Catalytic finance: When does it work?

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Abstract

In a model of debt crisis caused partly by creditor coordination failure, we show that bailouts that reduce ex post inefficiency will sometimes enhance the incentives for governments to take costly adjustment effort. This model helps us understand a debate about the role of the IMF in catalyzing lending to developing countries.
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1. Introduction

The doctrine of catalytic finance rests on the idea that the provision of official assistance to a country undergoing a financial crisis spurs other interested parties to take actions that mitigate the crisis. In particular, it rests on the premise that, under the right conditions, official assistance and private sector funding are strategic complements. That is, the provision of official assistance galvanizes the private sector creditors into rolling over short term loans, and thereby alleviating the funding crisis faced by the debtor country.

Until recently (i.e. before the Argentine default of 2001), catalytic finance was the cornerstone of the official community's strategy towards capital account crises. Ghosh et al. (2002) and Cottarelli and Giannini (2002) are two IMF papers that chronicle the emergence of the doctrine of catalytic finance and its apparent fall from grace among G7 policy makers. This is in spite of the fact that, as recently as September 2000, the communiqué of the International

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Monetary and Finance Committee – the so-called Prague framework – acknowledges that "the combination of catalytic official financing and policy adjustment should allow the country to regain full market access quickly."

What went wrong? Can the demise of the doctrine of catalytic finance be attributed to clear cut evidence of its ineffectiveness, or is it merely a reflection of the trauma following Argentina's default? Does the Argentine episode prove that debtor moral hazard is an inevitable consequence of catalytic finance, and hence doomed to failure? The empirical evidence cited by Ghosh et al. (2002) and Cottarelli and Giannini (2002) suggests that catalytic finance has not been effective. The evidence comes from studies of the effect of IMF intervention on net private capital flows (there seems to be little increase in net inflows), and on comparisons of initial projections of IMF assistance as compared to eventual IMF assistance ex post (the eventual assistance outstrips initial projections).[1]

However, two issues make the assessment problematic. There is, first, the question of what the relevant counterfactual is. In assessing the welfare effects of IMF intervention, the relevant question is what would have happened had the IMF *not* intervened. Tracking net capital flows fails to address the possibility that net outflows of private capital (and hence the severity of crisis) might have been even worse without IMF intervention.

Second, and more generally, there is no agreed theoretical rationale for catalytic finance that might assist in formulating the appropriate questions. The problem is especially acute when assessing the moral hazard implications of IMF intervention. Leaving the Argentine episode aside, does IMF intervention always exacerbate the moral hazard problem on the part of the debtor country? The relevant counterfactual here is what the debtor country would have done to stave off a crisis in the absence of IMF intervention. Would it have tried harder to avoid a crisis if it knew that the IMF was not there to extend help? Or was the adjustment effort made manageable *only because* the IMF's assistance mitigated the onerous domestic political costs of adjustment? The idea behind this latter possibility is that without the IMF's assistance, the political costs of embarking on an adjustment program would have been so prohibitive that the debtor government would have chosen to take the relatively "easier" option, and default. So, which side is correct? Does IMF intervention always exacerbate moral hazard, or could it sometimes mitigate it?

The importance of addressing the moral hazard implications of IMF assistance is underlined by the inconclusive debates on how to interpret the evidence from past interventions. Take, for instance, Eichengreen and Mody's (2000) finding that IMF loans to a country tend to narrow the spreads on that country's debt on the primary market. Cottarelli and Giannini (2002) take issue with this evidence as an argument in favour of IMF intervention for the reason that

> "... the regressions do not control for the change in economic policies that typically characterizes an IMF-supported program. This means that it is impossible to distinguish between the decline in the spread that is due to sounder policies, from that arising from the IMF's seal of approval" [p.28].

The counterargument would be that debtor country policies are endogenous. Even in the absence of explicit conditionality, IMF assistance affects economic policy by altering the slope of the tradeoff between the costs of domestic adjustment and the costs of repudiation. Far from

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[1] See Hovaguimian (2003) for an overview of the empirical evidence. The studies by Corsetti et al. (2002) and Roubini and Setser (2004) suggest that the evidence is somewhat mixed.

trying to isolate the effect of IMF assistance by controlling for shifts in domestic policy, a proper assessment of IMF assistance should proceed by trying to assess how much of the change in economic policy can be attributed to IMF assistance. For such an exercise, it is essential to have a theoretical framework that can account for the endogeneity of adjustment policy.

In fact, the endogeneity problem is more pervasive than we have hinted so far. Up to now, we have only commented on the endogeneity of debtor country adjustment policy. However, there are at least three groups of interested parties, namely

- The debtor country
- Private sector creditors
- IMF and other official lenders.

The decisions within each group are endogenous to the actions of the other groups. Thus, for instance, the private sector creditors will be galvanized to roll-over their short term claims if they believe that IMF assistance will tip the balance in favour of the debtor country embarking on an otherwise (politically) infeasible adjustment program. Recognizing its pivotal role, the IMF will then be willing to incur the costs of intervention. Finally, the debtor country will recognize that the virtuous circle described above will only come about if painful domestic adjustment policies are undertaken. In other words, the actions of all interested parties are strategic complements. Each party's action provides incentives for the other parties to take the appropriate action. To use a rather extravagant metaphor, it is as if every agent is standing on the shoulders of all other agents. The supporting role of each party is necessary for the participation of the others.

