimity to the interim optimal threshold is compatible with debtor's incentive constraint and there is no conflict between ex ante and interim optimality.

5.2 Calibration

We calibrate the model to quantify the welfare implications of two different scenarios: one where CACs are characterized by the unanimity rule and the other where CAC threshold is set equal to its interim optimal value. We focus on the case where there is a conflict between interim and ex ante efficiency, i.e. the case studied in Proposition 2. However, we will also examine a scenario where such a conflict does not arise.

Under the unanimity rule, $m = \frac{1}{n}$ and it is easily checked that $\gamma^*_{\frac{1}{n}} = 1$ so that the probability of a successful rollover $P^* = 0$. In their discussion of sovereign spreads, Cline and Barnes (1997) use a recovery rate of 0.5 a number consistent with other estimates of the recovery rate in Moody (2006)[22] and Sturzenegger and Zettelmeyer (2005). Accordingly, we will assume that the per capita creditor payoff, $g(n)$, is 0.5. Note also that, by definition, at the interim optimal threshold in the post-default creditor coordination game $\gamma^*_{\hat{m}} = g(n)$ so that we will set the interim optimal threshold equals to 0.5. Assuming that γ is uniformly distributed over $[0, 1]$, an assumption we will maintain throughout the calibration exercise, the probability of a successful debt rollover at the interim optimal threshold will be 0.5.

To quantify the ex ante implications of the two different CAC thresholds,

[22] Moody's Special Comment in April 2006 arrives at the figure of 0.5 by estimating the average, issuer weighted, trading price on sovereign bonds thirty days after its missed payment or where the initial default event was the distressed exchange itself, the average price shortly before the distressed exchange over a sample of 19 emerging market economies.

we will need to calibrate a number of different parameters in our model.

The first two such parameters are q^G and q^B. The Institutional Investor Ratings (IIR) given to countries on a scale of 0 to 100 are a measure of the likelihood of defaulting on the sovereign debt obligations with 100 given to those countries with the lowest likelihood. So $\frac{100-IIR}{100}$ is a measure of the vulnerability of country to sovereign default shock. Countries in Europe and North America that have had continuous access to capital markets tend to have an IIR above 90. We will set $q^G = 0.2$[23] following the threshold IIR in Reinhart and Rogoff (2009, page 29) to identify countries that have continuous access to capital markets (in our calibration exercise, when the sovereign debtor chooses G, lending by creditors always takes place). We will set $q^B = 0.8$ the number we obtain if we use the threshold IIR in Reinhart and Rogoff (2009, page 29) to identify countries that have no access to capital markets (in our calibration exercise when the sovereign debtor chooses B, no lending by creditors takes place).

A key parameter we will need to calibrate is the ratio $\frac{c^G}{Y-(1+r^G)nb}$: as noted above, this ratio is proportional to the maximum probability of a successful debt rollover in the post-default game consistent with debtor's incentive compatibility constraint. Divide both the numerator and the denominator of this ratio by GDP. Then, the numerator, the ratio of c^G to GDP, can be proxied by cost of carrying foreign exchange reserves expressed as a fraction of GDP. Rodrik (2006) obtains a estimate of 1%, which is the number we use[24]. The first term in the denominator, the ratio of Y to GDP, will be proxied by the percentage of output loss in the event of a debt crisis: this was estimated to be 19% in the Asian Crisis of 1997-1999 by Ruiz-Arranz and Zavadjel (2008), a number that we use in our calibration

[23] If, instead, we use $q^G = 0.1$ in the calibration exercise below, it is easily checked that we would still retain the conflict between ex ante and interim optimality.

[24] These costs are, typically, calculated as (i) the sum of the difference between investing in lower yield US treasury bonds and higher yield investment, and (ii) opportunity costs of not investing a share of reserves in boosting domestic economic growth and the costs of borrowing reserves in international capital markets. Sengupta (2008) estimates that the cost of carrying foreign exchange reserves for India, computed on the basis of physical investment foregone, is between 2% to 2.5% of GDP. Molina and Ruiz (2010) have estimated that the costs of maintaining foreign exchange reserves is approximately 2% of national output from developing countries. However, others such as Levy Yeyati and Sturzenegger (2010) claim that the reserves are costly due to wide sovereign spreads or heavy quasi-fiscal losses are overstated although they do not seem to account for the costs described in point (ii) above. We use the estimate obtained by Rodrik (2006) although his calculations also seem to ignore the costs described in point (ii) above.

exercise. Finally, the ratio of nb to GDP will be proxied by the ratio of short-term external debt to GDP: this was estimated to be 15% by Manase and Roubini (2009, table 2) in their study of the determinant of a debt crisis for a sample of 47 countries over 1970-2002.

