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IMF's Assistance: Devil's Kiss or Guardian Angel?

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Abstract

This paper contributes to the debate on the efficacy of IMF's catalytic finance in preventing financial crises. Extending Morris and Shin (2006), we consider that the IMF's intervention policy usually exerts a signaling effect on private creditors and that several interventions in sequence may be necessary to avert an impending crisis. Absent of the IMF's signaling ability, our results state that repeated intervention is required to bail out a country, whereby additional assistance may induce moral hazard on the debtor side. Contrarily, if the IMF exerts a strong signaling effect, one single intervention suffices to avoid liquidity crises.

Keywords: Catalytic Finance; Debtor Moral Hazard; Global Games

JEL Classification: C72, D82, F33

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1 Introduction

Since the increasing number of financial crises in the last decades, the master solution of the International Monetary Fund (IMF) to save emerging countries in need, referred to as *Catalytic Finance*, has come under harsh critics. Intrinsically, monetary assistance in terms of catalytic finance is only granted under requirements regarding the social, political or economic deficiencies of a country. The beneficiary has to agree to implement certain adjustment reforms according to instructions given by the IMF which are supposed to help the country in the long run. If the debtor country actually does implement these reforms, the changes should also inspire private sector creditors with trust and incite them to roll over their short-term loans so that a funding crisis eventually can be fought off. However, as many financial crises have shown in the past, the concept of catalytic finance has not always been successful.[1]

Being accused of boosting countries' defaults rather than preventing them, the IMF has lost its idolatrized role for emerging market countries at the latest by its failure during the Asian Crisis. One of the major accusations has been the generation of moral hazard distortions under the rule of catalytic finance, arising from the prospect of having external financial institutions to bail out a country (see e.g. Bird, 1999, Haldane and Taylor, 2003). The IMF's potential support is said to diminish a debtor government's incentive to adopt prudent policies ex ante, so that eventually economic and financial problems may be the outcome. Clearly, this *debtor moral hazard* argumentation is often regarded as a simplistic view on the actual issues. As Roubini (2000) points out, a sovereign government would not put its country's future at stake by pursuing destructive policies just in order to get conditioned assistance by the IMF. Nevertheless, although the intentional neglect of sound policy reforms cannot be imputed, a country having the prospect of external financial help might be tempted to disregard reasonable consequences drawn from its actual situation and rely on the IMF's assistance instead. In this respect, the analysis of such debtor moral hazard argumentations will be at the core of this paper.

Recently, a lot of theoretical work has been done to assess the impact of catalytic finance on a country's incentive to implement necessary policy reforms. Penalver (2002), Cordella and Levy-Yeyati (2004), and Jeanne and Zettelmeyer (2004), for instance, have derived ambiguous effects of IMF interventions on the occurrence of debtor moral hazard. A rather different approach within this strand of literature has been introduced by Morris and Shin (2006), who endogenously determine the

[1] See Hovaguimian (2003) for a survey of empirical evidence on the shortcomings of catalytic finance.

optimal behavior of the IMF, a continuum of private sector creditors, and a debtor country to analyze moral hazard distortions. They argue that catalytic finance will only be effective if the actions taken by the different parties are strategic complements. The IMF's assistance has to induce greater adjustment effort on the debtor side and should encourage the private sector creditors to decide in favor of rolling over their short-term loans. However, a more pessimistic scenario can arise when the IMF's inability to commit credibly not to intervene generates moral hazard on the part of the debtor country, which may fail to accomplish the reforms necessary to prevent a crisis in the long run. This in turn might prompt the private sector creditors to withdraw their short-term credits, therewith evoking a liquidity crisis of an intrinsically solvent country. In order to solve the coordination problem among the private lenders considering to foreclose or to roll over their credits, Morris and Shin (2006) build on the *Theory of Global Games* as introduced by Carlsson and van Damme (1993) and generalized by Frankel et al. (2003) and Morris and Shin (2003). Presuming incomplete public and private information regarding the debtor country's fundamental state, this game theoretic concept enables the conduction of a unique equilibrium which delivers clear-cut results on possible moral hazard distortions. It then solely depends on the debtor's economic fundamentals whether catalytic finance works or if it is more like the "devil's kiss", as provocatively claimed by Fidel Castro (2000).

Although Morris and Shin (2006) are able to delineate the basic conditions and causes for debtor moral hazard under official liquidity provision by the IMF, their approach represents a rather simplified notion of the actual issues. Accordingly, we augment their work on several counts, modeling the IMF as a large strategic player. Instead of adhering to the static Morris/Shin-scenario, assuming that one single IMF intervention suffices to impede a financial crisis, our paper captures the fact that crises slowly initiate over time and several interventions may be necessary to finally prevent default. In particular, we regard two of the various lending programs employed by the IMF during the Asian Crisis in sequence: Extended Fund Facilities (to solve long-term balance problems) and Supplemental Reserve Facilities (to meet very short-term financing needs).[2] This sequencing of interventions enables us to examine how the IMF's decision to support a country in need as well as possible moral hazard distortions are influenced by its past assistance policy. Additionally, our paper ascribes a more active and realistic role to the IMF by allowing for the possibility that it receives an informative private signal on the debtor country's

[2]Against the background of the IMF's various bail-out strategies in conjunction with the Asian Crisis, this differentiated approach to catalytic finance seems to be of prominent importance. While the Supplemental Reserve Facilities have been introduced in the context of the Asian Crisis to provide immediate short-term assistance, the Extended Fund Facilities already have been frequently used since 1974.

fundamental condition and hence disposes of valuable information to signal. The private sector creditors are thus able to update their beliefs regarding the country's economic situation when observing the IMF's intervention strategy. Consequently, our model implies that the IMF can patronize the fate of a debtor country not only by providing monetary assistance, but also by signaling this decision to the private lenders who in turn may feel encouraged to roll over their short-term loans.

