The efficient resolution of capital account crises: how to avoid moral hazard

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Abstract

This paper presents a model of capital account crises and uses it to study resolution mechanisms for both liquidity and solvency crises. It shows that liquidity crises should be dealt with by a standstill combined with IMF lending into arrears, whereas solvency crises should be resolved by debt write-downs. Dealing with solvency crises by lending would require a subsidy and this creates moral hazard, such as incentives for excessive borrowing, for too little equity financing and for investment in projects that are inefficient. The analysis underlines the importance of accurately assessing whether a crisis is rooted in a liquidity or a solvency problem.

Summary

This paper presents a model of capital account crises to evaluate alternative mechanisms for their resolution. The model is constructed to enable the analysis of two very different problems. Solvency crises can happen, in which firms in crisis countries have profitable opportunities for investment, but these are not viable because the potential profits are insufficient to cover interest payments on an overhang of debt. As a result, bankruptcies occur and efficient investment projects are terminated early. But beyond this, liquidity crises can take place, even when the borrower is solvent and there is no debt overhang. If all lenders roll over their loans, profitable investment can take place, but if they do not, firms will be unable to meet their obligations and default. So in the presence of profitable investment opportunities, and without any debt overhang, there is nevertheless a possibility of default, which is self-fulfilling.

As problems at the level of the firm translate into countrywide crises, policy intervention at a national (government) or international (IMF) level becomes necessary. The paper uses the model to evaluate the effectiveness of different forms of intervention to deal with each type of crisis and explores not only the impact of the alternative interventions *ex post*, but also their impact on the *ex-ante* incentives facing potential investors. Specifically, the paper considers whether the moral hazard problem will affect the amount of investment undertaken and the way in which it is financed.

The paper reaches two major conclusions. The first is a criticism of a lender of last resort regime. If there is a lender of last resort, which not only resolves liquidity crises by the provision of finance, but also resolves solvency crises by subsidised lending at sufficiently reduced interest rates to avoid bankruptcy, there will be incentives to borrow excessively, and too little equity will be invested in projects. This makes solvency crises more likely in the first place. In addition, firms might make the initial investment in circumstances where it is inefficient to do so, encouraged by the subsidy. These problems provide a clear argument in favour of the resolution of solvency crises by debt write-downs rather than by subsidised IMF lending.

The second conclusion is in support of a lender of last resort regime, but only for liquidity crises and as part of the response necessary to deal with them. Debt write-downs are an inappropriate response in this situation as the problem is not one of solvency. IMF financing can and should play a part. This need not result in moral hazard as no subsidy is required in these circumstances. But the practical reality is that IMF lending is limited, and so the best policy is a combination of

standstills, which prevent a co-ordination failure among creditors, and IMF lending into arrears, which ensures that new financing is available where necessary.

The paper underlines the importance of being able to distinguish between solvency and liquidity crises, given that the optimal response to each is different.

1 Introduction

A very great increase in international capital mobility has led, over the past ten years, to the increased integration of emerging capital markets with those of the advanced economies. It has also, as a *quid-pro-quo*, led to an increase in financial crises—in Mexico (1994/95), Asia (1997), Brazil and Russia (1998), and Argentina (2002)—crises which were clearly rooted in the capital account of the balance of payments (IMF (2002)). This has exposed weaknesses in the international financial architecture. In the face of this, there is a need for a new architecture in which crises can be managed and in which the likelihood of them can be reduced.

There is a need for greater clarity in this new architecture about the required role for the IMF. The US Treasury and the IMF have both argued that there should be a more straightforward and efficient process for sovereign debt restructuring, either through collective action clauses in sovereign bonds (Taylor (2002)), or through the institution of a sovereign debt reconstruction mechanism (SDRM) (Krueger (2001)).[(1)] The Bank of England and Bank of Canada have argued for an enhanced role for debt standstills and lending into arrears by the IMF (Haldane and Kruger (2001)). All of these sets of proposals have been put forward as an alternative to the IMF attempting to act as a lender of last resort (Fischer (1999)).

This paper aims to evaluate the appropriateness of such crisis resolution mechanisms. It builds on the work of Haldane, Irwin and Saporta (2004). In order to do this we develop a simple model of capital account crises, and we use it to perform welfare analysis of the various crisis resolution mechanisms.

The model is deliberately constructed to enable us to analyse two very different types of crisis. *Solvency* crises can happen in which firms in crisis countries have profitable opportunities for investment, but these are not viable because potential profits are not large enough to cover the interest obligations on an overhang of debt. As a result there are bankruptcies and efficient investment projects are terminated early. But beyond this, *liquidity* crises can occur, even when there is solvency and no debt overhang: if all lenders roll over their loans profitable investment can take place, but if they do not the firms will be unable to meet their obligations and so they default. That is, in the presence of profitable investment opportunities, and without any debt

(1) In 2003 the International Monetary and Financial Committee, which provides strategic direction to the IMF, concluded 'it is not feasible now to move forward to establish the SDRM', effectively sidelining this particular proposal for the time being.

overhang, there is nevertheless the possibility of a default which can be self-fulfilling.

As it is assumed that firms are representative, firm-level problems translate into country-wide crises, necessitating policy intervention at a national (government) or international (IMF) level. We use our model to show that the desirable treatment of liquidity and solvency crises differs. To make this comparison we need to distinguish between the appropriate responses *ex post*, after a crisis, and those which will, *ex ante*, set up the right environment in which the likelihood of crisis is minimised. (See again Haldane, Irwin and Saporta (2004).) The latter is necessary if there is to be an adequate consideration of the moral hazard problem which can lead to a crisis in the first place. The crucial contribution of the present paper is to set up a model in which some of the risks of investment are borne by equity holders. With this we explore not just the efficiency of *ex-post* crisis resolution (as in Haldane, Irwin and Saporta (2004)), but also the *ex-ante* incentives facing potential investors. Specifically we consider whether the moral hazard problem will affect the amount of investment that is undertaken and the way in which this is financed.

The model shows that the desirable treatment of these two kinds of crises differs. Solvency crises require debt write-downs, rather than reliance on subsidised IMF lending. Liquidity crises require either IMF lending, but without any need for a subsidy, or debt standstills, or some combination of the two.

This leads to two major conclusions. The first is a criticism of a lender of last resort regime. We show that if there is a lender of last resort, which not only resolves liquidity crises by the provision of finance, but which also resolves solvency crises by subsidised lending at sufficiently reduced interest rates to avoid bankruptcy, there will be incentives to borrow excessively, and too little equity invested in such projects. This makes solvency crises more likely. In addition, firms might make the initial investment in circumstances where it is inefficient to do so, under the influence of the subsidy. This provides a clear argument in favour of the resolution of solvency crises by debt write-downs rather than by subsidised IMF lending.

The second conclusion is in support of a lender of last resort regime, but only for liquidity crises and only as one part of the machinery necessary to deal with them. Debt write-downs are an inappropriate response to liquidity crises as the problem is not one of solvency. IMF financing can and should play a part. This need not result in moral hazard as no subsidy is required in these circumstances. But the practical reality is that IMF lending is limited, and so we find the best policy in the face of liquidity crises is a combination of standstills, which prevent a co-ordination

failure among creditors, *and* IMF lending into arrears which ensures that new financing is available where this is necessary.

1.1 The model setup

We use a two-period model. A crisis occurs if it becomes no longer possible, at some intermediate stage, to see investment projects through to the end, even though this would be the efficient outcome. We capture this feature by supposing that, midway through projects, after the first period, a stochastic shock hits the country. This determines how profitable the firms will be at the end of the second period. It is possible that they become insufficiently profitable for the projects to be attractive enough to be finished.

In more detail, we assume that any number of identical firms have the capacity to undertake a given two-period investment project. The production technology requires that an exogenously fixed amount, $k_1 = \bar{k}$, is invested at the beginning of the first period. There is no output until the end of the second period. A stochastic state variable, $\alpha \geq 0$, is realised at the end of the first period. After α is known the firms must decide how much of the investment to maintain in the second period. We assume that no investment over and above $\bar{k}$ is productive, so that $0 \leq k_2 \leq \bar{k}$. At the end of the second period the output of each firm is $y_2 = \alpha k_2$.[(2)]

An exogenous proportion of the initial investment, $\varepsilon\bar{k}$, is financed by the equity of the owners of each firm, with the remainder financed by short-term debt. We assume that international banks are the sole providers of short-term lending. Equity is invested for the full life of the project, but lending is for only one period at a time, so that if the investment is to continue in the second period the debt must be rolled over. It is this need for rollover which can give rise to capital account crises. In the first period, lending is at the (endogenous) market-determined interest rate, $r_1 \geq r_F$, where r_F is the (exogenous) risk-free rate. At the end of the first period, after α is known, the international banks must decide whether to continue lending to the firms in the second period, if the firms want to borrow. To simplify the analysis, and to sharpen the focus on the resolution of crises, we assume that all uncertainty is resolved once α is known. This means the international banks will only extend their credit if they know they will be repaid and they will

(2) Haldane, Irwin and Saporta (2004) investigate a model in which second-period output depends on structural adjustment effort of the government. This feature could be added to the present model, but we abstract from it in order to focus on the effects on crisis-vulnerability of different financing rules by firms.

do so at the rate r_F. We assume that the firms are unable to raise additional equity investment at the end of the first period.

