The Role of Sovereign Debt Standstills in Crisis Management*

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Preliminary: Not to be quoted without authors' permission.

December 13, 2000

Abstract

Recent debate on the reform of the international financial architecture has highlighted the potentially important role of temporary payments standstills in the management of sovereign liquidity crises. We examine how such public intervention in sovereign debt contracts affects efficiency, *ex ante* and *ex post*. Our results shed light on the scale of capital inflows with and without standstills, and we establish conditions under which a regime with standstills leads to an improvement in debtor country welfare. The efficacy of standstills depends critically on the quality of public sector surveillance and the size of the costs of disorderly liquidation generated by the creditor co-ordination problem.

JEL Classification: F33, F34

Keywords: international financial architecture, sovereign debt, financial crisis, standstills.

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*We are grateful to Michael Chui, Andrew Haldane, Adrian Penalver, and Paul Tucker for helpful comments and encouragement. We thank seminar participants at the Bank of England and the Bank of Japan for comments on an earlier version of the paper. The usual caveat applies. The views expressed herein are those of the authors and do not necessarily reflect those of the Bank of England.

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1. Introduction

There has been considerable debate on the reform of the international financial architecture in the aftermath of recent crises. Academics and policymakers alike have advocated a number of measures to prevent or at least limit the frequency and severity of crises. They include improvements in national balance sheet management to avoid severe currency and maturity mismatches, the provision of contingent credit lines for emergency official finance, and the development of codes and standards to allow better informed decisions by debtors and creditors.[1] By contrast, progress on public policies aimed at improving the process of *crisis resolution* has been slower, reflecting the difficulties inherent in promoting co-operative solutions between a sovereign debtor and its international creditors. Nevertheless, a broad consensus may be developing around the central objective of international crisis management, namely the restoration of confidence and the normal flow of private capital to the debtor.

There has also been a measure of agreement on the circumstances under which crises arise. The academic literature on financial crises has typically identified two main (and separate) causes.[2] First, inconsistent government policies and/or external shocks can bring about a secular deterioration in a country's fundamentals leading, for example, to an unsustainable build up of debt, or the exhaustion of foreign exchange reserves, thereby triggering a crisis. Second, crises may reflect a co-ordination problem among creditors - the actions of creditors can be mutually reinforcing as they 'race for the exits'. This interpretation highlights the important role of creditor beliefs. Pessimistic expectations can become both self-generating and self-fulfilling.[3] Reflecting these two lines of thinking, public policy approaches to crisis management have recognised the possible need for debt restructuring in cases where crises arise from poor performance and policy, laying stress on the important role of official finance in support of credible policy adjustment. And they have sought to limit investor panics by seeking to co-ordinate private creditors, for example by agreeing to roll over obligations coming due.

In practice, crisis management is likely to require a judicious mix of private

[1] An overview of the policy debate is offered in Drage & Mann (1999).

[2] See Krugman (1979), Diamond & Dybvig (1983), and Obstfeld (1996). Flood & Marion (1998) offer a comprehensive survey.

[3] Recent work by Morris & Shin (1998, 2000) on the co-ordination problem underlying financial crises shows how fundamentals and beliefs intertwine. The policy implications, for sovereign liquidity crises, of this approach are examined in Chui, Gai & Haldane (2000).

sector involvement and official finance.[4] But the method of achieving this mix is far from clear-cut. On one view, there is a danger that too rigid a set of rules would act as an unhelpful constraint. Crises arise for different reasons and differ in form, so should therefore be approached on a case-by-case basis. An alternative viewpoint is that too much discretion increases uncertainty about possible outcomes in the event of a crisis. For example, lack of clarity regarding the amount, timing and conditionality of official sector lending may compound the disorder in the workout process. If guidelines create an expectation of orderly crisis management, this may reduce the likelihood of sharp reversals in capital flows in circumstances where debtor fundamentals are perceived to be poor.

One possible measure in responding to a crisis is the imposition of a temporary suspension of payments - a 'standstill'. Such a pause may be a "process" measure that attempts to provide creditors with time to reflect, and to agree upon mutually beneficial actions in concert with the debtor so as to maximise the likelihood of preserving the value of creditors' claims. A standstill can also allow valuable time for appropriate policy adjustment programmes to be considered and implemented. Moreover, disruptions to the financial and real sectors of the economy from the creditor co-ordination problem would be mitigated. Radelet & Sachs (1998) argue that the resolution of the Korean crisis in 1997-98 was a demonstration that a standstill mechanism can work in practice, noting that "...economists will have to discover whether it can work in theory - and thereby be pursued more systematically in future cases...".

Some policymakers have increasingly begun to advocate sovereign debt standstills as an element of international financial crisis resolution. The G7 have formally endorsed the use of standstills among its tools for orderly debt restructuring. King (1999) also stresses the need to avoid the costs of disorderly liquidation and suggests that, in the absence of formal mechanisms, bodies such as the IMF could indicate official affirmation of a standstill by supporting a country that has temporarily suspended payments to its creditors. Critics, however, argue that if standstills were to become part of the international financial architecture, creditors may reduce investment in emerging markets. Moreover, declaration of standstills may have important spill-over effects - an officially sanctioned default in one country may trigger margin calls that lead investors to liquidate assets in other countries, thereby exacerbating and spreading the financial crisis.[5]

[4] See, for example, Summers (2000).

[5] See Schinasi and Smith (1999) for an analysis of how a shock to one asset market may lead some investors to liquidate holdings in other, apparently unrelated, markets.

In a recent paper, Dooley (2000) argues that the recent policy debate has focused too much on the amelioration of *ex post* inefficiencies, and has paid insufficient attention to the moral hazard problems of enforcing sovereign debt. Unlike corporate debt, the lack of collateral (or the means to seize it) means that a threat is necessary to provide the incentive for repayment of sovereign debt.[6] Drawing on Bolton & Scharfstein (1996), Dooley notes that an optimal structure for international debt needs to balance two concerns: on the one hand, it should deter strategic default; and on the other, it should not make unavoidable ('bad luck') defaults too costly. In Dooley's model, the incentive to repay debt is provided by the protracted loss in output caused by a creditor run. Thus, the coordination problem among private creditors, and the associated economic cost for the debtor, *is the feature* of the international financial system that makes international lending possible.[7] The implication of Dooley's analysis is that policies designed to eliminate the welfare costs posed by the creditor coordination problem could reduce, or even do away with, international debt flows. Optimal public policy intervention therefore needs to balance issues of *ex ante* and *ex post* efficiency: it should encourage adherence to the *ex ante* provisions of contracts while seeking to maximise the *ex post* value of the debtor.