Closely related to our work, also treating the IMF as a large strategic player in the coordination game among private sector creditors, is the global games model by Corsetti et al. (2006). Similar to Morris and Shin (2006), however, they merely confine their attention to the case of one-time assistance and abstract from the IMF's signaling ability by considering a simultaneous move game.

In scrutinizing the IMF's signaling effect within our sequential move game, we build on a global games approach by Schüle and Stadler (2005), which allows for closed-form solutions in the limiting cases when the IMF is arbitrarily worse and better informed, respectively, than the private sector creditors. Our results state that the IMF's benefit of the first move loses its prominent importance whenever it is informationally disadvantaged and thus has no valuable information to signal, as also assumed by Morris and Shin (2006). In this case the IMF's initial intervention in terms of Extended Fund Facilities may not suffice to prevent a liquidity crisis so that additional short-term assistance in the form of Supplemental Reserve Facilities is needed. We analyze under which conditions this second intervention induces debtor moral hazard and in what circumstances it actually increases a debtor's incentive to implement necessary policy reforms. Notably, we find that intermediate amounts of the IMF's prior intervention maximize the probability that Supplemental Reserve Facilities exert a catalytic effect. Considering the opposite extreme case when the IMF's private signal is infinitely more precise than the private sector creditors' information, our model implies that simply rolling over the initially granted Extended Fund Facilities is sufficient to prevent a liquidity crisis, so that moral hazard distortions arising from a second intervention can be excluded. This result is due to the fact that the IMF's trust in the debtor country's potential to fight off an impending crisis exerts a signaling effect strong enough to induce pure herding behavior among the private lenders.

The remainder of this paper is organized as follows. Section 2 introduces the model and describes the sequence of moves in the game. In section 3 we solve the coordination game of the private sector creditors and analyze moral hazard distortions in the case when the IMF disposes of no informational signaling ability, as proposed by Morris and Shin (2006). Section 4 examines the effects of the IMF's signaling ability. Finally, Section 5 concludes.

2 The Model

The model considers a simple economy consisting of three types of risk neutral agents, namely a debtor country which is threatened by a financial crisis, a continuum of ex ante identical private sector creditors, and the IMF. We assume that the IMF initially provides long-term monetary assistance in the form of Extended Fund Facilities, amounting to a proportion $t \in (0,1)$ of the country's total debt. The remaining fraction $1-t$ is financed via short-term credits by the private sector creditors. In order to refund its debt and fight off a potential crisis, the debtor's government can rely on liquid resources of $\theta \equiv f + e$, where $f \in \mathbb{R}$ denotes the underlying fundamental state of the economy and $e \geq 0$ represents a costly adjustment effort undertaken by the country to enhance its liquidity.

At an interim stage, the private sector creditors have to decide whether or not to roll over their short-term credits. Rolling over yields a return of $R > 0$ per unit of capital invested whenever the debtor country can finally prevent default, but leads to a return of 0 if a crisis occurs. To avoid such credit losses, the private lenders may decide to withdraw their short-term loans instead and invest the credits in a safe foreign asset which yields a certain payoff of $L \in (0, R)$ per unit of capital invested.

Similarly, the IMF reviews its initial intervention at an interim stage of the game, verifying whether the debtor country has so far fulfilled its obligations and implemented the reforms necessary to prevent a potential crisis. Since the IMF disposes of limited funds it thereby has to carefully weigh its options. It cannot justify to carry on supporting the country when the ensuing bail-out expenditures become extremely high, as these funds are then not available for other countries in need. Consequently, the IMF would have to withdraw its initially granted Extended Fund Facilities in such a situation. If the IMF considers the country's liquid resources as sufficient to fight off a crisis at relatively low costs, however, it decides to extend the initial credit and even may provide additional immediate assistance $m \geq 0$ if necessary. We assume that this ad hoc support, which can be interpreted as the IMF's Supplemental Reserve Facilities, is associated with a cost $c(m)$ for the IMF. For reasons of simplicity and without further loss of generality, the other payoffs of the IMF are assumed to be similar to the payoffs of the private sector creditors. That is, the IMF's gross utility from rolling over the Extended Fund Facilities is given by $R > 0$ per unit of capital invested if the debtor country avoids default, and it amounts to 0 in the event of a crisis. Contrarily, withdrawing the initially granted loans and supporting other needy countries instead yields a certain gross benefit of $L \in (0, R)$ per unit of capital invested. In the following, we normalize the country's total debt $\sum R$ to 1, so that $\sum L \equiv \lambda \in (0,1)$.

Whether the debtor country is able to avert a crisis and credits can be repaid eventually, decisively depends on the proportion of loans $\ell \in [0,1]$ foreclosed at the interim stage and on the amount of Supplemental Reserve Facilities m potentially granted by the IMF. More precisely, the country is supposed to fail whenever the disruption caused by withdrawn credits becomes sufficiently severe, $\ell > \theta + m$. The occurrence of a crisis can thus be excluded in case of high liquidity $\theta \geq 1$, independent of the IMF's intervention strategy and the credit decisions of the private lenders. In contrast, the country is doomed to failure without additional immediate assistance m if it is insolvent, $\theta < 0$. In the intermediate range $0 \leq \theta < 1$, it would be in the collective interest of all private sector creditors and the IMF to extend their initial loans, but uncoordinated credit withdrawals by the private lenders may evoke a liquidity crisis of an intrinsically solvent country.

We are now in a position to describe our setup more formally by delineating the sequence of moves in the game, the information available at all stages, and the accurate payoffs.