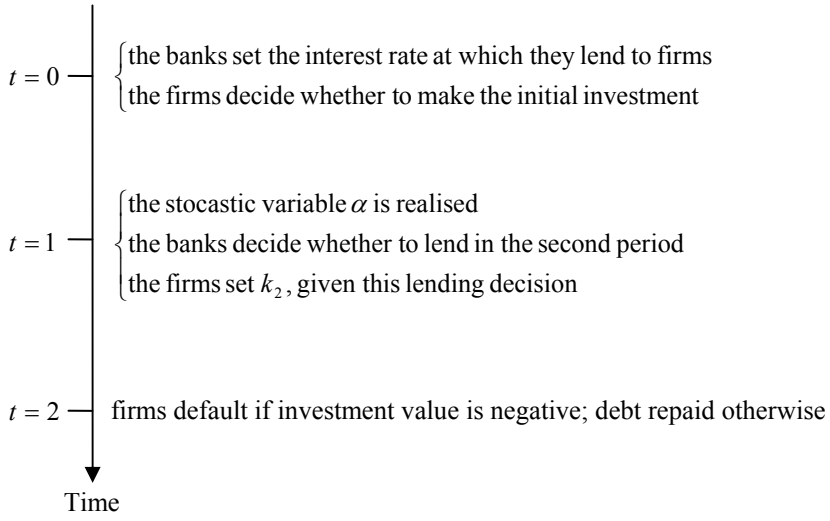
In addition to the cost of financing the investment, the firms must pay operating costs of $c_1\bar{k}$ and $c_2 k_2$ in the first and second periods respectively, where $0 \leq c_1 \leq 1$ and $0 \leq c_2 \leq 1$. These operating costs are net of any depreciation in the capital stock.

We assume the owners of each firm seek to maximise the value of their equity, and the international banks seek to maximise the return on their lending. As the firms are identical, the rate of return on lending received by each of the banks is the same regardless of which firm or firms it lends to and how much of any one firm's borrowing it finances. We assume that the financing provided by any one international bank to each firm is small compared to its full financing requirement. This introduces the possibility that there might be an inefficient outcome due to a failure of the international banks to coordinate when they make their individual lending decisions.

Diagram 1 summarises the timeline. The key decisions are taken at the beginning and the end of the first period. The model is solved in two stages which correspond with these key decision points. In the next two sections we focus on the second decision point. We assume that r_1 (which is endogenous in the first period) is taken as given at this stage. We also take as given the decision to make the initial investment. This allows us to focus on the decisions taken at the end of the first period, after α is known. At this point the international banks decide whether to lend in the second period, and the firms set k_2. We demonstrate that the *ex-post* outcome can be inefficient and how different forms of intervention can deal with this inefficiency.

In the fourth section we switch our focus to the first stage of the game. We endogenise r_1 given the condition that the expected pay-off to the international banks must equal the opportunity cost of the initial loan. This endogenous interest rate will itself depend on the 'intervention regime'; that is, the interventions which the international banks expect to occur *ex post*, to prevent an inefficient outcome in the second stage of the game. Once we have solved for this we are then able to consider whether the firms would choose to make the investment in the first place. This enables us to examine *ex-ante* efficiency and the moral-hazard implications of the different intervention regimes.

Diagram 1: The timeline



2 The second-stage solution

At the end of the first period, after α is known, the firms must set k_2 and the international banks must decide whether to continue lending. If they do it will be at the risk-free interest rate, r_F, given that, since α is known, all uncertainty is resolved by this stage.

2.1 Firms

At this stage the value of the investment undertaken by each firm is:

$$V_K = \left[1 - c_1 - (1 + r_1)(1 - \varepsilon)\right]\overline{k} + (\alpha - c_2 - r_F)k_2 / (1 + r_F) \qquad \textbf{(1)}$$

The first term is the difference between the value of the firm's liquid assets, $(1 - c_1)\overline{k}$, and its current liabilities, $(1 + r_1)(1 - \varepsilon)\overline{k}$. The second term is the discounted value of the amount of investment, k_2, which is undertaken through to the end of the second period. As noted above, we assume that the objective of each firm is to maximise the value of its equity, V_E, which is a function of the value of the investment, V_K:

$$V_E = \begin{cases} V_K & \text{when } V_K \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

The fact that V_E is non-negative reflects the assumption of limited liability.

At the end of the first period the representative firm has two choices. First, it must choose whether to default on its debt. Second, if it does not default, it must choose whether to demand

funds for investment in the second period. These two choices of the firm are interconnected, as follows.

The investment decision depends on α. Differentiating V_K with respect to k_2, we can see that the firm will maximise V_K, and therefore V_E, by choosing not to invest in the second period whenever $\alpha < \alpha^*$, where:

$$\alpha^* = c_2 + r_F \qquad \textbf{(2)}$$

This simply says that a firm will choose not to invest if it will not cover its operating and interest costs in the second period. Since there are no diminishing returns to investment, if $\alpha \geq \alpha^*$ firms will wish to maintain the full investment, $\bar{k}$, in the second period. However, for any firm to be able to do this requires both that it has not already defaulted and that it is not denied investment funds by the banks. We now turn to these questions.

The firm will default on its debt if (and only if) $V_K < 0$. The cases to consider now depend not only on α but also on ε. Define $\bar{\varepsilon} = (c_1 + r_1)/(1 + r_1)$. This is the amount of equity which would fully cover first-period operating costs and first-period interest obligations (after allowing for the fact that that equity financing itself lowers these interest obligations). Then we can re-write **(1)** as:

$$V_K = (1 + r_1)(\varepsilon - \bar{\varepsilon})\bar{k} + (\alpha - c_2 - r_F)k_2/(1 + r_F) \qquad \textbf{(3)}$$

There are two cases to consider. First suppose $\varepsilon \geq \bar{\varepsilon}$. We already know that the firms will invest in the second period when $\alpha \geq \alpha^*$, and that such investment is always profitable; and we also know that otherwise $k_2 = 0$. Hence the second term in **(3)** is always non-negative, which means that $\varepsilon \geq \bar{\varepsilon}$ is sufficient to ensure $V_K \geq 0$. Thus there will be no default if $\varepsilon \geq \bar{\varepsilon}$.

Second, suppose $\varepsilon < \bar{\varepsilon}$. This means that the firm is illiquid after the first period: from the definition of $\bar{\varepsilon}$ the value of the firm's short-term liabilities exceed the value of its liquid assets. If the international banks are unwilling to lend to the firm in the second period, this means $k_2 = 0$ and from **(3)** it follows that $V_K < 0$. The firm is therefore bankrupt and so it will default on its first-period debt. If, on the other hand, international banks do agree to lend enough to finance the full investment in the second period, the firm will remain solvent if α is high enough. From **(3)**, $V_K \geq 0$ when $\alpha \geq \tilde{\alpha}$, where:

$$\tilde{\alpha} = c_2 + r_F + (1 + r_F)(1 + r_1)(\bar{\varepsilon} - \varepsilon) \qquad \textbf{(4)}$$

Note that $\tilde{\alpha} > \alpha^*$ when $\varepsilon < \bar{\varepsilon}$. This is the level of α at which productivity is high enough, not just to pay operating costs and interest in the second period, but also to pay off the debt overhang which occurs because the equity financing is insufficient to cover the accumulation of operating costs and debt interest from the first period.

2.2 Banks

We assume that, if a firm is made bankrupt, its creditors are able to seize its liquid assets, but are unable to seize any output.[3] At the end of the first period the liquid assets of each identical firm are equal in value to $(1 - c_1)\bar{k}$. Therefore, the value of the loans made to each firm at this stage is:

$$V_B = \begin{cases} (1 + r_1)(1 - \varepsilon)\bar{k} & \text{when } V_K \geq 0 \\ (1 - c_1)\bar{k} & \text{otherwise} \end{cases} \qquad \textbf{(5)}$$

This is a measure of the return to each of the international banks from their lending in the first period.