Consider, first, the case, when $m = \frac{1}{n}$. In this case, clearly the expected recovery rate $K^* = 0.5$. Assuming that the risk-free interest rate r_f is 2.5%, it follows, using the representative creditor's participation constraint, that $1 + r^G = 1.1138$. By computation, it is checked that (i) for the debtor's incentive constraint to be satisfied, it must be true that $q^B - q^G = 0.6 \geq \frac{c^G}{Y-(1+r^G)nb} = 0.4363$, while (ii) for the debtor's participation constraint to be satisfied it must be true that $[1 - q^G] = 0.8 \geq \frac{c^G}{Y-(1+r^G)nb} = 0.4363$. It follows that with the unanimity rule, there is ex ante optimality, the debtor's incentive compatibility condition is satisfied and the project is undertaken, while, in the post-default game, there is no interim optimality as the project termination probability is one.

Next, we turn to the case where the interim optimal threshold prevails in the post-default game. In this case, the expected recovery rate $\hat{K} = 0.75$ under the assumption that γ follows the uniform distribution on $[0, 1]$. Again assuming that r_f is 2.5%, using the representative creditor's participation constraint, by computation, it follows that $1 + r^G = 1.1143$ while $1 + r^B = 1.5073$. By computation, it is checked that (i) for the debtor's incentive constraint not to be satisfied, it must be true that (using $\hat{P} = \frac{1}{2}$) $\frac{q^B - q^G}{2} = 0.3 < \frac{c^G}{Y-(1+r^G)nb} = 0.4377$, (ii) for the debtor's participation constraint not to be satisfied, it must be true that $Y - (1 + r^B)nb < 0 \Leftrightarrow \frac{Y}{GDP} - (1 + r^B)\frac{nb}{GDP} = -0.036 < 0$ and (iii) for the debtor's participation constraint to be satisfied it must be true that $[1 - q^G + \frac{q^G}{2}] = 0.85 \geq \frac{c^G}{Y-(1+r^G)nb} = 0.4377$. It follows that when the interim optimal threshold prevails in the post-default game, the debtor's incentive compatibility condition is not satisfied and the project is not undertaken even though there are payoff gains from doing so: there is no ex ante optimality.

We summarize the preceding computations in the following table:

	Unanimity CAC Threshold	*Interim Optimal CAC Threshold*
Recovery Rate	0.5	0.75
Pr. of successful debt rollover	0	0.5
$1 + r^G$	1.1138	1.1141
$1 + r^B$	n.a.	1.5073
Debtor's IC constraint satisfied?	Yes	No
Debtor's participation constraint conditional on G satisfied?	Yes	Yes
Debtor's participation constraint conditional on B satisfied?	n.a.	No
Ex ante optimal?	Yes	No

TABLE 1 Calibration Results

This simple calibration results reported in Table 1 provides a quantification of the trade-off between the ex ante and interim efficiency studied in Proposition 2. With improved creditor coordination due to strengthening CACs away from unanimity to the interim optimal threshold, the default payoffs of both the debtor and the creditor at the interim stage go up. Therefore, the debtor's ex ante incentives to put in good policy effort to avoid default are adversely affected and the debtor's incentive constraint is not satisfied. This pushes up the interest rate on sovereign debt via creditor's participation constraints, making it too costly for the debtor to undertake the ex ante Pareto improving project in the first place.

On the other hand, with unanimity, the ex ante incentive constraint of the sovereign debtor always holds; however, regardless of putting in the costly policy effort that lowers the probability of default, once default takes place all creditors would refuse to roll over debts with probability one resulting in an interim inefficient outcome. However, the interest rate on sovereign debt is now such that the debtor chooses to undertake the ex ante Pareto improving project.

Now suppose that the ratio of c^G to GDP is 0.5% instead of 1%. In this case, $\hat{P} = 0.5 < 1 - \frac{c^G}{(q^B - q^G)(Y-(1+r^G)nb)} = 0.6353$ so that interim optimal creditor coordination is compatible with debtor's incentive compatibility constraint. Moreover, the debtor's participation constraint is satisfied because $[1 - q^G + \frac{q^G}{2}] = 0.85 \geq \frac{c^G}{Y-(1+r^G)nb} = 0.2188$. It follows that, in this case, ex ante and interim efficiency are compatible, the case studied in Proposition 3.