In contrast, we could paint a more pessimistic picture of the strategic interaction between the creditors, debtor and the IMF. The inability of the IMF to commit not to intervene generates moral hazard on the part of the debtor country, which fails to take the necessary domestic adjustment effort. In turn, the creditors take advantage of the IMF's assistance to bail out of the country before economic conditions deteriorate. This combination paints a picture in which the IMF's assistance is a *strategic substitute* for the adjustment effort of the debtor and the roll-over decisions of the private creditors. Far from galvanizing the efforts of the other interested parties, the IMF's intervention serves to crowd out those actions that would mitigate the crisis.

In light of the contrasting strategic effects of IMF assistance, we could advance the following working definition of when catalytic finance is successful.

Working definition. Catalytic financing succeeds when it induces greater adjustment effort by the debtor *and* induces a greater incidence of roll-over by the creditors.

Our working definition points to the importance of the mutually reinforcing effect of adjustment effort and greater incidence of roll-over by the creditors. It should be contrasted with other related (but distinct) notions — such as the greater incidence of roll-over without greater adjustment effort by the debtor (a symptom of creditor moral hazard) or the reduction in the probability of default (which would be consistent with debtor moral hazard). The reduction in default probability would be a necessary condition for successful catalytic finance, but not sufficient.[2] Our definition is also related to the issue of the feasibility of an international lender of last resort (Fischer, 1999).

In what follows, we construct a theoretical framework for assessing the success or otherwise of catalytic finance by constructing a model that treats the actions of creditors, debtor

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[2] We are grateful to the co-editor and a referee for pointing out the distinct nature of these ideas.

government and the IMF as interested parties in a game where their interests are inextricably intertwined. Our model builds on the recently developed literature on global games, in which short term creditors must decide on whether or not to roll-over claims that are maturing imminently. The IMF seeks to intervene only when the fundamentals of the debtor country are sound (based on the basic conditions of the economy and the adjustment effort of the debtor government), but where there is a danger that short term creditors themselves may not be able to resolve the collective action problem. The debtor government's adjustment effort is itself chosen anticipating the actions of the IMF and the short term creditors.

We identify circumstances under which IMF assistance succeeds in spurring the debtor country not to slack off in its adjustment effort, and sometimes actually to increase it. The moral hazard implications of IMF intervention are quite subtle. IMF intervention can mitigate debtor moral hazard in some cases. For catalytic finance to work, the IMF's decision must be *strategic complements* with the adjustment effort of the decision country and the roll-over decisions of the private sector creditors. Catalytic finance fails when the IMF's decision becomes a strategic substitute for either the debtor country's adjustment effort, or the private sector creditors' roll-over decisions. The ambiguous effect of IMF assistance on debtor moral hazard has also been studied by Jeanne and Zettelmeyer (2004) and Cordella and Levy-Yeyati (2004), although both these papers employ a model quite different from our own.

Our results suggest that catalytic finance is most likely to work when the fundamentals are quite poor, but not hopelessly so. In such a situation, the existence of IMF assistance provides just enough of a lifeline for the debtor country to make the necessary adjustment effort. This, in turn, alters the incentives of the private sector creditors just enough to make them roll-over their maturing claims. However, our results also suggest that over some ranges of the fundamentals, the conventional "debtor moral hazard" effects may predominate. In this range, the inability of the IMF to commit to a tough intervention policy leads to a slackening of effort on the part of the debtor country. Similar results to ours on the catalytic effect of IMF assistance have been obtained by Penalver (2002) and Corsetti et al. (in press). We will discuss the related literature in a later section of our paper.

Our conclusion that catalytic finance can work is at variance with the "Powell doctrine" on this issue. The original (Colin) Powell doctrine is the military dictum that one should be selective in choosing whether to intervene; but once the decision is made to go in, one should employ "overwhelming force" to guarantee a successful outcome. For IMF interventions, the implication is that if intervention has been decided upon, the size of the assistance should be large enough to meet the funding gap in full. In this vein, Zettelmeyer (2000) and Jeanne and Wyplosz (2001) have suggested that any IMF intervention that leaves open the possibility of multiple equilibria would induce private sector creditors to act so as to undermine the program. Frankel and Roubini (2001) provide a survey of the arguments.

Our conclusions are rather different. Once we have circumvented the difficulties of predicting outcomes when there is more than one equilibrium by means of our global game methods, we find that the Powell doctrine (at least, as applied to IMF interventions) misses the pivotal role played by the strategic interplay between the actions of the three groups of interested parties—the debtor, the creditors, and the IMF. Under the right conditions, something less than a full bailout is sufficient to stave off a default.

We begin by presenting the model in the next section. The solution proceeds in steps in Sections 3 and 4. In Section 5, we discuss some related literature and how our model could be

adapted to incorporate other channels by which IMF lending might be catalytic. We conclude with some reflections on the possible implications of our findings on the debates on the scope and rationale for IMF lending.

2. Model

A debtor country needs funds to pay its creditors in order to tide itself over to the next period. It must find funds to pay interest of L on its outstanding long term sovereign debt, and has amount S of its short term debt maturing immediately. Unless the short term creditors roll-over their claims, the debtor must also find the money to repay principal of S on these maturing short term debt. In all, the debtor country faces an immediate funding need of

$$L + \ell S$$

if proportion ℓ of the short term creditors decline to roll-over. We suppose that there is a continuum of short term creditors.