Once α is revealed at the end of the first period there is no more uncertainty facing the international banks. We assume the banks are willing to lend the full amount that is required if they will in due course be repaid. Conversely, international banks never lend to a firm which they believe will subsequently default.[4] The problem for the banks is compounded as we assume each only provides a small share of the financing required by each firm, introducing the possibility of a coordination failure. These considerations mean that the lending decision will depend on ε. As in the case of the decision of the firms, there are two different scenarios to consider, depending on the value of ε.

(i) When $\varepsilon \geq \bar{\varepsilon}$ there is no default. The international banks will lend if the firms wish to borrow, which they will if $\alpha \geq \alpha^*$.

(ii) When $\varepsilon < \bar{\varepsilon}$ the firm is illiquid after the first period, since the value of its short-term liabilities exceeds the value of its liquid assets. If $\alpha < \tilde{\alpha}$ the investment is not profitable enough to resolve this problem and so there will be no lending. If $\alpha \geq \tilde{\alpha}$, however, the banks

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[3] This particular assumption is made for analytic convenience. The analysis that follows is not substantially altered providing there is some inefficiency associated with default. As in the corporate finance literature (for example, see Bolton and Scharfstein (1990)) we justify this particular approach by assuming the courts can verify the act of default, and the value of the liquid assets of the firm, but are unable to verify the value of any output produced. Note we can also rule out a strategic default by assuming the courts can inflict a sufficiently large punishment on the debtor in this event.

[4] The liquid assets of a firm defaulting in the second period are equal to $(1 - c_2)k_2$, which is necessarily lower in value than the loan principal, and so lending is never profitable when a default is anticipated.

will be repaid if they continue to lend. Two outcomes are possible.[5] If the banks are unwilling to lend, then $k_2 = 0$, and from **(3)** $V_K < 0$. The firm is therefore bankrupt and so it will default on its first-period debt. This would justify the banks' lack of willingness to lend in the first place. If, on the other hand, the banks agree to lend enough to finance the full investment in the second period, the investment is profitable enough for them to be repaid. This would justify the decision to lend.

2.3 Second-stage equilibria

We are now in a position to characterise the equilibria of the model in this second stage. There are two sets of cases to consider, depending on the amount of equity financing, ε; in each of these the outcome depends on the realisation for α.

(i) $\varepsilon \geq \bar{\varepsilon}$. For $\alpha < \alpha^*$ there is a unique equilibrium in which the firms liquidate their investments after the first period, but even though the productivity shock is a bad one the international banks still receive a full repayment, with interest, of their first-period loans, since there is enough equity cover for this. For $\alpha \geq \alpha^*$ there is a unique equilibrium in which the international banks continue lending and the firms maintain the full investment in the second period. In this case, the firms repay all of their debt in both periods.

(ii) $\varepsilon < \bar{\varepsilon}$. For $\alpha < \tilde{\alpha}$ there is a unique equilibrium in which the international banks stop lending and the firms default on their first-period debt. (Equity cover is insufficient to cover first-period interest and operating costs, and the productivity shock is not big enough to both make up the difference and cover second-period interest and operating costs.) For $\alpha \geq \tilde{\alpha}$ there are multiple equilibria. One equilibrium in which the international banks stop lending and the firms default, because of their debt overhang, and another in which the international banks continue lending, the full investment is maintained, and the firms repay all of their debt in both periods.

In case (ii) the outcome can be inefficient. The efficient investment rule is for the full investment to be maintained when $\alpha \geq \alpha^*$. In case (ii), when $\alpha^* \leq \alpha < \tilde{\alpha}$ the investment project is liquidated early for certain. When $\alpha \geq \tilde{\alpha}$ the investment project may or may not be liquidated early,

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[5] There are many banks and they play a Nash game in lending, competing on price. But, in addition, after the shock has been revealed, even if it is good, the expectations by one bank about the lending behaviour of others will affect its decision whether to lend. There can be an equilibrium where each small bank will lend, because it correctly believes that others will. There can also be an equilibrium where each small bank will not lend, because it correctly believes that others will not. See Tsomocos (2003) and Geanakopolous and Tsomocos (2002) for a discussion of this issue of fragility.

depending on which of the two equilibria materialises. We now examine these inefficiencies in more detail.

2.4 Inefficiencies

There are two features which combine to create this potential for an inefficient outcome in case (ii) (ie, when there is a low level of equity). First, at the end of period one a firm can be insolvent even in circumstances where maintaining the full investment is still efficient. This is because the firm is burdened by its first-period debts and operating costs. At the end of the first period these costs are effectively sunk, and should not, therefore, influence the investment decision in the second period. On the other hand, they do affect the solvency of the firm by creating a 'debt overhang'.

The second feature is that, in the event that a firm is insolvent, the banks stop lending to finance investment. We have assumed the banks are unable to seize the output of defaulting firms, which is sufficient to ensure they never lend to firms they believe will subsequently default. This assumption is important as otherwise the banks might still be willing to lend whenever $\alpha \geq \alpha^*$, if this raises the residual value of the firm sufficiently. However, this assumption is also quite realistic as legal and other costs must be borne when securing repayment from a bankrupt firm, and these are likely to be particularly high in those emerging markets which have an inadequate bankruptcy code.[6] In this model we assume this problem takes an extreme form for analytic convenience, but the main results hold providing there is at least some inefficiency associated with bankruptcy.

We describe the situation where there is an inefficient early liquidation of investment projects as a *capital account crisis*. It is useful to distinguish between two different types of crisis. We may have either a solvency crisis or a liquidity crisis. A *solvency* crisis is driven by α alone. In this case, when $\alpha^* \leq \alpha < \tilde{\alpha}$, the firm is insolvent and becomes bankrupt for sure. The international banks never continue to lend and a capital account crisis occurs. (Notice that when $\alpha < \alpha^*$ there is not a capital account crisis since it is efficient to liquidate the investment.) On the other hand, when $\alpha \geq \tilde{\alpha}$, solvency alone does not determine whether there is a crisis as there are multiple equilibria. In this region firms are vulnerable to a *liquidity* crisis: if the international banks

(6) Reducing these costs by developing efficient internal bankruptcy arrangements would provide an alternative and a more direct means to address the inefficiencies that arise in this model.

continue to lend they will be repaid; whereas if they do not the firms will default. The strategy of the international banks in each case is rational, as their expectations are self-fulfilling. The essential problem here is that the creditors of each firm are unable to coordinate their actions. When α is within this range there is clearly a potential for a capital account crisis, but this need not necessarily occur.

3 Interventions to prevent *ex-post* inefficiency

In this section we consider whether there are interventions which can prevent inefficient outcomes *ex post*. We restrict our attention to those interventions which do not make any of the affected parties worse off. The feasibility of interventions which make one or more of the affected parties worse off is open to question. First we consider liquidity crises, before turning to solvency crises.

3.1 Liquidity crises

When $\alpha \geq \tilde{\alpha}$ solvency crises cannot occur, but multiple equilibria exist and a liquidity crisis can occur. In a liquidity crisis the belief held by the international banks that the firms will default is self-fulfilling: because the internationals banks expect a firm to default they stop lending in the second period, and as a result the firm is forced to default. If they were to continue to lend the full amount in the second period the investment is sufficiently profitable that the firm would repay its loans with interest. Essentially there is a coordination problem among the international banks. However, in the absence of any means for them to coordinate their second-period lending decisions, there is always a possibility that a liquidity crisis will occur when α is within this range. The challenge is therefore to ensure that sufficient financing is available in the second period.

There are three possible responses to liquidity crises which, on the face of it, are equally effective in dealing with the problem: creditor committees, IMF financing, and standstills. We consider each in turn.