The analytical foundations of sovereign debt standstills have yet to be explored exhaustively.[8] In what follows, we develop a theoretical model to analyse some of the incentive effects and trade-offs surrounding officially endorsed standstills. It attempts to assess how public intervention in sovereign debt contracts could affect the scale of capital flows and, more importantly, the welfare of borrowers and lenders. More specifically, we describe a regime in which a temporary payments standstill is combined with clearly defined guidelines and measures to alleviate the costs of disorderly workouts - what we term '*orderly standstills*'. The additional measures could include IMF lending (known in official circles as "lending into arrears"), mediating in the workout process, or overseeing compliance with best

[6]See Eaton & Gersovitz (1981) for the seminal analysis of a sovereign debtor's incentives to repay.

[7]The incentive effects of a threat to terminate lending is discussed in Stiglitz & Weiss (1983). In a related argument in the literature on banking, Calomiris and Kahn (1991) argue that the threat of withdrawal of demand deposits provides an instrument for disciplining bank managers. Diamond & Rajan (2000) use similar intuition in their analysis of the role of short-term debt in recent financial crises.

[8]Miller & Zhang (1999), and Kumar, Masson & Miller (2000) are exceptions. In a complementary analysis, Bolton & Rosenthal (1999) also emphasise the trade-off between *ex ante* and ex post in efficiency in a model of debt moratoria.

practice guidelines for sovereign debt workouts.

The model clarifies the conditions under which such a regime leads to an improvement in welfare for the debtor, relative to a regime without such measures. It is cast in the general guise of the trade-off between *ex ante* and *ex post* efficiency in the design of the debt contract between the debtor and its creditors. An important additional element in a standstills regime, however, is the official sector's ability to judge the predominant cause of crisis and the effectiveness with which it can limit disorderly runs. The official sector thus plays the twin roles of *whistle blowe*r and *fire fighter*.[9] The first role helps enforce discipline on the debtor *ex ante* by curtailing "strategic" default, while the second mitigates the *ex post* costs of a run in the event of a "bad luck" default.

Whereas collective action clauses and workout guidelines naturally come into play once a debtor has defaulted, the official sanctioning of standstills requires a judgment to be made about the soundness of a debtor country's finances. So the efficacy of sanctioned standstills is likely to depend critically on the quality of this judgement. The policy is ineffectual, and indeed welfare-reducing, if the quality of official sector assessments of a debtor country's circumstances is poor. The effectiveness of standstills also depends importantly on the ability of the official sector to limit the costs of liquidation. The absence of a coherent framework with which to enforce a standstill and mitigate the co-ordination costs of crisis, may mean that official sector intervention could be unsuccessful in influencing the basic trade-off between *ex ante* and *ex post* efficiency, even if its judgment is sound.[10]

The paper proceeds as follows. Section 2 describes the basic framework of the model and establishes the incentive compatible level of lending in a regime without orderly standstills. We illustrate the main arguments made by critics of standstills, and show how lending varies with the output costs of disorderly liquidation. In Section 3, we introduce orderly standstills into the model and compare incentive compatible lending under the two regimes. We show how imperfect monitoring by the official sector can lead to a lower level of lending *ex ante*. The market based

[9] Clementi (2000) describes the fire-fighting analogy in greater detail.

[10] It is important to note that, in the model, the motive for standstills differs from the role of payments suspensions ('bank holidays') in a Diamond-Dybvig (1983) bank run. In a bank run, the potential for a bank holiday influences depositor expectations in such a way that self-fulfilling liquidity crises never arise. In this sense, a bank holiday is a crisis *prevention* measure. For sovereign countries, however, the potential for a shortfall in liquidity is an unavoidable feature of the real world. In the event of a payments shortfall, a sanctioned standstill can be enacted to co-ordinate creditor actions so as to avoid the unnecessary output costs of disorderly creditor grab races or work outs.

level of lending is shown to be only replicable if the official sector is able to gauge perfectly the state of nature in the debtor country. Although *ex ante* lending is likely to be lower in a world with standstills, an exclusive focus on capital inflows is inappropriate. Section 3 also establishes conditions under which expected output is higher under a standstills regime. Expected output can be higher because the benefits of a standstill are felt most in adverse circumstances, i.e. bad states of nature. The declaration of a standstill avoids the disruptive impact of disorderly liquidation in the bad/unlucky output case. The greater the *ex post* inefficiency from inter-creditor conflict in the bad state, the more beneficial a regime with standstills is likely to be. We also consider distributional issues surrounding the welfare impact of a standstills regime, and provide some analysis of the 'rules versus discretion' debate on public sector involvement in resolving debt crises. A final section discusses the policy implications of our findings, and concludes with suggestions for future work.

2. Basic Model

Our model is an account of the interaction between a single debtor country and a continuum of small creditors. The debtor has no resources of its own and can produce only if it is able to obtain loans. It has access to a production technology that transforms loans into output. There are three dates, *initial*, *interim* and *final* (dates 0, 1 and 2, respectively). At the initial date (date 0), the debtor is granted a loan of size L, and promises to repay rL at the interim date (date 1). For now, we treat the repayment rate r as being exogenous, returning later to endogenise it. When amount L is invested at date 0, the project generates an interim output at date 1, which is used to repay the creditors. The final output depends on the amount repaid by the debtor at the interim date. If the debtor pays the full promised amount rL, then the project is allowed to mature without intervention from the creditors. However, if there is a shortfall in the amount repaid, creditors can force costly liquidation commensurate with the amount of the shortfall. The damage caused by the forced liquidation will depend on factors such as the extent of collateralisation of the debt or the amount of debtor assets that can be seized in the creditor country. If we denote by x the amount repaid by the debtor at the interim date, the proportional *discretionary shortfall* s is the amount repudiated as a proportion of the amount owed, i.e.

$$s = \frac{rL - x}{rL} \tag{2.1}$$

Output in the final period (date 2) is assumed to be a function of the scale of the initial investment L, and the extent of the costly liquidation arising from s at date 1. We denote the output in the final period by

$$y(L, s) \tag{2.2}$$

which we assume to be strictly decreasing in s. This formulation captures, in a reduced-form fashion, the costs associated with disorderly liquidation. As stressed by Stiglitz & Weiss (1983), Bolton & Scharfstein (1990, 1996) and Allen & Gale (1998), liquidation or the termination of lending can be costly, and acts as a way of inducing the debtor country to repay creditors instead of diverting resources to itself.

The debtor may choose to repay the full amount if the interim output is sufficient, but we leave open the possibility that the debtor will choose not to honour its promise, and to repudiate some or all of its debt obligations even though it can afford to repay in full. But if the interim output falls short of the repayment amount rL, then the debtor is forced into defaulting on some of its debt. Thus, there is the possibility that a payment shortfall is due to bad luck. Whether the non-payment is intentional or the result of bad luck is not verifiable for the purpose of the loan contract between the debtor and the borrowers.

