**CENTRE FOR DYNAMIC MACROECONOMIC ANALYSIS**
**WORKING PAPER SERIES**

**CDMA07/11**

# Does Strengthening Collective Action Clauses (CACs) Help?*

Sayantan Ghosal
University of Warwick

Kannika Thampanishvong†
University of St Andrews

JUNE 2007
UPDATED OCTOBER 2007

**ABSTRACT**

We study the effect of strengthening CACs in a debt rollover model of a sovereign debt crisis. Conditional on default, there are multiple equilibria: the impact of strengthening CACs depends critically on the prevailing equilibrium. For a subset of equilibria, (i) given a fixed number of creditors, we derive an optimal CAC threshold and (ii) given a fixed CAC threshold, as the number of creditors becomes larger, we show a convergence to efficient information aggregation. Moreover, strengthening CACs may actually increase the ex ante probability of adverse shock. Our analysis makes the case for a formal sovereign bankruptcy procedure.

**Keywords:** Sovereign Debt, Bargaining, Coordination, Moral Hazard, Collective Action Clauses.
**JEL Classifications:** C72, C78, D82, F34

* We thank MarcusMiller and seminar participants atWarwick, RES Conference 2005 and EEA Conference 2006 for their helpful comments. The second author would like to thank the ORS, the CSGR and Department of Economics, University of Warwick for their financial supports. This research was partially funded by the ESRC project No. R000219236 "Moral Hazard and Financial Institution". This paper was previously circulated with the title 'Bargaining, Moral Hazard and Sovereign Debt Crisis'.

† Correspondence: School of Economics and Finance, University of St Andrews, St Andrews, KY16 9AL. Tel: +44(0)1334 462424; Fax +44(0)1334 462444; e-mail: kt30@st-andrews.ac.uk.

**CASTLECLIFFE, SCHOOL OF ECONOMICS & FINANCE, UNIVERSITY OF ST ANDREWS, KY16 9AL**
**TEL: +44 (0)1334 462445 FAX: +44 (0)1334 462444 EMAIL: cdma@st-andrews.ac.uk**
**www.st-andrews.ac.uk/cdma**

## 1 Introduction

Following Mexico's debt moratorium in 1982, there was a large-scale write-down under the Brady Plan and the market's response has been to switch from bank finance to bond-finance (Eichengreen and Portes, 1995). Typically, emerging markets issue New York bonds, which require the unanimous consent of all creditors to change any financial terms[1]. This requirement makes these sovereign debt contracts difficult to restructure (Roubini and Setser, 2003) thus substantially reducing the perceived risk of restructuring (Cline, 1984; Buchheit, 1999). However, a rash of emerging market liquidity crises during the 1990s, and the more recent Argentinian default, demonstrate that sovereign bonds, nevertheless, carry substantial default risk.

To reign back a seemingly unending series of bailouts[2], two principal mechanisms were considered: (a) an official Sovereign Debt Restructuring Mechanism (SDRM), based on Chapter 11 of the US bankruptcy code (Krueger, 2001) and (b) the market-driven adoption of Collective Action Clauses (hereafter, CACs[3]) in debt contracts as in the nineteenth cen-

[1] The financial terms are narrowly defined as payment dates and principal of the bond contract.

[2] The failure to bailout Russia in 1998 came as a shock to investors and sovereign risk premium rose to double figures.

[3] According to the current market practice, CACs consist of two main parts: the acceleration clauses and the majority restructuring provision. "The acceleration clauses are designed to limit the ability of a minority of bondholders in disrupting the restructuring process. According to these clauses, a vote by 25 percent of outstanding principal is needed to accelerate the claims and a vote of more than 50 percent is required to de-accelerate these claims. The majority restructuring provision allows a "qualified majority of bondholders of an issuance to bind all holders of that issuance to the financial terms of a restructuring, either before or after a default," (IMF, 2002, p.2). The majority restructuring provision enables the "maturity date, the amount of interest and principal, and the currency of payment to be modified by a vote of a qualified majority of bondholders," (IMF, 2002, p.4).

tury London capital market (Buchheit, 1999; Ghosal and Miller, 2003). The former has proved unpopular[4]. So CACs have been strongly promoted as a viable, market-driven alternative (Taylor, 2002), with Mexico taking a lead in early 2003 by issuing a $1 billion bond containing CACs in New York. Subsequently, other countries, such as South Korea, South Africa and Brazil, also issued bonds with CACs in New York.

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. In addition, empirical studies in this area provide a mixed results for the impact of CACs on interest rate premium. Eichengreen and Mody (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. 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. 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

[4] One reason why is that a formal sovereign bankruptcy procedure requires changing the Articles of Agreement of the IMF, a possibility which has been resisted by large borrowers and the US.

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.

Kletzer (2003), in a formal model of bargaining, has shown that strengthening CACs away from unanimity leads to welfare gains in post-default scenarios. Pitchford and Wright (2007) argue that introducing CACs increases welfare in post-default scenarios and has a net positive impact on welfare even after issues relating to debtor moral hazard are taken into account.

In this paper, we study the effect of strengthening CACs in an incomplete information debt rollover model of a sovereign debt crisis. In equilibrium scenarios where the actions of creditors do not depend on their privately observed signals, strengthening CACs away from unanimity eliminates the power of individual creditor holdouts. However, both situations where the debt rollover occurs with a probability zero or one are equilibria and strengthening CACs by itself does not determine which equilibrium creditors coordinate on. There is still a role for third parties (like the IMF or courts) or creditor coordination committees which are substitutes for CACs. Moreover, when the future net worth of the new one-period debt is low, the equilibrium where debt rollover occurs with a probability one is not necessarily interim efficient.

In equilibrium scenarios where individual creditor best responses are sensitive to her signals, coordination of actions across creditors depends on payoff relevant uncertainty. In such equilibrium scenarios, where creditors use threshold strategies, strengthening CACs does reduce crisis risk. Given a fixed number of creditors, we derive an interim optimal CAC threshold. However, we also show that given a fixed CAC threshold, as the number of creditors becomes larger[5], in equilibrium, there is a convergence to efficient information aggregation. For a fixed (and finite) number of creditors, given the strategy of other creditors, each creditor's decision to accept the debt rollover increases the probability of a successful debt rollover and therefore imposes an externality[6] on all other creditors. When the debt contract involves a large number of creditors, each creditor becomes small (relative to the group of creditors taken as a whole) and her marginal impact on the continuation probability of a successful debt rollover becomes zero. In the limit, there is an efficient information aggregation.

Taken together our results, in contrast to existing work, caution against concluding that strengthening CACs necessarily improves welfare in post-default interactions between the debtor and creditors. Our results imply that strengthening CACs is most effective in the scenarios with a small number of creditors but it is precisely in such scenarios that creditors will have access to other, perhaps more effective explicit coordination mechanisms (like the creditor committees).

With *ex ante* debtor moral hazard, in general, achieving both *ex ante* efficiency and interim efficiency may not be possible. Further, strength-

[5]In order to ensure that we compare like-for-like, per capita creditor payoffs are kept constant throughout the limiting argument.

[6]Given the number of creditors, whether this externality is negative (respectively, positive) depends on whether the fixed CAC threshold is above (respectively, below) the value of the interim optimal CAC threshold.

ening CACs may adversely impact the debtor's *ex ante* incentives and actually increase the *ex ante* probability of adverse shock.

Finally, we study the policy implications of our formal analysis. The IMF has an informational advantage in verifying the precise nature of policy effort undertaken by the debtor, and ensuring that bailouts help matters by sending out public signals so that creditors coordinate on the appropriate equilibrium in the debt rollover game. However, IMF bailouts could also have an adverse impact as the problem of creditor moral hazard might emerge.

An important element in our analysis is the conflict between *ex ante* efficiency and interim efficiency due to *ex ante* debtor moral hazard. A limitation of CACs is that it cannot address *ex ante* issues. This 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. We outline such a procedure.

The remainder of the paper is structured as follows. The next subsection discusses related literature. In section 2, we study the debt rollover in the debt rollover game with incomplete information. In section 3, we show how the probability of adverse shock can be endogenized by studying the *ex ante* debtor moral hazard. Section 4 is devoted to policy issues while section 5 concludes. Some of the more technical materials are reported in the appendix.

## 1.1 Related literature

Kletzer (2004b), 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. Some of our results are very different. First, we show that the effect of strengthening CACs depends critically on which equilibrium prevails in the debt rollover game. Second, when strengthening CACs has a positive impact, we derive an optimal CAC threshold. In Kletzer and Wright (2000), a higher probability of disagreement has a higher impact on the debtor willingness to pay. In a related work, Eichengreen et al. (2003) 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. We show that a positive crisis risk is necessary for resolving the incentive issues related to *ex ante* debtor moral hazard and that in general, there is a conflict between *ex ante* and interim efficiency. While in Gai et al. (2004), Roubini and Setser (2004) and Tanaka (2006) the crisis cost is exogenous to the mechanism of debt write-down, in our model, the crisis cost is endogenous through the threat of having an endogenously generated interim crisis risk.

