



# Sovereign liquidity crises: Analytics and implications for public policy

Michael Chui, Prasanna Gai \*, Andrew G. Haldane

*International Finance Division, Bank of England, Threadneedle Street, London EC2R 8AH, UK*

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## Abstract

This paper offers an analytical framework with which to assess some recent proposals for strengthening the international financial architecture. We develop a model of sovereign liquidity crises that reflects two sources of financial stress – weak fundamentals and self-fulfilling expectations. We examine the nature of the underlying co-ordination game and investigate the properties of the unique equilibrium. In so doing, we are able to characterise the welfare costs of belief-driven crises, which we find to be potentially significant. We also evaluate some recent policy proposals including prudent debt and liquidity management, capital controls, greater information disclosure, and the efficacy of monetary policy tightening in the midst of crisis. © 2002 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

The financial crises experienced in Asia, Russia, and Latin America during the late twentieth century have resulted in much ink being spilt in academic and policy circles. The debate has largely been conducted in terms of “first and

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\* Corresponding author. Fax: +44-207-601-5080.

*E-mail address:* prasanna.gai@bankofengland.co.uk (P. Gai).

second generation” models of currency crisis.<sup>1</sup> First generation models (e.g. Krugman, 1979) emphasise the importance of a secular deterioration in fundamentals, such as the level of foreign reserves, in triggering crises and demonstrate how speculative attacks on a currency can be generated as a result of inconsistent government policies. By contrast, second generation models (e.g. Obstfeld, 1996) argue that crises can arise even when policies are consistent with a fixed exchange rate. They show that currency crises embody a co-ordination problem, in which the actions of speculators are mutually reinforcing – it is more attractive to attack a currency if it already under attack from others. Multiple equilibria result. If no one believes that a crisis is about to occur, there will be no speculative attack. But if everyone believes that a crisis is about to occur, it becomes optimal for each speculator to attack if others do. But such models are silent about the reasons for the shifts in beliefs that cause the switch between equilibria. Explanations typically rely on “sun-spots”, i.e., random events, unrelated to changes in the real economy that affect investor beliefs in ways that turn out to be self-fulfilling.

A central feature of the recent problems experienced by emerging economies has been the sharp reversal of capital flows. By contrast, the academic literature has focused on crises in the currency markets, and relatively little attention has been given to investor behaviour in the capital markets.<sup>2</sup> Viewed from a second-generation perspective, the relationship between a sovereign debtor and its creditors also has the characteristics of a co-ordination problem. If a country is liquidity constrained and if one set of creditors attempt to exit, this imposes externalities on all other creditors in the event of their requiring repayment. A sovereign liquidity crisis is thus analogous to the Diamond and Dybvig (1983) bank run. King (1999) notes that while liquidity runs have played a major part in recent financial crises, factors fundamental to national balance sheets, such as a level of country’s resources, also played a part. So in practice, real-life crises are likely to have elements of both belief-driven and fundamentals-based attacks. Krugman (1999) attempts to reconcile the two types of model by highlighting the role of government guarantees on private sector debt and weaknesses in corporate and financial sector balance sheets. But again, the reason for the shift in creditor beliefs is left unexplained.

The indeterminacy of equilibrium has meant that the literature, to date, has had very little to say about the welfare costs of the creditor co-ordination problem and, consequently, the policies that should be followed to “manage” liquidity runs on a country.<sup>3</sup> In an environment where many equilibria can be

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<sup>1</sup> See Flood and Marion (1998) for a comprehensive review.

<sup>2</sup> The original contribution is that of Calvo (1988). Recent papers on this issue include Chang and Velasco (1999) and Powell (1999).

<sup>3</sup> Jeanne (1999) is an important exception.

generated by sunspots, it is difficult to compare outcomes against a first-best world where co-ordinated behaviour is assumed possible. As a result it is not possible to gauge the significance of the creditor co-ordination problem or to compare the efficacy of policies aimed at overcoming this inefficiency. A number of current policy proposals have been made with the creditor co-ordination problem in mind – they explore mechanisms designed to pre-commit or “bind in” private creditors to an emerging economy at times of crisis. Measures include the promotion of greater transparency between debtors and creditors, the maintenance of an appropriate debt structure, temporary debt payment standstills, capital controls, and the use of contingent-credit lines.

Recent work by Morris and Shin (1998), in the context of currency crises, suggests that it is possible to resolve the problem of indeterminacy and to capture key elements of first and second generation models. They argue that the key short-coming of existing models of multiple equilibria is the assumption that economic actors have common knowledge of the underlying fundamentals. The introduction of small disparities in the information set of economic agents generates uncertainty about the beliefs of others and dictates a particular course of action as being the uniquely optimal one. Speculators employ a *switching* strategy, i.e., a rule where the action chosen is determined by whether the best estimate of fundamentals is above or below a pre-determined benchmark signal, bearing in mind that other market participants are engaged in a similar exercise using the same benchmark signal. Fundamentals and beliefs interact explicitly in this framework. Within some range of fundamentals, the economy operates as a first-generation model, guided by fundamentals. But the weaker the fundamentals, the more fragile the situation becomes in the sense that fewer participants are required to trigger a crisis. When fundamentals fall below the benchmark, a run takes hold. The model is thus “canonical” in the spirit of Chang and Velasco (1999).

This paper applies the Morris–Shin framework to the problem of sovereign liquidity crises and explores its policy ramifications. But unlike Morris and Shin (1998, 1999), the range of fundamentals within which the model operates as first generation is endogenous and has a ready interpretation in terms of debtor liquidity ratios. We identify the unique liquidity crisis equilibrium of the game and are, thus, able to characterise and calibrate the welfare costs of sovereign liquidity crises. We illustrate how changes in various parameters can affect the probability of crisis and decompose the welfare effects of our comparative static exercise into their fundamentals and belief-based elements. This allows us to evaluate some specific policy proposals: namely, prudent debt management, improved information disclosure, and capital controls. We are also able to comment on the efficacy of monetary policy tightening in the midst of crisis, under circumstances where inflation expectations are well-anchored. The paper thus provides an analytical framework for the debate currently underway on the international financial architecture.

The structure of the paper is as follows. Section 2 describes a model of complete information in which liquidity crises arise as part of the multiple equilibria of a co-ordination game. The indeterminacy of equilibria prevents the satisfactory categorisation of welfare costs in the model. Accordingly, Section 2.3 introduces noisy, private information and shows how this leads to a unique trigger point for a liquidity crisis. Section 3 examines the welfare implications of the model using numerical simulations, and draws some inferences for policy. Section 4 concludes.

## 2. The model

### 2.1. The framework

The framework we adopt is an open-economy variant of the Diamond and Dybvig (1983) model. A small open economy is populated by a representative social planner who is confronted by three stages in time ( $t = 0, 1, 2$ ). The planner receives two exogenously determined endowments during stage 0: a productive asset ( $E$ ) which can be thought of as domestic capital; and a non-productive asset ( $A$ ) which can be thought of as the stock of liquid reserves. Production is based on a constant-returns-to-scale technology which is risky, needs time to mature, and is realised only at  $t = 2$ . To augment domestic capital, the planner can borrow abroad at interest rate,  $r_L > 0$ , during stage 0.

Foreign lenders are small in that an individual creditor's stake in the project is negligible as a proportion of the whole. So the set of creditors can be indexed by the unit interval  $[0, 1]$ . At time  $t = 0$ , each foreign investor lends an *exogenous* amount  $L$  to the planner (of the debtor country) who agrees to payback  $L(1 + r_L)$  in stage 2.<sup>4</sup> However, in the event the planner proves unable to repay his loan at  $t = 2$ , the investors will get nothing in return (we discuss the planner's constraint below).

At an interim stage ( $t = 1$ ), before the final realisation of the project, foreign lenders have an opportunity to review their investment. They may choose either to roll over their loan until maturity in stage 2, or to reclaim their money in full and abandon the project in favour of a risk-free liquid international asset in stage 1.