Period 0:

- The country raises funds from the private sector creditors and obtains assistance in terms of Extended Fund Facilities from the IMF.
- Nature draws the fundamental state f of the debtor country. Afterwards, f becomes the country's private information.
- The country chooses an adjustment effort e, considering the value of f and the costs $k(e)$ associated with restructuring. Let $k(e)$ be any strictly increasing function with $k(0) = 0$.
- The IMF and the private lenders do not obtain any public information on the debtor's liquidity and thus on its ability to prevent a crisis, i.e. $\theta = f + e$ is a random variable with an improper uniform prior over the real line from their perspective.[3]

Period 1:

- The IMF as well as the private sector creditors receive private signals regarding the debtor country's liquid resources. The IMF observes the realization of the noisy signal

$$y = \theta + \tau\eta \,, \tag{1}$$

[3]As Morris and Shin (2003) point out, improper uniform priors are well behaved, as far as we are concerned only with conditional beliefs, and can be interpreted as the limiting case where the information in the prior density becomes diffuse.

where $\tau > 0$ is a scale factor indicating the amount of noise and η is a random variable drawn from the standard normal distribution. Likewise, a private sector creditor i obtains the private signal

$$x_i = \theta + \sigma\varepsilon_i \tag{2}$$

with the scale factor $\sigma > 0$ and $\varepsilon_i \sim$ i.i.d. $N(0,1)$.

- Based on its private signal y, the IMF reviews its initial intervention. Following Morris and Shin (2006), we define the IMF's objective function such that it benefits from preventing a liquidity crisis ($\theta \geq 0$) if the associated opportunity costs are sufficiently low, but not from fighting off a solvency crisis ($\theta < 0$). Given our normalization of the country's total debt, the IMF's payoff from rolling over the Extended Fund Facilities and granting additional short-term assistance can then be expressed as

$$u(\theta, m, \ell, t) = \begin{cases} t - c(m) & \text{if } \theta + m \geq \ell \text{ and } \theta \geq 0 \\ -c(m) & \text{otherwise}\,. \end{cases}$$

  Provided that the IMF rolls over the initial loans, it chooses an amount of Supplemental Reserve Facilities $m \geq 0$ so as to maximize this payoff. Afterwards, m is announced publicly and hence becomes common knowledge among all.

- The private sector creditors are able to observe the IMF's intervention strategy and make their own credit decisions based on this observation and on their private signals x_i. The normalized payoff from having all private lenders rolling over their credits is is given by

$$v(\theta, m, \ell, t) = \begin{cases} 1 - t & \text{if } \theta + m \geq \ell \\ 0 & \text{otherwise}\,. \end{cases}$$

Period 2:

- The country either defaults or can prevent a liquidity crisis, depending on the actions taken before by all parties.

- The respective payoffs are realized. For simplicity we assume that the country's payoff net of the other players' claims amounts to 1 and 0, respectively, contingent on the occurrence of a crisis. Taking additionally into account the adjustment costs $c(e)$, the debtor country has to choose an adjustment effort e in Period 0 so as to maximize

$$w(\theta, m, \ell, e) = \begin{cases} 1 - k(e) & \text{if } \theta + m \geq \ell \\ -k(e) & \text{otherwise}\,. \end{cases}$$

3 The Equilibrium

Our model can be solved by backwards induction, analyzing successively the private lenders' credit decisions, the intervention strategy adopted by the IMF, and the adjustment effort incurred by the debtor country in order to fight off an impending liquidity crisis.

3.1 Credit Decisions of Private Sector Creditors

In solving the subgame in which the private sector creditors make their roll over or foreclosure decisions contingent on their expectations of the debtor country's liquid resources and the IMF's intervention policy, we build on a global game as analyzed by Schüle and Stadler (2005). Within the class of switching-strategies, this sequential move game has a unique equilibrium characterized by the 5-tuple of thresholds $\hat{y}$, $\underline{x}$, $\overline{x}$, $\underline{\theta}$, $\overline{\theta}$. The IMF's threshold signal is given by $\hat{y}$, implying that it rolls over its proportion t of the country's total debt and provides additional immediate assistance $m \geq 0$ only when observing a private signal y higher than $\hat{y}$. For signals lower than this threshold, the IMF either considers the debtor country as insolvent ($\theta < 0$), or it expects the opportunity costs associated with further effective assistance to be prohibitive and thus rather decides to foreclose the initially granted Extend Fund Facilities. The private sector creditors observe the IMF's behavior, availing this additional information to update their prior beliefs regarding the country's liquidity θ. Consequently, if the IMF opts for further assistance, the private lenders only feel incited to foreclose their short-term loans for sufficiently low private signals $x_i < \underline{x}$. Whenever the IMF believes the country to be too weak to fight off a potential liquidity crisis and therefore withdraws its initial credit, however, the private sector creditors follow the IMF's mistrust even in case of less pessimistic prior expectations, foreclosing their short-term loans for signals below the upper threshold $\overline{x}$. Finally, as the lenders' private information is correlated with θ, there have to exist liquidity thresholds $\underline{\theta}$ and $\overline{\theta}$ corresponding to $\underline{x}$ and $\overline{x}$, such that the IMF's behavior exerts decisive influence on the fate of the debtor country if $\underline{\theta} \leq \theta < \overline{\theta}$.