Weinschelbaum and Wynne (2005) study how CACs determine debtor country' governments' fiscal incentives, bond yields and probability of default. Their empirical results have already been noted. In their theoretical model, they show that CACs are useful in coordinating creditors within the same jurisdiction. Strengthening CACs lowers the cost of restructuring debt. However, strengthening CACs can also have an impact on the debtor government's incentive to run reckless fiscal policies that increase the possibility of crisis.

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 adverse shock and the probability of a debt crisis, conditional on default. In contrast, here while the maturity structure of debt is taken as given, both the probability of adverse shock and the probability of debt crisis, conditional on default, are endogenous.

Our results are consistent with the empirical studies, which support the ambiguous effects of CACs. Eichengreen and Mody (2000, 2004) conduct empirical investigations basing on the primary market yields and conjecture that the credit rating of the issuer matter. This result is confirmed by Eichengreen et al. (2003) who expand the data to include both primary and secondary market yields. Using data for both primary and secondary market yields, Becker et al. (2003), however, report that the use of CACs in a bond issue did not increase the cost of borrowing for that particular bond. Richards and Gugiatti (2003) find that CACs do not have a significant impact on bond pricing in the secondary market. Our model predicts that strengthening CACs will reduce borrowing costs for issuer with high credit rating only when it lowers interim crisis risk. Our analysis of the efficacy of various policy interventions is related to Rodrik (1998) who suggests that, when financing development by issuing bonds exposes the country to excessive crises, the unrestricted use of such debt instruments should be limited.

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, in contrast, 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[7].

# 2 Debt rollover with incomplete information

## 2.1 The model

There are three time periods, $t = 0, 1, 2$. At $t = 0$, a sovereign debtor embarks on a project which is financed by bonds, each with a face value of $b$, issued at $t = 0$. The two-period bonds are sold to $n$ identical private creditors. The promised return for each private creditor is $r$ at $t = 1$ and $(1 + r)$ at $t = 2$. For future reference, note that all payoffs are denoted in $t = 1$ units.

We assume that the sovereign debtor's capacity to service the existing debt at $t = 1$ is determined by the fiscal resources not already committed elsewhere. Suppose, for the moment, that at $t = 1$ there is an exogenous and unanticipated (at $t = 0$) shock[8] so that the available fiscal resources

[7] There are, of course, other technical differences. We look at a model with a finite number of creditors (although we do study the limit of Bayesian equilibria as the number of creditors becomes large). In our model, the (privately observed) signalling has finite support.

[8] An example of such adverse shock could be a devaluation when sovereign debt is denominated in dollars. Later in this paper, we extend the model to endogenize the probability of adverse shock and allow creditors to anticipate such shock with a correct probability.

are less than the payment due to creditors, $rnb$. This triggers a "technical default" at $t = 1$.

Conditional on default at $t = 1$, the debtor issues a new one-period bond rolling over the outstanding interest and capital owed in the existing two-period bond. Simultaneously, each private creditor decides whether or not to roll over, i.e. accepting the new one-period debt issued by the debtor. If the proportion of creditors who reject the debt rollover exceeds the critical CAC threshold, a "sovereign debt crisis" occurs[9]

Built into the existing two-period sovereign debt contract is a 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[10]. In general, increasing $m$ is equivalent to strengthening CACs, which would make debt rollover easier. Moreover, since all the private creditors are *ex ante* symmetric, by invoking the doctrine of pari passu, we will assume that any offer made by the debtor treats each creditor symmetrically.

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

[9] It is important to note the distinction between a technical default and a sovereign debt crisis. A *technical default* occurs when the sovereign debtor is unable to pay the promised returns to the private creditors in the first period due to the occurrence of an adverse shock. Conditional on default, debt rollover game takes place and each creditor decides whether to accept the debt rollover. A *sovereign debt crisis* only occurs when a sufficiently large number of creditors decide not to roll over the debts.

[10] Consider the case when $m = \frac{1}{n}$. In this case, a decision of only one private creditor not to roll over the short-term debts is sufficient for the project to be terminated. This is, in fact, equivalent to requiring a unanimity in the debt rollover decision.

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 normalized per capita creditor payoffs, the amount owed by the debtor to each creditor at $t=2$ is 1.

Conditional on default at $t=1$, the normalized per capita creditor payoffs are determined by $\gamma$ where $\gamma \in [0,1]$ is the actual worth of the new one-period bond issued by the debtor so that $\gamma(1+r)^2 b$ is the amount actually paid out by the debtor at $t=2$. The (prior) probability over $\gamma$ is given by some continuous probability density function $f(.)$ (with $F(.)$ being the associated cumulative probability distribution).

Conditional on default at $t=1$, there is incomplete information: each private creditor $i$ receives a privately observed signal $\sigma^i \in \{\gamma-\varepsilon, \gamma+\varepsilon\}$ of the true value of $\gamma$ where $\varepsilon > 0$ but small. Specifically, $\varepsilon < \bar{\varepsilon}$, $\bar{\varepsilon} > 0$ and $\bar{\varepsilon} < \frac{1}{K}$ for large but finite $K > 2$. Conditional on $\gamma$, for each $i$, $\sigma^i$ is i.i.d. over $\{\gamma-\varepsilon, \gamma+\varepsilon\}$ according to the distribution $\left\{\frac{1}{2}, \frac{1}{2}\right\}$[11].

We label an individual private creditor by $i$, where $i = 1, ..., n$. Each creditor privately observes a signal $\sigma$. Conditional on $\sigma$, each creditor chooses an action $a^i(\sigma) \in \{\text{Accept } (A), \text{Reject } (R)\}$. A strategy of the creditor $i$ is a map that specifies an action for each $\sigma$. Conditional on $\boldsymbol{\sigma} = (\sigma^1, ..., \sigma^n)$, let $a(\boldsymbol{\sigma}) = (a^1(\sigma^1), ..., a^n(\sigma^n))$. For each $\sigma$, let $\tilde{n}_a(\sigma) = \#\{i : a^i(\sigma) = R\}$ denote the number of private creditors who choose to reject the debt rollover when the value of the signal is $\sigma$. Given $\gamma$, let $n_a(\gamma) = \tilde{n}_a(\gamma-\varepsilon) + \tilde{n}_a(\gamma+\varepsilon)$ denote the number of creditors who reject the debt rollover. Conditional on $\gamma$, in order to determine each

[11] Of course, 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.

creditor $i$'s payoffs, there are two scenarios to be considered:

1. $n_a(\gamma) \geq mn$. In this scenario, the private creditors successfully reject the debt rollover, a debt crisis occurs and litigation ensues. If $a^i(\sigma) = R$, the normalized per capita creditor payoff is $g$ while if $a^i(\sigma) = A$, the normalized per capita payoff to creditor $i$ is $l$, where $g > l$[12].

2. $n_a(\gamma) < mn$. In this scenario, the debt rollover is successful. If $a^i(\sigma) = R$, the normalized per capita creditor payoff is $\gamma - \varphi$, while if $a^i(\sigma) = A$, the normalized per capita payoff to creditor $i$ is $\gamma$, where $\varphi$ is the privately borne legal cost for the individual creditor who rejects the debt rollover but whose attempt is unsuccessful. We assume that $l > \varphi$, i.e. the payoff to any individual creditor of being a second mover in the asset grab race is higher than the privately borne legal cost from an unsuccessful attempt to stop the debt rollover.

Conditional on default, after observing her private signal, each creditor simultaneously decides whether or not to accept the debt rollover.

We study the Bayesian equilibria of this game. In most policy discussions, and in our model, 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[13] the equilibrium crisis risk is interim efficient[14].

[12] Let $g = \alpha - \frac{L'}{(1+r)b}$, while $l = \beta - \frac{L''}{(1+r)b}$, where (a) the parameters $\alpha$ and $\beta$ denote the liquidation payoffs (expressed as a proportion of $(1+r)b$) to creditors with $0 < \alpha < 1$, $0 < \beta < 1$ and $\alpha > \beta$ and (b) $L'$ and $L''$ denote the privately borne legal cost of entering into the asset grab race. The assumption $g > l$ implies that $\alpha > \beta$ and $L'' > L'$ which we interpret as the first-mover advantage in the asset grab race which ensues when the debt rollover is rejected.

[13] The first-best benchmark corresponds to the case with complete information about the future net worth of the new one-period debt.