In order to meet this funding requirement, the debtor country can draw on available cash of

$$\theta$$

which is the realization of a normally distributed random variable with mean

$$\phi + e$$

and variance $1/\alpha$. The two variables ϕ and e have the following interpretation.

- The variable ϕ represents the strength of the underlying economic fundamentals of the debtor country, irrespective of any adjustment effort on its part. The ϕ stands for "fundamentals".
- The variable e represents the increased likelihood of additional cash available to the debtor government if it embarks on a painful domestic adjustment program (such as fiscal stringency). The e stands for "adjustment effort". The adjustment effort is costly for the debtor country, as will be described later.

For the sake of simplicity, we will suppose that the country's finances are viable in the long run provided that θ is large enough to cover the interest payment L on the long term loan only. This means that all creditors (both long term creditors, and those short term creditors who roll-over) will be repaid. Hence, we will say that the country is *fundamentally sound* if

$$L \leq \theta$$

If θ is large enough to meet both L and the maturing short term debt S, then there is no problem. However, if θ is in the intermediate range where

$$L < \theta < L + S \tag{1}$$

then the fate of the country lies in the hands of its short term creditors. If they all roll-over, then θ is large enough to meet the debt payments. However, if sufficiently many of them decline to roll-over, θ is not large enough to avoid default. The consequences of default for all the

interested parties will be described in more detail below. By shifting the origin and adjusting the units, we will normalize the debt repayments L and S so that

$$L = 0$$

$$L + S = 1$$

and the variables ϕ, e and θ are normalized accordingly.

The final interested party in our model is the IMF. The IMF has the capacity to intervene by providing additional funds to the debtor country based on its knowledge of the fundamentals ϕ and adjustment effort e. The IMF's objective function will be defined so that, provided that the debtor country is fundamentally sound, it gains by assisting the debtor country fulfil its obligations to the short term creditors, thereby staving off default.

2.1. Extensive form of the game

We can now describe our model more formally, by supplying the payoffs of all the interested parties, their sequence of moves and the information available at all points. The game proceeds as follows.

- Nature draws ϕ; ϕ is common knowledge among all.
- The debtor country chooses adjustment effort e based on its knowledge of ϕ. Once e has been chosen, it is common knowledge among all.
- The IMF chooses the amount of funding m that is extended to the debtor country based on ϕ and e. The amount m is announced publicly and hence is common knowledge among all.
- Nature draws θ from a normal density with mean $\phi + e$ and variance $1/\alpha$. No-one observes the true realization of θ.
- However, each short term creditor i observes the realization of his signal

    $$x_i = \theta + \varepsilon_i$$

    where ε_i is normal with mean 0 and variance $1/\beta$, and where the noise terms ε_i and ε_j for distinct i and j are independent. Thus, a short term creditor's information consists of the publicly known variables ϕ, e, m and his private signal x_i. Based on this information each short term creditor decides whether to roll-over or not.

In our model, the long term creditors are passive players. They are called into action only when the debtor country defaults and cross-default clauses are triggered. Since the long term creditors play no role in determining whether the country defaults or not, we will confine our attention to the actions of the short term creditors.

Using our normalization for L and S introduced earlier, and denoting by ℓ as the proportion of short term creditors that decline to roll-over, the debtor country defaults on its debt if and only if

$$\theta + m < \ell$$

That is, the domestic resources θ plus the IMF assistance m is not enough to meet the funding gap. The short term creditor who declines to roll-over has an investment opportunity that gives payoff λ, where $0 < \lambda < 1$. The short term creditor who rolls over faces an uncertain payoff. If the

country defaults, he gets payoff of 0. However, if it does not default, his payoff is 1. Thus, the payoff of a short term creditor who rolls over is given by

$$v(\theta, m, \ell) \equiv \begin{cases} 1 & \text{if} \quad \theta + m \geq \ell \\ 0 & \text{if} \quad \theta + m < \ell \end{cases}$$

We now turn to the payoff of the debtor country. In order to preserve tractability of the model, we will define the payoffs of the debtor country as being identical to the payoff of the short term creditors who roll-over, except for the cost of adjustment effort $c(e)$. Thus, the debtor country's payoff is given by

$$v(\theta, m, \ell) - c(e)$$

where $c(\cdot)$ is an increasing convex function. This definition of the debtor's payoff is adopted for simplicity and neglects some important features. We will return in a later section to discuss how our analysis can be generalized.

Finally, we come to the IMF's payoff function. We will suppose that the IMF's interests coincide with the short term creditors who decide to roll-over their claims, except for two qualifications. First, the IMF seeks to intervene only when the debtor country's economy is fundamentally sound (i.e. when $\theta \geq 0$). Second, the IMF bears a cost bm in providing the assistance m, where $b > 0$ is a positive constant. The IMF's payoff function is thus given by

$$w(\theta, m, \ell) \equiv \begin{cases} v(\theta, m, \ell) - bm & \text{if} \quad \theta \geq 0 \\ -bm & \text{if} \quad \theta < 0 \end{cases} \tag{2}$$

It is worth noting that the IMF's interests coincide with both the debtor country and the short term creditors who roll-over, except for the fact that the short term creditors and the debtor country benefit from the IMF's assistance even when the debtor is not fundamentally sound (i.e. when $\theta < 0$). In this case, any assistance by the IMF constitutes a straight transfer to the short term creditors. Our analysis can be extended to alternative payoff specifications for the interested parties provided that the social welfare function and the objective function for the IMF (if different) can be specified explicitly; we discuss some alternative payoff specifications in Section 5.1.