Given these thresholds, a crisis can be prevented for states $\theta \geq \underline{\theta}$ whenever the IMF continues to assist the threatened country and employs additional immediate support m as appropriate. Bearing in mind that by assumption the IMF benefits from further interventions if and only if the debtor country's economy is fundamentally sound ($\underline{\theta} \geq 0$), the respective payoff is given by

$$tPr(\theta \geq \max\{\underline{\theta}, 0\}|y) - c(m) = t\Phi\left(\frac{y - \max\{\underline{\theta}, 0\}}{\tau}\right) - c(m)\,,$$

where $\Phi(\cdot)$ denotes the cumulative standard normal PDF. Contrarily, the IMF gains $t\lambda$ from withdrawing the initial credit and investing the amount of t to bail out other countries in need. The threshold signal $\hat{y}$ is thus implicitly defined by the *cutoff condition*

$$t\Phi\left(\frac{\hat{y}-\max\{\underline{\theta},0\}}{\tau}\right)-c(m)=t\lambda\,,$$

which can be rewritten as

$$\hat{y}=\max\{\underline{\theta},0\}+\tau\Phi^{-1}\left(\lambda+\frac{c(m)}{t}\right). \tag{3}$$

If the IMF decides to further assist the debtor country because of a private signal $y \geq \hat{y}$, the marginal private sector creditor who receives the critical signal $\underline{x}$ is indifferent between rolling over its short-term credit and foreclosing if

$$Pr(\theta \geq \underline{\theta} | y \geq \hat{y}, x_i = \underline{x}) = \lambda\,. \tag{4}$$

In this case, due to the assumed independence of private signals and the continuum of private lenders, the mass of loans foreclosed at any θ can be expressed as $\ell = (1-t)Pr(x_i < \underline{x}|\theta)$. Since the debtor country is on the margin of a crisis at the liquidity state θ for which $\theta + m = \ell$, the associated *critical mass condition* is given by

$$\underline{\theta}+m=(1-t)Pr(x_i<\underline{x}|\theta=\underline{\theta})\,. \tag{5}$$

Provided that the IMF withdraws its initially granted credit, supporting other needy countries instead, a liquidity crisis can only be fought off if $\theta \geq \overline{\theta}$. Then, the private creditors' relevant threshold signal $\overline{x}$ is implicitly defined by their cutoff condition

$$Pr(\theta \geq \overline{\theta} | y < \hat{y}, x_i = \overline{x}) = \lambda \tag{6}$$

and the corresponding critical mass condition without further interventions by the IMF is

$$\overline{\theta}=t+(1-t)Pr(x_i<\overline{x}|\theta=\overline{\theta}). \tag{7}$$

To conduct the threshold values characterizing the equilibrium of this subgame, the equations (3) to (7) have to be solved simultaneously. While closed-form solutions are not procurable for general parameter values, however, we are able to derive the equilibrium thresholds in the two limiting cases when the IMF is arbitrarily better and worse informed, respectively, than the private sector creditors. Confining to these limits, Proposition 1 clearly indicates that the IMF's informational (dis-)advantage σ/τ exerts considerable influence on its ability to coordinate the credit decisions of the private lenders.

Proposition 1 *The debtor country's liquidity thresholds contingent on the IMF's intervention policy converge to*

$$\underline{\theta} = \lambda(1-t) - m \tag{8}$$

$$\overline{\theta} = \lambda(1-t) + t \tag{9}$$

whenever the IMF disposes of arbitrarily less precise private information than the private sector creditors ($\sigma/\tau \to 0$)*, and they tend to*

$$\underline{\theta} = -m \tag{10}$$

$$\overline{\theta} = 1 \tag{11}$$

if the IMF is arbitrarily better informed ($\sigma/\tau \to \infty$).

Proof. *See the Appendix.*

In the limit as $\sigma/\tau \to 0$, the IMF's influence on the event of a crisis, measured by $\overline{\theta} - \underline{\theta}$, is obviously just equal to its potential amount of monetary assistance $t + m$. As a consequence, the mass of private lenders who withdraw their credits has to be independent of the IMF's prior intervention strategy. This implies that the private sector creditors make their decisions whether or not to foreclose the short-term loans entirely based on their private signals x_i, without updating these prior expectations regarding the debtor country's liquid resources. In this respect, the limiting case of our model in which the IMF does not dispose of any valuable information to signal ($\sigma/\tau \to 0$) is akin to the static approach by Morris and Shin (2006) who abstract from a signaling effect.

However, in the opposite extreme case when $\sigma/\tau \to \infty$ our setting induces a vigorous signaling effect of the IMF, as indicated by the equations (10) and (11). The debtor country's liquidity thresholds $\underline{\theta}$ and $\overline{\theta}$ converge to their lower and upper bounds, respectively, implying that the IMF exerts maximum influence on the roll over and foreclosure decisions of the private sector creditors if it disposes of arbitrarily more precise information. The private lenders follow the IMF's intervention policy blindly, irrespective of their own private signals x_i and the amount of monetary assistance t initially granted by the IMF. Clearly, the better informed IMF takes this pure herding behavior among the private sector creditors into account when estimating the country's prospect to avoid an impending liquidity crisis with the aid of further assistance.

When solving for the equilibrium below, we firstly concentrate on the case in which the IMF has no valuable information to signal, as also proposed by Morris and Shin (2006). To analyze the impact of the IMF's signaling ability on its intervention policy and on the incidence of debtor moral hazard distortions arising

from additional immediate assistance in terms of Supplemental Reserve Facilities, the opposite extreme case when $\sigma/\tau \to \infty$ will then be addressed in Section 4.

3.2 The IMF's Decision: Lending or Leaving?

For the time being, we abstract from a signaling effect when analyzing the IMF's intervention policy contingent on the state θ of the debtor country's liquid resources, as is also assumed by Morris and Shin (2006). Within our dynamic setting, embedding the possibility of several interventions, this enables us to examine the impact of a prior subvention on the IMF's willingness to engage in further assistance.

Remember that the IMF rolls over its initial credit and opts for providing Supplemental Reserve Facilities so as to maximize the expected payoff

$$\begin{aligned} u(m) &= tPr(\theta \geq \underline{\theta}(m)|y) - c(m) \\ &= t\Phi\left(\frac{y - \underline{\theta}(m)}{\tau}\right) - c(m) \end{aligned} \tag{12}$$

whenever it considers the debtor country not to be insolvent ($\underline{\theta} \geq 0$) and if the benefits from additional short-term assistance exceed the payoff from bailing out other threatened countries instead ($u(m) \geq t\lambda$).