[14] From an *ex ante* viewpoint, the relevant welfare comparison would have to take

## 2.2 Creditor coordination and CACs

We study two different equilibrium scenarios, one where the actions of creditors do not depend on their privately observed signals and the other where they do.

We begin by noting an extreme form of coordination failure between creditors: conditional on default, it is always an equilibrium for all creditors to choose not to roll over irrespective of their signals. As long as $m < \frac{n-1}{n}$, if $n-1$ creditors reject the debt rollover, then the remaining creditor will also reject the debt rollover. Evidently, in such a scenario, strengthening CACs will have no effect on the debt rollover.

At the other extreme, when $m > \frac{1}{n}$, there is also always an equilibrium where the debt is rolled over with a probability one. Indeed, if all other creditors agree to a debt rollover (i.e. accept the new one-period bond issued by the sovereign debtor after a technical default occurs at $t = 1$), a deviation by an individual creditor cannot terminate the debt rollover. Note that such an equilibrium persists even when the signal observed by an individual creditor, $\sigma$, is close to zero.

It follows that for each $\gamma \in [0, 1]$ and privately observed signal $\sigma$, 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 both Bayesian equilibria. Therefore, starting from a situation where $m = \frac{1}{n}$, increasing $m$ (which is equivalent to strengthening CACs away from unanimity to remove the possibility of an individual

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. Unless explicitly stated otherwise, we assume that in the first-best *ex ante* scenario, the project will be funded.

creditor holdout) implies that a new equilibrium where debt rollover occurs with a probability one exists.

However, even here strengthening CACs by itself does not necessarily lead to the resolution of a sovereign debt crisis: there is still a role for third parties (like the IMF or courts) or creditor coordination committees to ensure that creditors coordinate on the equilibrium where the debt rollover occurs with a probability one.

Furthermore, there is no reason why, for low values of $\gamma$ and hence, $\sigma$, the equilibrium where debt rollover occurs with a probability one is efficient.

Next, we show that there are other equilibria where creditors choose threshold strategies i.e. a creditor rejects the debt rollover as long as her privately observed signal is below a certain threshold. For such equilibria, creditor coordination depends on payoff relevant uncertainty.

Suppose all creditors use a symmetric threshold strategy so that for some $\bar{\gamma} \in [0,1]$, whenever $\sigma \geq \bar{\gamma}$, creditor $i$ rolls over, but whenever $\sigma^i < \bar{\gamma}$, creditor $i$ does not roll over. Let us denote such a strategy configuration by $a_{\bar{\gamma}}$. Conditional on observing $\sigma$, let $E_R^m(\sigma, a_{\bar{\gamma}})$ denote creditor $i$'s expected payoff from not agreeing to the debt rollover and $E_A^m(\sigma, a_{\bar{\gamma}})$ denote creditor $i$'s expected payoff from agreeing to a debt rollover. Note that when creditor $i$ is choosing a best response, (a) whenever $E_R^m(\sigma, a_{\bar{\gamma}}) - E_A^m(\sigma, a_{\bar{\gamma}}) > 0$, creditor $i$ does not agree to the debt rollover, (b) whenever $E_R^m(\sigma, a_{\bar{\gamma}}) - E_A^m(\sigma, a_{\bar{\gamma}}) \leq 0$, creditor $i$ agrees to the debt rollover[15].

[15] In the main body of the paper, we have assumed, for simplicity, that a creditor always agrees to the debt rollover if she is indifferent between agreeing and not agreeing to the debt rollover. The general case where each creditor $i$ rolls over

Given the strategies of other creditors, conditional on observing a signal $\sigma$, 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 any private creditor $i$, given $m$, if all other private creditors $k \neq i$ are following a symmetric threshold strategies $a_{\bar{\gamma}}$, and creditor $i$ observes a signal $\sigma = \bar{\gamma}$, let $f_{\bar{\gamma}}(j, \bar{\gamma})$ [16] denote the probability that exactly $j$ other creditors (from a population of $n-1$ other creditors) do not agree to the debt rollover. Given a threshold strategy $\bar{\gamma}$, notice that $\{f_{\bar{\gamma}}(j, \bar{\gamma})\}_{j=0}^{n-1}$ is a symmetric binomial distribution and by computation, for two different threshold strategies $\bar{\gamma}$ and $\bar{\gamma}'$, $f_{\bar{\gamma}}(j, \bar{\gamma}) = f_{\bar{\gamma}'}(j, \bar{\gamma}') = \binom{n-1}{j}\left(\frac{1}{2}\right)^n = f(j)$, i.e. the distribution $\{f_{\bar{\gamma}}(j, \bar{\gamma})\}_{j=0}^{n-1}$ is identical to the distribution $\{f_{\bar{\gamma}'}(j, \bar{\gamma}')\}_{j=0}^{n-1}$.

Next, we compute creditor $i$'s expected payoffs under two cases: (i) when she agrees to the debt rollover and (ii) when she does not agree to the debt rollover. Let[17] $n(m) = \max\{0, mn-2\}$. For any private creditor $i$, given $m$, if all other private creditors $k \neq i$ are following a symmetric threshold strategies $a_{\bar{\gamma}}$, conditional on observing the signal $\sigma = \bar{\gamma}$, creditor $i$'s expected payoff from not agreeing to the debt rollover is given by the expression $E_R^m(\bar{\gamma}, a_{\bar{\gamma}}) = g \sum_{j=mn-1}^{n-1} f(j) + [\bar{\gamma} - \varphi] \sum_{j=0}^{n(m)} f(j)$, while creditor $i$'s expected payoff from agreeing to the debt rollover is given by the expression $E_A^m(\bar{\gamma}, a_{\bar{\gamma}}) = l \sum_{j=mn}^{n-1} f(j) + \bar{\gamma} \sum_{j=0}^{mn-1} f(j)$. Notice that both $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$ and $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ are increasing linear functions of $\bar{\gamma}$

the debt with probability $v$ and does not roll over with probability $(1-v)$, where $0 \leq v \leq 1$, is straightforward but is computationally tedious. All computations for the general case are reported in Appendix A.

[16] The exact expression for $f_{\bar{\gamma}}(j, \bar{\gamma})$ is contained in Appendix A.

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

and the slope of $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ is steeper than the slope of $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$. When $\bar{\gamma}$ is close to zero, $E_R^m(\bar{\gamma}, a_{\bar{\gamma}}) > E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ as long as $\varphi$ is small enough. It follows that there is a $\bar{\gamma}_m^* > 0$ such that $E_R^m\left(\bar{\gamma}_m^*, a_{\bar{\gamma}_m^*}\right) - E_A^m\left(\bar{\gamma}_m^*, a_{\bar{\gamma}_m^*}\right) = 0$ and whenever $\bar{\gamma}_m^* \leq 1$, $\bar{\gamma}_m^*$ is a Bayesian equilibrium threshold; it is interior when $\bar{\gamma}_m^* < 1$. A Bayesian interior equilibrium threshold is depicted in figure 1 below.

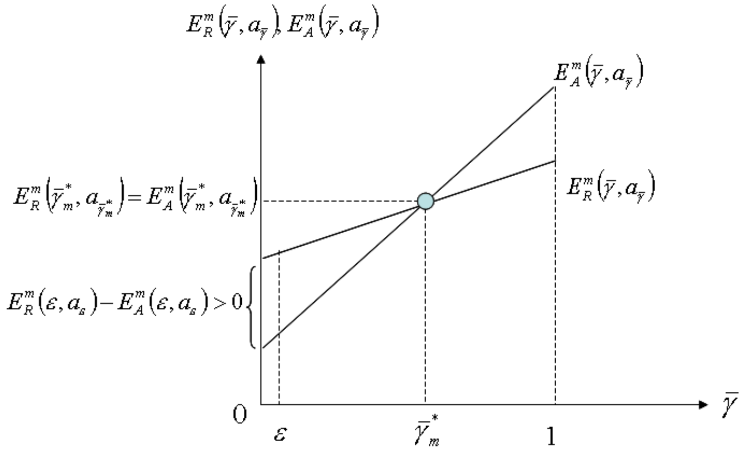


Figure 1: A Bayesian interior equilibrium threshold

For later reference, by computation, note that the expression for $\bar{\gamma}_m^*$ is given by

$$\bar{\gamma}_m^* = g + \frac{(g-l)\sum_{j=mn}^{n-1} f(j) - \varphi \sum_{j=0}^{n(m)} f(j)}{f(mn-1)}. \tag{1}$$

What is the impact of strengthening CACs? Strengthening CACs (equivalently, increasing $m$) increases the proportion of private creditors required to prevent a successful debt rollover. We find that the impact of strengthening CACs depends *critically* on the prevailing equilibrium in the debt rollover game. For the Bayesian equilibria with extreme coordination failure, as previously discussed, strengthening CACs has no impact. However, when there is an interior Bayesian equilibrium threshold, $\bar{\gamma}_m^*$, it is possible to show that $\bar{\gamma}_m^*$ is decreasing in $m$. Figure 2 below depicts how the graphs of $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$ and $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ change with $m$ (again detailed derivations are contained in Appendix A). As $m$ increases, the events where there is a successful debt rollover have a higher probability. By using the expressions for creditor payoffs, it follows that, as $m$ increases, (a) below $l$, $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ decreases in value while, above $l$, $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ increases in value, i.e. the graph of $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ becomes steeper (when $m$ increases) and (b) below $g + \varphi$, $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$ increases in value while above $g+\varphi$, $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$ decreases in value i.e. the graph of $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$ becomes flatter (when $m$ increases). Thus, for higher values of $m$, the point of intersection between $E_R^m(\bar{\gamma}, a_{\bar{\gamma}})$ and $E_A^m(\bar{\gamma}, a_{\bar{\gamma}})$ now must be lower in value. It, therefore, follows that strengthening CACs reduces crisis risk. Figure 2 illustrates.