The decision to flee is costly, however. Specifically, the creditor faces a cost,  $c \in (0, 1]$ , for each dollar of lending withdrawn. This can be thought of as a transfer from creditors to debtors, i.e., a "haircut" or exit tax, incurred when fleeing a country. The value of  $c$  is independent of the scale of the run. More

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<sup>4</sup> The model is, thus, partial equilibrium in nature as we do not explicitly set out to capture the optimal borrowing decision.

generally,  $c$  can be thought of as the break-up value of collateral or as a transaction cost incurred when reallocating capital.<sup>5</sup> Without loss of generality, we assume that the riskless world interest rate,  $r^*$ , is zero. Thus, if foreign creditors flee, their return is  $L(1 - c)$  in stage 1, and this part of foreign capital ceases to be involved in the productive process. If this happens, we say that a “run” on the country has taken place. We, therefore, have the following payoff matrix for the individual creditor:

Investor	Time of payoff	Planner	
		Repay	Default
Flee	$t = 1$	$L(1 - c)$	$L(1 - c)$
Stay	$t = 2$	$L(1 + r_L)$	0

The planner’s ability to repay fleeing foreign creditors in stage 1 depends on the endogenous level of liquid reserves ( $A$ ), with any excesses of debt over reserves being met by liquidating the illiquid (production) asset ( $E$ ). Reserves are held in a long-term storage technology that yields a return,  $r_A$ , on liquid reserves remaining at the end of stage 2.<sup>6</sup> Let  $\lambda$  be the proportion of creditors who decide to flee at  $t = 1$ . Then at  $t = 2$ , total liquid reserves at the planner’s disposal is given by  $(1 + r_A)(A - \lambda L)$ . The planner’s debt obligations at the end of stage 2 are therefore characterised by the proportion of creditors who flee at the interim stage ( $t = 1$ ), the final net reserve position, and by the value of production. The value of production at the end of the game depends on two factors – the underlying state of fundamentals,  $\theta$ , and the degree of disruption to the production process caused by the premature departure of foreign creditors. The severity of disruption is given by  $k\lambda L$ , where  $k > 0$  is the marginal disruption to output caused by a single fleeing creditor.<sup>7</sup> So the total net resources available to the planner to meet repayments is given by

$$\theta(E + L) - k\lambda L + (1 + r_A)(A - \lambda L), \quad (1)$$

where  $\theta$  is normally distributed with mean  $\mu_\theta$  and variance  $\sigma_\theta^2$ .

<sup>5</sup> In interpreting  $c$  as the break-up value of collateral, it should be noted that in the event of a forced sale of assets, collateral re-sale value would depend on the scale of the run. In reality, therefore,  $c$  would be an endogenous variable. For tractability, we treat it as exogenous, an extension could endogenise it. The implications of a change in  $c$  are considered in Section 3.

<sup>6</sup> Alternatively, one can think of the storage technology as involving a two-part investment strategy by the planner. Between stages 0 and 1, the planner invests  $A$  in international markets at the safe world interest rate,  $r^* = 0$ . After paying out fleeing investors at  $t = 1$ , he re-invests any remaining liquid reserves in a high yielding short-term asset with return ( $r_A$ ).

<sup>7</sup> The output costs of runs, the premature scrapping of value-enhancing investments has recently been stressed by Allen and Gale (1998) and Dooley (2000).

We implicitly assume that there is no side trading in the form of a secondary market, and that costs from future exclusion from capital markets are prohibitively expensive for the planner. Our approach thus focuses on a country's pure *ability to pay* (see also Sachs, 1984; Rodrik and Velasco, 1999) and abstracts from the important issue of strategic default and the notion of a debtor country's *willingness to pay* highlighted by authors such as Eaton et al. (1986) in the literature on sovereign debt. Note also that, in our model, the problem of sovereign debt enforcement means that optimal contract between debtors and creditors are typically skewed towards debt (rather than equity) instruments.<sup>8</sup>

The timing of moves and events in the model can be summarised as follows. First, the social planner enters the game with a given amount of external finance,  $L$ , and liquid and physical assets ( $A$  and  $E$ ). Then nature chooses the state of fundamentals,  $\theta$ . Both the planner (debtor) and the creditor know the distribution from which  $\theta$  is drawn, but neither learns the value of fundamentals until the end of the game. There are two possible scenarios. In the complete information game, foreign creditors have perfect information on each other's actions, and receive the same signal on fundamentals as the debtor. In the imperfect information game, each creditor observes a noisy signal  $x_i$  of  $\theta$ , which means that individually (and collectively) they have less information than the debtor, who observes the distribution of  $\theta$ . Given a particular state of fundamentals and the aggregate strategy of other creditors, an individual creditor chooses between fleeing or staying in the intermediate stage ( $t = 1$ ). Payment to fleeing creditors is made from liquid reserve assets and/or the break-up of domestic capital. Finally, at  $t = 2$ , observing the proportion of creditors who flee, the social planner satisfies any remaining obligations if feasible. Fig. 1 depicts this move order as a time line. As in other games of this type, Bayesian Nash equilibria are obtained by backward induction.

## 2.2. Perfect information game

In stage 2, the planner observes  $\theta$  and the proportion of creditors who stay, given the state of fundamentals. Debt repayments due at the end of stage 2 are given by  $(1 - \lambda)(1 + r_L)L$ . The solvency constraint facing the planner is

$$\theta(E + L) - k\lambda L + (1 + r_A)(A - \lambda L) \geq (1 - \lambda)L(1 + r_L), \quad (2)$$

where we assume that the costs incurred by fleeing creditors are unavailable to the debtor. Thus the critical proportion of creditors needed to trigger default is given by

<sup>8</sup> Rogoff (1999) observes that international capital markets do not adequately support equity finance and direct investment, resulting in strong biases towards debt finance for sovereigns. As a result, the Jacklin (1987) argument which shows how the Diamond–Dybvig run is avoided in money-market mutual funds is not appropriate in this context.

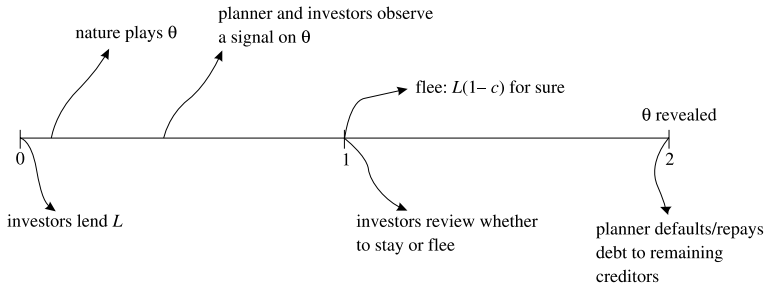


Fig. 1. The time-line of the model.

$$\lambda^*(\theta) = \frac{\theta(E + L) + (1 + r_A)A - (1 + r_L)L}{(k + r_A - r_L)L}. \tag{3}$$

Stage 2 output in the economy is given by

$$Y = \begin{cases} \theta(E + L) - k\lambda L, & \text{if } \lambda > \lambda^*, \\ \theta(E + L), & \text{if } \lambda \leq \lambda^*. \end{cases} \tag{4}$$

So the decision rule for the government is to declare default only if the observed fraction of fleeing creditors is greater than the critical mass  $\lambda^*(\theta)$  in the prevailing state  $\theta$ . Note that the stronger the fundamentals and/or the larger the proportion of staying creditors, the greater the likelihood of the planner repaying debt obligations.

Following Morris and Shin (1998), if creditors have perfect knowledge of  $\theta$  before deciding on their roll-over decision, we are able to partition the space of fundamentals into three regions of interest. Denote by  $\bar{\theta}$  that value of  $\theta$  such that the planner is able to repay his debts even if all other creditors flee. So if  $\lambda = 1$ ,  $\bar{\theta}$  is given by

$$\bar{\theta} = \frac{kL}{E + L} + \frac{(1 + r_A)L}{E + L} - \frac{(1 + r_A)A}{E + L}. \tag{5}$$

If  $\theta > \bar{\theta}$ , it is always optimal for creditors to remain in the country. The intuition is straightforward. If fundamentals are so strong that net resources are more than enough to ensure repayment, the planner will not default in any case. But, if fundamentals are particularly weak, there will be values of  $\theta$  for which the planner always defaults. Specifically, denote by  $\underline{\theta}$  that value of  $\theta$  such that the planner will be unable to meet debt repayments even if all creditors remain in the country, i.e.,  $\lambda = 0$ :

$$\underline{\theta} = \frac{(1 + r_L)L}{E + L} - \frac{(1 + r_A)A}{E + L}. \tag{6}$$

If  $\theta < \underline{\theta}$ , it is always optimal for the individual creditor to liquidate his position, even if all other creditors were to roll over their loans.