Creditor committees enable the international banks lending to each individual firm to coordinate their lending decisions in the second period. The problems faced by a firm in a liquidity crisis follow from a lack of coordination by its creditors. When a liquidity crisis occurs the

international banks stop lending in the second period and the firm defaults. However, there is always another equilibrium in which the international banks extend their financing to the second period and, given that the investment is sufficiently profitable, they are repaid with interest. Consequently, if there is a means for the creditors to coordinate their second-period lending decisions, they will always decide to provide the firm with continued financing, and so a crisis can be avoided. The outcome will be efficient *ex post*. Of course ensuring the coordination required for creditor committees will be difficult.[7]

The second possibility is IMF lending. Suppose the international banks call in their loans at the end of the first period. If the IMF bridges the full financing gap by lending (through the government) to the firms the international banks can receive a full repayment of their first-period loans with interest, and the full investment can be maintained by the firms. The investment is sufficiently profitable for the IMF to be repaid with interest at the market rate, in this case the risk-free interest rate r_F, which covers the opportunity cost of the Fund's lending. This financing does not involve any element of a subsidy. This is the rate at which the international banks would themselves be willing to lend to the firms in the other equilibrium in which no crisis occurs. With this intervention all of the parties are made better off and any inefficiency from the early liquidation of the investment projects is avoided. The outcome will also be efficient *ex post*. The difficulty with this approach may be the inability of the IMF to mobilise sufficient funds to provide what is required.

This leads us to the third possibility—that of a standstill. Under a standstill the international banks are prevented from calling in their loans after the first period and are therefore forced to roll over their existing stock of lending to the second period. However, on its own this may be insufficient to ensure that the full investment is financed in the second period. This is because, in order for that to be possible, an additional inflow of capital is required as some of the borrowed funds must be used to cover the outstanding operating costs from the first period (ie, precisely that amount not covered by equity financing). If there is no additional financing and just a standstill, the outcome will be a lower amount of investment in the second period, equal to $k_2 = (1-c_1)\overline{k}$. This means that the productivity of investment must be larger in order to avoid default: by substitution into **(3)** the firms will not default when $\alpha \geq \hat{\alpha}$, where:

$$\hat{\alpha} = c_2 + r_F + (1+r_F)(1+r_1)(\overline{\varepsilon} - \varepsilon)/(1-c_1) \qquad \textbf{(6)}$$

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(7) Haldane, Irwin and Saporta (2004) demonstrate that an aggregation problem may arise when coordination is required across firms. This means that creditor committees can only provide a partial solution to the liquidity crisis problem.

In the case where $\alpha \geq \hat{\alpha}$ a standstill alone is effective. In this case α is so large that each lender knows it will get its money back on the further lending required to maintain the stock of investment at its original level, even if there is in fact no further lending by any of the other banks (so that the size of the capital stock is curtailed in the second period to just the amount made possible by the standstill). As a result each lender will actually invest the further funds required to ensure that the stock of capital remains as originally. In this case the standstill will, having prevented a withdrawal of capital, also prevent a default and the full investment is maintained in the second period. Note that $\hat{\alpha} > \tilde{\alpha}$ when $c_1 > 0$, and so that what has just been described applies to only part of the range in which liquidity crises can occur.

In the range $\tilde{\alpha} \leq \alpha < \hat{\alpha}$, a standstill on its own is unable to prevent a liquidity crisis. In this case, even if a liquidity crisis is accompanied by a standstill, each lender knows that it will not get its money back on the further lending required to maintain the stock of investment at its original level, unless other banks lend as well, and so the coordination problem remains. As a result we conclude that although standstills reduce the range over which liquidity crises occur, they do not eliminate this range.

A solution to this problem might be found if, at the same time as the standstill is called, new financing is given seniority over the existing debts of the firm. This might be sufficient to remove any possibility of a default on new financing.[8] Alternatively, the IMF could provide the additional financing that is required by lending at the market rate, r_F. The combination of standstills and IMF lending, in which the IMF meets just the net financing requirement of the firms, would obviate the need for a large injection that is otherwise required when the Fund bears the full brunt of liquidity-crisis resolution. Such a combination might be necessary if there are to be limits placed on IMF lending to a particular country at a time of crisis. If such a combination were to be implemented, then this would require a willingness by the IMF to lend into arrears.

3.2 Solvency crises

In a solvency crisis the international banks call in their loans for sure and the firms become bankrupt. Unlike the case of a liquidity crisis this is not a consequence of a self-fulfilling expectation of a default: irrespective of how much the international banks lend in the second

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[8] But this might not be enough to prevent the emergence of an equilibrium in which each lender did not lend because it feared that other lenders would not lend.

period the firms will still default and so it is never profitable for the international banks to extend their lending. The outcome is, nevertheless, inefficient. To achieve an efficient outcome two challenges must be met. First, sufficient financing must be available to maintain the full investment in the second period. In a liquidity crisis this is itself sufficient to prevent the firms from defaulting. In the case of a solvency crisis the provision of continued financing alone is insufficient to do this. Some means must be found of dealing with the second problem: the overhang of debt. This is caused by the fact that equity investment is not sufficient to pay for first-period operating costs and interest costs. There needs to be some way of preventing that from leading to default. The question addressed in this subsection is whether there are interventions which might allow this. We consider four alternatives: standstills, creditor committees, IMF financing, and write-downs.

(i) Standstills and creditor committees

Standstills and creditor committees will, by themselves, be insufficient to prevent a default and an inefficient outcome. A standstill will prevent capital from being withdrawn at the end of the first period, but the firms will still default and so the international banks are made worse off. Indeed, none of the parties is made better off. And creditor committees alone will neither ensure sufficient financing is available nor prevent a default. In both cases, the problem remains because a solvency crisis is not simply the result of a coordination problem. Since the firms are insolvent the unique equilibrium is the one in which the international banks stop lending and the firms default.

(ii) IMF financing

By contrast, IMF financing can potentially provide a solution. Clearly IMF financing at the rate, r_F, will be insufficient to prevent a default. Suppose, instead, that the IMF provides financing at a subsidised rate, $\tilde{r}_2 < r_F$. If this is sufficiently low the firms will not default. There is obviously a cost of doing this which, ultimately, must be borne by the governments of the creditor countries which effectively finance the IMF. However, they may be willing to do so, even in the absence of any altruism, because of the benefit to the international banks. The banks benefit because they receive a full repayment rather than the partial repayment which occurs under a default. We

assume the creditor-country governments are willing to sanction lending by the IMF at a subsidised rate, providing the gain to the international banks exceeds the cost of the subsidy.[9]

Suppose the IMF bridges the full financing gap at the subsidised rate, so that $k_2 = \overline{k}$. This requires the IMF to lend each firm $(c_1 + (1+r_1)(1-\varepsilon))\overline{k}$, which is what is required to fund the full second-period investment and to pay the costs outstanding from the first period. From equation **(1)** this will be sufficient to prevent each firm defaulting providing:

$$(1+\tilde{r}_2)(c_1 + (1+r_1)(1-\varepsilon)) \leq 1 + \alpha - c_2$$

that is, providing the interest rate on the IMF lending is sufficiently low that the project is productive enough to service the repayment of and interest on the debt overhang, at this low interest rate.[10] If the subsidised-financing package is successful the international banks are made better off as they receive a full repayment. The question is whether their gain is sufficiently large to outweigh the cost to the creditor countries. The gain to the international banks is equal to their repayment minus what they would get in the case of default. The latter, measured at the end of the second period (after grossing up by one period of interest), is: $(1+r_F)(c_1 + (1+r_1)(1-\varepsilon) - 1)\overline{k}$. The cost of the subsidy to the creditor countries is $(r_F - \tilde{r}_2)(c_1 + (1+r_1)(1-\varepsilon))\overline{k}$. Comparing these two expressions, the benefit will outweigh the cost providing:

$$(1+\tilde{r}_2)(c_1 + (1+r_1)(1-\varepsilon)) \geq 1 + r_F$$

Both of these conditions can be satisfied at the same time, so that the subsidy will be enough to prevent default, and also give a benefit to banks higher than the cost of the subsidy, if (and only if) $\alpha \geq \alpha^*$. That is, our condition for subsidised lending to be successful is that it is efficient to invest in the second period. Accordingly, subsidised lending can result in the first-best outcome *ex post*, and avoid any of the inefficiencies associated with a solvency-based capital-account crisis, in this wide range of circumstances.

(iii) Write-downs of debt

The final possibility is for the firms and the international banks to negotiate a write-down of the first-period debt. Suppose the international banks agree to a write-down on the first-period debt

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(9) Implicitly we assume that the creditor-country governments are indifferent to the distribution of resources between the international banks and their taxpayers. Should they favour the latter (former) over the former (latter) this would reduce (increase) the range of outcomes for α over which interventions occur, permitting inefficient outcomes *ex post* in some cases.

(10) The investment is not productive enough to do this at the risk-free interest rate; that is why there is a solvency crisis.

of each firm from $(1+r_1)(1-\varepsilon)\bar{k}$ to $(1+\bar{r}_1)(1-\varepsilon)\bar{k}$. If this write-down is sufficiently large the firms will not default, and so the international banks will be willing to provide sufficient financing to allow the full investment in the second period. Note that this will still require coordination among the international banks lending to each firm, even after a write-down has been agreed, so for this reason the write-down may have to be complemented by either a standstill or by coordination through a creditor committee to ensure that the efficient outcome is achieved.