Next, we ask whether the interim crisis risk is inefficiently high or inefficiently low. Interim efficiency corresponds with the situation when there is a complete information about $\gamma$. Interim efficiency requires that the private creditor should only not agree to the debt rollover if her payoff when debt rollover is successful (thus project continues to completion at $t = 2$), given by $\gamma$, is less than or equal to the payoff she receives from being the first mover in the asset grab-race that ensues when debt rollover is unsuccessful (thus project is liquidated at $t = 1$), given by $g$. Therefore, the requirement for interim efficiency is that

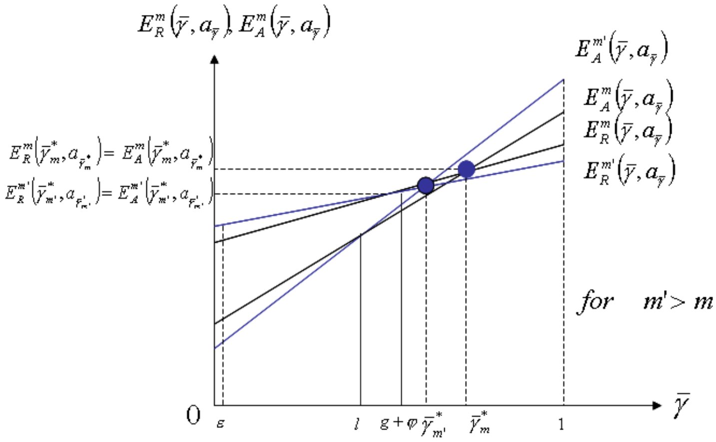


Figure 2: Impact of strengthening Collective Action Clauses

$\gamma \leq g$.

With incomplete information about $\gamma$ (which is the case we consider here) and under our assumptions, a creditor's expected payoff from a successful debt rollover is the expected value of $\gamma$ conditional on her privately observed signal $\sigma$: this is simply equal to $\sigma$. In general, Bayesian equilibria where the actions of creditors do not depend on their privately observed signals cannot be efficient. When creditors use threshold strategies, using the expression derived for $\bar{\gamma}_m^*$, by computation, for a fixed $n$, our results show that when $m = \frac{1}{n}$, $\bar{\gamma}_m^* > g$, while when $m = 1$, $\bar{\gamma}_m^* < g$. Correcting for integer effects, there exists a value of $m$, called $\hat{m}$, for which $\bar{\gamma}_{\hat{m}}^* = g$. Thus, for a fixed $n$, $\hat{m}$ is the interim optimal CAC threshold.

Next, for a fixed $m$, we study what happen to the interior Bayesian equilibrium threshold, $\bar{\gamma}_m^*$, when $n$ becomes infinitely large[18]. We show

[18] We assume that all the per capita payoff variables like $g$, $l$ and $\gamma$ are held fixed in the limiting argument.

that for all $0 < m < \frac{1}{2}$ (and symmetrically, for all $\frac{1}{2} < m < 1$), as $n \to \infty$, $\bar{\gamma}_m^* \to g$. It follows that the larger the number of creditors, the smaller is the inefficiency associated with a Bayesian equilibrium in threshold strategies and in the limit, the inefficiency vanishes.

The formal arguments underlying this result relies on a version of the central limit theorem and is quite technical. We, therefore, present these arguments in Appendix B. Here we point out that the efficiency is obtained in the limit due to efficient information aggregation. For a fixed $n$, given the strategy of other creditors, each creditor's decision to accept the debt rollover increases the probability of a successful debt rollover and therefore imposes an externality on all other creditors. As already pointed out, given the number of creditors, whether this externality is negative (respectively, positive) depends on whether the fixed CAC threshold is above (respectively, below) the value of the interim optimal CAC threshold, $\hat{m}$. As $n \to \infty$, each creditor becomes small (relative to the group of creditors taken as a whole) thus her marginal impact on the continuation probability of a successful debt rollover becomes zero and there is an efficient information aggregation.

The following proposition summarizes the efficiency result obtained here.

**Proposition 1** (Efficiency) *(i) Strengthening CACs (increasing $m$, for a fixed $n$) reduces crisis risk i.e. $\bar{\gamma}_m^*$ is decreasing in $m$ and we derive an interim optimal CAC threshold $\hat{m}$. (ii) For all $0 < m < \frac{1}{2}$ (and symmetrically, for all $\frac{1}{2} < m < 1$), as $n \to \infty$, $\bar{\gamma}_m^* \to g$ i.e. strengthening CACs works only when $n$ is not too large as we find that, for a fixed value* *of the CAC threshold of $m > 0$, $m < 1$, the larger the number of creditors (higher $n$), the smaller is the inefficiency associated with a Bayesian equilibrium in threshold strategies and, in the limit (as $n \to \infty$), the inefficiency vanishes.*

We interpret Proposition 1 as casting doubt on the efficacy of strengthening CACs in resolving sovereign debt crisis. With a fixed number of creditors, when creditors use threshold strategies, CACs do improve interim efficiency of a debt rollover and it is possible to derive an optimal CAC threshold. However, for any fixed CAC threshold, as the number of creditors becomes larger, the inefficiency associated with an equilibrium in threshold strategies becomes smaller and vanishes in the limit. Proposition 1 suggests that CACs are most effective in scenarios with a small number of creditors but it is precisely in such scenarios that creditors will have access to other, perhaps more effective explicit coordination mechanisms (like creditor committees).

## 3 Ex ante debtor moral hazard

There are two main motivations for studying *ex ante* debtor moral hazard. First, we would like to endogenize the probability of adverse shock. Second, we want to rule out the possibility of long-term bullet debt contracts maturing at $t = 2$. In principle, the presence of long-term bullet debt contracts maturing at $t = 2$ could be welfare improving in that it would rule out interim inefficient creditor coordination. With *ex ante* debtor moral hazard, a positive crisis risk, conditional on default, is a necessary condition for resolving debtor's *ex ante* incentives. Therefore, long-term bullet debt contracts will not to be used with *ex ante* debtor moral hazard.

We denote the *ex ante* action of the debtor by $a_0$, where $a_0 \in \{G, B\}$ and $G$ and $B$ denote good and bad *ex ante* effort by the debtor, respectively[19]. We assume that $c^{a_0} \in \left\{c^G, c^B\right\}$ denote the cost of effort, measured in $t = 1$ payoff units. We also assume that it is more costly for the debtor to exert good effort than to choose bad effort so $c^G > c^B$. Let $p^{a_0}$ denote the *ex ante* probability of adverse shock when the *ex ante* action $a_0 \in \{G, B\}$ is chosen by the debtor. We assume that the probability of adverse shock is higher if the debtor chooses bad effort so $p^B > p^G$. If there is no adverse shock or if there is a successful debt rollover at $t = 1$, the debtor obtains a non-contractible payoff $Z > 0$[20]; otherwise, the debtor obtains a payoff of zero. We also 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[21]. We will also assume that the *ex ante* optimality requires that the debtor chooses $a_0 = G$.

As a function of the equilibrium threshold $\bar{\gamma}_m^*$ prevailing in the debt

[19] In this context, good effort could correspond to a situation where money is borrowed and used to promote R&D in the export sector and bad effort could correspond to transferring borrowed money to local elites who are then free to put it in tax havens overseas. Refer to Ghosal and Miller (2003) for more examples on *ex ante* debtor moral hazard and for other relevant results.

[20] Following Eaton and Gersovitz (1981), we interpret this non-contractible payoff as the benefit at $t = 1$ of gain in national output at $t = 2$ when a debt crisis is prevented at $t = 1$. Another example of such non-contractible payoff can be described as follows. Suppose the funds borrowed by the sovereign are used to finance a publicly operated infrastructure project. If the infrastructure project succeeds, the government enjoys the prospect of higher tax revenue as more domestic and foreign firms invest and employment is generated. No private creditor can attach the future tax revenues generated by the infrastructure project.