The main consequence of the simplified payoffs assumed here is that it minimizes the distributional issues between debtor and creditors, and we can concentrate on the efficiency aspect of IMF intervention. However, since "distributional issues" is a euphemism for default, we are missing an important element of the discussion on sovereign debt. Subject to this qualification, we examine the equilibrium that arises from our model.

3. Equilibrium

Our purpose is to gauge the moral hazard implications of the IMF assistance, and the interplay between the IMF's assistance and short term capital flows. As such, our main focus will be on the adjustment effort e of the debtor country and the determination of the IMF's assistance m and its relationship with the roll-over decision of the short term creditors.

3.1. Roll-over by short term creditors

In solving the subgame that begins with Nature's draw of θ (the fourth stage of our extensive form game), we employ global game methods used in our earlier work on currency attacks and

creditor runs (Morris and Shin, 1998, 2004). The focus in this subgame is on the roll-over decisions of the short term creditors.

A *strategy* for short term creditor i is a decision rule which maps each realization of x_i to an action (i.e. to roll-over the loan, or not). An *equilibrium* of the subgame is a profile of strategies – one for each short term creditor – such that a creditor's strategy maximizes his expected payoff conditional on the information available, when all other creditors are following the strategies in the profile. We will confine our attention to equilibria in switching strategies in which a creditor rolls over whenever his estimate of θ is higher than some given threshold level. We will comment below on why this is not a restrictive assumption in our model. Let us define

$$y \equiv \phi + e$$

to be the ex ante mean of θ.

When short term creditor i observes the realization of the signal x_i, his posterior distribution of θ is normal with mean

$$\xi_i \equiv \frac{\alpha y + \beta x_i}{\alpha + \beta} \tag{3}$$

and precision $\alpha + \beta$. When creditors use a switching strategy, they have a threshold level ξ (the 'switching point') for their switching strategies, and roll-over the loan if and only if the private signal x is greater than

$$x(\xi, y) \equiv \frac{\alpha + \beta}{\beta} \xi - \frac{\alpha}{\beta} y. \tag{4}$$

3.2. Critical value of fundamentals

The critical value of θ at which the country is on the margin of crisis is when $\theta + m = \ell$, where ℓ is the proportion of creditors who decline to roll-over resulting from the switching strategy around ξ. We denote by θ^* the critical state θ at which the debtor country defaults. The incidence of foreclosure ℓ is given by the mass of creditors who have received a signal below the marginal signal x. Hence $\ell = \Phi(\sqrt{\beta}(x - \theta^*))$, where $\Phi(\cdot)$ is the cumulative distribution function for the standard normal. Since $\theta^* + m = \ell$, we have

$$\theta^* + m = \Phi\left(\sqrt{\beta}(x - \theta^*)\right)$$
$$= \Phi\left(\sqrt{\beta}\left(\frac{\alpha + \beta}{\beta}\xi - \frac{\alpha}{\beta}y - \theta^*\right)\right) = \Phi\left(\frac{\alpha}{\sqrt{\beta}}(\xi - y) + \sqrt{\beta}(\xi - \theta^*)\right). \tag{5}$$

This gives us our first equation in terms of ξ and θ^*.

For our second equation, we appeal to the fact that at the switching point ξ, a creditor is indifferent between rolling over and foreclosing. The payoff to foreclosure is λ, while the expected payoff to rolling over is the probability that the country does not default. Since the debtor country avoids default whenever $\theta \geq \theta^*$, and since the conditional density over θ is normal with mean ξ and precision $\alpha + \beta$, this indifference condition is given by

$$1 - \Phi\left(\sqrt{\alpha + \beta}(\theta^* - \xi)\right) = \lambda \tag{6}$$

which implies

$$\theta^* - \xi = \frac{\Phi^{-1}(1-\lambda)}{\sqrt{\alpha+\beta}}. \tag{7}$$

This gives us our second equation. From this pair of equations, we can solve for our two unknowns, θ^* and ξ. Solving for θ^*, we have

$$\theta^* + m = \Phi\left(\frac{\alpha}{\sqrt{\beta}}\left(\theta^* - y + \Phi^{-1}(\lambda)\frac{\sqrt{\alpha+\beta}}{\alpha}\right)\right). \tag{8}$$

The critical state θ^* is obtained as the intersection between a cumulative normal distribution with mean $y - \Phi^{-1}(\lambda)\frac{\sqrt{\alpha+\beta}}{\alpha}$ and precision α^2/β, with a straight line of slope 1 with intercept m.