When will it be possible to write down debt so as to prevent a default? From **(1)**, given $k_2 = \bar{k}$, the write-down will be sufficient to prevent a default providing:

$$(1+\bar{r}_1)(1-\varepsilon) \leq (\alpha - c_2 - r_F)/(1+r_F) + 1 - c_1$$

This is sufficient to ensure that, with continued financing, the firms have a positive value, and so the owners of the firms are better off than if they defaulted. The international banks are also better off lending in the second period, providing that they get more than they would if the firms simply defaulted. That is, if :

$$(1-c_1) \leq (1+\bar{r}_1)(1-\varepsilon)$$

Substitution of the second condition in the first shows that these constraints are mutually compatible if (and only if) $\alpha \geq \alpha^*$. That is, as long as it is efficient to invest in the second period, there always exists a write-down which would take care of the debt overhang from the first period and make both firms and banks willing to invest in the second period. This condition, that a solvency crisis can be averted by write-down providing only that it is efficient to invest in the second period, is exactly the same as the condition necessary for it to be possible to prevent a crisis by subsidised financing.

In this section we have considered various approaches to the efficient *ex-post* resolution of capital account crises. We have found a striking equivalence between some of the alternative approaches to dealing with this problem. Both IMF financing at the market (or unsubsidised) interest rate and creditor committees can prevent any of the inefficiencies associated with liquidity crises, and a standstill may also help to do so in certain circumstances. (Indeed, a combination of these approaches should be able to prevent liquidity crises from occurring in the first place.) Furthermore, both IMF financing at a subsidised rate and write-downs can provide alternative, but equally effective responses to solvency crises: either can prevent any *ex-post* inefficiency.

There are of course obstacles in the way of the proposals discussed. The use of IMF lending to solve liquidity crises may be constrained if there are limits placed on IMF lending to a particular country at a time of crisis, and might require it to be combined with standstills, which would, in turn, require a willingness of the IMF to lend into arrears. Such limits on lending amounts would also constrain the use of IMF loans to solve solvency crises, and might require such loans to be combined with debt write-downs. Furthermore debt write-downs might lead to collective-action problems between the creditors. There is the risk of litigation by creditors against the debtor (Krueger (2001)). And there is the risk of some creditors holding out against an agreed write-down of debts in the hope of a more favourable settlement (Haldane, Irwin and Saporta (2004)).

More than this, the methods chosen to resolve crises may create incentives, *ex ante*, for inefficiencies in the decision to invest by firms or in the form of financing used. We discuss these in the next section, before proceeding to an overall evaluation of methods of crisis resolution.

4 The first-stage solution and *ex-ante* efficiency

At the beginning of the first period the firms must decide whether to invest, and choose the form of financing, while the banks must determine the interest rate on first-period loans, r_1, at which they are willing to lend to the firms.

Examining these decisions enables us to address *ex-ante* efficiency and the moral hazard issue. We consider the incentive that each firm has to make the initial investment and whether this will lead it to make a socially efficient decision. We examine whether there are pressures to undertake too little or too much investment. We also consider whether the owners of each firm have the correct incentive to take the one action that will remove any vulnerability to a crisis in the first place: that is, to raise the proportion of the investment that this financed by equity, ε, above the threshold, $\overline{\varepsilon}$.

To do this we begin by endogenising the first-period interest rate, r_1, using the condition that the expected return from lending to each firm must equal the opportunity cost to the international banks, which is $(1+r_F)(1-\varepsilon)\overline{k}$ in each period. The (implicit) solution will depend on both the distribution of α shocks, and the assumption regarding the interventions that will occur in the event of both liquidity and solvency crises, which we describe as the intervention regime. We can

then use the solution for r_1 to solve for the expected value of the firm in each case. The owners of each firm will choose to make the initial investment if the expected value of their equity investment exceeds the opportunity cost, which is equal to $(1+r_F)\varepsilon\bar{k}$ each period, under the assumption that the providers of equity financing are risk neutral. Whether or not the owners of each firm have an incentive to raise or lower ε will depend on whether the expected value of their equity investment, less the opportunity cost, is increasing or decreasing in ε.

We first assume that α is drawn from a distribution with the probability density function $f(\alpha)$, over the interval (α_L, α_U), where $\alpha_L < \alpha^*$ and $\alpha_U > \tilde{\alpha}$. This means the distribution of α shocks will encompass a range where the investment is liquidated early but this is efficient and does not constitute a crisis, a range where there is a solvency crisis, and a range where there might be a liquidity crisis. We assume that, if there are multiple equilibria, the probability of there being a capital account crisis is exogenous and equal to γ, where $0 \le \gamma \le 1$.

4.1 No vulnerability to crisis

First, we consider the outcome when sufficient equity is invested so that there is no vulnerability to a crisis—that is, when $\varepsilon \ge \bar{\varepsilon}$. In this situation the international banks are guaranteed a full repayment of their first-period loans, and so the interest rate in the first period, r_1, will equal the risk-free rate, r_F. This implies $\bar{\varepsilon} = \hat{\varepsilon}$, where we define $\hat{\varepsilon} = (c_1 + r_F)/(1+r_F)$.

We can solve for the expected value of equity by integrating across the distribution of α. If $\alpha < \alpha^*$ each firm will terminate its investment after one period and the value of equity is given by the excess of the value of the firm's assets over its short-term liabilities. On the other hand, if $\alpha \ge \alpha^*$, each firm will maintain the full investment in the second period. Given $r_1 = r_F$ the expected value of equity at the end of the first period is:

$$EV_E = \int_{\alpha_L}^{\alpha^*} \left[1 - c_1 - (1+r_F)(1-\varepsilon)\right]\bar{k}f(\alpha)d\alpha + \int_{\alpha^*}^{\alpha_U} \left[1 - c_1 - (1+r_F)(1-\varepsilon) + (\alpha - c_2 - r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha$$

which simplifies to:

$$EV_E = \left[1 - c_1 - (1+r_F)(1-\varepsilon)\right]\bar{k} + \int_{\alpha^*}^{\alpha_U} \left[(\alpha - c_2 - r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \qquad \textbf{(7)}$$

A firm will invest if $EV_E \geq \varepsilon(1+r_F)\bar{k}$, which is the opportunity cost of the equity investment in the firm. The equation shows that the owners of each firm will have the correct incentive to make the initial investment: they will invest precisely if it is expected that the return for those high values of α for which the second-period investment is profitable, is large enough to compensate for those low values of α for which the investment is terminated after just one period at a loss. Moreover, as the expected value of equity EV_E, net of the opportunity cost, $\varepsilon(1+r_F)\bar{k}$, is independent of the ε, the owners are indifferent as to the mix between debt and equity financing.

Thus in this case the interest rate is no higher than the risk-free rate, there is no incentive either to invest too much or too little, and there is no incentive to change the financing of investment in inefficient ways. Hence in the model that we are presenting here, all vulnerability to crisis, and all inefficiency associated with crisis, is avoided if there is sufficient equity invested in projects. We now turn to consider what happens if this is not the case.

4.2 Vulnerability, but no intervention

First, we consider the outcome when there is no intervention *ex post*. If there is no crisis the banks expect to receive a full repayment. On the other hand, in the event of crisis, without any intervention, they expect to receive just $(1-c_1)\bar{k}$, which is the value of the firm's assets at the end of the first period. Consequently, the pay-off expected by the international banks is:

$$EV_B^N = \int_{\alpha_L}^{\tilde{\alpha}} (1-c_1)\bar{k}f(\alpha)d\alpha + \gamma\int_{\tilde{\alpha}}^{\alpha_U} (1-c_1)\bar{k}f(\alpha)d\alpha + (1-\gamma)\int_{\tilde{\alpha}}^{\alpha_U} (1+r_1)(1-\varepsilon)\bar{k}f(\alpha)d\alpha \qquad \textbf{(8)}$$

where the superscript indicates that this is the case with no intervention *ex post*. We assume that the behaviour in the market for international banking sets the interest rate just such that this pay-off, EV_B^N, is equal to the opportunity cost of lending, $(1+r_F)(1-\varepsilon)\bar{k}$.[11] From **(8)** we get the following implicit expression for this interest rate, r_1:

[11] Banks are competitive in that they do not act collectively in a strategic manner, although, as we have seen above, the expectations by one bank about the lending behaviour of others affects its decision whether to lend. The assumption here is that they undercut each other to eliminate any tendency to excess profits.

$$(1-\gamma)\int_{\tilde{\alpha}}^{\alpha_U}(1+r_1)(1-\varepsilon)\bar{k}f(\alpha)d\alpha = (1+r_F)(1-\varepsilon)\bar{k} - \int_{\alpha_L}^{\tilde{\alpha}}(1-c_1)\bar{k}f(\alpha)d\alpha - \gamma\int_{\tilde{\alpha}}^{\alpha_U}(1-c_1)\bar{k}f(\alpha)d\alpha \quad \textbf{(9)}$$

This is in effect a supply curve for lending, and shows that the less productive are projects, perhaps because the upper value of α falls, the higher the interest rate will be. But the relationship between α_U and the interest rate is non-linear. This is because a higher interest rate not only increases the return to the banks when there is no bankruptcy, but also increases the range of α over which there will be bankruptcy and so no payment. Indeed, if projects are insufficiently productive there may be no value of the interest rate such that the investment is expected to yield a return equal to the opportunity cost of lending. Unless there is, the international banks will be unwilling to lend in the first period. Whether or not there is a value for r_1 which satisfies this condition will depend on $f(\alpha)$ and the parameters of the model.