The interim output $\tilde{x}$ of the debtor is a random variable which takes the value rL with probability θ, but is uniformly distributed on the interval $[0, rL]$ with probability $1 - \theta$. In other words, there is probability θ that the debtor has sufficient resources to pay back the loan in full. However, with probability $1 - \theta$, there are insufficient resources to repay. In this latter case, the amount of the shortage in resources is uniformly distributed over the possible range. We let

$$z = \frac{rL - \tilde{x}}{rL} \tag{2.3}$$

denote the size of the proportional *natural shortfall* in resources at the interim date. Then z is a random variable which takes the value of 0 with probability θ and is uniformly distributed on the unit interval with probability $1 - \theta$. The shortfall in the amount actually repaid may be larger than z (since the debtor may choose not to repay all of this output), but the shortfall in the actual repayment cannot be smaller than z, since the debtor cannot repay more than it can afford.

2.1. Optimal Contract

The optimal contract for the debtor solves for the size of loan L that maximises the expected output net of the repayment costs, taking into account the possible disruptions caused by premature liquidation. Denoting by $\mathrm{E}(\cdot)$ the expectations operator associated with the random variable z, the optimal contract selects the loan size L to maximise:

$$\mathrm{E}\left[y\left(L,z\right)-\left(1-z\right)rL\right] \tag{2.4}$$

subject to two sets of constraints. The first is the participation constraint

$$\mathrm{E}\left[y\left(L,z\right)-\left(1-z\right)rL\right]\geq 0 \tag{2.5}$$

which requires that the debtor is better off with the debt contract than without. The second set of constraints are the incentive compatibility constraints which require that

$$y\left(L,z\right)-\left(1-z\right)rL \;\geq\; y\left(L,s\right)-\left(1-s\right)rL \tag{2.6}$$

for all z and all $s\geq z$. This means that if there is no resource shortage (i.e. $z=0$), then the debtor has an incentive to pay back the full amount to the lender. It also ensures that if Nature has dealt a resource shortage of z, the debtor has no incentive to keep back any of the realized output from the creditors.

2.2. Parametric Example

In what follows, we will solve the optimal contracting problem for a parametric example. Specifically, we examine the case where $y\left(L,s\right)$ takes the form:

$$y\left(L,s\right)\equiv\left(1-\alpha s\right)L^{\lambda} \tag{2.7}$$

where α and λ are parameters satisfying $0<\alpha<1$ and $0<\lambda<1$. The parameter α captures the extent of the damage done by the premature liquidation by the creditors at the interim date. If there is repudiation of s, the output at the final period is reduced by a factor of αs. The parameter λ determines the elasticity of final output with respect to the size of initial investment L.

The incentive compatibility constraints (2.6) can be given a simple characterisation in this context. Given the realization of z (the realized shortage in resources), the debtor decides on the amount of the actual shortfall s in the repayment to the creditors, subject to s being no smaller than z. The debtor's problem is therefore to maximise

$$\left(1-\alpha s\right)L^{\lambda}-\left(1-s\right)rL \tag{2.8}$$

subject to $s \geq z$. Since this expression is linear in s, the debtor would choose to repay all of the available resources at the interim date if $\alpha L^{\lambda} > rL$, but would choose to repudiate all of its debt if $\alpha L^{\lambda} < rL$. So the set of incentive compatibility constraints (2.6) can be boiled down into a single condition on the size of the loan L. The initial loan must be small enough so that $\alpha L^{\lambda} \geq rL$. In other words,

$$L \leq \left(\frac{\alpha}{r}\right)^{\frac{1}{1-\lambda}} \tag{2.9}$$

It remains to determine when this constraint will be binding in the optimal contract. The unconstrained maximisation of the objective function (2.4) entails solving for L that maximises:

$$\theta\left[L^{\lambda} - rL\right] + (1-\theta)\left[(1 - \alpha \cdot \mathrm{E}\left(z \mid z > 0\right)) L^{\lambda} - (1 - \mathrm{E}\left(z \mid z > 0\right)) \cdot rL\right] \tag{2.10}$$

where $\mathrm{E}(z \mid z > 0)$ is the expectation of z conditional on its being strictly positive. Since z is uniformly distributed on the unit interval in this case, $\mathrm{E}(z \mid z > 0) = \frac{1}{2}$. The solution to the unconstrained maximisation can then be obtained from the first order condition:

$$\lambda L^{\lambda-1}\left\{\theta + (1-\theta)\left(1 - \frac{\alpha}{2}\right)\right\} - r\left\{\theta + \frac{1-\theta}{2}\right\} = 0$$

which yields

$$L = \left(\frac{\lambda}{r}\frac{(2 - \alpha(1-\theta))}{1+\theta}\right)^{\frac{1}{1-\lambda}} \tag{2.11}$$

The incentive compatibility constraint (2.9) fails to bind if and only if $\alpha \geq \lambda(2 - \alpha(1-\theta))/(1+\theta)$, or

$$\alpha \geq \frac{2\lambda}{1 + \theta + \lambda(1-\theta)} \tag{2.12}$$

Thus, if α is large enough, there are no impediments to borrowing the *ex ante* optimal amount. The threat that arises from the effects of premature liquidation by the lenders is enough to discipline the borrower to repay as much as it can. Knowing this, the creditors are prepared to lend the full amount. Conversely, if α is too small, incentive problems limit the amount of borrowing. This feature of our model captures the point made by Dooley (2000), who argues that in a world of standstills, or similar policies that seek to promote orderly *ex post* renegotiations, the aggregate flow of lending could well be lower owing to incentive problems.

To complete the solution of the optimal contract, we need to check that the participation constraint (2.5) is satisfied for positive levels of the loan L. This is straightforward in our context, since the production function satisfies $\underset{L \to 0}{lim} \partial y / \partial L = \infty$, so that the optimal loan L is given by an interior solution. Thus, to summarise, the solution to the optimal contract in our model is given by

$$L_* = \min \left\{ \left(\frac{\alpha}{r} \right)^{\frac{1}{1-\lambda}}, \ \left(\frac{\lambda}{r} \frac{(2 - \alpha (1 - \theta))}{1 + \theta} \right)^{\frac{1}{1-\lambda}} \right\} \tag{2.13}$$

2.3. Endogenizing r

So far, we have treated the repayment rate r as being an exogenous parameter. In a world with default on the part of the debtors, it would not be appropriate to view r as a 'world interest rate'. Instead, it should reflect the risks inherent in lending in our model. When the initial loan of L is the solution to the optimal contracting problem, the incentive compatibility constraints are satisfied so that the amount repaid is equal to the amount of resources available at the interim date. The expected repayment by the borrower under the optimal contract is therefore given by

$$\theta r L + (1 - \theta) r L \cdot E (1 - z | \, z > 0) = r L \left(\frac{1 + \theta}{2} \right)$$

If we assume that the lenders expect a return of ρ on their loans (reflecting cost of funds, time discount rates or any rents), then the repayment rate r is given by

$$r = \left(\frac{2}{1 + \theta} \right) \rho \tag{2.14}$$

Substituting this expression into (2.13) will allow us to solve for the optimal contract in terms of the fundamentals of the model. More importantly, we note that the expression for r only involves the parameters θ and ρ. This feature becomes useful in our welfare analysis below.