Eq. (8) has a unique solution if the expression on the right hand side has a slope that is less than one everywhere. The slope of the right hand side is given by $\phi \cdot \alpha/\sqrt{\beta}$ where ϕ is the density of the standard normal evaluated at the appropriate point. Since $\phi \leq 1/\sqrt{2\pi}$, a sufficient condition for a unique solution for θ^* is given by

$$\frac{\alpha}{\sqrt{\beta}} \leq \sqrt{2\pi} \tag{9}$$

Since α is the precision of the ex ante distribution of θ, while β is the precision of the creditors' signals, condition (9) is satisfied whenever the private signals are precise enough relative to the underlying uncertainty. When Eq. (9) holds, there is a unique equilibrium in switching strategies. It turns out that Eq. (9) is also sufficient for uniqueness of equilibrium in *any* class of strategies—not simply the switching strategies. Condition (9) is necessary and sufficient for there to be a unique dominance-solvable equilibrium (see Morris and Shin, 2004).

3.3. Limiting case

In order to keep the analysis tractable enough to investigate moral hazard effects, we will be interested in the limiting case when the private signals of the short term creditors become very precise. This corresponds to the case where $\beta \rightarrow \infty$. From Eq. (8), the failure point θ^* satisfies

$$\theta^* + m \rightarrow \Phi\left(\Phi^{-1}(\lambda)\right) = \lambda$$

so that, in the limit,

$$\theta^* = \lambda - m \tag{10}$$

The fact that the payoff parameter λ and IMF assistance m are related in this manner is a consequence of our payoff normalization, and should not be read too literally. Of more importance is the observation that m determines whether the critical value of fundamentals θ^* allows inefficient crises or not. When $\lambda > m$, we have $\theta^* > 0$, so that there are states between 0 and θ^* at which the debtor country defaults even when it is fundamentally sound.

Eq. (10) also shows that inefficiencies may persist even when the private signals x_i now reveals what the underlying state θ is. The key to understanding this result is to note that *strategic uncertainty* – uncertainty over the actions of other short term creditors – is not resolved even when the private signal becomes very precise.

One way to show this is to ask what is the subjective probability distribution over ℓ, the proportion of creditors who foreclose. From the point of view of any creditor, the equilibrium ℓ

is a random variable, and has a density over the unit interval $[0,1]$. One could say something about the degree of strategic uncertainty in terms of the shape of the density over $[0,1]$. For instance, if the density is a degenerate spike at 0, this would suggest that there is no strategic uncertainty, since no-one forecloses. Similarly if the density is the degenerate spike at 1, then everyone forecloses, so that again, there is no strategic uncertainty. However, if the density is more diffuse, then there is uncertainty over what the other creditors will do. For the case where $\beta \rightarrow \infty$, it turns out that the subjective density for ℓ held by a player at the equilibrium switching point is given by the *uniform density*. Since the uniform density is the most diffuse of all densities over the unit interval, this suggests that strategic uncertainty is at is greatest when $\beta \rightarrow \infty$. The reader may consult our survey paper of global games (Morris and Shin, 2003, section 2) for more details. The analysis of this limiting case demonstrates quite starkly how even when information concerning the underlying fundamentals becomes very precise, the strategic uncertainty concerning the actions of other players may, nevertheless, be very severe. It is the interplay between these two types of uncertainty that determines the equilibrium outcome, and this interplay can be quite subtle.

4. When does catalytic finance work?

Our solution for the critical value of θ at which debtor default is triggered can now be used in evaluating the decision of the IMF in deciding on the size of the assistance m, and the extent of adjustment effort e exerted by the debtor country.

Consider the IMF's decision. It knows the fundamentals ϕ and the adjustment effort e, and hence knows that θ is normally distributed with mean $y = \phi + e$ and variance $1/\alpha$. From Eq. (2) the IMF's expected payoff is given by

$$\begin{cases} 1 - \Phi(\sqrt{\alpha}(\theta^* - y)) - bm & \text{if} \quad \theta^* \geq 0 \\ 1 - \Phi(-\sqrt{\alpha}y) - bm & \text{if} \quad \theta^* < 0 \end{cases}$$

$$= 1 - \Phi\big(\sqrt{\alpha}(\max(0, \theta^*) - y)\big) - bm$$

$$= 1 - \Phi\big(\sqrt{\alpha}(\max(0, \lambda - m) - y)\big) - bm \tag{11}$$

where the last equation follows from the fact that $\theta^* = \lambda - m$. The IMF chooses m to maximize Eq. (11). Note that when $y \rightarrow \infty$, or when $y \rightarrow -\infty$, the optimal choice is $m = 0$. In other words, when y is either very large or very small, the IMF chooses not to intervene. When y is very large, the debtor's economy is very strong, and no assistance is needed. When y is very small, the economy is not fundamentally sound, and hence assistance is wasted. The optimal choice of m is largest for intermediate values of y, when the economy is weak, but not hopelessly so.

4.1. Solution in a limiting case

We will assume that the cost parameter b is small relative to the benefits of intervention. The expected payoff given by Eq. (11) was obtained as the limiting expression when $\beta \rightarrow \infty$. We can obtain a further simplification and obtain an explicit solution for the IMF's decision problem if we further take the limit as $\alpha \rightarrow \infty$. In other words, we take two limits, the first with respect to β, and then with respect to α. When $\alpha \rightarrow \infty$, the ex ante distribution of θ becomes a degenerate spike around its mean y. In this case, the IMF's information is a very

good predictor for the true state of the debtor's finances. As $\alpha \to \infty$, the IMF's expected payoff tends to the discontinuous limit:

$$\begin{cases} 1 - bm & \text{if} \quad y > 0 \quad \text{and} \quad y > \lambda - m \\ - bm & \text{if} \quad y \leq 0 \quad \text{or} \quad y \leq \lambda - m \end{cases}$$