Providing there is an interest rate at which the banks are willing to lend in the first period, the expected value of each firm is:

$$EV_E^N = (1-\gamma)\int_{\tilde{\alpha}}^{\alpha_U}\left[1-c_1-(1+r_1)(1-\varepsilon)+(\alpha-c_2-r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha$$

After substituting out for the interest rate using **(9)**:

$$EV_E^N = \left[1-c_1-(1+r_F)(1-\varepsilon)\right]\bar{k} + (1-\gamma)\int_{\tilde{\alpha}}^{\alpha_U}\left[(\alpha-c_2-r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \quad \textbf{(10)}$$

This is necessarily lower than EV_E, the expected value when there is no vulnerability, given that $\gamma > 0$ and $\tilde{\alpha} > \alpha^*$. This is because of the inefficiencies introduced by the possibility of liquidity crises and solvency crises. As a result of the expected value of equity being lower in this way, the owners of the firm have an incentive to raise the amount of equity financing above the threshold, $\hat{\varepsilon}$, so that no vulnerability would exist. This would necessarily raise the expected return from their equity investment.

What about the conditions necessary for lending from banks to be forthcoming in the first place? To examine these, let us assume a particular distribution for α which allows us to derive explicit conditions for the existence of a solution for r_1. For simplicity, we assume α is uniformly distributed between the lower and upper bounds, α_L and α_U respectively. Given this distribution for α condition **(9)** reduces to:

$$(1-\gamma)(\alpha_U-\tilde{\alpha})\left[(1+r_1)(1-\varepsilon)-(1-c_1)\right]=(\alpha_U-\alpha_L)\left[(1+r_F)(1-\varepsilon)-(1-c_1)\right] \quad \textbf{(11)}$$

As $\tilde{\alpha}$ is a linear function of r_1, this expression is quadratic in r_1. After substitution for $\tilde{\alpha}$ we find that a solution for r_1 exists providing:[12]

$$\varepsilon \geq \hat{\varepsilon}-(\alpha_U-c_2-r_F)^2(1-\gamma)/4(\alpha_U-\alpha_L)(1+r_F)^2 \quad \textbf{(12)}$$

This condition sets a limit on how low the amount of equity financing can sink before it renders projects infeasible due to too high a risk of liquidity and solvency crises. Beyond this point investment projects are not expected to support sufficient repayments to the international banks to cover the opportunity cost of lending, however high the interest rate is set, and so they will not be funded.

Thus, without intervention, we have identified two features of the lending process. First, there are incentives on the owners of the firms to set the equity input high enough to avoid the vulnerability to crises. But, second, if they are unable to make this choice, there is a limit to how low the amount of equity financing can be if projects are to attract international lending. The lower the amount of equity, the greater the risks of liquidity and solvency crises, and the higher the interest rate needs to be, but beyond a certain point there is no interest rate at which the international banks are willing to lend to finance the investment in the first place.

In the following subsections we consider, in turn, the impact of interventions to prevent *ex-post* inefficiency in the event of liquidity and solvency crises.

4.3 Intervention in response to liquidity crises

The effect of all three forms of intervention—creditor committees, unsubsidised financing by the IMF, and standstills combined with additional IMF financing where necessary—is straightforward to determine. Effectively each of these interventions mean $\gamma=0$. This will reduce the equilibrium interest rate (if one exists—see below), and increase the profit that the providers of equity expect to make from the initial investment. Equation **(10)** now becomes:

$$EV_E^L=\left[1-c_1-(1+r_F)(1-\varepsilon)\right]\bar{k}+\int_{\tilde{\alpha}}^{\alpha_U}\left[(\alpha-c_2-r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \quad \textbf{(13)}$$

where the superscript indicates this is the outcome with intervention in response to liquidity crises. The expected value is now greater than it is when there is a vulnerability to a crisis but no

[12] Note that, if this condition is satisfied, two positive solutions for the interest rate will exist. Competition among the international banks will ensure that the lower one holds.

intervention, since there is now no risk of a liquidity crisis. But it is lower than in the case where there is no vulnerability at all, since there is still a risk of a solvency crisis.[13] Once again the owners of the firms have an incentive to raise ε above the threshold $\hat{\varepsilon}$, as this necessarily raises the expected return on their investment.

As already noted the equilibrium interest rate will now be lower because of the ruling-out of liquidity crises, and—correspondingly—the condition necessary for there to be lending by the international banks is weaker. If we again assume that α is uniformly distributed, then with $\gamma = 0$ conditions **(11)** and **(12)** reduce to:

$$(\alpha_U - \tilde{\alpha})\left[(1+r_1)(1-\varepsilon)-(1-c_1)\right] = (\alpha_U - \alpha_L)\left[(1+r_F)(1-\varepsilon)-(1-c_1)\right] \qquad \textbf{(14)}$$

$$\varepsilon \geq \hat{\varepsilon} - (\alpha_U - c_2 - r_F)^2 / 4(\alpha_U - \alpha_L)(1+r_F)^2 \qquad \textbf{(15)}$$

Note that condition **(15)** is weaker than condition **(12)**. With intervention to prevent liquidity crises alone, equity investors still have an incentive to set the equity input high enough to avoid the vulnerability to solvency crises. If they are unable to make this choice, there still remains a limit to how low the amount of equity financing can be, if the projects are to attract international lending. This lower limit on equity financing is, however, less than that in the previous subsection, since there is no longer the possibility of a costly liquidity crisis.

4.4 Intervention by write-downs in response to solvency crises

In this subsection we turn our attention to the intervention that follows a solvency crisis. To isolate the effects of a solvency crisis we simply assume $\gamma = 0$, which means liquidity crises never occur, although it should be noted that the same result could be brought about by any of the interventions considered in the previous subsection. First, we deal with write-downs, before examining subsidised IMF financing.

Suppose that, in the event of a solvency crisis, the first-period debt of each firm is written down to $(1+\overline{r}_1(\alpha))(1-\varepsilon)\overline{k}$, where $\overline{r}_1(\alpha)$ is within the range, identified in Subsection 3.2, that is sufficient to prevent a firm from defaulting. This write-down takes place after the draw on α and may be dependent on α. The pay-off expected by the international banks is now:

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(13) We know that $EV_E^L < EV_E$, because in **(13)** the cut-off point for α is $\tilde{\alpha}$ and not α^* which it is in **(7)**.

$$EV_B^{WS} = \int_{\alpha_L}^{\alpha^*} (1-c_1)\overline{kf}(\alpha)d\alpha + \int_{\alpha^*}^{\tilde{\alpha}} (1+\overline{r}_1(\alpha))(1-\varepsilon)\overline{kf}(\alpha)d\alpha + \int_{\tilde{\alpha}}^{\alpha_U} (1+r_1)(1-\varepsilon)\overline{kf}(\alpha)d\alpha \quad \textbf{(16)}$$

where the superscript indicates that this is the outcome with a write-down in the event of a solvency crisis. We assume, as before, that the competitive market for international banking sets the interest rate precisely so that this pay-off is equal to the opportunity cost of lending, so that $EV_B^{WS} = (1+r_F)(1-\varepsilon)\overline{k}$. This gives the following condition for the first-period interest rate, r_1 :

$$\int_{\alpha^*}^{\tilde{\alpha}} (1+\overline{r}_1(\alpha))(1-\varepsilon)\overline{kf}(\alpha)d\alpha + \int_{\tilde{\alpha}}^{\alpha_U} (1+r_1)(1-\varepsilon)\overline{kf}(\alpha)d\alpha = (1+r_F)(1-\varepsilon)\overline{k} - \int_{\alpha_L}^{\alpha^*} (1-c_1)\overline{kf}(\alpha)d\alpha \quad \textbf{(17)}$$

Below we solve for a condition on ε such that a solution for r_1 exists which satisfies this, but for now assume that it does.