The expressions for  $\underline{\theta}$  and  $\bar{\theta}$  described in Eqs. (5) and (6) can be interpreted as values of the productivity parameter that are consistent with critical net liquidity ratios for a sovereign borrower. In essence, they are a combination of gross gearing and gross reserve asset ratios (adjusted for the marginal costs of leveraging,  $r_L$ , and maintaining reserves,  $r_A$ ). So in this setup, the boundary on fundamentals is to be linked directly to the net liquidity position of the sovereign. It is below the liquidity boundary ( $\underline{\theta}$ ) that solvency problems kick in. This is important for understanding some of the beneficial effects of prudent debt and liquidity management described below. Notice that  $\bar{\theta} > \underline{\theta}$  when  $k > r_L - r_A$ , i.e., when the marginal production costs of leveraging exceed the net marginal cost of borrowing.

When  $\theta$  lies in the region  $[\underline{\theta}, \bar{\theta}]$ , a co-ordination problem among creditors arises.<sup>9</sup> As stressed by Obstfeld (1996), this stems from the presence of strategic complementarities in creditor payoffs, i.e., the decision to flee by creditor  $i$  raises the marginal profitability of fleeing for investor  $j$ . Thus, if all other creditors opt to stay then the payoff to staying,  $L(1 + r_L)$ , exceeds the payoff from early liquidation,  $L(1 - c)$ . But if all creditors opt to flee, the payoff from staying is (0), which is less than the payoff from early liquidation. In the presence of complete information,  $\lambda$  and  $\theta$  cannot be simultaneously determined. So, with many creditors, there are a potentially infinite number of equilibria when fundamentals lie in the region  $\theta \in [\underline{\theta}, \bar{\theta}]$ .

Fig. 2 plots the range of  $\theta$  consistent with this tri-partite classification. The region under the normal density function  $\phi(\theta)$  to the left of  $\underline{\theta}$  depicts values of  $\theta$  consistent with ‘fundamentals’ insolvency. Outcomes to the left of  $\underline{\theta}$  and the ensuing capital flight and default are synonymous with the fundamentals-driven crises of the sort highlighted by the first-generation models (e.g., Krugman, 1979). The area under the curve to the right of  $\bar{\theta}$  depicts the range of  $\theta$  for which the economy might be considered strongly solvent. In the middle range, where the economy is solvent and liquid, subject to there not being a run, belief-driven crises may occur.<sup>10</sup> Specifically, the flight of creditors resulting from their inability to co-ordinate may result in default for some  $\theta < \hat{\theta}$ . The value  $\hat{\theta}$  denotes some trigger value of fundamentals (as one of the many possible equilibria) at which creditors are sufficiently nervous that they flee, a

<sup>9</sup> For  $\underline{\theta}$  to be greater than 0,  $(1 + r_L)L > (1 + r_A)A$ . In words, the total debt repayment has to exceed total liquid reserve assets.

<sup>10</sup> In line with Obstfeld (1996), if creditors believe that the debtor will repay, then it is optimal not to flee. This, in turn, induces the planner to repay, thereby vindicating the creditors’ decision to rollover their loans. On the other hand, if creditors believe that default is inevitable, the rational action is to flee, inducing a liquidity crisis that vindicates the creditor’s decision to liquidate positions.



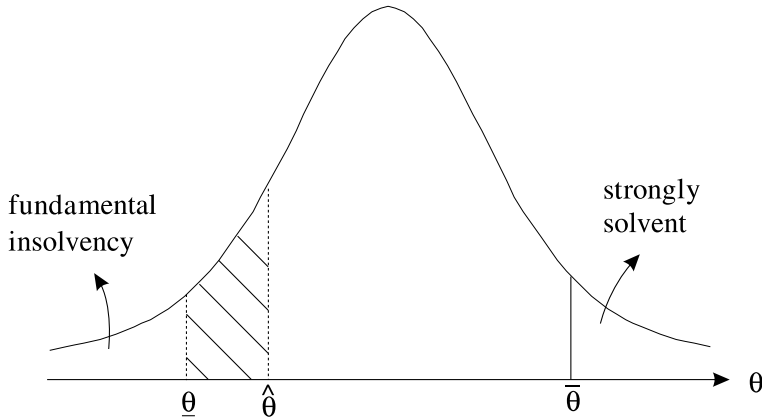


Fig. 2. The tri-partite classification of fundamentals.

run develops and the country is driven to default. The welfare consequence of purely belief driven crises – the cost of non-cooperation among creditors – is related to the shaded area between  $\underline{\theta}$  and  $\hat{\theta}$ . It is the price of co-ordination failure and is manifest in value-enhancing investments being shelved. Specifically, the welfare cost to the debtor arises from lost production at  $t = 2$  as a result of the disruption caused by fleeing creditors. As noted above, in the complete information game with common knowledge of fundamentals,  $\hat{\theta}$  is indeterminate. Consequently little can be said about the welfare costs of a purely belief driven crisis and comparative static exercises are not possible. In what follows, we demonstrate how the introduction of imperfect information allows a unique value of  $\hat{\theta}$  to be determined in the range  $[\underline{\theta}, \bar{\theta}]$  in terms of the parameters of the model.

### 2.3. The imperfect information game

The previous section assumed that creditors had *common knowledge* about the state of fundamentals. Such an assumption is unlikely to hold in practice. Information about the fundamentals of an economy is frequently not transparent and creditors are often unsure about the information and analysis of other market participants. We therefore relax this assumption by allowing each creditor to privately observe, at the interim stage  $t = 1$ , a noisy signal  $x_i$  of the state of fundamentals at  $t = 2$ . In particular,

$$x_i = \theta + \varepsilon_i \quad \forall i, \tag{7}$$

where  $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$  and is independent from  $\theta$  and  $\varepsilon_j, \forall i \neq j$ . The mean and variance of  $x_i$  are given by

$$\begin{aligned} E(x_i) &= \mu_\theta, \\ \text{Var}(x_i) &= \sigma_\theta^2 + \sigma_\varepsilon^2, \quad \forall i. \end{aligned}$$

Note that signal  $x_i$  is informative about the underlying state  $\theta$  but only to a certain extent (or with error  $\varepsilon$ ). Nevertheless, it is also through  $\theta$  (as all creditors are identical), that creditor  $i$  obtains information on creditor  $j$ 's signal.

Once again the solution is obtained through two stages. As noted earlier, in the final stage the planner defaults if the observed proportion of fleeing creditors is greater than a critical mass  $\lambda^*(\theta)$  for some state of fundamentals,  $\theta$ . Taking this final stage strategy as given, we proceed to derive the optimal strategy for creditor  $i$  by solving the reduced form game between creditors. A strategy for creditor  $i$  is a decision rule that maps each realisation of  $x_i$  to an action,

$$x_i \mapsto \{\text{flee, stay}\}.$$

And a *Bayesian Nash equilibrium* is a profile of strategies, one for each creditor, such that creditor  $i$ 's strategy maximises his expected payoff conditional on information available, when all other creditors are following the strategies in the profile.

A formal account of the solution to co-ordination games of this type is offered in Morris and Shin (1998, 1999). Building upon the work of Carlsson and van Damme (1993) they demonstrate that, for sufficiently informative private signals, there exists a unique equilibrium of the imperfect information game in which the planner defaults whenever  $\theta \leq \hat{\theta}$ .<sup>11</sup>

Here we sketch the derivation of the unique equilibrium and begin by considering the aggregate strategy for creditors. For a given profile of creditor strategies, denote by  $v(x)$  the proportion of creditors who flee when the value of the signal is  $x$ . Let  $s(\theta, v)$  be the proportion of investors who flee, given the aggregate strategy  $v$ , when the state of fundamentals is  $\theta$ . Formally,

$$s(\theta_j, v) \equiv \int_{-\infty}^{\infty} v(x) \phi(x | \theta_j) dx, \quad (8)$$

where  $\phi(x | \theta_j)$  represents the density function of signals for some state of fundamentals,  $\theta_j$ . Note  $\phi(x | \theta_j) \sim N(\theta_j, \sigma_\varepsilon^2)$ .