Thus, for large but finite values of α, and for a cost parameter b that is small enough, the optimal choice of m as a function of y can be derived approximately as the value of m that sets $\lambda - m - y = 0$, provided that y lies between 0 and λ. In other words, the optimal value of m satisfies:

$$m^*(y) \simeq \begin{cases} 0 & \text{if} \quad y < 0 \\ \lambda - y & \text{if} \quad 0 \leq y < \lambda \\ 0 & \text{if} \quad y \geq \lambda \end{cases} \tag{12}$$

This solution makes intuitive sense. Whenever the debtor country is fundamentally sound $(y \geq 0)$, but where the coordination problem among the short term creditors leads to default $(y < \lambda)$, the IMF intervenes to provide assistance to the debtor country. The amount of assistance is just enough to ensure that the sum of domestically available resources and IMF assistance is sufficient to stave off default—that is, $y + m = \lambda$.

Given the IMF's decision rule (12), we can now address the issue of debtor country moral hazard. We maintain the assumption that α is large, so that $y = \phi + e$ provides a good estimate of θ. In this case, anticipating the intervention of the IMF whenever $0 \leq \phi + e < \lambda$, the payoff function for the debtor country is given by

$$\begin{cases} 1 - c(e) & \text{if} \quad \phi + e \geq 0 \\ - c(e) & \text{otherwise} \end{cases} \tag{13}$$

The debtor country chooses adjustment effort e to maximize this expression. Let us consider the special case in which the cost function is quadratic, so that $c(e) = e^2$. Then the optimal choice of e is given by

$$e^*(\phi) = \begin{cases} - \phi & \text{if} \quad -1 \leq \phi < 0 \\ 0 & \text{otherwise} \end{cases} \tag{14}$$

Thus, adjustment effort is maximized when $\phi = -1$, and diminishes linearly in ϕ.

4.2. Moral hazard implications of IMF assistance

Let us now compare the adjustment effort of a debtor country in a world without IMF assistance—that is, a world in which m is set equal to zero. In this case, the critical state θ^* is equal to λ. In the limiting case where $\alpha \to \infty$, the expected payoff of the debtor country as a function of its adjustment effort is given by

$$\begin{cases} 1 - c(e) & \text{if} \quad \phi + e \geq \lambda \\ - c(e) & \text{otherwise} \end{cases} \tag{15}$$

The difference between Eqs. (15) and (13) is that the hurdle that must be met for $\phi + e$ in order to avoid default is higher without IMF intervention. Without the IMF, the debtor country must have $\phi + e$ be at least as large as λ. In contrast, with IMF intervention, the hurdle is lower. The debtor country need only have $\phi + e$ be at least as large as 0.

What does this imply for moral hazard? The value of e that maximizes (15) is given by

$$\hat{e}^*(\phi) = \begin{cases} \lambda - \phi & \text{if } -(1-\lambda) \leq \phi < \lambda \\ 0 & \text{otherwise} \end{cases} \tag{16}$$

Comparing (14) and (16) now allows us to compare the extent of adjustment effort with and without IMF intervention. We can see that adjustment effort cannot be ranked unambiguously across the two regimes. Adjustment effort depends on the strength of the underlying fundamentals ϕ. When ϕ is low, but not hopelessly so, adjustment effort is higher *with* the IMF, than without. In the interval where $-1 \leq \phi < -(1-\lambda)$, the debtor country puts in more adjustment effort when it anticipates IMF assistance, as compared to when there is no IMF assistance. The debtor country anticipates the additional assistance that the IMF will provide to push it over the threshold, and puts in adjustment effort that is just sufficient to stave off default. Without IMF intervention, the adjustment effort would be too onerous for the debtor country, and the country puts in no adjustment effort whatsoever, and defaults. Thus, in the interval where $-1 \leq \phi < -(1-\lambda)$, the anticipation of IMF assistance *increases* adjustment effort.

In contrast, the interval where $-(1-\lambda) \leq \phi < \lambda$ is the region where the standard argument on moral hazard of IMF bailouts takes hold. In this region, the anticipation of IMF assistance makes the debtor country less willing to incur costly adjustment effort. In this region, the debtor country is quite capable of avoiding default even without IMF assistance. But, knowing that the IMF will put in additional resources, the debtor country slacks off.

4.3. Successful catalytic finance

Our working definition of successful catalytic finance has been that it should induce both greater adjustment effort by the debtor *and* a greater incidence of roll-over by the creditors. The effect of IMF assistance on debtor moral hazard has been discussed above. The effect of IMF assistance on creditor roll-over decisions is much simpler, at least in the limiting case that we have focused on in this paper. The equilibrium in our model is characterized by switching strategies on the part of the creditors where they roll-over provided that the signal is higher than some threshold value. In the limit as private information becomes infinitely precise, the threshold value of the signal coincides with the threshold value of the fundamentals. Hence, the incidence of roll-over is fully determined by the threshold value θ^*. In the additional limiting case where $\alpha \to \infty$, the IMF has full information of the underlying fundamentals and is able to set assistance so that $\theta^* = 0$. There are no inefficient crises. In contrast, without IMF assistance, we have $\theta^* = \lambda > 0$. Thus, the effect of IMF assistance is to increase the incidence of roll-over decisions in those states where roll-over would be efficient.