As before the expected value of equity investment is found by taking the expectation of outcomes across the range of α values:[14]

$$EV_E^{WS} = \int_{\alpha^*}^{\tilde{\alpha}} \left[1-c_1-(1+\overline{r}_1(\alpha))(1-\varepsilon)+(\alpha-c_2-r_F)/(1+r_F)\right]\overline{kf}(\alpha)d\alpha + \int_{\tilde{\alpha}}^{\alpha_U} \left[1-c_1-(1+r_1)(1-\varepsilon)+(\alpha-c_2-r_F)/(1+r_F)\right]\overline{kf}(\alpha)d\alpha \quad \textbf{(18)}$$

After substitution of **(17)** we obtain:

$$EV_E^{WS} = \left[1-c_1-(1+r_F)(1-\varepsilon)\right]\overline{k} + \int_{\alpha^*}^{\alpha_U} \left[(\alpha-c_2-r_F)/(1+r_F)\right]\overline{kf}(\alpha)d\alpha \quad \textbf{(19)}$$

This is a key result. Not only is EV_E^{WS} independent of $\overline{r}_1(\alpha)$, but it is also precisely equal to EV_E, which is the expected value of equity when no vulnerability to crisis exists. EV_E^{WS} is independent of $\overline{r}_1(\alpha)$ for the following simple reason. We assume the international banks act in a competitive

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(14) We assume that the international banks and the owners of the firms share the same expectation regarding the severity of the write-down that will occur in the event of a solvency crisis. It has been suggested to us that it might be in the interests of a debtor government to agree that write-downs would be the minimum necessary and then once a write-down takes place to make it the maximum possible, in a time-inconsistent way. To sustain time-consistent
non-maximum write-downs would require an institutional framework such as the sovereign debt reconstruction mechanism in which commitments could be given about the degree of write-down that would take place if a crisis emerges.

manner.[15] This means that, although the obligation to the banks is reduced if debt is written down, the expectation of this leads to a burden which is passed back to the firms in the form of a higher interest rate. Thus, in expected-value terms, the write-down of itself has no effect. Indeed, because of this, it does not matter for the expected value of the firms how strong the write-downs are. What does matter is that an adequate write-down occurs whenever this is necessary to ensure the viability of efficient investment in the second period. Because write-downs can occur in all circumstances in which it is efficient, EV_E^{WS} is precisely equal to EV_E.

As a consequence of this result, the expected value of equity EV_E^{WS}, net of the opportunity cost, $\varepsilon(1+r_F)\bar{k}$, is independent of the ε, so the owners of the firms have no incentive to manipulate this variable.

Both results are striking. They suggest that, from an *ex-ante* perspective, the outcome under this intervention regime is identical to that where no vulnerability exists in the first place.

Now consider whether the banks are willing to lend in the first place—that is, the conditions under which there exists an interest rate that satisfies condition **(17)**. Once again, we assume a uniform distribution for α.

The condition for there to be lending *will* depend on the generosity of the write-down that is expected. Suppose the write-down is expected to be at the maximum level within the feasible range, so that $(1+\bar{r}_1)(1-\varepsilon)=(1-c_1)$. In this case the benefit of the write-down is fully appropriated *ex post* by the firms; the international banks do not gain as their participation constraint is just binding. This means that over the whole range of α for which there are solvency crises, the banks get no more than they would if the firms did default. In this situation condition **(17)** reduces to **(14)**, and any solution for r_1, together with the condition on ε for the existence of a solution, is identical to that in the case with interventions in response to liquidity crises alone.

On the other hand, suppose the write-down is expected to be at the minimum level within the feasible range, so that $(1+\bar{r}_1)(1-\varepsilon)=(\alpha-c_2-r_F)/(1+r_F)+(1-c_1)$. Now the benefit from the

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[15] This means that the pricing behaviour of the banks will be such that they do not expect to make supernormal losses or profits if they lend to the firms at the beginning of the first period.

write-down is fully appropriated *ex post* by the international banks. This means that over the whole range of α for which there are solvency crises, the banks get more than they would if the firms defaulted, and this amount increases with α. Equation **(17)** now becomes:

$$(\alpha_U - \tilde{\alpha})\left[(1+r_1)(1-\varepsilon)-(1-c_1)\right] = (\alpha_U - \alpha_L)\left[(1+r_F)(1-\varepsilon)-(1-c_1)\right] + (\tilde{\alpha}-\alpha^*)\left[(\tilde{\alpha}+\alpha^*)/2-(c_2+r_F)\right]/(1+r_F) \quad \textbf{(20)}$$

After substituting for $\tilde{\alpha}$ we once again have a quadratic expression for r_1. A solution exists if:

$$\varepsilon \geq \hat{\varepsilon} - (\alpha_U - c_2 - r_F)^2 / 2(\alpha_U - \alpha_L)(1+r_F)^2 \quad \textbf{(21)}$$

This condition is now weaker than in any of the other cases considered so far. This is understandable. If the effects of a write-down are fully borne by the firms, then the banks need to pass on less in the way of higher interest rates, and so it is more likely that the banks can set an interest rate at which they cover their opportunity cost of lending.

Thus, with intervention by write-downs to prevent solvency crises, there are no longer any incentives on investors to set the equity input high enough to avoid such crises. But there remains a limit to how low the equity input proportion can be set, if the projects are to attract international lending. This limit on the equity input is, however, lower than it would be without such an intervention, unless the banks bear the full costs of the debt write-down.

4.5 Intervention by subsidised lending in response to solvency crises

Finally we consider the case of subsidised financing by the IMF at the rate $\tilde{r}_2(\alpha)$, where $\tilde{r}_2(\alpha)$ is a function of α that lies within the boundaries identified in Subsection 3.2. We make the realistic assumption that the creditor-country governments bear the cost of the subsidy, but do not pass this on to the international banks who are lending to the firms that undertake the investment. The pay-off expected by the international banks is now:

$$EV_B^{FS} = \int_{\alpha_L}^{\alpha^*} (1-c_1)\bar{k}f(\alpha)d\alpha + \int_{\alpha^*}^{\alpha_U} (1+r_1)(1-\varepsilon)\bar{k}f(\alpha)d\alpha \quad \textbf{(22)}$$

where the superscript indicates that this is the outcome with subsidised financing by the IMF in the event of a solvency crisis. Given the condition that $EV_B^{FS} = (1+r_F)(1-\varepsilon)\bar{k}$, from **(22)** we get:

$$\int_{\alpha^*}^{\alpha_U} (1+r_1)(1-\varepsilon)\bar{k}f(\alpha)d\alpha = (1+r_F)(1-\varepsilon)\bar{k} - \int_{\alpha_L}^{\alpha^*} (1-c_1)\bar{k}f(\alpha)d\alpha \quad \textbf{(23)}$$

As the left-hand side is linearly increasing in r_1 a solution for r_1 which satisfies **(23)** must always exist. Given the distribution for α we can solve for r_1 to get:

$$r_1 = \left[r_F(1-\varepsilon)\alpha_U - ((1+r_F)(1-\varepsilon)-(1-c_1))\alpha_L + (c_1-\varepsilon)\alpha^* \right] / (\alpha_U - \alpha^*)(1-\varepsilon)$$

Note that $r_1 \geq r_F$ given $\alpha^* \geq \alpha_L$. The interest rate is higher than the risk-free rate because when $\alpha < \alpha^*$ the firms still default, and so the interest rate has to be set high enough to cover this possibility.