Consider the particular aggregate strategy profile which focuses on a switching strategy by investors, namely a rule of action in which the action chosen is determined by whether the best estimate of the underlying funda-

<sup>11</sup> More specifically, uniqueness holds when  $\sqrt{2\pi}(E+L)/[(k+r_A-r_L)L] > \sigma_\varepsilon/\sigma_\theta^2$ . The implications of this condition are considered in Section 3 below. An informal treatment of incomplete information co-ordination games is offered in Cooper (1999).

mentals is above or below some pre-determined benchmark level,  $\hat{x}$ . The aggregate strategy  $v$  is then given by the indicator function,

$$I_{\hat{x}} = \begin{cases} 0, & \text{if } x \geq \hat{x}, \\ 1, & \text{if } x < \hat{x}, \end{cases} \tag{9}$$

i.e. every creditor flees if and only if he receives a signal  $x < \hat{x}$ . Substituting Eq. (9) into Eq. (8) implies:

$$\begin{aligned} s[\theta, I(\hat{x})] &= \int_{-\infty}^{\hat{x}} 1 \cdot \phi(x|\theta)dx + \int_{\hat{x}}^{\infty} 0 \cdot \phi(x|\theta) dx = \int_{-\infty}^{\hat{x}} \phi(x|\theta)dx \\ &\equiv \Phi[(\hat{x} - \theta)/\sigma_{\varepsilon}] = \text{prob}(x > \hat{x}), \end{aligned} \tag{10}$$

where  $\Phi(\cdot)$  denotes a standard normal distribution function.<sup>12</sup>

Now at an equilibrium switching point when the state of fundamentals is  $\hat{\theta}$ , it must be the case that the proportion of creditors fleeing,  $s$ , equals the critical mass necessary to cause default. Thus from the solvency constraint (2),

$$\hat{\theta}(E + L) - ksL + (1 + r_A)(A - sL) = (1 - s)(1 + r_L)L,$$

or

$$\hat{\theta} = \frac{(1 + r_L)L - (1 + r_A)A}{E + L} + \frac{(k + r_A - r_L)L}{E + L} \left[ \Phi\left(\frac{\hat{x} - \hat{\theta}}{\sigma_{\varepsilon}}\right) \right]. \tag{11}$$

We now calculate a creditor’s posterior belief of  $\theta$  conditional on his information  $x_j$ . From Bayes’ rule, it follows that  $\phi(\theta|x = x_j)$  is normally distributed with

$$\begin{aligned} \text{mean :} & \quad \tilde{\theta}_j = \frac{\mu_{\theta}\sigma_{\varepsilon}^2 + \sigma_{\theta}^2x_j}{\sigma_{\theta}^2 + \sigma_{\varepsilon}^2}, \\ \text{variance :} & \quad \frac{\sigma_{\theta}^2\sigma_{\varepsilon}^2}{\sigma_{\theta}^2 + \sigma_{\varepsilon}^2}. \end{aligned}$$

On re-arranging the expression for the mean to write  $x_j$  in terms of  $\tilde{\theta}$  and when  $x_j = \hat{x}$ , we have

$$\hat{x} = \frac{\sigma_{\theta}^2 + \sigma_{\varepsilon}^2}{\sigma_{\theta}^2} \tilde{\theta} - \frac{\sigma_{\varepsilon}^2}{\sigma_{\theta}^2} \mu_{\theta}. \tag{12}$$

For the switching strategy described above to occur at the interim stage  $t = 1$ , the expected payoff for the creditor must equal  $L(1 - c)$  when  $x_j = \hat{x}$ .

<sup>12</sup> In our model, the return of the creditor is linear and there is a clear distinction between payoffs in the good and bad states. So our results are not dependent on partial/total withdrawal assumptions as the only circumstance in which a creditor would withdraw partially is when he is indifferent between withdrawing or not.

That is, the creditor must be indifferent between fleeing and staying at the switching point. Denoting the expected payoff by  $u(\hat{x})$ , we have:

$$u(\hat{x}) = \int_{\hat{\theta}}^{\infty} L(1+r_L)\phi[\theta|\hat{x}]d\theta \\ = L(1+r_L)\left\{1 - \Phi\left[\frac{(\hat{\theta} - \bar{\theta})\sqrt{\sigma_\varepsilon^2 + \sigma_\theta^2}}{(\sigma_\varepsilon\sigma_\theta)}\right]\right\} = L(1-c). \quad (13)$$

On rearranging, we have

$$\frac{r_L + c}{1 + r_L} = \Phi\left[\frac{(\hat{\theta} - \bar{\theta})\sqrt{\sigma_\varepsilon^2 + \sigma_\theta^2}}{\sigma_\varepsilon\sigma_\theta}\right]. \quad (14)$$

The critical default point depends on the switching point ( $\hat{\theta}$ ) and vice versa. Substituting the expression for the creditor signal (12) into the solvency condition (11) and the exit condition (14), we have a simultaneous equation system with two equations and two unknowns,  $\bar{\theta}$  and  $\hat{\theta}$ . After some manipulation we can establish that the value of the fundamentals at the switching point is

$$\hat{\theta} = \frac{(1+r_L)L - (1+r_A)A}{E+L} + \frac{(k+r_A-r_L)L}{E+L} \\ \times \Phi\left[\frac{\sigma_\varepsilon}{\sigma_\theta}\left(\frac{\hat{\theta} - \mu_\theta}{\sigma_\theta}\right) - \frac{\sqrt{\sigma_\varepsilon^2 + \sigma_\theta^2}}{\sigma_\theta}\Phi^{-1}\left(\frac{r_L + c}{1 + r_L}\right)\right], \quad (15)$$

or

$$\hat{\theta} = \underline{\theta} + (\bar{\theta} - \underline{\theta})\Phi\left[\frac{\sigma_\varepsilon}{\sigma_\theta}\left(\frac{\hat{\theta} - \mu_\theta}{\sigma_\theta}\right) - \frac{\sqrt{\sigma_\varepsilon^2 + \sigma_\theta^2}}{\sigma_\theta}\Phi^{-1}\left(\frac{r_L + c}{1 + r_L}\right)\right]. \quad (16)$$

Notice that, when the variance of the private signal becomes sufficiently small, say  $\sigma_\varepsilon \rightarrow 0$ , the  $\Phi(\cdot)$  terms become

$$\Phi\left[-\Phi^{-1}\left(\frac{r_L + c}{1 + r_L}\right)\right] = 1 - \frac{r_L + c}{1 + r_L} = \frac{1 - c}{1 + r_L} < 1.$$

So,  $\hat{\theta} \in [\underline{\theta}, \bar{\theta}]$  for sufficiently small  $\sigma_\varepsilon$ . In other words, small disparities in the information set of creditors are a sufficient condition for a unique equilibrium to occur in the co-ordination problem region  $[\underline{\theta}, \bar{\theta}]$ .

Eq. (16) shows how the trigger point for fundamentals depends on the insolvency boundary  $\underline{\theta}$ , plus an adjustment which depends on the scale of the co-ordination problem ( $\bar{\theta} - \underline{\theta}$ ) and on the creditor's ex ante and ex post assessments of expected payoffs, given the actions of other creditors. In a best case scenario, where a creditor's ex ante priors match his ex post judgement,  $\Phi(\cdot) = 0$ . The trigger point thus occurs at the lowest value of fundamentals, i.e.,  $\hat{\theta} = \underline{\theta}$ . Runs are simply fundamentals based. As a wedge develops between

ex ante and ex post beliefs, runs occur at higher values of  $\theta$ . In the limit, when  $\Phi(\cdot)$  is at a maximum, i.e., at unity, a run will occur as long as  $\theta < \bar{\theta}$ . Runs are, thus, belief-driven.

### 3. Policy implications

The model of sovereign liquidity crises outlined above provides a natural framework with which to address some of the recent proposals aimed at forestalling financial crises and to investigate their welfare consequences. By running, creditors impose externalities on other creditors and disrupt activity in the debtor economy. The co-ordination problem facing creditors results in welfare costs. These are the losses, depicted in Fig. 2, that show up through otherwise value-enhancing investments being liquidated or shelved.

In what follows, we first define a welfare criterion with which to examine some of the public intervention measures that have been advocated to reduce the risk of liquidity crises. These policy measures can induce changes in the trigger value of fundamentals,  $\hat{\theta}$ , thus affecting the likelihood of a belief-driven crisis. They can also induce changes in  $\underline{\theta}$ , and affect the likelihood of a fundamentals-driven crisis. Our method allows us to decompose the welfare effects of a policy change into two parts: (i) the changes in welfare caused by changes in the likelihood of belief driven crises, and (ii) changes in welfare related to changes in the likelihood of a fundamentals crisis. We then examine the effect, on welfare, of a number of policy measures, including tighter monetary policy, increased transparency, and prudent debt management.<sup>13</sup>

#### 3.1. Welfare

Our definition of welfare focuses on the socially wasteful impact of sovereign liquidity crises on the debtor economy.<sup>14</sup> Let  $\phi(\cdot)$  be the density function of the normally distributed random variable  $\theta$ . Then, in a first-best world, *absent any co-ordination problems*, expected output is given by

$$E[Y]_{\text{first best}} = \int_{-\infty}^{\hat{\theta}} [\theta(E + L) - kL] \phi(\cdot) d\theta + \int_{\hat{\theta}}^{\infty} [\theta(E + L)] \phi(\cdot) d\theta. \quad (17)$$

<sup>13</sup> See Drage and Mann (1999) for a comprehensive discussion of policy proposals and initiatives.