To preserve tractability of the model, we consider without any loss of generality the linear cost function $c(m) = m$ and, to obtain more clear-cut results regarding the IMF's intervention policy, we confine our attention to the limiting case in which its private information becomes arbitrarily precise ($\tau \to 0$). In the limit when the IMF does not dispose of any valuable information to signal ($\sigma/\tau \to 0$), the solution to the above optimization problem is then summarized by the following proposition.[4]

Proposition 2 *As $\tau \to 0$ and $\sigma/\tau \to 0$, the IMF's optimal amount of additional immediate assistance m as a function of the country's liquidity θ is given by*

$$m^*(\theta) = \begin{cases} \lambda(1-t) - \theta & \text{if } \max\{\lambda - t, 0\} \leq \theta < \lambda(1-t) \\ 0 & \text{otherwise}\,. \end{cases} \tag{13}$$

Proof. *See the Appendix.*

In the absence of a signaling effect, the IMF obviously has to resort to Supplemental Reserve Facilities m for a considerable range of liquid resources in order to bail out the indebted country. Only if the country's liquidity is effectually high

[4]The interpretation of the ordered limit in which $\sigma/\tau \to 0$ and $\tau \to 0$ is that we are letting σ approach 0 with an infinitely faster rate than τ.

$(\theta \geq \lambda(1-t))$, rolling over the initially granted Extended Fund Facilities without engaging in additional immediate assistance suffices to fight off a crisis. For low states $\theta < \max\{\lambda - t, 0\}$, however, the IMF even forecloses its initial credit and chooses to support other economies rather than carrying on to assist the endangered country. Clearly, the IMF has to pursue such an intervention policy whenever a country is fundamentally insolvent $(\theta < 0)$, as in this case there is no prospect to prevent a debt crisis in the long run. But if the IMF disposes of no informational signaling ability to coordinate the credit decisions of private lenders, even solvent countries cannot necessarily rely on the IMF's standby. Since the IMF cannot justify to roll over its initial loan and to provide Supplemental Reserve Facilities if it is more beneficial to invest the scarce resources in the support of other countries $(\lambda > t)$, coordination failures by the private sector creditors lead to a liquidity crisis whenever $0 \leq \theta < \lambda - t$.

To analyze how the IMF's initial intervention affects the provision of additional short-term assistance, define $I \equiv \lambda(1-t) - \max\{\lambda - t, 0\}$ as the IMF's willingness to employ Supplemental Reserve Facilities. It is then easy to see that the incentive of the IMF to grant further immediate support is a non-monotonic function of the size t of its prior intervention:

$$I(t) = \begin{cases} t(1-\lambda) & \text{if } t < \lambda \\ \lambda(1-t) & \text{if } t \geq \lambda\,. \end{cases}$$

Thus, we can state:

Corollary 1 *The IMF's willingness to provide short-term support in terms of Supplemental Reserve Facilities is maximized for an intermediate amount of the prior intervention.*

This result makes intuitively sense when considering the following trade-off of the IMF. On the one hand, higher amounts t of the prior intervention imply that the disruption caused to a country by uncoordinated credit withdrawals of private lenders becomes less severe, so that further assistance may not be necessary. On the other hand, the IMF's provision of Extended Fund Facilities is associated with "sunk costs" if a crisis cannot be averted, implying that higher amounts of t increase the IMF's commitment to provide additional assistance in the future. Obviously, this second effect overbalances the first effect in case of sufficiently low amounts of initial monetary assistance, whereas the opposite holds for effectually strong prior interventions.

3.3 Moral Hazard Implications of IMF's Assistance

Having derived the IMF's optimal intervention strategy, we are now able to examine how the provision of Supplemental Reserve Facilities affects the debtor country's incentive to implement required policy reforms. In doing so, we still concentrate on the limiting case where the IMF obtains arbitrarily precise information regarding the country's liquid resources. Referring to this limit as $\tau \to 0$ facilitates our analysis to the effect that an impending liquidity crisis can be averted if and only if the IMF rolls over its initial credit and engages in additional short-term assistance as appropriate ($y \geq \hat{y}$).[5] Hence, anticipating the subsequent intervention policy of the IMF and the private sector creditors' actions, the debtor country chooses its adjustment effort e so as to solve

$$\max_{e \geq 0} \quad w(e) = \begin{cases} 1 - k(e) & \text{if } y \geq \hat{y} \\ -k(e) & \text{otherwise}\,. \end{cases}$$

Note that in the limit as $\tau \to 0$ we obtain $y \to \theta = f + e$ and from (13), confining again to the case in which the IMF has no valuable information to signal, $\hat{y} \to \underline{\theta} = \max\{\lambda - t, 0\}$. Following Morris and Shin (2006) by considering exemplarily the convex cost function $k(e) = e^2$, the above optimization problem can thus be rewritten as

$$\max_{e \geq 0} \quad w(e) = \begin{cases} 1 - e^2 & \text{if } f + e \geq \max\{\lambda - t, 0\} \\ -e^2 & \text{otherwise}\,. \end{cases} \tag{14}$$