[21] For instance, it takes time for 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.

rollover game, let $b(\bar{\gamma}_m^*)$ denote the debtor's expected payoff conditional on default, measured in $t = 1$ payoff units. The debtor's payoff from choosing a good effort is given by the expression $(1 - p^G)Z + p^G b(\bar{\gamma}_m^*) - c^G$, while the debtor's payoff from choosing a bad effort is given by the expression $(1 - p^B)Z + p^B b(\bar{\gamma}_m^*) - c^B$. The incentive compatibility constraint, which ensures that the sovereign debtor chooses good effort, is determined by the following expression

$$(1 - p^G)Z + p^G b(\bar{\gamma}_m^*) - c^G \geq (1 - p^B)Z + p^B b(\bar{\gamma}_m^*) - c^B \qquad (2)$$

This yields an upper bound on $b(\bar{\gamma}_m^*)$ namely

$$b(\bar{\gamma}_m^*) \leq Z + \frac{(c^B - c^G)}{(p^B - p^G)}. \qquad (3)$$

Since we assume that $c^B < c^G$ and $p^G < p^B$, $\left[\frac{(c^B - c^G)}{(p^B - p^G)}\right] < 0$. As $b(\bar{\gamma}_m^*) \geq 0$, if $Z + \frac{(c^B - c^G)}{(p^B - p^G)} < 0$, there is no solution to the debtor's *ex ante* incentive problem. On the other hand, if $Z > \frac{c^G - c^B}{p^B - p^G}$, a solution is possible.

Suppose $Z > \frac{c^G - c^B}{p^B - p^G}$ so that a solution to the debtor's *ex ante* incentive problem is possible. Let $\bar{\gamma}^{eff.}$denote the interim efficient equilibrium threshold in the debt rollover game. If $b(\bar{\gamma}^{eff.}) > Z + \frac{(c^B - c^G)}{(p^B - p^G)}$, interim efficiency and *ex ante* efficiency are incompatible. By computation, $b(\bar{\gamma}^{eff.}) = (1 - F(\bar{\gamma}^{eff.} + \varepsilon))Z +$

$\left[F(\bar{\gamma}^{eff.} + \varepsilon) - F(\bar{\gamma}^{eff.} - \varepsilon)\right] [\Pr_{\hat{m}} Z]$, where $\Pr_{\hat{m}}$ is the probability of a successful debt rollover at the interim efficient CAC threshold, $\hat{m}$. Note that $b(1) = 0$ (the debtor's payoff from an unsuccessful debt rollover) and clearly, as long as $Z > 0$, $b(\bar{\gamma}^{eff.}) > b(1)$. More generally, by computation, it is checked that $b(\bar{\gamma}_m^*)$ is decreasing in $\bar{\gamma}_m^*$. Therefore, if $b(\bar{\gamma}^{eff.}) > Z + \frac{(c^B - c^G)}{(p^B - p^G)} > 0$, there will be an equilibrium threshold in the debt rollover game that ensures *ex ante* efficiency but necessarily requires interim inefficiency. Clearly, strengthening CACs so that $\bar{\gamma}_m^*$ converges to $\bar{\gamma}^{eff.}$ can actually increase the probability of adverse shock.

We summarize the above discussion with the following proposition:

**Proposition 2** *With ex ante debtor moral hazard, a positive interim crisis risk, conditional on default, is necessary to solve the debtor's ex ante incentives. In general, there is a conflict between interim and ex ante efficiency. Strengthening CACs may actually increase the ex ante probability of adverse shock.*

# 4 Evaluating policy interventions

## 4.1 IMF intervention as a public signal

In the previous sections, we have shown that the *ex post* policy intervention, such as strengthening CACs, depends critically on which equilibrium prevails in the debt rollover game. Typically, the IMF has an informational advantage over private creditors because the IMF can verify the precise nature of the policy effort undertaken by the debtor. When there is a technical default, conditional on putting in place appropriate structural adjustment effort, the IMF usually provides loans[22] to the debtor so that her debt servicing obligation can be met in the first period. Our model suggests that if, in addition, the IMF conditions its

[22] These loans are used by the debtor to pay off its existing creditors. According to Fischer (2001) and Miller and Zhang (2000), the IMF is effectively gamed into providing bailouts in order to avoid the disorderly default by the sovereign debtor.

support on the outcome of the debt rollover game, any such intervention will have a bigger marginal impact on the incentives of the debtor to choose higher policy effort.

Conditional on the technical default, any announcement by the IMF serves as a public signal to the creditors. Why should this help? In the debt rollover game, the creditors can use this public signal to coordinate on the appropriate equilibrium. However, it is important to note that IMF intervention might, at the same time, give rise to the problem of creditor moral hazard as, with bailout, each creditor is now effectively insured against the possibility of default.

## 4.2 A sovereign bankruptcy procedure

In our model, we have assumed that the sovereign debtor obtains a payoff in the second period if the project continues to completion and such payoff is non-contractible[23]. An important element in our analysis is the conflict between *ex ante* efficiency and interim efficiency due to *ex ante* debtor moral hazard. A limitation of CACs is that it cannot address *ex ante* issues. This 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. The key element of such procedure relies on the ability of the court in making the debtor's non-contractible payoff becomes contractible *ex ante*[24]. With those elements

[23]Such payoff determines the debtor's incentive to bargain with the private creditors in the first period.

[24]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.

being embedded to it, such appropriately designed sovereign bankruptcy procedure is useful in solving the problem of *ex ante* debtor moral hazard and leading to more orderly sovereign debt restructuring. In fact, this view has also been shared by several authors, including Sachs (1995), Buchheit and Gulati (2002) and Krueger (2001, 2002).

In what follows, we outline a formal sovereign bankruptcy procedure similar to the SDRM outlined by Anne Krueger of the IMF (Krueger, 2001). First, such a formal sovereign bankruptcy procedure would require establishing an international sovereign bankruptcy court. Second, such a court will need to ensure (and the sovereign debtor to credibly commit to) some 'contractibility' on sovereign debtor's non-contractible payoffs (realized at $t = 2$) and that some foreign interest payments and loans could be diverted in favor of creditors as part of the bargaining process. Third, following an adverse shock, when a technical default occurs, the bankruptcy court would order a 'standstill', which legitimizes the suspension of payments and protects the debtor from litigation (by 'vultures') that might inhibit debtor-creditor negotiations (Miller and Zhang, 2000). The standstill would provide a breathing space for a 'discovery phase', a period when the bankruptcy court tries to discover the future net worth, $\gamma$, of any restructured debt. Let $\hat{\tau}$ denote the payoff measured in period $t = 1$ units which makes each private creditor indifferent between investing in the project and the risk-free security. Finally, during the resolution phase, the court would enforce a transfer $\hat{\tau} - \gamma$ to each creditor. When $\hat{\tau} - \gamma \leq \frac{Z}{n}$, then using the debtor's payoffs, both capacity to repay at $t = 1$ and the future payoff realized at $t = 2$, is enough to guarantee participation by creditors in the market for sovereign debt. On the other hand, when $\hat{\tau} - \gamma > \frac{Z}{n}$, either the court would have to order a debt restructuring or a debt write-down.

To summarize, first, note that any payments made in the resolution phase can be made conditional on the policy effort undertaken by the debtor. Second, since this particular formal sovereign bankruptcy procedure makes some of the debtor's non-contractible future payoff become contractible *ex ante*, it is useful in solving the *ex ante* debtor moral hazard.

## 5 Conclusion

We develop a model of sovereign debt crisis when lending takes place through the bond markets. We study the interaction between inefficiencies in the debt rollover game and *ex ante* debtor moral hazard. Conditional on a technical default, there are multiple, interim inefficient equilibrium outcomes and the impact of strengthening CACs depends on the prevailing equilibrium. For a subset of equilibria, (i) given a fixed number of creditors, we derive an optimal CAC threshold and (ii) given a fixed CAC threshold, as the number of creditors becomes larger, we show that there is a convergence to efficient information aggregation.

With *ex ante* debtor moral hazard, a positive interim crisis risk, conditional on default, is necessary to solve the debtor's *ex ante* incentives and in general, there is a conflict between *ex ante* efficiency and interim efficiency. Our analysis makes the case for a formal sovereign bankruptcy procedure.

Extending the model to a dynamic setting to study the interaction between sovereign debt crisis and endogenous growth is an important topic for future research.