<sup>14</sup> Jeanne (1999) defines an aggregate welfare criterion in terms of the sum of the utilities of all agents in the model. But as the pay-off matrix for the individual creditor (see Section 2.1) shows, creditor payoffs from staying or fleeing are clearly Pareto-ranked, namely  $L(1 + r) > L(1 - c) > 0$ . We, therefore, focus on the welfare implications for the debtor.

Similarly, expected output in a second-best environment *with co-ordination problems* is

$$E[Y]_{\text{second best}} = \int_{-\infty}^{\underline{\theta}} [\theta(E+L) - kL] \phi(\cdot) d\theta + \int_{\underline{\theta}}^{\hat{\theta}} [\theta(E+L) - k\lambda(\theta)L] \phi(\cdot) d\theta + \int_{\hat{\theta}}^{\infty} [\theta(E+L)] \phi(\cdot) d\theta, \quad (18)$$

where the function  $\lambda(\theta)$  denotes the (ex ante) critical proportion of creditors needed to induce the planner to default in states of the world between  $\underline{\theta}$  and  $\hat{\theta}$  (see Eq. 3). This differs from the first-best by the extent of the disruption to production induced by the creditor co-ordination problems over the range of fundamentals  $\theta \in [\underline{\theta}, \hat{\theta}]$ .

So a measure of debtor country welfare cost of co-ordination failure,  $W$ , is simply the difference between first and second best outcomes,

$$W = kL \int_{\underline{\theta}}^{\hat{\theta}} \lambda(\theta) \phi(\cdot) d\theta = k \left[ \frac{(\hat{\theta} - \underline{\theta})(E+L)}{k + r_A - r_L} \right], \quad (19)$$

which is of course directly proportional to the shaded region in Fig. 2. Policy measures affect welfare to the extent that they have an influence on  $\hat{\theta}$  and/or on  $\underline{\theta}$  (or the other terms in Eq. (19)). Eq. (19) allows us to decompose changes in welfare from a given policy action. Denoting  $\Delta W \equiv W - W'$  as the change in the value of welfare following the public policy action:

$$\Delta W = [(\hat{\theta}' - \hat{\theta}) - (\underline{\theta}' - \underline{\theta})] \frac{k(E+L)}{k + r_A - r_L}, \quad (20)$$

where  $\hat{\theta}'$  and  $\underline{\theta}'$  are the new first and second-best state of fundamentals following the policy action. So the effects of a given public policy measure can be calculated in welfare terms and decomposed into whether they influence the probability of a fundamentals-driven (first-generation) or belief-driven (second-generation) crisis.

### 3.2. Comparative statics and numerical results

Given that there are no closed-form solutions to our model, we resort to numerical simulations to conduct our welfare analysis. Table 1 summarises the baseline parameter values of the model, and expresses the welfare cost imposed by the creditor co-ordination problem as a percentage of ex ante expected output.

The parameter values used in Table 1 are to some extent arbitrary, but have been motivated by recent experience. Spreads on external debt of 500–1000 basis points are frequently faced by emerging market borrowers, so  $r_L = 10\%$ . And, in line with returns in industrial country financial markets, a return of 5%

Table 1  
Baseline simulation parameters

Description	Parameter	Value
Cost of external short-term debt <sup>a</sup>	$r_L$	10%
Return on liquid reserves <sup>a</sup>	$r_A$	5%
Proportional “exit cost” to creditors from fleeing	$c$	20%
Short-term debt to reserve ratio	$L/A$	150%
Sovereign gearing ratio	$L/(E + L)$	50%
Sovereign reserve/asset ratio	$A/(E + L)$	33%
Marginal output cost of fleeing	$k$	0.4
Mean of fundamentals	$\mu_\theta$	0.29
Variance of fundamentals	$\sigma_\theta^2$	0.025
Variance of private sector forecasts of fundamentals	$\sigma_\varepsilon^2$	0.05
Minimum net liquidity ratio	$\underline{\theta}$	0.2
Maximum net liquidity ratio	$\bar{\theta}$	0.38
Critical net liquidity ratio	$\hat{\theta}$	0.37
Total welfare cost (% of ex ante expected output)	$W$	66%

<sup>a</sup> Spread over international rate ( $r^* = 0$ ).

on liquid reserves appears plausible. The recent Malaysian experiment with capital controls involved a proportional exit tax of 20%, which we take to be our value for  $c$  in the baseline. More generally, however,  $c$  can be thought of as the break-up value of collateral or the transaction cost of unwinding deposits from a country.

The choice of a short-term debt/reserve ratio and, by extension, the gearing and reserve/asset ratios also seems consistent with recent experience. For example, short-term debt/reserve ratios in Thailand and Argentina averaged 87% and 175% over 1987 and 1998 respectively. Ahead of their crisis in 1997, debt/reserves ratios in Thailand were around 150% and around 200% in Korea and Indonesia. We set the debt/reserves ratio at 150% as a benchmark.

The expected value of  $\theta$ ,  $\mu_\theta$ , lies between  $\underline{\theta}$  and  $\bar{\theta}$ , and is taken to be 0.29. The variance of the distribution,  $\sigma_\theta^2$ , is taken to be 0.025. A standard deviation of 15 pp for the debt/reserve ratio does not seem unreasonable in an emerging markets context. For example, the standard deviations on the Thai and Brazilian debt/reserve ratios, based on quarterly data between 1990 and 1999, were 25 and 19 pp respectively. For simplicity, we assume that the variance across the private sector of fundamentals is one and a half times that regarding fundamentals in aggregate, so  $\sigma_\varepsilon^2 = 0.05$ . The marginal output cost of the withdrawal of short-term credit is harder to gauge, however. The range of parameter values for  $k$  are determined by the uniqueness condition and the requirement that  $k > r_L - r_A$ , i.e., that  $k$  exceed the chosen interest rate differential. In our stylised baseline case this implies a value for  $k$  between 0.05 and 0.6. In an emerging markets context, interest rate differentials can be much

higher than 5%, and spreads are frequently 20% or higher. So we assume somewhat arbitrarily, that  $k = 0.4$ , i.e., that a dollar withdrawn by a creditor reduces output by 40 cents – somewhat greater than our chosen value for the expected marginal product of capital,  $\mu_\theta$ . The qualitative results of our analysis are not affected by the choice of  $k$ .

The welfare cost imposed on the debtor by the collective action problem in this stylised economy is substantial. It amounts to some two-thirds of ex ante expected output in stage 2. Because of the uncertainty which surrounds the true value of  $k$ , the absolute value of the costs of co-ordination failure should not be taken too literally. For very small values of  $k$ , e.g.,  $k = 0.06$ , welfare costs are of the order of 10% of ex ante expected output. Such results suggest that these costs are decidedly non-trivial. It points to the potentially important role of public policy in ameliorating these efficiency losses. We, therefore, examine the effects of different policy measures on the welfare costs of our stylised economy, and decompose welfare changes into their belief and fundamentals-based components.

### 3.2.1. *The effects of domestic and foreign interest rates*

3.2.1.1. *Domestic monetary policy.* Policy debate in the aftermath of recent financial crises has focussed on the efficacy of the authorities tightening monetary conditions in the midst of a country run. In countries such as Brazil, sovereign liquidity crises have been intertwined with downward pressure on fixed/managed exchange rate regimes. Risks to financial stability thus stem from interruptions to debt service as well as the potential build-up of inflationary expectations resulting from a breakdown of the nominal anchor. By in large, monetary policy in a number of crisis countries has been set with the latter consideration in mind.