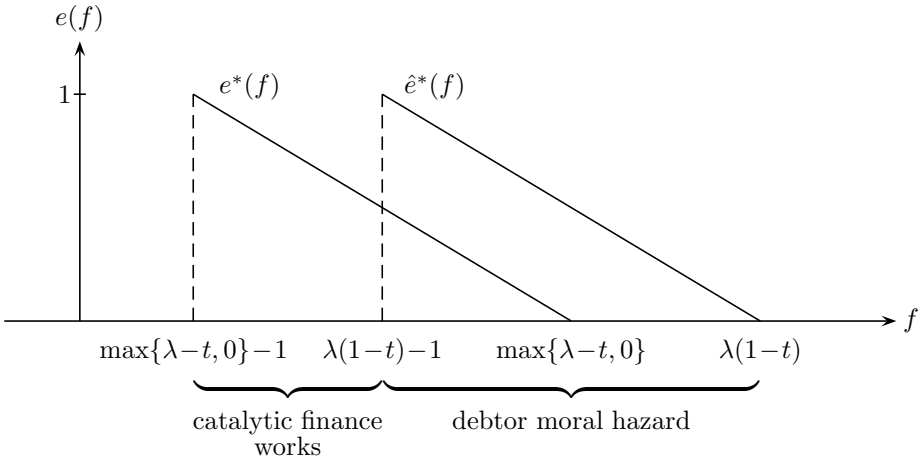
The country's optimal level of adjustment effort as a function of the economy's fundamental state f then amounts to

$$e^*(f) = \begin{cases} \max\{\lambda - t, 0\} - f & \text{if } \max\{\lambda - t, 0\} - 1 \leq f < \max\{\lambda - t, 0\} \\ 0 & \text{otherwise}\,. \end{cases} \tag{15}$$

Obviously, the debtor country embarks on a costly adjustment effort only for intermediate values of economic fundamentals and the effort level diminishes linearly in f. Whenever the underlying fundamental state of the economy is effectually strong, $f \geq \max\{\lambda - t, 0\}$, the country anticipates that continued lending by the private sector creditors and the IMF's decision to provide further assistance are sufficient to fight off a crisis without any adjustment effort. In contrast, if $f < \max\{\lambda - t, 0\} - 1$,

[5] Deviating from the limit as $\tau \to 0$ would considerably complicate our analysis without changing the results qualitatively, since we additionally would have to consider the cases where (i) the IMF continues to assist but the country defaults, (ii) the IMF stops lending but a crisis can still be prevented.

Figure 1:
Effects of additional IMF assistance on the country's effort level



a financial crisis cannot be prevented even with the maximum affordable adjustment effort, so that it is a dominant strategy for the debtor country to abstain from any policy reforms.

In order to analyze to what extent the country's anticipation of being supported by the IMF exerts influence on its incentive to incur adjustment efforts, equation (15) has to be compared to a world in which the IMF can credibly commit not to grant additional immediate assistance m. In the absence of Supplemental Reserve Facilities, equation (8) reduces to $\underline{\theta}(m=0) = \lambda(1-t)$, so that (14) transforms to

$$\max_{e \geq 0} \quad w(e) = \begin{cases} 1 - e^2 & \text{if } f + e \geq \lambda(1-t) \\ -e^2 & \text{otherwise}\,. \end{cases} \tag{16}$$

The difference between (14) and (16) is that the minimum level of liquid resources $f + e$ necessary to fight off a financial crisis has to be larger without anticipated supplementary assistance by the IMF. Solving the debtor country's optimization problem (16),

$$\hat{e}^*(f) = \begin{cases} \lambda(1-t) - f & \text{if } \lambda(1-t) - 1 \leq f < \lambda(1-t) \\ 0 & \text{otherwise}\,, \end{cases} \tag{17}$$

and comparing (17) to the level of adjustment effort (15) of a country anticipating the IMF's forbearing intervention policy, we can state:

Proposition 3 *As $\tau \to 0$ and $\sigma/\tau \to 0$, the IMF's catalytic finance works if $\max\{\lambda - t, 0\} - 1 \leq f < \lambda(1-t) - 1$, whereas it induces moral hazard on the debtor side whenever $\lambda(1-t) - 1 \leq f < \lambda(1-t)$.*

Thus, in conformity with the results derived by Morris and Shin (2006), our model implies that additional short-term assistance of an IMF which has no valu-

able information to signal to the private sector creditors exerts ambiguous influence on the debtor's willingness to conduct required adjustment reforms. The effects are also depicted in Figure 1. Whenever $\lambda(1-t)-1 \leq f < \lambda(1-t)$, the economic fundamentals lie in a region where the indebted country would incur enough adjustment effort to prevent a crisis without the aid of Supplemental Reserve Facilities, but where the prospect of being supported by the IMF is detrimental for its effort level. Consequently, in such a situation the frequently addressed debtor moral hazard argumentation applies. Conversely, anticipating the IMF's intervention strategy to provide further assistance, the debtor country feels incited to implement necessary policy reforms to fight off a crisis if $\max\{\lambda - t, 0\} - 1 \leq f < \lambda(1-t) - 1$. In this range of fundamentals, however, the costs of preventing a liquidity crisis would be prohibitive without the IMF's support, implying that the country would rather abstain from adjustment efforts and default. Hence, catalytic finance can work, although the "window of effectiveness" may be quite narrow.

To determine how this window is affected by the IMF's initial intervention, characterize $J \equiv \lambda(1-t) - 1 - [\max\{\lambda - t, 0\} - 1]$ as the probability of successful catalytic finance *ex ante*, before nature chooses the fundamental state f. Then, rewriting this probability as

$$J(t) = \begin{cases} t(1-\lambda) & \text{if } t < \lambda \\ \lambda(1-t) & \text{if } t \geq \lambda\,, \end{cases}$$

the effects of additional IMF assistance can easily be derived:

Corollary 2 *The provision of Supplemental Reserve Facilities is most likely to exert a catalytic effect for an intermediate amount of the prior intervention.*

Thus, our consideration of various sequential interventions within the basic Morris/Shin-scenario in which the IMF has no valuable information to signal allows for the following conclusion. An intermediate amount of the initial intervention ($t = \lambda$) does not only maximize the IMF's willingness to provide further monetary assistance, but it also maximizes the probability of effective catalytic finance.