3. Model with Orderly Standstills

Although the disciplining role of the threat of a disorderly creditor run allows the borrower greater access to credit, it comes at a substantial cost. If the borrower is genuinely unlucky and is forced into default by adverse conditions, and if the potential damage that the co-ordination problem inflicts on the economy, α, is large, the implications for international financial stability may be severe. Merely to focus on the incentive mechanism determining the access to credit markets understates the potential role that public policy can play in crisis management. Public policy can potentially have a two-fold effect. First, it is possible that increased scrutiny from the official sector may substitute for private sector discipline, by distinguishing publicly between "bad luck" and "strategic" defaults. This could be done through the sanctioning of a standstill. Such "whistle blowing" can help ensure *ex ante* good behaviour by the debtor. Second, if the framework for public intervention is effective, policymakers can mitigate *ex post* co-ordination costs, i.e. act as "firemen". This might be achieved, for example, by providing limited official finance, mediating in work outs, or endorsing temporary controls on capital outflows. In fact, as we now demonstrate, public sector actions that mitigate the costs of disorderly liquidation may well be capable of generating similar levels of lending as the regime in which the threat of termination by private creditors is the sole source of discipline on the debtor's willingness to repay. And this, together with the elimination of *ex post* inefficiency, generates an improvement in welfare.

To illustrate this we introduce a third party, assumed to be a representative of the international financial community, which we refer to as the 'IMF'. The IMF has no role in the initial period when the loan L is granted to the borrower, but has a role at the interim date. It has access to an imperfect signal concerning the state of the borrower's finances at the interim date. Specifically, it has a signal as to whether the borrower has sufficient resources to pay the loan in full - that is, whether z is zero or positive. Based on this information, the IMF gives a pronouncement of its view of the current state of fundamentals and reaches a judgement about the need for official intervention. We assume that the IMF's message space is coarse, consisting of only two messages $\{$Good, Bad$\}$. The joint distribution over the messages and the underlying state of fundamentals z is given by the following matrix.

		Message that fundamentals are good	Message that fundamentals are bad
Fundamentals	Good ($z=0$)	$\theta(1-\varepsilon)$	$\theta\varepsilon$
	Bad ($z>0$)	$(1-\theta)\varepsilon$	$(1-\theta)(1-\varepsilon)$

The IMF's signal is imperfect in two senses. First, the message space is binary, merely indicating whether the fundamentals are good or bad. Second, even this binary signal suffers from noise. Conditional on $z = 0$, the IMF gets the incorrect message that the fundamentals are 'bad' with probability ε. We assume that $\varepsilon < 0.5$, implying that the signal has some information value. There is an analogous probability of mistaking $z > 0$ (i.e. bad fundamentals) for good fundamentals. The parameter ε indicates the degree of noise in the IMF's signal. Crucially, if there is a shortfall in the repayment to the creditors, the announcement by the IMF that the fundamentals are bad results in a payments standstill being called in the country. In our set-up, a standstill is a public action that seeks to avoid the costs of disorderly and destructive creditor liquidation. A full characterisation of the effects of standstills - for example, practical issues of enforcement and duration - is beyond the scope of this paper. The effects of standstills are captured in our model in reduced form fashion by the parameter σ (see below), which reflects the extent to which the public sector is able to reduce the output losses generated by the co-ordination problem. In essence, σ can be interpreted as measuring the efficacy of the official community's framework for crisis management. In this context, a standstill can be thought of as an officially sanctioned temporary measure, based on established guidelines. These measures could include a temporary suspension of debt payments by the country, which locks-in creditors while orderly work-out procedures are put in place and while the debtor implements remedial policy measures. In addition, it could involve policies that entail limited official assistance to offset the costs of the creditor co-ordination problem, such as IMF 'lending into arrears'.

In terms of our model, the effect of the IMF's announcement of a standstill has several effects. We list them below.

- One consequence of a standstill is to attenuate the effect of the parameter α, thereby mitigating the costs of disorderly liquidation by the creditors. In particular, we assume that the IMF standstill reduces this parameter by a factor σ (where 'σ' stands for 'standstill'and reflects the efficiency of public intervention), where $0 \leq \sigma \leq 1$. Thus, output in the final period given shortfall s when the IMF has called a standstill is given by

$$(1 - \sigma\alpha s)\, L^{\lambda} \tag{3.1}$$

- When a standstill is called correctly (the event represented by the bottom right hand cell of the matrix), the debtor's true resources $\tilde{x}$ become verifiable to the IMF, so that the creditors receive the true realization of $\tilde{x}$. This means that the realized payment shortfall s is equal to the true shortage of resources given by realization of the random variable z. In other words, the IMF provides discipline consistent with the incentive compatibility constraint.

- If a standstill is called incorrectly (the event given by the top right hand cell of the matrix), the IMF mistakenly attributes any *deliberate default* as having arisen from bad luck. In other words, the IMF mistakenly believes that any shortfall in payment s is due to a lack of resources, and does not recognize that the shortfall has arisen from diversion of funds. Creditors are inappropriately locked in to the workout process, the IMF acts to ameliorate the impact of liquidation, and the debtor cheats successfully.

- Finally, when the IMF mistakenly *fails* to call a standstill (the event represented by the bottom left cell of the matrix), it makes the opposite error. Even though the shortfall in payment is due to bad luck, it mistakenly believes that the shortfall is due to diversion of funds and its failure to intervene exposes the country to the full impact of a creditor grab-race.

  The welfare consequences of introducing the IMF into our model are twofold. On the one hand, by reducing the costs of disorderly liquidation in the event of default, the IMF can mitigate the welfare costs when z is positive. However, there is a welfare cost arising from the reduced disciplining effect of default, leading to a sub-optimal level of initial credit. The net benefit of the IMF arises only if the first effect outweighs the second.