In circumstances where inflationary expectations are well anchored (or develop with considerable inertia), so that policy is not being set with a view to re-establishing credibility, two views on tighter domestic monetary condition dominate. On one view, higher interest rates make it more attractive for creditors to hold on emerging economy's assets, thereby strengthening the exchange rate at a time when creditors are reaching for the door (e.g., IMF, 1999). On another, monetary tightening undermines confidence by contributing to the economic downturn, raising fears of insolvency, and adding to downward pressure on exchange rates.<sup>15</sup> Although our model is completely real and has no formal role for money and nominal exchange rates, we can nonetheless utilise our framework to shed some light on this debate.

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<sup>15</sup> See, e.g., Furman and Stiglitz (1998).



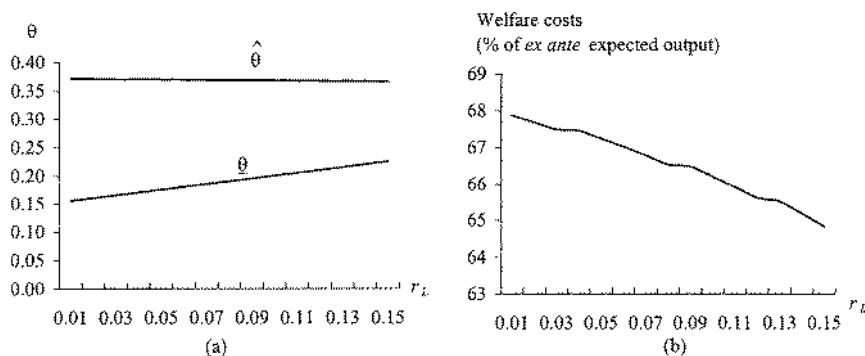


Fig. 3. Effects of increasing interest rates.

To the extent that tighter monetary policy contributes to the attractiveness of staying in the debtor country, a rise in  $r_L$  can capture the role of monetary policy in our model. As can be seen from Eq. (6), a rise in  $r_L$  increases  $\underline{\theta}$ . This increases the likelihood of a fundamentals-based crisis as increased interest rates have an adverse effect on the debtor's solvency – the *Stiglitz effect*. But, a higher  $r_L$  also increases the expected returns to the creditor from staying, and the expected marginal costs (production and borrowing) to the debtor from leveraging. This seems to reduce co-ordination problems and lower  $\hat{\theta}$  – the *IMF effect*. Fig. 3(a) illustrates how  $\underline{\theta}$  rises and  $\hat{\theta}$  falls as interest rates are increased. Although  $\hat{\theta}$  falls unambiguously in the parametric range over which co-ordination problems are a concern, the increase in  $\underline{\theta}$  is dominant. In other words, although higher interest rates increase the likelihood of creditors staying in a country, the problems of insolvency are paramount at a time of co-ordination failure, using our baseline parameterisation. Fig. 3(b) shows how tighter monetary policy ameliorates co-ordination inefficiencies.<sup>16</sup>

**3.2.1.2. Monsoonal effects.** Common shocks, or “monsoonal” effects, such as a rise in world real interest rates, have played an important role in debt crises through their interaction with domestic fundamentals (Masson, 1998). Since, in our model, we choose to normalise the world real interest rate ( $r^*$ ) to zero, the effects of a rise in  $r^*$  is equivalent to a simultaneous increase in  $r_L$  and  $r_A$ . Fig. 4(a) shows how the simultaneous increase in  $r_L$  and  $r_A$  has very little impact on the values of  $\hat{\theta}$  and  $\underline{\theta}$ . They both fall negligibly, with  $\hat{\theta}$  falling by slightly more.

<sup>16</sup> Note that our model does not formally capture the effects of monetary policy on output. There is a potential linkage between the disruption costs to production,  $k$ , and interest rates,  $r_L$ . If  $k$  is an increasing function of  $r_L$ , i.e., if tighter monetary conditions have a very swift, adverse impact on production, then it is likely that the results suggested above would be strengthened.

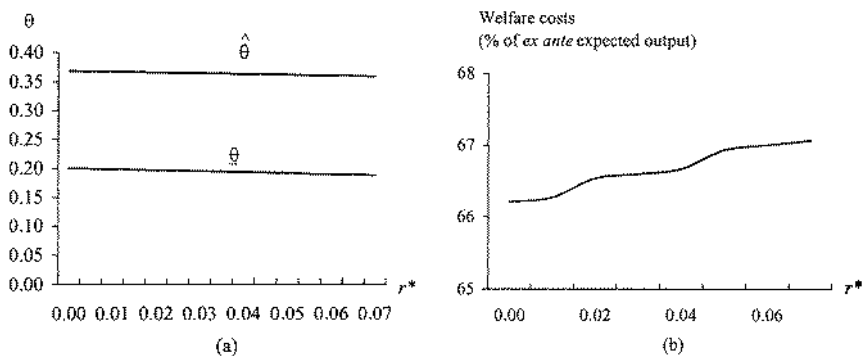


Fig. 4. Effects of increasing world interest rates.

As a result, as Fig. 4(b) shows, a rise in the world real interest rate increases welfare costs to the debtor – but only marginally. In our model, this is because the negative impact of rising borrowing costs is offset, to a degree, by the higher return to liquid reserves invested in the storage technology.

### 3.2.2. Debt and liquidity management

Prudent management of national debt and liquidity is being seen as an increasingly important part of the international financial architecture. It has been emphasised recently by, among others, Summers (1999) and Greenspan (1999), and has been taken forward by policymakers in the context of the Financial Stability Forum. Greenspan (1999), following earlier unpublished ideas by former Argentine Finance Minister Guidotti, discusses the possibility that, as a rule of thumb, a country should always have enough foreign exchange reserves to cover a year's foreign currency liabilities.<sup>17</sup> Recent empirical work also shows that the ratio of short-term debt to reserves is as good a predictor of crisis as any other macroeconomic variable (see, e.g., Berg and Pattillo, 1999; Bussière and Mulder, 1999).

In the context of our model, prudent debt and liquidity management has an important bearing on the welfare costs of crisis and affects the likelihood of both a belief-driven and a fundamentals-driven crisis. We consider public policies of three types: increases in the government's liquid assets; reductions in their short-term liabilities; and, combining the first two, attempts to change the ratio of short-term debt to reserves, in line with the rule of thumb. Prudent debt and liquidity management affects both liquidity and solvency. Using

<sup>17</sup> He also discusses the proposal that, as a benchmark, the average maturity of external debt should exceed three years – which we do not consider here.

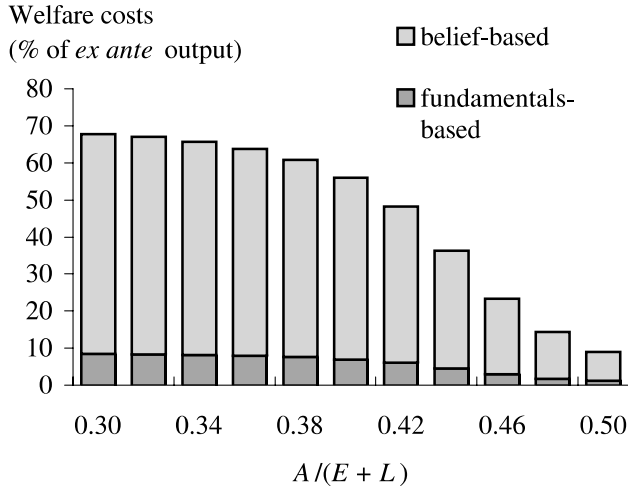


Fig. 5. Welfare effects of increasing reserves.

Eq. (20), we decompose these (liquidity and solvency) welfare effects. The resulting total welfare cost turns out to be first-order.

*3.2.2.1. Bolstering reserves.* An increased liquid reserve asset ratio  $A/(E+L)$  has an important impact on the welfare costs posed by the co-ordination problem. An increase in liquid reserves ( $A$ ) reduces the probability of both fundamentals and belief-driven liquidity crises, and as Fig. 5 shows, welfare costs are reduced dramatically. An improvement in the reserve/asset ratio from 30% to 50% virtually eliminates the welfare cost of creditor co-ordination. Fig. 5 also shows how the belief and fundamentals based components of welfare evolve as reserves increase. The lighter shaded area shows the costs of co-ordination, while the darker shaded area illustrates the probability of a fundamentals-based run. As can be seen, improvements in the reserve/asset ratio begin to have a noticeably sharp impact on both components when the ratio exceeds 40%. It should be noted, however, that  $A$  is an exogenous variable in our model and the strength of the result stems from the independence of liquid ( $A$ ) and productive ( $E$ ) resources. More generally, the build-up of reserves by a country diverts resources away from production and is costly. So the results in Fig. 5 are likely to exaggerate somewhat the role of a build-up in reserves in dealing with sovereign liquidity crises.