## Appendix

In this Appendix, we present the missing parts of our discussion in the main text. Appendix A and B are devoted for the detailed proofs of our arguments in the debt rollover game, given in section 2.2. In Appendix A, we derive Bayesian equilibria for the general case when a creditor agrees to the debt rollover with probability $v$, $0 \leq v \leq 1$, if she is indifferent between accepting or rejecting the debt rollover. In Appendix B, we study the impact of increasing $n$, for a fixed $m$, on the interior Bayesian equilibrium threshold. In other words, for a generic $m > 0$, $m < 1$, what happen to $\bar{\gamma}_m^*$ as $n \to \infty$?

*Appendix A*

For any private creditor $i$, given $v$ and $m$, if all other private creditors $k \neq i$ are following a symmetric threshold strategies $a_{\bar{\gamma}}$, and creditor $i$ observes a signal $\sigma$, let $f_{\bar{\gamma}}(v, j, \sigma)$ denote the probability that exactly $j$ other creditors do not agree to the debt rollover given that creditor $i$ observes a private signal $\sigma$. By computation, note that for given threshold strategies $\bar{\gamma}$ and $\bar{\gamma}'$, the expression for $f_{\bar{\gamma}}(v, j, \bar{\gamma})$ is

$$\left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n}\right] v^{n-1-j} + \left(\frac{1}{2}\right)\sum_{k=0}^{j-1}\left[\binom{n-1}{k}\left(\frac{1}{2}\right)^{n-1}\right]\binom{n-1-k}{j-k}(1-v)^{j-k}\, v^{n-1-j}$$
$$+\left(\frac{1}{2}\right)\sum_{k=j+1}^{n-1}\left[\binom{n-1}{k}\left(\frac{1}{2}\right)^{n-1}\right]\binom{k}{j}(1-v)^{j}\, v^{k-j} + \left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n}\right](1-v)^{j},$$

and therefore for two different thresholds $\bar{\gamma}$ and $\bar{\gamma}'$, the distribution $\{f_{\bar{\gamma}}(v, j, \bar{\gamma})\}_{j=0}^{n-1}$ is identical to the distribution $\{f_{\bar{\gamma}'}(v, j, \bar{\gamma}')\}_{j=0}^{n-1}$.

Next, let us compute the expected payoff of creditor $i$ for the two cases: when she agrees to the debt rollover and when she does not agree to the debt rollover. Let[25] $n(m) = \max\{0, mn - 2\}$. For any private creditor $i$, given $v$ and $m$, if all other private creditors $k \neq i$ are following a symmetric threshold strategies $a_{\bar{\gamma}}$, conditional on observing the signal $\sigma = \bar{\gamma}$, creditor $i$'s expected payoff from not agreeing to the debt rollover is given by the expression $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}}) = g \sum_{j=mn-1}^{n-1} f_{\bar{\gamma}}(v, j, \bar{\gamma}) + [\bar{\gamma} - \varphi] \sum_{j=0}^{n(m)} f_{\bar{\gamma}}(v, j, \bar{\gamma})$, while creditor $i$'s expected payoff from agreeing to the debt rollover is given by the expression $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}}) = l \sum_{j=mn}^{n-1} f_{\bar{\gamma}}(v, j, \bar{\gamma}) + \bar{\gamma} \sum_{j=0}^{mn-1} f_{\bar{\gamma}}(v, j, \bar{\gamma})$. Notice that both $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ are linear functions of $\bar{\gamma}$ and the slope of $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ is steeper than the slope of $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and when $\bar{\gamma} = \varepsilon$, $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}}) > E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$. It follows that there is a $\bar{\gamma}_m^{*v}$ such that $E_R^{m,v}\left(\bar{\gamma}_m^{*v}, a_{\bar{\gamma}_m^{*v}}\right) - E_A^{m,v}\left(\bar{\gamma}_m^{*v}, a_{\bar{\gamma}_m^{*v}}\right) = 0$ and whenever $\bar{\gamma}_m^{*v} \in [0,1]$, $\bar{\gamma}_m^{*v}$ is a Bayesian equilibrium threshold. For each $v$, where $v \in [0,1]$, $E_R^{m,v}\left(\bar{\gamma}_m^{*v}, a_{\bar{\gamma}_m^{*v}}\right) - E_A^{m,v}\left(\bar{\gamma}_m^{*v}, a_{\bar{\gamma}_m^{*v}}\right) = 0$ implies that $\bar{\gamma}_m^{*v}$ satisfies the following equation:

$$\begin{aligned} \bar{\gamma}_m^{*v} = & \left[\frac{(g-l)}{f_{\bar{\gamma}_m^{*v}}(v, mn-1, \bar{\gamma}_m^{*v})} \sum_{j=mn}^{n-1} f_{\bar{\gamma}_m^{*v}}(v, j, \bar{\gamma}_m^{*v})\right] + g \\ & - \left[\frac{\varphi}{f_{\bar{\gamma}_m^{*v}}(v, mn-1, \bar{\gamma}_m^{*v})} \sum_{j=0}^{n(m)} f_{\bar{\gamma}_m^{*v}}(v, j, \bar{\gamma}_m^{*v})\right]. \end{aligned} \tag{A1}$$

If $\bar{\gamma}_m^{*1} < 1$, by continuity of $\bar{\gamma}_m^{*v}$ in $v$, there exists $\bar{v} < 1$ such that for all $v \in (\bar{v}, 1]$, if $\bar{\gamma}_m^{*v}$ satisfies expression (A1), then $\bar{\gamma}_m^{*v} \in (0,1)$. Thus, interior Bayesian equilibrium threshold exists.

[25] As before, we assume that $mn$ is an integer.

Next, to prove that multiple Bayesian equilibria exist, we need to begin by showing that multiple symmetric self-fulfilling Bayesian equilibrium thresholds exist. This can be done by proving that whenever $\bar{\gamma}_m^{*v}$ satisfies (A1), $\bar{\gamma}_m^{*v}$ is decreasing in $v$. Specifically, note that for $v' < v$, the probability distribution $\{f_{\bar{\gamma}}(v', j, \bar{\gamma})\}_{j=0}^{n-1}$ first-order stochastically dominates $\{f_{\bar{\gamma}}(v, j, \bar{\gamma})\}_{j=0}^{n-1}$. For $v' < v$, note that (a) when $\bar{\gamma} < g + \varphi$, $E_R^{m,v'}(\bar{\gamma}, a_{\bar{\gamma}})$ is less than $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$; when $\bar{\gamma} = g + \varphi$, $E_R^{m,v'}(\bar{\gamma}, a_{\bar{\gamma}})$ is equal to $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and finally when $\bar{\gamma} > g + \varphi$, $E_R^{m,v'}(\bar{\gamma}, a_{\bar{\gamma}})$ is greater than $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and (b) when $\bar{\gamma} < l$, $E_A^{m,v'}(\bar{\gamma}, a_{\bar{\gamma}})$ is greater than $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$; when $\bar{\gamma} = l$, $E_A^{m,v'}(\bar{\gamma}, a_{\bar{\gamma}})$ is equal to $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and when $\bar{\gamma} > l$, $E_A^{m,v'}(\bar{\gamma}, a_{\bar{\gamma}})$ is less than $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$. For $v' < v$, it follows that $\bar{\gamma}_m^{*v'} > \bar{\gamma}_m^{*v}$. Let $\bar{\gamma}_m^{*R} = \min\{\bar{\gamma}_m^{*0}, 1\}$. Since $\bar{\gamma}_m^{*v}$ is decreasing in $v$, the set of symmetric self-fulfilling Bayesian equilibrium thresholds is given by $\left[\bar{\gamma}_m^{*1}, \bar{\gamma}_m^{*R}\right]$. Taking into account the existence of Bayesian equilibria with extreme coordination failure, it follows that multiple Bayesian equilibria exist and are given by $\left[\bar{\gamma}_m^{*1}, \bar{\gamma}_m^{*R}\right] \cup \{1\}$.

Finally, for a fixed $n$, we study the impact of strengthening CACs for the general case when a creditor agrees to the debt rollover with probability $v$, $0 \leq v \leq 1$, if she is indifferent between accepting or rejecting the debt rollover, and for a fixed $n$. Specifically, we want to prove that, for a fixed $n$, if $\bar{\gamma}_m^{*v}$ satisfies (A1), then $\bar{\gamma}_m^{*v}$ is decreasing in $m$. For some $v$, let us consider $\bar{\gamma}_m^{*v}$. For $m' > m$, note that (a) when $\bar{\gamma} < g + \varphi$, $E_R^{m',v}(\bar{\gamma}, a_{\bar{\gamma}})$ is greater than $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$; when $\bar{\gamma} = g + \varphi$, $E_R^{m',v}(\bar{\gamma}, a_{\bar{\gamma}})$ is equal to $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and finally when $\bar{\gamma} > g + \varphi$, $E_R^{m',v}(\bar{\gamma}, a_{\bar{\gamma}})$ is less than $E_R^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$ and (b) when $\bar{\gamma} < l$, $E_A^{m',v}(\bar{\gamma}, a_{\bar{\gamma}})$ is less than $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$; when $\bar{\gamma} = l$, $E_A^{m',v}(\bar{\gamma}, a_{\bar{\gamma}})$ is equal to $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$

and when $\bar{\gamma} > l$, $E_A^{m',v}(\bar{\gamma}, a_{\bar{\gamma}})$ is greater than $E_A^{m,v}(\bar{\gamma}, a_{\bar{\gamma}})$. For $m' > m$ and for a fixed $n$, it follows that $\bar{\gamma}_{m'}^{*v} < \bar{\gamma}_m^{*v}$. Therefore, for a fixed $n$ and when the number of private creditors is not too large, strengthening CACs can help reduce the power of holdout creditor (who accelerate payments) and crisis risk.