4 The IMF's Signaling Effect: Does it Reduce Moral Hazard Distortions?

Similar to the approach by Morris and Shin (2006), the previous analysis has been confined to the assumption that the IMF disposes of no more information than the private sector creditors. This implied that the private lenders are able observe the IMF's intervention policy, but they cannot use this observation to update their

beliefs regarding the debtor country's financial condition. As a consequence, our results have mainly approved the critics on catalytic finance, insofar as one single intervention never suffices to fight off an impending liquidity crisis and as additional assistance by the IMF may induce moral hazard on the debtor side. Referring to the limiting case in which the IMF is arbitrarily better informed than the private sector creditors ($\sigma/\tau \to \infty$), we now examine to what extent the efficacy of catalytic finance is enhanced when incorporating the IMF's signaling ability.

Bearing in mind the presumed objective function of the IMF, we know that it never benefits from carrying on to support a fundamentally insolvent debtor country. That is, the IMF forecloses its initial credit and invests the withdrawn capital to help other economies in need whenever $\underline{\theta} < 0$, rather than trying to bail out the insolvent country with the aid of additional short-term assistance m. In the limit as $\sigma/\tau \to \infty$, however, equation (10) implies that $\underline{\theta}$ is negative for any $m > 0$. Thus, if the IMF disposes of arbitrarily more precise information than the private sector creditors, it never has to resort to immediate support in the form of Supplemental Reserve Facilities in order to prevent a threatening liquidity crisis ($m^* = 0$). Rather, it can always avoid such a crisis merely by continuing to employ the initially granted Extended Fund Facilities. Due to its strong signaling effect, the IMF's faith in the debtor country's potential to fight off an impending liquidity crisis incites all private lenders to roll over their short-term loans. Thereby, the failure of an intrinsically solvent country, evoked by uncoordinated credit withdrawals of the private lenders, can always be prevented without the need of supplementary IMF interventions.

As a consequence of this intervention policy, debtor moral hazard distortions arising from the country's prospect to receive additional immediate help if necessary can be excluded when the IMF exerts a strong signaling effect. Anticipating the IMF's intervention strategy and the ensuing herding behavior among private sector creditors, the debtor country always incurs the maximum affordable adjustment effort to avert a solvency crisis, but it never has to worry about the occurrence of a liquidity crisis, as follows from (16) in the limit when $\tau \to 0$ and $\sigma/\tau \to \infty$:

$$e^*(f) = \begin{cases} -f & \text{if } -1 \leq f < 0 \\ 0 & \text{otherwise .} \end{cases}$$

The following proposition summarizes our results on the efficacy of catalytic finance when the IMF exerts a strong informational signaling effect.

Proposition 4 *As $\tau \to 0$ and $\sigma/\tau \to \infty$, the IMF can always prevent a liquidity crisis without resorting to Supplemental Reserve Facilities, implying that debtor moral hazard distortions cannot occur.*

5 Concluding Remarks

This paper has contributed to the ongoing discussion regarding debtor moral hazard distortions evoked by the IMF's intervention policy in order to prevent financial crises. Specifically, by augmenting the seminal global games approach to catalytic finance by Morris and Shin (2006), we were able to complement the previous theoretical literature on two counts. Firstly, our model incorporates actual lending programmes employed by the IMF in the form of Extended Fund Facilities and Supplemental Reserve Facilities, taking into account that several interventions in sequence may be necessary to fight off an impending crisis. Secondly, it considers that the IMF might exert accessory influence on the fate of a threatened debtor country by signaling its intervention strategy to the private sector creditors.

When neglecting this signaling effect, as also proposed by Morris and Shin (2006) or Corsetti et al. (2006), our results mainly approve the critical view on the efficacy of IMF's catalytic finance. We found that the IMF's initial intervention never suffices to avert a liquidity crisis fostered by coordination failures among the private lenders and that a the occurrence of a crisis sometimes even cannot be avoided with the aid of additional short-term assistance. Moreover, this provision of Supplemental Reserve Facilities induces moral hazard on the debtor side for a considerable range of economic fundamentals, whereas the "window of effectiveness" in which the IMF's supplementary support actually increases a debtor country's effort to implement required policy reforms is quite narrow.

By incorporating the IMF's signaling ability, our model reveals a crucial determinant for these often discussed shortcomings of catalytic finance. In the limiting case of an arbitrarily strong signaling effect, our results state that the IMF's faith in a country's fundamental condition inspires all private sector creditors with trust and incites them to roll over their credits. Due to this pure herding behavior among the private lenders, the IMF can always prevent an impending liquidity crisis merely by continuing to employ its initially granted Extended Fund Facilities, so that debtor moral hazard distortions cannot arise either. Although these findings are contingent on the extreme case where the IMF is able to coordinate the behavior of private lenders perfectly, our elementary conclusions should equally apply in case of weaker signaling effects. Namely, the efficacy of IMF interventions crucially depends on its capability to influence the beliefs of private sector creditors, rather than on the actual amount of monetary assistance granted to bail out countries in need. In this respect, the IMF's primary objective should consist in obtaining the confidence of other involved market participants in order to make catalytic finance work.