3.1. Optimal Contract in Presence of IMF

The possibility that the IMF will call a standstill, and thereby mitigate the costs of disorderly liquidation, entails a more stringent set of incentive compatibility conditions in the choice of loan size L. Let us first consider the incentives facing the borrower with $z = 0$ - that is, the borrower who has sufficient resources to repay in full. Conditional on $z = 0$, the IMF will mistakenly announce a standstill with probability ε, while with probability $1 - \varepsilon$, there is no standstill. Thus, the debtor's maximisation problem is to choose $s \geq 0$ so as to maximise:

$$(1-\varepsilon)\left((1-\alpha s)\,L^{\lambda}-(1-s)\,rL\right)+\varepsilon\left(\left((1-\sigma\alpha s)\,L^{\lambda}-(1-s)\,rL\right)\right) \tag{3.2}$$

which can be written as

$$L^{\lambda}\left(1-s\underbrace{\alpha\left((1-\varepsilon)+\sigma\varepsilon\right)}_{\hat{\alpha}}\right)-(1-s)\,rL \tag{3.3}$$

Comparing with (2.8), the effect of the IMF's presence in the optimisation problem for the debtor is to multiply the factor α by $(1-\varepsilon)+\sigma\varepsilon$, which is strictly less than 1. Thus, we have the following incentive compatibility condition for the debtor with $z = 0$ analogous with (2.9), where $\hat{\alpha}$ is the shorthand for $\alpha\left((1-\varepsilon)+\sigma\varepsilon\right)$.

$$L \leq \left(\frac{\hat{\alpha}}{r}\right)^{\frac{1}{1-\lambda}} \tag{3.4}$$

Let us now consider a debtor with $z > 0$. The debtor knows that the IMF will (correctly) call a standstill with probability $1-\varepsilon$, but will fail to call the standstill with probability ε. If the standstill is called correctly, the IMF can verify the true realization of z, and enforce payment of the true available resources. Thus, the only event in which the debtor's choice of s matters is when the IMF fails to call the standstill. Thus, the debtor's net expected output is given by

$$\varepsilon\left((1-\alpha s)\,L^{\lambda}-(1-s)\,rL\right)+(1-\varepsilon)\left(\left((1-\sigma\alpha z)\,L^{\lambda}-(1-z)\,rL\right)\right) \tag{3.5}$$

and the objective is to choose $s \geq z$ so as to maximise this expression. Following the same argument as before, this leads to the incentive compatibility constraint

$$L \leq \left(\frac{\alpha}{r}\right)^{\frac{1}{1-\lambda}} \tag{3.6}$$

which is identical to the incentive constraint (2.9) facing the borrower in the regime without the IMF. In particular, since $\hat{\alpha} < \alpha$ the constraint (3.6) never binds in the optimal contract that satisfies (3.4), and we may safely neglect it. The intuition for why this second incentive constraint does not bind is easily conveyed. When $z = 0$, the debtor knows that the IMF may call a standstill incorrectly, in which case there is a positive gain from cheating. As long as this possibility exists, the temptation to cheat weakens the disciplining effect of disorderly liquidation, so that the debtor's access to the credit market is curtailed. In contrast, when $z > 0$, the debtor realizes that the IMF will (correctly) call a standstill with high probability, in which case the true resources are revealed and disorderly liquidation is averted. The only event in which cheating may have an effect is when the IMF mistakenly *fails* to call a standstill. In this event, there is no relief from the damaging effect of disorderly liquidation, and the incentive not to cheat is as high as in the regime without the IMF. This relaxes the incentive constraint, explaining why (3.6) does not bind.

It remains for us to determine when the incentive compatibility constraint (3.4) binds. Note that the solution to the unconstrained problem is identical to the unconstrained problem without the IMF, given by (2.13), since the IMF does not affect the underlying fundamental features of the economy. Also, as before, the participation constraint does not bind in our model. So the solution to the optimal contracting problem is the level of the loan given by

$$\hat{L}_* = \min\left\{ \left(\frac{\widehat{\alpha}}{r}\right)^{\frac{1}{1-\lambda}}, \left(\frac{\lambda}{r}\frac{(2-\alpha(1-\theta))}{1+\theta}\right)^{\frac{1}{1-\lambda}} \right\} \tag{3.7}$$

where we have used the notation $\hat{L}_*$ to indicate the solution to the optimal contracting problem in the presence of the IMF. Comparing this expression with (2.13), we see that the presence of the IMF reduces the amount of the credit available to the borrower. The difference between $\hat{L}_*$ and L_* depends on two factors: the quality of the IMF's judgement regarding the debtor's fundamentals, represented by ε; and the efficacy of the IMF's actions to limit the effects of liquidation, represented by σ. These two factors work in different ways. On the one hand, as the IMF's judgement tends to perfection ($\varepsilon \to 0$), the discipline of IMF surveillance increasingly substitutes for market discipline in the no-standstills case, and lending in the standstills regime approaches the market solution ($\widehat{\alpha} \to \alpha$ so that $\hat{L}_* \to L_*$). On the other hand, the lower the effectiveness of official-sector involvement in limiting the costliness of liquidation ($\sigma \to 1$), the more irrelevant the IMF's involvement becomes in determining creditor and debtor payoffs - if there is little or no reduction in ex post inefficiency, the degree of debtor moral hazard becomes negligible, and once again we see that $\hat{L}_* \to L_*$. But outside of these extremes, the borrower cannot get full access to credit and so is worse off, representing an inefficient outcome relative to the market-based solution.

Also, provided that the repayment rate r is priced correctly according to (2.14), it would be reasonable to assume that the lenders' payoffs are increasing in the level of loans L. To this extent, the presence of the IMF is unambiguously bad news for the lenders. Whereas the borrower can look forward to a trade-off between lower loans but less drastic effects of default, the lenders have no such trade-off. Since loans are priced correctly, the lenders' payoffs are only determined by the amount of loans L. And since the presence of the IMF reduces the equilibrium L, this makes the lenders unambiguously worse off.

3.2. Expected Output

Having examined the detrimental effect of the IMF's presence, we now examine the main beneficial effect of the IMF's presence - namely, its ability to mitigate the *ex post* inefficiencies that result from a 'bad luck' default. We have a method of examining the welfare effect of the IMF in a systematic way. The debtor's objective function is expected output net of the repayment costs, while the lenders' payoff is the expected repayment proceeds. Hence, if we define the welfare function as the *sum* of all the payoff functions of the interested parties, we have a convenient welfare function in terms of the total expected output, gross of the repayment on the loans.

Denote by W the (*ex ante*) total expected output in the regime without the IMF, and by $\hat{W}$ the (*ex ante*) total expected output in the presence of the IMF. Then, from (2.13) and (3.7), and the fact that $\mathrm{E}(z|z>0)=\frac{1}{2}$:

$$\begin{aligned} W &= L_*^\lambda \left\{\theta + (1-\theta)\left(1-\frac{\alpha}{2}\right)\right\} \\ \hat{W} &= \hat{L}_*^\lambda \left\{\theta + (1-\theta)\left[\varepsilon\left(1-\frac{\alpha}{2}\right) + (1-\varepsilon)\left(1-\frac{\sigma\alpha}{2}\right)\right]\right\} \\ &= \hat{L}_*^\lambda \left\{\theta + (1-\theta)\left(1-\frac{\alpha}{2}\left(\varepsilon+\sigma\left(1-\varepsilon\right)\right)\right)\right\} \end{aligned}$$

Although $\hat{L}_* \leq L_*$ (the level of the loan is lower with the IMF), we also have $\alpha\left(\varepsilon+\sigma\left(1-\varepsilon\right)\right) < \alpha$ (the effect of default is mitigated with IMF), so that there is no general ranking of expected output in the two cases. Whether the IMF has a net beneficial effect depends on the parameters of the model. We will focus, in particular, on the relative rankings of the two regimes as a function of the noise parameter ε. We will ask how sound the judgement of the IMF has to be (as captured by the noise parameter ε) in order for it to have a net beneficial effect.