How do we need to calibrate the parameters to ensure that there is no conflict between interim and ex ante efficiency.

Finally, note that as the threshold in the post-default game is decreasing in m and all the inequalities in our calibration exercise are strict, a slight strengthening CACs away from unanimity will always be efficiency improving as there will be a gain in interim efficiency without violating the incentive constraint of the debtor.

6 Policy discussion

A key question in the policy debate on reducing the costs of protracted sovereign debt restructuring in a sovereign debt crisis is: Would improving creditor coordination post-default alter the incentives of the sovereign debtor so that default becomes more likely in the first place? Our result that there is a potential trade-off between ex ante and interim efficiency as a consequence of strengthening CACs is one possible way to address this question. Clearly such a trade-off limits the potential efficiency gains from CACs and raises the question of whether there is a role for an appropriately designed formal sovereign bankruptcy procedure that addresses both ex ante and ex post issues.

In addition to improving creditor coordination and shifting some of the payoff losses to creditors via the threat of debt restructuring, two key additional elements in a sovereign bankruptcy procedure which are not also present in a market based approach such as strengthening CACs are:

(i) the ability of the sovereign debt restructuring court to make the debtor's payoff contractible ex ante[25];

[25] It is, in practice, difficult to establish a formal sovereign bankruptcy procedure if it requires the court to make the debtor's non-contractible payoffs realized at $t = 2$ to become contractible as it is only the sovereign debtor who usually has a private information about the non-contractible payoff not the court nor the private creditors.

(ii) the ability of the sovereign debt restructuring court to order a standstill conditional on default and obtain more information (the discovery process) about debtor's ex ante actions before restructuring is complete and thus make any final payments conditional on the ex ante policy effort of the sovereign debtor.

These two elements, in principle, simultaneously address issues of ex ante debtor moral hazard and interim creditor coordination and lead to more orderly sovereign debt restructuring (Sachs (1995), Buchheit and Gulati (2002) and Krueger (2001, 2002)). Ordering a temporary standstill addresses any concerns relating to creditor coordination by a temporary stay on creditor litigation. It allows for a discovery process where efforts are made to establish the underlying causes of default i.e. whether it was the negative exogenous shock or bad policy effort. If this reveals that the debtor had undertaken appropriate policy effort a debt restructuring – involving both lengthening debt maturities and writing down the value of the debt – could take place.

Of course, establishing ex ante contractibility over debtor payoffs, would be an additional instrument that can be deployed to directly addresses debtor incentives to undertake costly policy effort to reduce the probability of default: if the debtor was revealed not to have undertaken appropriate policy effort then he will be penalized with payoffs changed in ways that have already been agreed ex ante. The obvious practical problem of such an arrangement is that it involves waiving sovereign immunity ex ante (i.e. before a crisis occurs).

An alternative to a formal sovereign bankruptcy procedure might be establishing an agency that engineers a standstill while a discovery process is underway to determine the cause of the default. Once the cause is discovered and debt is restructured, creditors decide whether or not to rollover the restructured debt. We can use the calibration presented in Section 5.2 to illustrate the key role of credible discovery process even when debtor's payoffs are not contractible i.e. investigate what happens if the post-default equilibrium can be conditioned directly on the action chosen by the debtor. Assuming that the project is terminated with probability one if the debtor chooses B, and the interim optimal CAC threshold prevails if the debtor chooses G, the incentive compatibility constraint of the debtor is equivalent to requiring that $\left(q^B - q^G + q^G \hat{P}\right) = 0.7 \geq \frac{c^G}{(Y-(1+r^G)nb)} = 0.4377.$

This suggests that, even in the absence of establishing contractibility over debtor's payoffs, the conflict between interim and ex ante optimality may be mitigated in scenarios where the action chosen ex ante by the debtor can be observed before creditors make their decision to rollover outstanding debt.

7 Conclusion

In this paper, we examine the potential conflict between ex ante and interim efficiency as a consequence of strengthening CACs in the presence of both sovereign debtor moral hazard and creditor coordination under incomplete information. At the interim stage, we find that there are multiple Bayesian equilibria and strengthening CACs away from unanimity makes debt restructuring easier, resulting in a move towards interim efficiency: moreover, we characterize the interim efficient CAC threshold. However, we also show the robust possibility of a conflict between interim and ex ante efficiency as a consequence of strengthening CACs and we quantify the implications of such a trade off by a simple calibration exercise.

In further research we plan to explore the issue of an optimal sovereign debt restructuring procedure in greater detail and also extend the analysis reported here to examine the link between sovereign debt crisis and long-run growth.

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