Thus, taking both the debtor adjustment effort and creditor roll-over decisions together, we can conclude that catalytic financing succeeds precisely in those states where debtor effort is higher than in the case without IMF assistance. In our simplified model, successful catalytic financing coincides with reduction in debtor moral hazard.

5. Extensions and related literature

There is a basic trade-off at the heart of many policy discussions between the ex post incentive to inject liquidity to prevent a financial crisis (perhaps caused by coordination failure of creditors) and the ex ante moral hazard that the anticipation of such intervention might cause. This trade-off is central to discussions of both domestic banking regulation and the international

financial architecture. Eichengreen et al. (2003) is a recent, comprehensive review of the current debates. Our paper offers one stylized model that generates that trade-off and suggests a way to frame the debate about catalytic finance. These issues have been studied in many different models (e.g., Jeanne, 2004). Like our paper, Goldstein and Pauzner (2005), Rochet and Vives (2004) and recent work of Corsetti et al. (in press) use global games (coordination games with a small amount of uncertainty) as a way of pinning down the equilibrium amount of inefficient coordination failure and add on a prior effort decision by some actor. Of these, the paper by Corsetti et al. (in press) is closest in spirit and subject matter to our paper. The main difference between our paper and that of Corsetti et al. is that they adopt a global game in which all players move simultaneously, but where the IMF is a large player relative to the other creditors (extending Corsetti et al., 2004). The size and information precision of the IMF then determine the nature of the strategic interactions of the creditors. The switching point of the creditors' strategy then shifts, leading to similar effects to those examined here.

However, there are many different modelling choices to make. Here, we review some of these modelling choices and how each might affect the conclusions of our analysis. Our focus is on alternative assumptions on the payoffs of the three types of agents in our game, government, IMF and creditors. Then we discuss how our analysis would change as we vary the rules of the game. In doing so, we will see how other issues could be incorporated into our analysis and how our work relates to other approaches.

5.1. Changing payoffs

5.1.1. Changing the government objective

We assumed that the government cares only about the probability of a crisis and the cost of effort in preventing the crisis. But our qualitative conclusions rely only on the assumption that there is a discrete jump in government utility depending on whether a crisis can or cannot be averted. We can easily add in that the government obtains additional benefit from improving fundamentals through costly effort, independent of whether a payments crisis is prevented. For example, suppose that the government's utility were given by

$$v(\theta, m, l) + h(\theta) - c(e),$$

where the additional term $h(\cdot)$ is a concave function of θ. Now in our full information limit, there would be a background level of optimal effort,

$$\hat{e}(\phi) = \underset{e}{\text{argmax }} h(\phi + e) - c(e),$$

that the government would choose in absence of the incentive to prevent a payment crisis. In the full information limit (where $\beta \rightarrow \infty$ and $\alpha \rightarrow \infty$), the optimal policy in the absence of the IMF would be

$$\begin{cases} -\phi, & \text{if } -\phi > \hat{e}(\phi) \quad \text{and} \quad 1 + h(0) - c(-\phi) > h(\phi + \hat{e}(\phi)) - c(\hat{e}(\phi)) \\ \hat{e}(\phi), & \text{otherwise} \end{cases}.$$

With IMF assistance, the optimal policy would be

$$\begin{cases} \lambda - \phi, & \text{if } \lambda - \phi > \hat{e}(\phi) \quad \text{and} \quad 1 + h(\lambda) - c(\lambda - \phi) > h(\phi + \hat{e}(\phi)) - c(\hat{e}(\phi)) \\ \hat{e}(\phi), & \text{otherwise} \end{cases}.$$

As before, this would imply that anticipating IMF assistance would create moral hazard in some range of (relatively good) fundamentals and create a catalytic effect in some range of (relatively bad) fundamentals.

5.1.2. Changing the IMF objective

We assumed that the IMF only obtained utility from preventing a crisis if fundamentals were above 0. This was a reduced form way of capturing the idea that IMF only wants to help solvent but illiquid countries. Suppose instead we assumed that the IMF's objective was to maximize

$$v(\theta, m, l) - bm$$

but they face a constraint that the probability of being repaid in the long run must be greater than some threshold $\mu \in (0, 1)$; and suppose that they would get repaid in the long run only if θ were greater than 0. Then the IMF's objective would be to maximize

$$1 - \Phi\big(\sqrt{\alpha}(\lambda - m - y)\big) - bm$$

subject to the constraint if m is positive, we must have

$$1 - \Phi\big(\sqrt{\alpha}(-y)\big) \geq \mu.$$

As $\alpha \rightarrow \infty$, the IMF's optimal policy will again be to set

$$m^*(y) \simeq \begin{cases} 0 & \text{if} \quad y < 0 \\ \lambda - y & \text{if} \quad 0 \leq y < \lambda \,. \\ 0 & \text{if} \quad y \geq \lambda \end{cases} \tag{17}$$

5.1.3. Changing the creditors' objective

We assumed that creditors care about getting repaid and that getting repaid depends only on whether the number of creditors rolling over their debt exceeds a stochastic threshold; we also assumed the creditors who declined to roll-over were guaranteed a return λ independent of what others chose to do. Goldstein and Pauzner's (2005) analysis of bank runs contains a finer modelling of creditor repayment in the type of informational setting in this paper. The threshold nature of the unique equilibrium is robust to this detail.