*3.2.2.2. Reducing short-term foreign borrowing.* Reducing the sovereign gearing ratio in our model has the same qualitative effect as a bolstering of reserves.

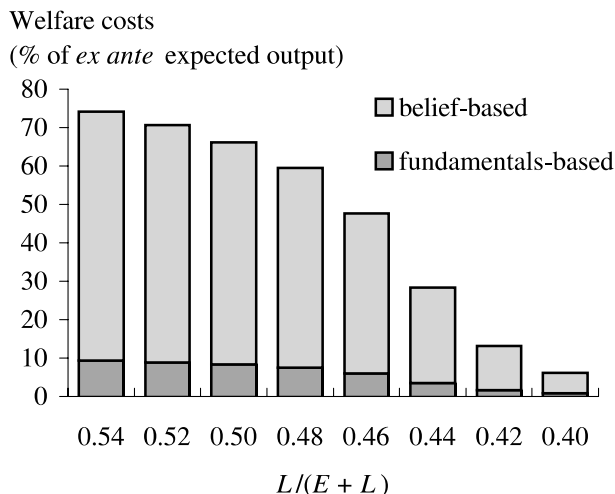


Fig. 6. Welfare effects of a reduction in gearing ratio.

As Fig. 6 shows, a reduction in the gearing ratio from 50% to 40% lowers welfare costs of co-ordination significantly – a 10% point reduction in the ratio results in an improvement in welfare cost of over 50% points (see Fig. 6). The probability of a fundamentals-based run also falls markedly. Our results point to the importance of developing capital markets that allow debtors to borrow at longer maturities and intermediate savings domestically.

*3.2.2.3. Simple rules.* Fig. 7 shows the results of progressively lowering the short-term debt/reserve ratio. Implementing a “Guidotti” rule, as discussed in Greenspan (1999), that limits countries to a specific debt/reserves ratio (100% in this example) results in substantial welfare gains, relative to the baseline. Welfare losses are cut by a factor of more than six. A decomposition of the welfare costs suggests that the rule has a similar impact on the belief-based component of welfare costs as in the previous two cases.

It should be noted that, while suggestive, our model is atemporal and cannot discuss formally the issues of periodicity and maturity implied by such rules. To have a richer understanding of the welfare implications of the Guidotti rule, we need to capture debt maturity by endogenising interest rates in our model. Our results are also strengthened somewhat because liquid reserves and domestic capital resources are treated as exogenous and independent of each other. But, all in all, our findings point to an important role for prudent debt and liquidity management in mitigating (in particular, the belief-based) costs of crisis.

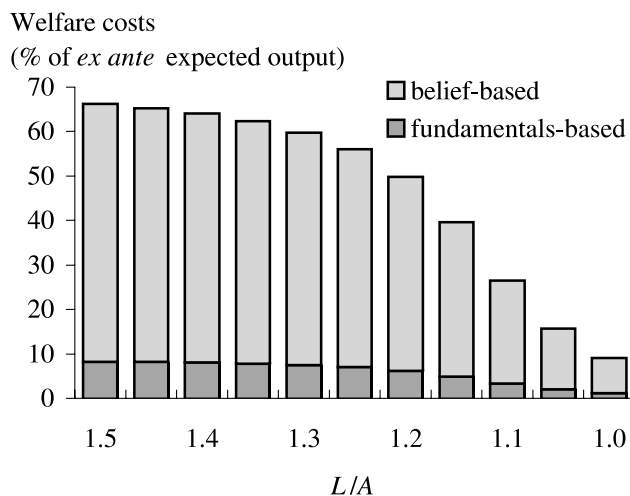


Fig. 7. Effects on welfare of a simple rule.

### 3.2.3. Information and disclosure

Improved information about fundamentals, and greater transparency about this information, are at the heart of recent efforts to improve the financial architecture.<sup>18</sup> Significant strides have been made in recent years to improve the quantity and quality of data, especially in the emerging markets. Some of this data is captured under the IMF's special data dissemination standard (SDDS). A complementary set of initiatives have sought to increase the transparency of this and other information: again through the SDDS; through establishing codes and standards of monetary, financial and fiscal policies; and through the ongoing experiment with publishing IMF Article IV country reports. Most recently, a selection of countries have published pilot reports on the observance of standards and codes (ROSCs). These summarise the extent of their compliance with disclosure standards and codes of conduct, and include so-called "transparency about transparency".

It is interesting to explore the welfare effects of greater information availability and disclosure using the model set out above. The model yields rich – though subtle – insights about the merits of information provision and disclosure. This richness derives from the presumption of two levels of informational distortion. At one level, there is underlying uncertainty about fundamentals. Improvements in the quantity and quality of the pool of current information will lower  $\sigma_\theta^2$  – information initiatives. At another level, each

<sup>18</sup> See, e.g., King (1999) and the findings of the G22 Report of the Working Group on Transparency and Accountability published in October, 1998.

individual creditor in the private sector may have a different information set to the other (and to the debtor), so  $\sigma_\varepsilon^2 > 0$ . Improvements in the degree of public transparency by debtors to creditors collectively will lower  $\sigma_\varepsilon^2$  – disclosure initiatives. In addressing issues of information availability and disclosure, we need to differentiate clearly between these two levels of informational distortion.

Consider, first, the perfect information game described in Section 2.2. This is a game in which the players have common knowledge about fundamentals,  $\theta$ . In other words, the numerous creditors and the planner know the distribution (or data generating process) of  $\theta$ , and each knows that the other knows it. In this instance, a reduction in  $\sigma_\theta^2$  is equivalent to reducing the underlying uncertainty on the fundamental state,  $\theta$ .<sup>19</sup> In the limit,  $\sigma_\theta^2 = 0$ , fundamentals are deterministic and the game among private creditors collapses. In second generation games of this type, multiple equilibria obtain and welfare costs are difficult to characterise. Improved quantity or quality of data does not, by itself, solve co-ordination problems and the accompanying indeterminacy of equilibria.

The assumption of common knowledge amongst policymakers and the private sector is clearly unrealistic. In practice, there are thus small disparities in the information sets of the players in the game, including between planner and creditors and  $\sigma_\varepsilon^2 > 0$ . Greater transparency on the part of the debtor amounts to reductions in  $\sigma_\varepsilon^2$ .

What are the welfare effects of information disclosure of this type? The relationship between the information disclosure and welfare is complicated and non-linear. Consider first the conditions under which the uniqueness condition,  $\sqrt{2\pi}(E + L)/[(k + r_A - r_L)L] > \sigma_\varepsilon/\sigma_\theta^2$ , holds and there is a single equilibrium,  $\hat{\theta}$ . In such circumstances, greater information disclosure – in the sense that private sector forecasts become more accurate relative to the underlying uncertainty about fundamentals (i.e., a fall in  $\sigma_\varepsilon^2/\sigma_\theta^2$ ) – is welfare enhancing. Disclosure reduces the likelihood of belief-based crises. This can be seen in Fig. 8, which simulates the effects on welfare costs, of a fall in  $\sigma_\varepsilon^2/\sigma_\theta^2$ . It is clear from the figure that, while welfare enhancing, the effect of improving private sector forecasts is not large. In our stylised example, doubling the precision of private signals relative to the baseline succeeds in reducing welfare costs from 66% to 62% of ex ante output. Our calibration has been chosen with recent experience in mind. A different set of parameter values may deliver stronger results.

It should be noted, however, that this result is not general. Consider the extreme case when  $\sigma_\varepsilon^2 = 0$ , common knowledge obtains, and we are back to the complete information game described in Section 2.2. So it is possible that complete information disclosure is self-defeating. Intuitively, this is because

<sup>19</sup> Recall, from Fig. 2, that there are potentially an infinite number of equilibria between the range  $\underline{\theta}$  and  $\hat{\theta}$ . A reduction in  $\sigma_\theta^2$  – a squashing of the distribution function – does not change this.