The expected output in the absence of the IMF does not depend on ε. However, $\hat{W}$ depends on ε, both because the level of the loan is affected by it, but also because ε affects the degree of mitigation of the harmful effects of bad luck default. From (3.7), we see that $\hat{L}_*$ is decreasing in ε, while $\varepsilon + \sigma(1-\varepsilon)$ is increasing in ε. Thus, for both reasons, the expected output in the presence of the IMF is a strictly decreasing function of ε. This makes intuitive sense. When ε is large, the scope for errors of judgement by the IMF is significant. This reduces the access to the credit market for the borrower, and also makes the *ex post* intervention less effective after default. In the extreme case where $\varepsilon = 0$ (when the IMF never gets it wrong), we know that

$$\hat{L}_* = L_* \quad \text{but} \quad \sigma\alpha < \alpha$$

implying that

$$\hat{W} > W$$

Since $\hat{W}$ is a continuous function of ε, this implies that for sufficiently small ε, the IMF has a net beneficial welfare effect. The question is how small ε must be for this to hold. Denoting by $\hat{W}(\varepsilon)$ the expected output in the IMF regime expressed as a function of ε, we can answer this question by solving for ε from the equation

$$\hat{W}(\varepsilon) = W$$

Given the highly non-linear nature of this equation, simple closed form solutions are not available. Nevertheless, we can gain intuition from some numerical examples. Chart 1 shows how, for chosen benchmark levels, lending and welfare differ in a regime with and without standstills. The index used to measure welfare is based on *ex ante* expected output. If the ability of the official sector to call a standstill is perfect ($\varepsilon = 0$), the level of lending in the two regimes is the same. But the level of welfare under the standstills regime is higher because the official sector is correctly able to stem a country run in the case of 'bad luck' default. However, as the quality of judgement declines, both lending and welfare fall and, for sufficiently high values of ε, a regime with standstills may prove welfare reducing. Nevertheless, if judgment error is sufficiently small, standstills can be welfare enhancing. Moreover, as Chart 2 shows, the welfare benefits of standstills are higher when the real cost of the creditor co-ordination problem (α) is higher.

Chart 3 illustrates the importance of the official community's dual role as "whistleblower" and "fireman". It again compares welfare in a regime with standstills to welfare in a regime without. This time, however, we examine the effects of varying the efficacy of standstills (σ), for given levels of judgement error (ε) and output cost (α). It is assumed that the costs of the creditor co-ordination problem are high, $\alpha = 0.6$. As can be seen, in the case where the IMF's judgment is perfect ($\varepsilon = 0$) but its ability to mitigate the co-ordination costs of crisis is poor ($\sigma \to 1$), welfare in the two regimes is the same. But as the ability of the official community to contain the costs of crisis improves ($\sigma \to 0$), welfare in a regime with standstills rise above that in a regime without. If the IMF is less than perfect in exercising judgment ($\varepsilon = 0.2, \varepsilon = 0.3$ in Chart 3), welfare in a standstills regime can still be higher than with no standstills, as the value of a reduced cost of crisis outweighs the effect of lower lending. But if $\sigma \to 0$, welfare in the standstills regime falls below that in a no-standstills world. This is because the moral hazard effects created by the combination of weak public monitoring and extremely effective crisis management overwhelm the gains from the elimination of the creditor co-ordination problem. Although the sensitivity of welfare to the choice of parameters is a reminder of the trap of taking estimates from a simple model too seriously, the qualitative features of our model serve as a useful starting point for future research.

3.3. Divergence of Interests

So far, we have conducted our welfare analysis in terms of the total expected output, without taking into account distributional issues. Although the *sum* of the borrower's and lenders' payoffs coincides with our welfare measure, the interested parties may have divergent goals. For the lenders, since the repayment rate is correctly priced by (2.14), their payoff is increasing in the amount lent. Since the loan is always larger without the IMF, the lenders are strictly worse off . Moreover, since the loan amount $\hat{L}_*$ is decreasing in ε, lenders are especially badly affected if the quality of public sector judgement is poor.

For the borrower, the comparison is more equivocal. On the one hand, if judgement error is high (i.e. ε is high), then the borrower is worse off with the IMF than without, since the incentive problems generated by the IMF hinder the borrower from accessing the credit market. In this case, the borrower's interests are aligned with the lenders' interests. Both sides would be better off without the IMF. However, when the IMF judgement is sound (i.e. ε is small), then there is a divergence of interest between the lenders and the borrower. The lenders (as always) would prefer the regime without the IMF. For the borrower, however, the moderate impediment in the access to the credit market is more than outweighed by the beneficial effect of the IMF standstill in preventing the harmful effects of disorderly liquidation. We have seen above that this gain in *ex post* efficiency not only outweighs the negative effect on the *debtor's* payoff, but also outweighs the negative effects on the *creditors'* payoffs. This is so, since the sum of the two sides' payoffs is given by the total expected output $\hat{W}$, and we have seen that this exceeds the total expected output in the regime without the IMF provided that $\varepsilon < \varepsilon^*$. In other words, the beneficial effect of preventing *ex post* inefficiency is quantitatively very large, relative to the harmful effect on the *ex ante* access to credit. In this sense, competent public policymakers more than justify their existence in our set-up.

3.4. Case by Case Intervention

Our framework allows us to examine the welfare consequences of a policy in which intervention to stem disorderly liquidation during crisis takes place on a 'case by case' basis, according to the perceived merits of the case. If we assume that the underlying informational acuity of the public body remains fundamentally unchanged, then such a policy amounts to intervening in only a subset of those cases for which the policy maker has received a 'bad' signal. Within our simplified model, we can represent such a policy in terms of a mixed strategy in which the policy maker follows the rule below.

$$\begin{cases} \text{Good signal} & \rightarrow \quad \text{No action} \\ \\ \text{Bad signal} & \rightarrow \quad \begin{cases} \text{Intervene with prob } p \\ \text{No action with prob } 1-p \end{cases} \end{cases}$$

We can use the table of joint probabilities over states and signals used previously to construct a table of joint probabilities over states and intervention policies generated by the above strategy. It is given by

Fundamentals		Policy: No action	Policy: Intervene
	$z = 0$	$\theta(1-\varepsilon) + (1-p)\,\theta\varepsilon$	$p\theta\varepsilon$
	$z > 0$	$(1-\theta)(\varepsilon + (1-p)(1-\varepsilon))$	$p(1-\theta)(1-\varepsilon)$

There is a precise sense in which the policy of 'case-by-case' intervention is an intermediate policy that lies between the regime without the IMF and the regime with the IMF. First, the fact that the top right hand cell is reduced by a factor of p implies that the incentive compatibility condition analogous to (3.4) is weakened, allowing a larger loan size L. This is so, since the borrower now has to fear that the policy maker will intervene with a smaller probability. This enhances the disciplining effect of premature liquidation, and makes the creditors more willing to lend.