Appendix

Proof of Proposition 1

Combining (1) and (2), we can rewrite the IMF's private signal as

$$y = x_i + \tau\eta - \sigma\varepsilon_i. \tag{A1}$$

Using the equations (3) and (A1), a private sector creditor's posterior probability assessment of the prevention of a crisis, contingent on x_i and observing the IMF continuing lending, can be expressed as

$$Pr(\theta \geq \underline{\theta} \,|\, y \geq \hat{y},\, x_i) = Pr\left(\varepsilon_i \leq \frac{x_i - \underline{\theta}}{\sigma} \,\middle|\, \tau\eta - \sigma\varepsilon_i \geq \max\{\underline{\theta}, 0\} - x_i + \tau\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right),$$

so that the cutoff condition (4) transforms to

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}-\underline{\theta}}{\sigma},\, \tau\eta - \sigma\varepsilon_i \geq \max\{\underline{\theta}, 0\} - \underline{x} + \tau\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)}{Pr\left(\tau\eta - \sigma\varepsilon_i \geq \max\{\underline{\theta}, 0\} - \underline{x} + \tau\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)} = \lambda\,. \tag{A2}$$

Equivalently, the indifference condition (6) can be converted to

$$\frac{Pr\left(\varepsilon_i \leq \frac{\overline{x}-\overline{\theta}}{\sigma},\, \tau\eta - \sigma\varepsilon_i < \max\{\underline{\theta}, 0\} - \overline{x} + \tau\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)}{Pr\left(\tau\eta - \sigma\varepsilon_i < \max\{\underline{\theta}, 0\} - \overline{x} + \tau\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)} = \lambda\,. \tag{A3}$$

To derive explicit solutions to the equations (A2) and (A3) in the limiting case when $\sigma/\tau \to 0$, we rewrite (A2) as

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}-\underline{\theta}}{\sigma},\, \eta - \frac{\sigma}{\tau}\varepsilon_i \geq \frac{\max\{\underline{\theta}, 0\} - \underline{x}}{\tau} + \Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)}{Pr\left(\eta - \frac{\sigma}{\tau}\varepsilon_i \geq \frac{\max\{\underline{\theta}, 0\} - \underline{x}}{\tau} + \Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)} = \lambda\,.$$

Taking the limit as $\sigma/\tau \to 0$ yields

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}-\underline{\theta}}{\sigma},\, \eta \geq \frac{\max\{\underline{\theta}, 0\} - \underline{x}}{\tau} + \Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)}{Pr\left(\eta \geq \frac{\max\{\underline{\theta}, 0\} - \underline{x}}{\tau} + \Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)} = \lambda\,,$$

which, given independence of the error terms ε_i and η, implies that

$$\underline{x} = \underline{\theta} + \sigma\Phi^{-1}(\lambda)\,. \tag{A4}$$

Inserting (A4) into (5) eventually delivers equation (8). Similarly, equation (A3) can be rewritten as

$$\frac{Pr\left(\varepsilon_i \leq \frac{\overline{x}-\overline{\theta}}{\sigma},\, \eta - \frac{\sigma}{\tau}\varepsilon_i < \frac{\max\{\underline{\theta}, 0\} - \overline{x}}{\tau} + \Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)}{Pr\left(\eta - \frac{\sigma}{\tau}\varepsilon_i < \frac{\max\{\underline{\theta}, 0\} - \overline{x}}{\tau} + \Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)} = \lambda\,,$$

reducing to

$$\overline{x} = \overline{\theta} + \sigma\Phi^{-1}(\lambda) \tag{A5}$$

in the limit as $\sigma/\tau \to 0$. Substituting (A5) into (7) then yields equation (9).

To derive explicit solutions to the equations (A2) and (A3) in the opposite extreme case when $\sigma/\tau \to \infty$, rewrite (A2) as

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}-\underline{\theta}}{\sigma},\, \frac{\tau}{\sigma}\eta - \varepsilon_i \geq \frac{\max\{\underline{\theta},0\}-\underline{x}}{\sigma} + \frac{\tau}{\sigma}\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)}{Pr\left(\frac{\tau}{\sigma}\eta - \varepsilon_i \geq \frac{\max\{\underline{\theta},0\}-\underline{x}}{\sigma} + \frac{\tau}{\sigma}\Phi^{-1}\left(\lambda + \frac{c(m)}{t}\right)\right)} = \lambda\,.$$

Taking the limit as $\sigma/\tau \to \infty$, the L.H.S. tends to

$$\frac{Pr\left(\varepsilon_i \leq \frac{\underline{x}-\underline{\theta}}{\sigma},\, \varepsilon_i \leq \frac{\underline{x}-\max\{\underline{\theta},0\}}{\sigma}\right)}{Pr\left(\varepsilon_i \leq \frac{\underline{x}-\max\{\underline{\theta},0\}}{\sigma}\right)}\,,$$

which is equal to 1. Since $\lambda < 1$, the private sector creditors' threshold signal converges to $\underline{x} \to -\infty$. Hence, substituting $\underline{x}$ into (5) implies that equation (10) must holds. Finally, symmetric arguments establish via (A3) that in the limiting case when $\sigma/\tau \to \infty$, $\overline{x} \to \infty$ and thus $\overline{\theta} = 1$ as stated in Proposition 1. ■

Proof of Proposition 2

Maximization of the IMF's unconstrained optimization problem (12) in case of the linear cost function $c(m) = m$ yields the first order condition

$$\frac{t}{\tau}\phi\left(\frac{y - \lambda(1-t) + m}{\tau}\right) - 1 \stackrel{!}{=} 0\,, \tag{A6}$$

with $\phi(\cdot)$ denoting the standard normal density function. According to the standard normal properties, a solution to (A6) exists if and only if $t \geq \tau\sqrt{2\pi}$. Taking this into account when solving the first order condition for m delivers

$$m(y) = \lambda(1-t) - y + Q\,, \tag{A7}$$

where $Q \equiv \tau\phi^{-1}\left(\frac{\tau}{t}\right) > 0$ must hold due to the second order condition. Note that in the limit as $\tau \to 0$, we get $y \to \theta$ and $Q \to 0$. The optimal intervention strategy as given in Proposition 2 then directly follows from equation (A7) and consideration of the IMF's lending constraints $m(y) > 0$, $\underline{\theta}(m(y)) \geq 0$ and $u(m(y)) \geq t\lambda$. ■

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