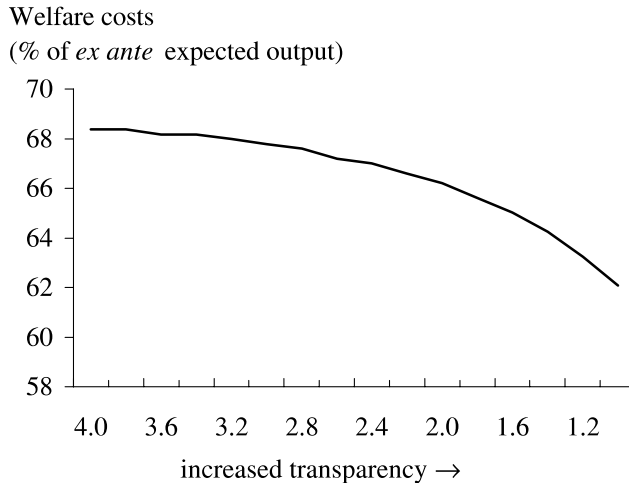


Fig. 8. Welfare cost of information disclosure.

there is no necessary link between transparency and the likelihood of a self-fulfilling run – turning the lights on will not necessarily stop creditors running for the door. The point here is a general one: economic theory offers little guidance on how better information about payoffs to the players of a co-ordination game affects the probability of co-ordination (Morris and Shin, 1999).

What does all this imply for public policy? Improved data quality – improving the pool of common knowledge – appears to do little, by itself, to resolve liquidity crises and their associated welfare costs.<sup>20</sup> Meanwhile, disclosure of information by debtors to creditors can be a mixed blessing. Improved transparency can be welfare enhancing up to a point, even though the effects are small according to our calibration. But on occasions, disclosure could in fact help trigger a run, with attendant welfare costs. Policies that seek to promote information disclosure are certainly not a panacea and are unlikely, by themselves, to be decisive in eliminating sovereign liquidity crises.

#### 3.2.4. Capital controls

The parameter,  $c$ , can be thought of as either an exit (or Tobin) tax, or as the portfolio adjustment cost facing creditors seeking to reallocate capital. To the

<sup>20</sup> This does not, however, mean that there can be no role for policies that seek to expand the pool of publicly available information. Recall that our model is partial equilibrium in nature and does not explicitly model the optimal lending decision of creditors. Increasing the pool of publicly available information could well increase the willingness to lend at some prior stage (i.e., before  $t = 0$ ).

extent that  $c$  can be viewed as a formal control on capital outflows, the proceeds of an exit tax could potentially be used to bolster liquid assets.<sup>21</sup> To sharpen our results, we assume instead that the proceeds of the exit tax are wasted, and are unavailable to the planner. Imposed in such a manner, capital controls do not affect the probability of a fundamentals-based crisis (i.e., changes in  $c$  do not affect  $\underline{\theta}$ ). Rather, they impact directly on the trigger value of fundamentals,  $\hat{\theta}$ , thereby affecting the likelihood of a belief-driven crisis.

There is an active public policy debate on the efficacy of controls on capital outflows. The IMF's position has historically been to oppose such controls (e.g., Fischer, 1999). But that view has recently been questioned. Malaysia is one example of a country which has put that policy into practice. Payments moratoria can be thought of as a limiting case of capital case of capital controls, where the effective tax rate is set to unity. They also have recently been actively debated in international fora and have found advocates both from within both academic and public policy circles (e.g., Miller and Stiglitz, 1999).

The model here is only partial equilibrium but nonetheless offers some clues to the potential scale of the gross benefits of such controls. Fig. 9 illustrates how the planner's welfare is affected by increasing the exit costs to creditors from fleeing. As can be seen, an increase in the exit tax from 5% to 20% does not have a dramatic effect on welfare – the welfare cost as a percentage of ex ante expected output falls only slightly, from 68% to 66%. Controls confer small benefits, as co-ordination problems are mitigated slightly. But welfare costs do fall dramatically when exit taxes exceed 35%, and taxes in excess of 75% effectively eliminate the co-ordination problem. The sharp fall reflects the non-linearity of the distribution function. The use of other functions, e.g., uniform, would lead to a more gradual reduction in welfare costs. But, regardless of the choice of distribution function, our findings suggest that welfare costs are only eliminated at high exit tax rates. So relatively modest controls on capital outflows, or “sand in the wheels of international finance”, may not be a particularly effective means of limiting a speculative run or the co-ordination costs imposed by creditors. High exit taxes – or, in the limit, formal moratoria – appear necessary to defuse the incentives to run sufficiently to confer the full benefits of co-ordination.

But it is important to recognise the limitations of our model for evaluating the efficacy of capital controls. Whilst the presence of quantitative barriers can prove effective, it raises questions about the willingness of creditors to lend in

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<sup>21</sup> This would lower the probability of both a fundamentals- and a belief-based crisis, i.e., it would lower  $\underline{\theta}$  and  $\hat{\theta}$ . Note that, since we do not model the borrowing/lending decision at stage  $t = 0$ , we do not consider “Chilean-style” capital inflow controls. Our model can, in principle, be extended to assess the welfare implications of such measures. For a detailed discussion of the Chilean experience, see Edwards (1998).



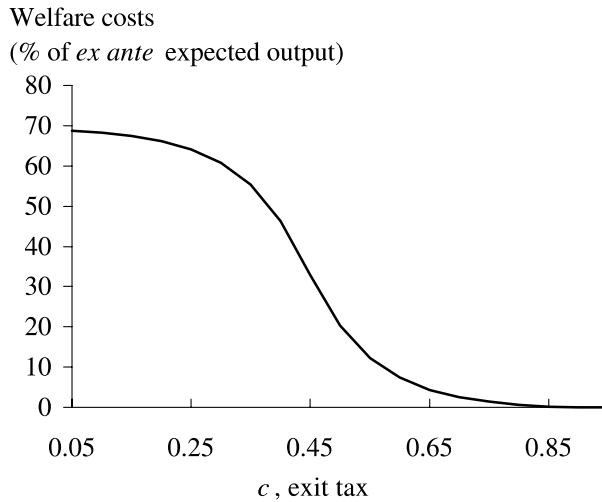


Fig. 9. Welfare effects of increasing exit taxes.

the first place. Our model is cast as a one-shot game, and abstracts from the credibility issues associated with the presence of capital controls in a repeated game. For that reason, our policy simulation is perhaps best thought of as a “surprise” introduction of controls which abstracts from time consistency issues. These reputational, dynamic losses would need to be set against the static gains when conducting a general equilibrium evaluation of welfare merits of capital controls.

#### 4. Conclusions

This paper offers a welfare-theoretic framework with which to assess some recent policy proposals for strengthening the international financial architecture. In so doing, it builds on recent insights by Morris and Shin (1998, 1999). A central feature of the analysis is the focus on the collective action problems amongst creditors and the interaction of fundamentals and strategic behaviour. We show how the welfare cost of non-cooperation among creditors, which is manifest in value-enhancing investments being shelved or liquidated, could be substantial. We are also able to decompose the welfare cost of a country run into its fundamentals and belief-based elements. This allows us to examine the efficacy of different policy measures in tackling the issues posed by first and second-generation models of crisis.

Although our numerical results are sensitive to the choice of parameter values, they are nevertheless suggestive. Of the policy measures considered, prudent debt management (namely increases in a government’s liquid assets,

reductions in their short-term liabilities and, combining the two, reductions in the short-term debt/reserves ratio) appears most effective as a means of reducing the welfare cost of creditor co-ordination and limiting the likelihood of both fundamentals and belief-based crises. Extending debt maturity may also have its place, and a natural extension of our work would be to endogenise the term structure of interest rates in the model to examine the welfare effects of such proposals.

Our results also shed further light on the role played by transparency in crisis management. The increased dissemination of information about a debtor does not, of itself, prevent a fundamentals-based crisis. And though information disclosure can help reduce efficiency losses, the sensitivity of our results to parameter values lends force to the notion that a policy of increased transparency, on its own, is unlikely to be a panacea. Our model, although real, also suggests that the efficacy of monetary policy in preventing country runs may be limited in circumstances where medium-term inflation expectations are well anchored.

Sovereign liquidity crises may also be wasteful in ways that are beyond the scope of this paper. For example, there may be *distributional costs*, as fleet-of-foot creditors benefit at the expense of other creditors. These are losses that stem from the inability to ‘bail-in’ creditors on a comparable basis. Such distributional costs are likely to be most relevant for official creditors, who do not have the same incentives, or the ability to run, as private sector creditors. Architectural proposals involving the official sector such as emergency liquidity provision and IMF-sanctioned contingent credit lines need to be assessed with these issues in mind. A welfare-theoretic investigation along these lines is an important area for future research.

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