Second, this policy is also intermediate in terms of the expected total output effect arising from intervention. Since the unwillingness to intervene cuts across both good and bad states, the *ex post* output effect from failing to stem the disorderly liquidation lowers expected output in the bad state as compared to the IMF regime. However, since intervention takes place some of the time, some of the detrimental effects are contained relative to the regime with no public sector intervention.

The welfare effects are also worthy of note. For the lenders (whose payoff is increasing in the level of loans), a move from the IMF regime to a case-by-case policy rule will make them better off. But, if ε is low, so that the underlying signals are accurate, then the borrower is strictly worse off. Indeed, for sufficiently low ε, total welfare will decline following this move, since the borrower's welfare loss outweighs the payoff gain by the lenders. So a move from the IMF regime to the regime with case-by-case intervention represents a distributional shift away from borrowers towards lenders, and this shift is achieved at the expense of lower aggregate welfare. Ironically, the detrimental effects are largest when the policy maker is most competent (i.e. ε is low).

4. Policy Implications and Conclusions

The model outlined above, although simple, sheds some light on the recent policy debate on crisis resolution measures. Some policymakers emphasise the benefits of temporary standstills in the face of liquidity crises, arguing that they can provide a breathing space that curbs destabilising speculation. By contrast, private creditors frequently oppose such proposals, arguing that regimes that include standstills discourage much needed adjustment effort by debtor countries, and reduce capital flows to emerging economies.

We argue, however, that the introduction of standstills based on systematic guidelines could bring welfare benefits, to individual debtor economies and at an aggregate level. Although the introduction of standstills may reduce the level of capital inflows ex ante, it could compensate for this by ameliorating the disruptive effects of country runs ex post. The benefits of regimes such as standstills are most likely to accrue if the official sector is capable of identifying the source of financial problems and utilising emergency finance effectively.

The model is useful for exploring how public sector actions can affect the trade-offs inherent in sovereign debt contracts. The sensitivity of the results to parameter values means that unambiguous welfare conclusions about different regimes cannot be reached. But the analysis raises some important general issues about the nature of official involvement in sovereign debt contracts. It shows, for example, how the efficacy of proposals like standstills depend critically on the quality of public sector monitoring of debtor country conditions. This disciplining effect plays an important part in determining the ex ante terms of the debt contract, i.e. the level of lending and the conditions of the loan. The greater the transparency and accountability of debtor governments, the more effective public monitoring is likely to be. So our results underline the critical role played by IMF surveillance and data disclosure by debtor countries.

Although our model shows there may be clear gains under an orderly standstills regime, these gains accrue to the debtor country while creditors appear disadvantaged in so far as the level of *ex ante* lending is lower. Again, this may explain the reticence of creditors to embrace standstills. As Scharfstein & Stein (1990) note, a banker's ability to place loans is fundamental to his/her standing in the labour market, so a regime that lowers capital inflows to emerging markets is unlikely to be welcome. But there is no reason why lower *ex ante* lending should be a general result in a richer model than ours. For example, if orderly standstills mean that a crisis country recovers more quickly, investors are likely to be confronted with a greater number of profitable investment opportunities over any given period in time. Creditors are, thus, likely to be unwilling to accept standstills proposals if such gains are not clearly defined. More generally, this issue raises important questions about measuring global welfare in a regime with standstills - one that takes into account both debtor and creditor gains, and weights them accordingly.

It should be stressed that the strength of the case for standstills rests heavily on the extent of the output costs of disorderly liquidations. In the event of the bad state occurring, large scale termination of short-term debt and litigation to recover contracted debt repayments has to have a significant impact on output. Although the most recent crises have indeed been accompanied by significant declines in output, this is by no means a certainty. This suggests that policymakers need to establish the likely scale of the costs posed by creditor co-ordination problems before attempting to intervene.

The focus of the model is the trade-off between *ex ante* and *ex post* inefficiencies in sovereign lending. As such, it does not have a straightforward read-across to the literature on self-fulfilling currency attacks. In our model, 'bad luck' reflects default having been caused by a shortage of funds as opposed to wilful default. This bad luck then translates into possible runs that are damaging. The model does not tackle the situation where bad luck is itself an investor panic with no basis in fundamentals. An explicit treatment of self-fulfilling attacks in the context of sovereign debt standstills is an interesting area of future research.

Finally, two frequently used argument against standstills are that they raise the possibility of spillovers and contagion to other countries, and that they promote a bias towards shorter-term debt. The first may arise, for example, because leveraged investors may be forced to liquidate positions in other markets to meet margin calls. But it is not obvious that an officially sanctioned temporary standstill would trigger a run in another country. Because standstills are likely to be more predictable and less costly in this setting, spillovers could well be mitigated. On the second issue, the credit supply-side reaction to changes in the international financial architecture, including the role of debt maturity as a solution to the incentive problem, remains an important topic for future study.

References

[1] Allen, F & D Gale (1998), "Optimal Financial Crises", *Journal of Finance.*

[2] Bolton, P & D Scharfstein (1990), "A Theory of Predation Based on Agency Problems in Financial Contracting", *American Economic Review*, 80, pp 93-106.

[3] Bolton, P & D Scharfstein (1996), "Optimal Debt Structure and the Number of Creditors", *Journal of Political Economy*, 104, pp 1-25.

[4] Bolton, P & H Rosenthal (1999), "Political Intervention in Debt Contracts: moratoria and bailouts", *mimeo*, Princeton University.

[5] Calomiris, C & C Kahn (1991), "The Role of Demandable Debt in Structuring Optimal Banking Arrangements", *American Economic Review*, 3, pp 497-513

[6] Chang, R & A Velasco (1998), "Financial Crises in Emerging Markets - a canonical model", *NBER Working Paper No 6606.*

[7] Chui, M, P Gai & A Haldane (2000), "Sovereign Liquidity Crises: Analytics and Implications for Public Policy", *Bank of England Working Paper* No 121.

[8] Clementi, D (2000), "Crisis Prevention and Resolution - Two Aspects of Financial Stability", *Financial Stability Review*,9, pp.

[9] Diamond, D & P Dybvig (1983), "Bank Runs, Deposit Insurance, and Liquidity", *Journal of Political Economy, 91,* pp 401-19.

[10] Diamond, D & R Rajan (2000), "Banks, Short-Term Debt and Financial Crises: theory, policy implications, and applications", *NBER Working Paper No 7764.*

[11] Dooley, M (2000), "Can Output Losses Following International Financial Crises be Avoided?", *NBER Working Paper No 7531.*

[12] Drage, J & F Mann (1999), "Improving the Stability of the International Financial System", *Financial Stability Review, 6,* pp 40-77.