*Appendix B*

In Appendix B, we study what happen when the number of private creditors become large (i.e. when $n \to \infty$) for a given $m$. Note that, in order to ensure that we compare like-for-like, per capita creditor payoffs are kept constant throughout the limiting argument. We assume that $v = 1$. Let $\tilde{n}(x) = \frac{e^{-\frac{1}{2}x^2}}{\sqrt{2\pi}}$, and let $\tilde{N}(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}y^2} dy$.

Let $m > \frac{1}{2}$. For large $n$, as $z_n \to \infty$ but $\frac{z_n}{n} \to 0$, by Feller (1984, pp. 184 and 195), a version of the central limit theorem can be applied and therefore,

$$\Pr\left(z_n \leq \frac{j - \frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\right) \sim 1 - \tilde{N}(z_n).$$

Moreover, as $z \to \infty$ by Feller (1984, pp. 175), $1 - \tilde{N}(z) \sim \frac{\tilde{n}(z)}{z}$. Now, by computation, it follows that

$$\frac{mn - \frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}} = \frac{n}{\sqrt{n-1}}\left(2m - 1 - \frac{1}{n}\right),$$

and therefore,

$$\lim_{n\to\infty} \frac{mn - \frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}} = \lim_{n\to\infty} \frac{n}{\sqrt{n-1}}\left(2m - 1 - \frac{1}{n}\right) = \infty,$$

while

$$\lim_{n\to\infty}\frac{mn-\frac{n-1}{2}}{n\frac{\sqrt{n-1}}{2}}=\lim_{n\to\infty}\frac{\left(2m-1-\frac{1}{n}\right)}{\sqrt{n-1}}=0.$$

It follows that for a fixed $m$ and large $n$,

$$\Pr\left(mn\leq j\right)=\Pr\left(\frac{mn-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\leq\frac{j-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\right)\sim 1-\tilde{N}\left(\frac{mn-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\right).$$

Consider, first, the case when $m>\frac{1}{2}$. Then, by computation, for large $n$, $\frac{n}{\sqrt{n-1}}\left(2m-1-\frac{1}{n}\right)\sim\sqrt{n}\left(2m-1\right)$ and therefore, as $n\to\infty$, the expression $\lim_{n\to\infty}\frac{n}{\sqrt{n-1}}\left(2m-1-\frac{1}{n}\right)=\lim_{n\to\infty}\sqrt{n}\left(2m-1\right)=\infty$. It follows that for large $n$,

$$1-\tilde{N}\left(\frac{mn-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\right)\sim\frac{\tilde{n}\left(\sqrt{n}\left(2m-1\right)\right)}{\sqrt{n}\left(2m-1\right)}.$$

Moreover, for large $n$, again, by the central limit theorem,

$$\binom{n-1}{mn-1}\left(\frac{1}{2}\right)^{n}\sim\tilde{n}\left(\frac{(mn-1)-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\right),$$

and by computation, $\frac{(mn-1)-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}=\frac{n}{\sqrt{n-1}}\left(2m-1\right)\sim\sqrt{n}\left(2m-1\right)$ for large $n$ and as $n\to\infty$, $\lim_{n\to\infty}\frac{n}{\sqrt{n-1}}\left(2m-1\right)=\lim_{n\to\infty}\sqrt{n}\left(2m-1\right)=\infty$. Therefore, for large $n$,

$$\tilde{n}\left(\frac{(mn-1)-\frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}}\right)\sim\tilde{n}\left(\sqrt{n}\left(2m-1\right)\right),$$

and the ratio

$$\frac{\sum_{j=mn}^{n-1}\left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n-1}\right]}{\binom{n-1}{mn-1}\left(\frac{1}{2}\right)^{n-1}} \sim \frac{\frac{\tilde{n}\left(\sqrt{n}(2m-1)\right)}{\sqrt{n}(2m-1)}}{\tilde{n}\left(\sqrt{n}\,(2m-1)\right)} = \frac{1}{\sqrt{n}\,(2m-1)},$$

and therefore,

$$\lim_{n\to\infty}\frac{\sum_{j=mn}^{n-1}\left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n-1}\right]}{\binom{n-1}{mn-1}\left(\frac{1}{2}\right)^{n-1}} = \lim_{n\to\infty}\frac{1}{\sqrt{n}\,(2m-1)} = 0.$$

Using the fact that $\tilde{n}(-x) = \tilde{n}(x)$ and $\tilde{N}(-x) = 1 - \tilde{N}(x)$, a symmetric argument establishes that when $m < \frac{1}{2}$,

$$\lim_{n\to\infty}\frac{\sum_{j=mn}^{n-1}\left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n-1}\right]}{\binom{n-1}{mn-1}\left(\frac{1}{2}\right)^{n-1}} = \lim_{n\to\infty} -\frac{1}{\sqrt{n}\,(2m-1)} = 0.$$

Again, by a symmetric argument, as $n \to \infty$, it also follows that when $m > \frac{1}{2}$,

$$\lim_{n\to\infty}\frac{\sum_{j=0}^{mn-2}\left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n-1}\right]}{\binom{n-1}{mn-1}\left(\frac{1}{2}\right)^{n-1}} = \lim_{n\to\infty} -\frac{1}{\sqrt{n}\,(2m-1)} = 0,$$

and when $m < \frac{1}{2}$,

$$\lim_{n\to\infty}\frac{\sum_{j=0}^{mn-2}\left[\binom{n-1}{j}\left(\frac{1}{2}\right)^{n-1}\right]}{\binom{n-1}{mn-1}\left(\frac{1}{2}\right)^{n-1}} = \lim_{n\to\infty}\frac{1}{\sqrt{n}\,(2m-1)} = 0.$$

Note that, when $m = \frac{1}{2}$, $\lim_{n\to\infty} \frac{mn - \frac{n-1}{2}}{\frac{\sqrt{n-1}}{2}} = 0$ and as $\tilde{n}(0) = 1$ and $\tilde{N}(0) = \frac{1}{2}$, by central limit theorem,

$$. \lim_{n\to\infty} \frac{\sum_{j=0}^{mn-2} \left[ \binom{n-1}{j} \left(\frac{1}{2}\right)^{n-1} \right]}{\binom{n-1}{mn-1} \left(\frac{1}{2}\right)^{n-1}} = \frac{1}{2} = \lim_{n\to\infty} \frac{\sum_{j=mn}^{n-1} \left[ \binom{n-1}{j} \left(\frac{1}{2}\right)^{n-1} \right]}{\binom{n-1}{mn-1} \left(\frac{1}{2}\right)^{n-1}}.$$

Therefore, $\bar{\gamma}_m^* \to g + \frac{1}{2}(g - l - \varphi)$ as $n \to \infty$. It follows that for $m \neq \frac{1}{2}$, $m \in (0,1)$, as $n \to \infty$, $\bar{\gamma}_m^* \to g$.

## Acknowledgments

We thank Marcus Miller and seminar participants at Warwick, RES Conference 2005 and EEA Conference 2006 for their helpful comments. The second author would like to thank the ORS, the CSGR and Department of Economics, University of Warwick for their financial supports. This research was partially funded by the ESRC project No. R000219236 "Moral Hazard and Financial Institution".

## References

[1] Becker, T., Richards, A., Thaicharoen, Y., 2003. Bond restructuring and moral hazard: are collective action clauses costly? Journal of International Economics 61, 127–161.

[2] Buchheit, L.C., 1999. A lawyer's perspective on the new international financial architecture. Journal of International Banking Law 14(7), 225–9.

[3] Buchheit, L.C., Gulati, M.G., 2002. Sovereign bonds and the col-

lective will. Georgetown University Law Center Working Paper 34.

[4] Bulow, J., Rogoff, K., 1989. A constant recontracting model of sovereign debt. Journal of Political Economy 97(1), 155–178.