5.2. Changing the game

Our assumptions about information and order of moves are also clearly somewhat arbitrary. Actions of government, IMF and creditors are interwoven. The IMF might be more informed than the creditors about fundamentals. We believe the basic conclusion of model will be robust to alternative specifications. The key driving force of our analysis was that the IMF wants to intervene at intermediate levels of fundamentals, not when fundamentals are very bad or very good. This non-monotonicity will imply an ambiguous relationship between bailouts and moral hazard in many models.

1. *Signalling*. We assumed that the IMF knows no more than the creditors do. If the IMF knows more about the economy than private creditors do, then clearly its funding decision has the potential to catalyze lending not merely by its direct effect on creditors' probability of getting repaid, but indirectly via the information that is revealed in equilibrium. This indirect

signalling channel is certainly alluded to in the policy debate, i.e., the idea that an IMF agreement plays a certification role independent of the size of loans that are provided. This channel was excluded from our analysis. This channel could be incorporated but it is important to note that under our (or any natural) assumptions on the IMF payoffs, their behavior would be a non-monotonic function of their information, since the IMF would like to intervene for intermediate levels of fundamentals and not for extreme levels.[3] Corsetti et al. (in press) allow the IMF to have independent information about fundamentals but remove the signalling role of IMF policy by having the IMF and creditors move simultaneously. Some empirical evidence is presented in Mody and Saravia (2003).

2. *Commitment*. We assumed that the IMF chooses a sequentially rational action, after observing the government's effort decision but before the creditors' action choices. In particular, this implies that funding cannot be made contingent on the effort decision and that IMF cannot optimally design its intervention to minimize moral hazard. The idea of having crisis funding conditional on earlier actions of the government occurs in both policy discussions and earlier models (see Jeanne, 2004). It would be a natural extension to incorporate these important effects into this model, although in this case, it would also be natural to have imperfect observation of government effort by the IMF.

3. *Endogenous financing*. We assumed that there was a fixed amount of outstanding debt, exogenously given. In the banking model of Rochet and Vives (2004), depositors choose whether to make long run or short run deposits. In the financial architecture model of Jeanne (2004), the government decides whether to issue short or long term debt. Clearly, the endogeneity of the debt overhang is potentially important, especially when short run debt is playing a role in disciplining behavior. Moreover, much of the concern in policy circles about IMF bailouts is about moral hazard for lenders rather that the government. The possibility of an ex post bailout may induce private lenders to lend to a country that otherwise would not be creditworthy. This alternative form of moral hazard could also be incorporated in the model.

We hope that the clean benchmark model of this paper highlights when we should expect the moral hazard implications of ex post bailouts to be ambiguous. The model focuses on one channel by which ex post bailouts generate ex ante moral hazard. However, it is easy to see how to build other mechanisms into this benchmark model and we expect the general conclusion that there is no simple relationship between bailouts and ex ante moral hazard to be robust (for example, the argument of Corsetti et al. (in press) works through different channels but comes to a similarly ambiguous conclusion).

6. Concluding remarks

Catalytic finance can work in principle. However, the "window of effectiveness" may be quite narrow. For catalytic finance to work, it must succeed in spurring the debtor country not to slack off in its adjustment effort. Also, it must succeed in shifting the incentives of the private sector creditors to roll-over their claims. For catalytic finance to work, the IMF's decision must be

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[3] Two models look at signalling in closely related contexts. In the dynamic model of Corsetti et al. (2004), a large player moves first, and his action influences the actions of a continuum of small players both directly, via the strategic complementarities, and indirectly via signalling. In Angeletos et al. (2003), a government is setting an interest rate prior to the actions of the small traders. In the latter work, the non-monotonicity of the government's optimal action in the absence of signalling makes signalling very inefficient and sometime self-defeating in equilibrium.

strategic complements with the adjustment effort of the decision country and the roll-over decisions of the private sector creditors. Catalytic finance fails when the IMF's decision becomes a strategic substitute for either the debtor country's adjustment effort, or the private sector creditors' roll-over decisions.

Our model also suggests that the appropriate measure of the effect on creditor incentives is not the raw net capital flows as such, but rather the roll-over decisions of the short term creditors. As we have emphasized in the model, the active players that generate the greatest degree of spillover effects on other players are the short term creditors. It is they who determine the size of the funding gap most directly through their roll-over decisions. The long-term creditors are essentially passive players who are brought into action only when default happens and cross-default clauses are triggered. More empirical work is called for in examining the behavior of short term claim holders and how this roll-over decision is affected by IMF intervention. Marchesi (2003), in one of the few studies on this issue, finds evidence that IMF intervention does, indeed, induce short term creditors to roll-over.

By means of a simple limiting case of a creditor roll-over game using the techniques of global games, we have seen that catalytic finance can work. It is most likely to succeed when the fundamentals are quite poor, but not hopelessly so. In such a situation, the existence of IMF assistance provides just enough of a lifeline for the debtor country to make the necessary adjustment effort. This, in turn, alters the incentives in the game among private sector creditors enough to make them roll-over. Much still remains to be done. The results reported in our paper have been for a limiting case chosen for analytical tractability. The general solution away from the limit may display richer behaviour that has not been captured here.

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