[13] Eaton J & M Gersovitz (1983), "Debt with Potential Repudiation - theory and estimation", *Review of Economic Studies.*, 48, pp 289-309.

[14] Flood, R & N Marion (1998), "Perspectives on the Recent Currency Crisis Literature", *IMF Working Paper* No 98/130.

[15] Institute of International Finance (1996), Resolving Sovereign Financial Crises, Washington DC.

[16] King, M (1999), "Reforming the International Financial System - the Middle Way", *Financial Stability Review,* 7, pp 203-11.

[17] Krugman, P (1979), "A Model of Balance of Payments Crises", *Journal of Money, Credit and Banking*, 11, pp 311-25.

[18] Kumar, M, P Masson & M Miller (2000), "Global Financial Crises: institutions and incentives". *IMF Working Paper no 105.*

[19] Miller, M & L Zhang (2000), "Sovereign Liquidity Crisis: The Strategic Case for Payments Standstill", *Economic Journal* 110, pp 309-34.

[20] Morris, S & H S Shin (1998), "Unique Equilibrium in a Model of Self-fulfilling Currency Attacks", *American Economic Review*, 88, pp 587-97.

[21] Morris, S & H S Shin (2000), "Rethinking Multiple Equilibria in Macroeconomic Modelling", *NBER Macroeconomics Annual, forthcoming, MIT Press.*

[22] Obstfeld, M (1996), "Models of Currency Crisis with Self-Fulfilling Features", *European Economic Review*, 40, pp 1037-47.

[23] Radelet, S & J Sachs (1998), "The East Asian Financial Crisis: Diagnosis, Remedies, Prospects", *Brookings Papers on Economic Activity*, 1, pp 1-74.

[24] Rogoff, K (1999), "International Institutions for Reducing Global Financial Instability", *Journal of Economic Perspectives.*

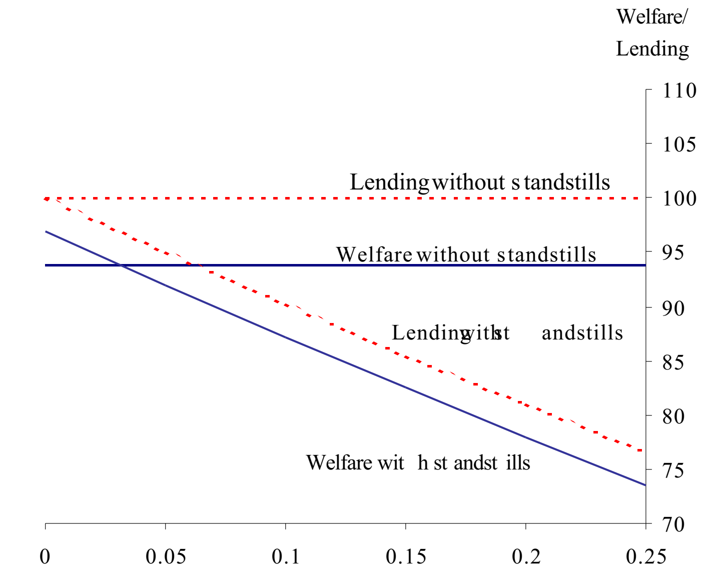
[25] Schinasi, G & RT Smith (1999), 'Portfolio Diversification, Leverage, and Financial Contagion', *IMF Working Paper* No 99/136

[26] Scharfstein, D & J Stein (1990), 'Herd Behavior and Investment', *American Economic Review*, 80, pp 465-79

[27] Stiglitz, J & A Weiss (1983), "Incentive Effects of Terminations: Applications to the Credit and Labour Markets", *American Economic Review*, 73, pp 912-27.

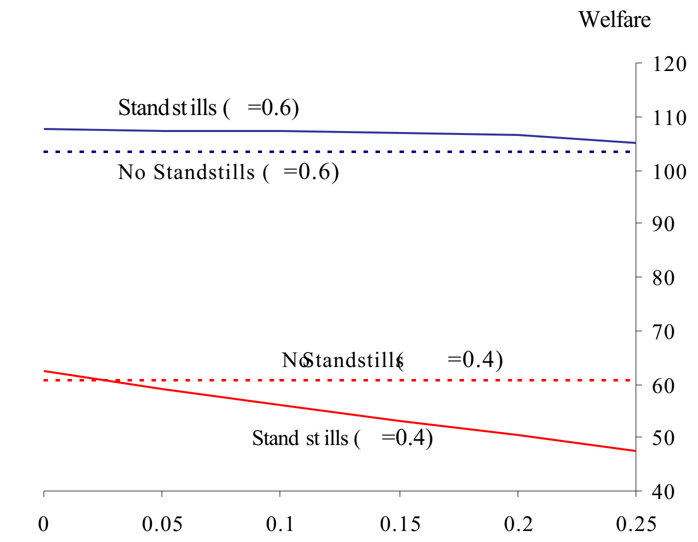
[28] Summers, L (2000), "International Financial Crises: Causes, Prevention, and Cures", Richard T Ely Lecture, Papers & Proceedings, *American Economic Review*, 90, 2, pp 1-16.

Chart 1: The impact of standstills on lending and welfare



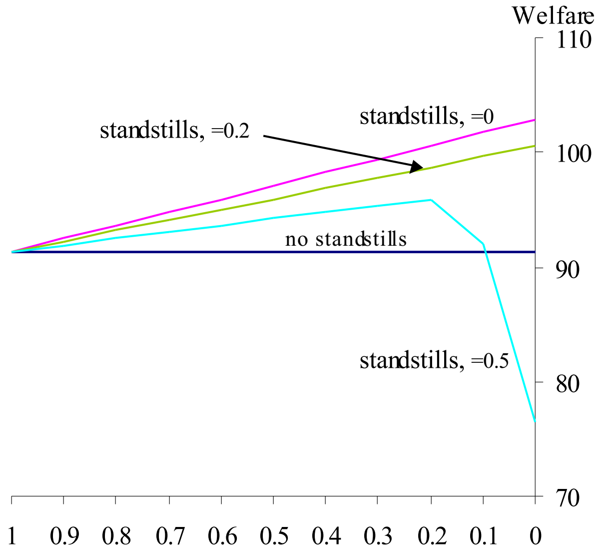
Note: Other parameter values are as follows:
=0.5, =0.05, =0.75, =0.5.

Chart 2: Welfare and the costs of disruption



Note: Other parameter values are as follows:
=0.5, =0.05, =0.75, =0.5.

Chart 3: Welfare and the efficacy of measures to mitigate disruption costs



Note: Other parameter values are as follows:
=0.5, =0.05, =0.75, =0.9.