The expected value of the equity investment is:

$$\begin{aligned} EV_E^{FS} = & \int_{\alpha^*}^{\tilde{\alpha}} \left[1 - c_1 - (1+r_1)(1-\varepsilon) + (\alpha - c_2 - \tilde{r}_2(\alpha))/(1+\tilde{r}_2(\alpha))\right]\left[(1+\tilde{r}_2(\alpha))/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \\ & + \int_{\tilde{\alpha}}^{\alpha_U} \left[1 - c_1 - (1+r_1)(1-\varepsilon) + (\alpha - c_2 - r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \end{aligned}$$

After substitution of **(23)** we get:

$$\begin{aligned} EV_E^{FS} = & (1-c_1)\bar{k} - (1+r_F)(1-\varepsilon)\bar{k} + \int_{\alpha^*}^{\alpha_U} \left[(\alpha - c_2 - r_F)/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \\ & + \int_{\alpha^*}^{\tilde{\alpha}} \left[(r_F - \tilde{r}_2(\alpha))(c_1 + (1+r_1)(1-\varepsilon))/(1+r_F)\right]\bar{k}f(\alpha)d\alpha \end{aligned} \qquad \textbf{(24)}$$

EV_E^{FS} is always greater than EV_E and EV_E^{WS}, with the difference precisely equal to the expected cost of the subsidy discounted to the end of the first period. This is a significant result. The increase in the expect value of equity is the result of the fact that the cost of the subsidy, required in the event of a solvency crisis, is not passed on to the banks, who cannot, therefore, pass it on to the firms. This means this cost is external to the firms and so the owners take no account of it when they make the initial investment decision. For this reason they may be tempted to invest in projects even when this is socially inefficient. Moreover, the owners of each firm can raise the expected return on their equity by reducing ε, so as to maximise the expected value of the subsidy. This means that the expectation of subsidised financing, in response to a solvency crisis, could potentially result in a vulnerability to a crisis, where no vulnerability would otherwise exist.

Thus we can draw three conclusions about the outcome when the IMF provides subsidised lending in the face of solvency crises. First, in contrast to the other cases, there is never a minimum amount of equity financing that is required by the banks before they are willing to lend to the firms. Second, there is an incentive to reduce the amount of equity financing to increase the

expected value of the subsidy. This will have the effect of increasing the vulnerability of firms to a crisis. Third, there is a tendency to encourage investment in projects whose expected return on capital is lower than the opportunity cost of capital. This is because of the externality that the prospect of a subsidy creates.

4.6 Implications for *ex-ante* efficiency

From the analysis of this section we can draw three conclusions. First, the international banks might not be willing to lend if there is insufficient equity financing. The strictness of this constraint depends on the intervention regime. This potential constraint on lending is strongest if there is no intervention when a crisis occurs. It is weakened if there is intervention which prevents liquidity crises. The constraint is further weakened if there are debt write-downs, providing that some of the burden of these is borne by the firms. This constraint only disappears when the IMF is expected to provide subsidised financing in the event of a solvency crisis, as only then are the international banks necessarily willing to lend irrespective of the amount of equity investment.

Second, in the absence of any intervention, or if there is only intervention in response to a liquidity crisis, the owners of the firms have an incentive to raise the amount of the investment that is financed by equity. They have this incentive because doing so reduces the possibility of liquidity or solvency crises. If they raise the amount of equity financing sufficiently, there will be no vulnerability to a crisis. On the other hand, if a write-down is expected in the event of a solvency crisis, the owners of the firms are indifferent as to the amount of the investment that is financed by equity. This is because write-downs eliminate the inefficiencies associated with crises. Finally, if the IMF is expected to provide subsidised financing in the event of a solvency crisis, the owners of the firms now have an incentive to *minimise* the amount of the investment that is financed by equity. This is because this maximises the expected value of the subsidy they receive in the event of a solvency crisis.

Third, in contrast to all other cases, the provision of financing at a subsidised rate in the face of a solvency crisis creates an externality that could lead to too much investment in the first instance. This is because the creditor countries bear the cost of the subsidy and there is no mechanism by which this is be passed on to the firms. As this cost is external to the firms the owners do not take this into account when they make the initial investment decision.

Given the importance of subsidised lending as a channel for the creation of moral hazard in this paper, it is necessary to consider the evidence on the extent of IMF subsidies in practice. Mussa (2004) finds that the value of the subsidy is low, relative to the full amount of capital flows to emerging markets. He argues that the IMF's own balance sheet places an upper limit on the amount of the subsidy which can feasibly exist.[16] Others find that the evidence on moral hazard is more mixed (Dell'Ariccia *et al* (2002)). It may be that the channel for moral hazard arises in ways other than those considered here.[17] In particular it may be that, in the absence of IMF lending there would be default in the case of a solvency crisis, as in this paper, and that (i) the IMF lends at the risk-free rate rather than at a subsidised rate but that (ii) the costs required for repayment of this loan are met (subsequently) by the borrower-country government rather than governments in the countries where lending banks are located. In this case moral hazard remains, but of a kind not measured in the IMF's balance sheet, since its costs are born by borrower governments. A useful extension to the present analysis would be to develop the model to capture this alternative channel for moral hazard.

5 Conclusions

This analysis has shown that liquidity crises and solvency crises present policymakers with different challenges. For liquidity crises the challenge is to ensure that sufficient financing is available to the firms in the second period to prevent an unnecessary early liquidation of the investment projects. In the case of a solvency crisis, the provision of financing is also an essential element. However, there is a further challenge as financing alone is insufficient to prevent the firms from defaulting. To prevent an inefficient outcome some additional mechanism must be found to achieve this. This can take the form of a write-down of the debt overhang, or the provision of subsidised lending by the IMF.

Given the different nature of the problems faced there is no reason why the optimal form of intervention should be the same in each case. The analysis of this paper suggests that this is unlikely to be the case.

When dealing with a liquidity crisis three forms of intervention are effective: creditor committees, unsubsidised financing by the IMF, and (in some cases) standstills. However in

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(16) Jeanne and Zettelmeyer (2001) develop a similar argument.

(17) Haldane and Taylor (2003), Haldane and Scheibe (2004) and Gai and Taylor (2004) find evidence to support the existence of other, more indirect channels for moral hazard.

practice, if there is a potential shortage of IMF money, IMF financing may have to be combined with a standstill. We found that each of these approaches can ensure *ex-post* efficiency and that they had identical implications for *ex-ante* efficiency. None of these interventions create moral hazard pressures: even with them in place investors still have an incentive to set equity financing high enough to avoid vulnerability to liquidity or solvency crises.

In the case of a solvency crisis we found that two interventions were able to achieve an outcome that is efficient *ex post*. These are write-downs and IMF financing at a subsidised interest rate. But we also found that subsidised financing has serious *ex-ante* implications: it creates moral hazard by encouraging investors to reduce equity financing so as to maximise the expected value of the subsidy they receive in the event of a crisis, and so increases the likelihood of a crisis in the first place.

There is another way to understand this conclusion. We can view *ex-post* interventions in the same way we would view any interventions designed to offset a market failure. The first theorem of welfare economics tells us that, if the market failures which prevent the continuation of efficient investment in the second period are the only market failures, then correcting for them, using any of the alternative approaches considered in this paper, will achieve a first-best or Pareto-efficient outcome. It is for this reason that we conclude that each of the *ex-post* measures—with the notable exception of subsidised financing—will not have any moral hazard cost (at least in the absence of some other exogenous market failure). Subsidised financing is the exception because it *causes* another market failure: the subsidy itself creates an external cost of the investment that is not taken into account when the owners of the firms make their initial investment decisions.

The problem analysed in this paper—vulnerability to crisis due to a low proportion of financing through equity—may arise for a subtle reason. In emerging markets it may be that originally a low amount of equity financing arises not from choice. Instead, underdeveloped capital markets may mean that projects have to be financed largely by borrowing. This might mean either the investment cannot be financed at all if the banks are unwilling to lend, or if they do that a vulnerability to a crisis exists. But subsidised bailouts are a poor response to this. Although bailouts can deal with crises when they do occur, they make crises more likely in the first place as they provide firms with an incentive to keep the amount of equity financing low. In such a situation an ill-judged policy response to a failing in the market may hinder the market from subsequent development.

The paper raises a more general problem. As different responses are required to liquidity and solvency crises, we must be able to distinguish between different types of crisis. But in general this may not be possible, and a lack of timely information might make this judgment subjective and probabilistic. A mistake could have consequences more serious than those discussed in this paper. It may be that dealing with a liquidity crisis speedily is important—to prevent a worsening of the fundamentals and make a future solvency crisis less likely.[18] Such arguments have been used recently in the case of Brazil. But if the perceived liquidity crisis is in fact an emerging solvency crisis, then dealing with it as a liquidity crisis may delay the onset of the solvency crisis and may make the cost much worse. This appears to be what happened in the case of Argentina. This suggests that much more work is required on what to do if there are signs of an emerging crisis but insufficient indication of which kind.

[18] Haldane *et al* (2004) explore this sort of interlinkage between liquidity and solvency crises.

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