[5] Carlsson, H., van Damme, E., 1993. Global Games and Equilibrium Selection. Econometrica 61, 989–1018.

[6] Cline, W., 1984. International Debt: Systemic Risk and Policy Responses. MIT Press, Cambridge.

[7] Eaton, J., Gersovitz, M., 1981. Debt with Potential Repudiation: Theoretical and Empirical Analysis. The Review of Economic Studies 48(2), 289–309.

[8] Eichengreen, B., Portes, R., 1995. Crisis? What Crisis? Orderly Workouts for Sovereign Debtors. CEPR, London.

[9] Eichengreen, B., Mody, A., 2000. Would Collective Action Clauses Raise Borrowing Costs? NBER Working Paper 7458.

[10] Eichengreen, B., Kletzer, K.M., Mody, A., 2003. Crisis Resolution: Next Steps. Paper presented at the Brookings Trade Forum.

[11] Eichengreen, B., Mody, A., 2004. Do Collective Action Clauses Raise Borrowing Costs? The Economic Journal 114(495), 247–264.

[12] Feller, W., 1984. An introduction to probability theory and its applications, Vol.1. Wiley Eastern Ltd, New Delhi.

[13] Fischer, S., 2001. The International Financial System: Crises and Reform. Paper presented at the Lionel Robbins Lecture, London School of Economics.

[14] Gai, P., Hayes, S., Shin, H.S., 2004. Crisis costs and debtor discipline: the efficacy of public policy in sovereign debt crises. Journal of International Economics 62(2), 245–262.

[15] Ghosal, S., Miller, M., 2003. Co-ordination failure, moral hazard and sovereign bankruptcy procedures. The Economic Journal 113, 276–304.

[16] International Monetary Fund, 2002. Collective Action Clauses in Sovereign Bond Contracts - Encouraging Greater Use. Paper prepared by the Policy Development and Review, International Capital Markets and Legal Department, International Monetary Fund. https://www.imf.org/external/np/psi/2002/eng/060602a.pdf

[17] Kletzer, K.M., Wright, B.D., 2000. Sovereign debt as international barter. American Economic Review 90(3), 621–639.

[18] Kletzer, K.M., 2003. Sovereign Bond Restructuring: Collective Action Clauses and Official Crisis Intervention. IMF Working Paper 03/134.

[19] Kletzer, K.M., 2004a. Resolving Sovereign Debt Crises with Collective Action Clauses. Federal Reserve Bank of San Francisco Economic Letter Number 2004-06.

[20] Kletzer, K.M., 2004b. Sovereign bond restructuring: collective action clauses and official crisis intervention, in: Haldane, A. (Ed.), Fixing Financial Crises in the $21^{st}$ Century. Routledge, pp. 230–253.

[21] Krueger, A., 2001. International financial architecture for 2002: a new approach to sovereign debt restructuring. International Monetary Fund, Washington D.C. http://www.imf.org/external/np/speeches/2001/112601.htm

[22] Krueger, A., 2002. A New Approach to Sovereign Debt Restructuring. International Monetary Fund, Washington D.C. http://www.imf.org/external/pubs/ft/exrp/sdrm/eng/index.htm

[23] Miller, M., Zhang, L., 2000. Sovereign liquidity crises: the strategic case for a payment standstill. The Economic Journal 110(460), 335–362.

[24] Morris, S., Shin, H.S., 1998. Unique equilibrium in a model of self-fulfilling currency attacks. American Economic Review 88(3), 587–597.

[25] Pitchford, R. and Wright, M.L.J., 2007. Restructuring the Sovereign Debt Restructuring Mechanism. Federal Reserve Bank of Minneapolis, Research Department Staff Report.

[26] Richards, A., Gugiatti, M., 2003. Do Collective Action Clauses Influence Bond Yields? New Evidence from Emerging Markets. International Finance 6(3), 415–447.

[27] Rodrik, D., 1998. Who needs capital account convertibility?, in: Kenen et al. (Eds.), Should the IMF pursue capital account convertibility?, Essays in International Finance 201. Princeton University.

[28] Roubini, N., Setser, B., 2003. Improving the Sovereign Debt Restructuring Process: Problems in Restructuring, Proposed Solutions and a Roadmap for Reform. Institute for International Economics, Washington D.C.

[29] Roubini, N., Setser, B., 2004. The reform of the sovereign debt restructuring process: problems, proposed solutions, and the Argentine episode. Journal of Restructuring Finance 1(1), 1–12.

[30] Sachs, J., 1995. Do we need an international lender of last resort. http://www.cid.harvard.edu/archive/hiid/papers/intllr.pdf

[31] Tanaka, M., 2006. Bank loans versus bond finance: Implications for sovereign debtors. The Economic Journal 116(510), C149–C171.

[32] Taylor, J.B., 2002. Sovereign debt restructuring: a US perspective. Department of Treasury PO-2056. Paper presented at the Conference on Sovereign debt workouts: hopes and hazards? Institute for International Economics, Washington D.C.

[33] Tirole, J., 2003. Inefficient Foreign Borrowing: A Dual- and Common-Agency Perspective. American Economic Review 93(5), 1678–1702.

[34] Weinschelbaum, F., Wynne, J., 2005. Renegotiation, collective action clauses and sovereign debt markets. Journal of International Economics 67, 47–72.

## ABOUT THE CDMA

The **Centre for Dynamic Macroeconomic Analysis** was established by a direct grant from the University of St Andrews in 2003. The Centre funds PhD students and facilitates a programme of research centred on macroeconomic theory and policy. The Centre has research interests in areas such as: characterising the key stylised facts of the business cycle; constructing theoretical models that can match these business cycles; using theoretical models to understand the normative and positive aspects of the macroeconomic policymakers' stabilisation problem, in both open and closed economies; understanding the conduct of monetary/macroeconomic policy in the UK and other countries; analyzing the impact of globalization and policy reform on the macroeconomy; and analyzing the impact of financial factors on the long-run growth of the UK economy, from both an historical and a theoretical perspective. The Centre also has interests in developing numerical techniques for analyzing dynamic stochastic general equilibrium models. Its affiliated members are Faculty members at St Andrews and elsewhere with interests in the broad area of dynamic macroeconomics. Its international Advisory Board comprises a group of leading macroeconomists and, ex officio, the University's Principal.

**RECENT WORKING PAPERS FROM THE CENTRE FOR DYNAMIC MACROECONOMIC ANALYSIS**

| Number | Title | Author(s) |
|---|---|---|
| CDMA06/06 | Optimal Time Consistent Monetary Policy | Tatiana Damjanovic (St Andrews), Vladislav Damjanovic (St Andrews) and Charles Nolan (St Andrews) |
| CDMA06/07 | Monetary-Fiscal Interactions When Public Debt is Stationary | Michal Horvath (St Andrews) |
| CDMA06/08 | Bank Lending with Imperfect Competition and Spillover Effects | Sumru G. Altug (Koç and CEPR) and Murat Usman (Koç) |
| CDMA06/09 | Real Exchange Rate Volatility and Asset Market Structure | Christoph Thoenissen (St Andrews) |
| CDMA06/10 | Disinflation in an Open-Economy Staggered-Wage DGE Model: Exchange-Rate Pegging, Booms and the Role of Preannouncement | John Fender (Birmingham) and Neil Rankin (Warwick) |
| CDMA06/11 | Relative Price Distortions and Inflation Persistence | Tatiana Damjanovic (St Andrews) and Charles Nolan (St Andrews) |
| CDMA06/12 | Taking Personalities out of Monetary Policy Decision Making? Interactions, Heterogeneity and Committee Decisions in the Bank of England's MPC | Arnab Bhattacharjee (St Andrews) and Sean Holly (Cambridge) |
| CDMA07/01 | Is There More than One Way to be E-Stable? | Joseph Pearlman (London Metropolitan) |
| CDMA07/02 | Endogenous Financial Development and Industrial Takeoff | Alex Trew (St Andrews) |
| CDMA07/03 | Optimal Monetary and Fiscal Policy in an Economy with Non-Ricardian Agents | Michal Horvath (St Andrews) |
| CDMA07/04 | Investment Frictions and the Relative Price of Investment Goods in an Open Economy Model | Parantap Basu (Durham) and Christoph Thoenissen (St Andrews) |
| CDMA07/05 | Growth and Welfare Effects of Stablizing Innovation Cycles | Marta Aloi (Nottingham) and Laurence Lasselle (St Andrews) |

For information or copies of working papers in this series, or to subscribe to email notification, contact:

Alex Trew
Castlecliffe, School of Economics and Finance
University of St Andrews
Fife, UK, KY16 9AL

Email: awt2@st-and.ac.uk; Phone: +44 (0)1334 462445; Fax: +44 (0)1334 462444.