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Self-Fulfilling Credit Market Freezes✧

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This paper develops a model of a self-fulfilling credit market freeze and uses it to study alternative governmental responses to such a crisis. We study an economy in which operating (nonfinancial) firms are interdependent, with their success depending on the ability of other operating firms to obtain financing. In such an economy, we show, inefficient credit market freeze may arise in which banks abstain from lending to operating firms with good projects because (and only because) of their (self-fulfilling) expectations that other banks will not be lending. We show how inefficient credit freeze equilibria may result from the arrival of information about fundamentals or a negative shock to the banking system's capitalization. While such equilibria result from the arrival of information about fundamentals, they do represent a "coordination failure:" banks' separate and fully rational decisions produce an outcome that would have been avoided had they been able to choose a coordinated action.

Our model enables us to study the effectiveness of alternative measures for getting an economy out of an inefficient credit market freeze. In particular, we study the effectiveness of (1) interest rate cuts, (2) infusion of capital into financial firms, (3) infusion of capital under terms that commit financial firms receiving it to use it to extend loans, (4) direct lending to operating firms by the government, and (5) lending to operating firms by funds owned by the government and managed by private agents compensated with a share of the profits generated by the fund. Throughout, we discuss the implications of our analysis for understanding and responding to the credit crisis of 2008.

Key words: Credit freeze, credit crunch, credit thaw, self-fulfilling crisis, run on the economy, global game, coordination failure, bank capital, lending, strategic complementarities.
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1. Introduction

An important aspect of the economic crisis of 2008 has been the "freezing" of credit to nonfinancial firms.[1] During the fall of 2008, despite government efforts to provide substantial liquidity and additional capital to the financial sector, financial firms have displayed considerable reluctance to extend loans to nonfinancial firms (as well as households). Because governments have traditionally left to the financial sector the role of lending to nonfinancial firms, financial firms' reluctance to lend to nonfinancial firms, and their election to hoard their capital for the time being, can have severe consequences for the economy. Some observers have attributed the reluctance of financial firms to lend to irrational fear, while others have attributed it to a rational assessment of the fundamentals of the economy which can be expected to make it difficult for operating firms to repay extended loans.

This paper develops a model of how coordination failure among financial institutions, and self-fulfilling rational expectations, can lead to inefficient "credit markets freeze" equilibria. In such equilibria, financial institutions rationally avoid lending to nonfinancial firms (operating firms) that have projects that would be worthy if banks did not withdraw from the lending market en masse, doing so out of self-fulfilling fear, validated in equilibrium, that other financial institutions would withhold loans and that operating companies would not be able to succeed in an environment in which other operating firms fail to obtain financing.

The paper also analyzes which government policies can best get the economy out of an inefficient credit market freeze equilibrium. This analysis identifies the potential limitations of interest rate cuts and infusion of capital into the financial sector. It analyzes the extent to which outcomes can be improved by the government's asking financial firms to commit to extend loans as a condition for capital infusion. It further shows how direct forms of government intervention in lending to nonfinancial companies – by establishing funds capitalized by the government and managed by private money managers, or by the government's committing to bear the losses on portfolios of new loans

[1] For a description of the crisis and the events leading to it, see Brunnermeier (2008) and International Monetary Fund (2008).

extended by financial firms in return for a cut of the profits – can contribute to getting the economy out of an inefficient credit freeze equilibrium.

Our analysis is based on the premise that operating firms, or at least a significant fraction of such firms, are interdependent – that is, that the returns they will make on capital they borrow depend on whether other operating firms are able to obtain financing. The success of a given operating firm might depend on other firms' operations to the extent that the other firms provide necessary inputs or that the other firms, or those generating income from them, provide demand for the firm's output. This interdependence makes the decision of any given financial institution whether to lend to a given operating firm depend not only on the financial institution's assessment of the firm's project but also on its expectations as to whether other financial institutions will lend money to other operating firms. (Below we refer to financial institutions as banks for simplicity.)

This interdependence can give rise to multiple equilibria when each of many operating firms has a project that would be worth financing if other operating firms obtained financing for their project but not otherwise. In an efficient "lending" equilibrium, banks expect other banks to lend to operating firms with worthy projects, and these expectations are self-fulfilling. In an inefficient "credit freeze" equilibrium, banks have self-fulfilling expectations that other banks will withdraw from the lending market, and they rationally avoid lending to operating firms.

We use a global game methodology to identify which equilibrium will arise. The unique equilibrium is determined by the information that banks get about macroeconomic fundamentals (with each bank getting a noisy signal) and about the capital available to the financial sector. We identify a certain threshold of unfavorable information about fundamentals (or about depletion of banks' capital) below which a credit freeze equilibrium results. If the information about fundamentals is bleak enough, the withholding of credit would be efficient, reflecting the inability of firms to produce sufficient returns even if no banks were to withhold from lending. However, there is a range within which the credit freeze equilibrium would be inefficient, with banks not lending to operating firms whose projects would be worth financing if banks were all to lend to such firms.

During the economic crisis of 2008, the Fed and other central banks around the world slashed interest rates. Although interest rate cuts by the central bank make a credit market freeze less likely, by reducing the payoff to banks that avoid lending and invest in government bonds, we show that such cuts, however large, cannot be relied on to get the economy out of a credit market freeze equilibrium. To the extent that lending to a given operating company would produce a negative return if other operating firms fail to obtain financing, a bank would prefer to avoid lending to an operating company when other banks do not lend even if the economy's interest rate is barely positive, and an interest rate cut might consequently fail to produce a credit thaw.

Our analysis indicates that a shock to the banking system that depletes the amount of capital banks have makes an inefficient credit market freeze equilibrium more likely. As a result, intervention through the infusion of capital into financial firms, which governments in the US, UK, and other countries did during 2008, can be beneficial. However, we show that, like interest rate cuts, the effectiveness of capital infusion in producing a credit market thaw is limited. The reason is that, as long as other banks are expected to avoid lending to operating firms, banks that have ample capital will still choose to park it in government bonds rather than lend it to operating firms that are expected to fail to return it in the economic conditions that result from a credit freeze equilibrium.

We next examine the possibility of addressing a credit market freeze by the government's conditioning the infusion of capital into a given bank on the bank's committing to extend loans to operating firms. We show that for such an approach to be successful, a sufficiently large number of banks would have to be induced to make such a commitment simultaneously. Without such simultaneity, a credit freeze equilibrium may persist, as banks asked for such a commitment might decline the infusion of capital to avoid the required commitment and the loss that lending to firms can be expected to produce in such an equilibrium.

We then turn to examine the possibility of the government's providing loans directly to operating firms. Should the government serve as "lender of last resort" to operating firms? The problem with such direct lending by the government is that it is reasonable to assume that the government does not have the same ability as private

financial firms to distinguish between operating firms with good and bad projects. Thus, while direct government lending can provide financing to some firms with good projects that could otherwise fail to get financing due to an inefficient credit freeze equilibrium, it might also provide financing to some operating firms with bad projects that should not be financed and would not get funding even in an efficient lending equilibrium. The superior ability that financial firms have in screening operating firms seeking credit is presumably the reason why governments have thus far focused on shoring up the financial sector in the hope that it will in turn provide efficient financing to operating firms.

The problem that our analysis highlights, however, is the existence of circumstances in which the financial firms, acting on their own in ways that are individually rational, and armed with sufficient information about operating firms and with sufficient capital, will produce an outcome that is collectively suboptimal even though it is individually rational due to coordination failure. This leads us to examine yet another approach in which the government assumes the risk of lending to operating firms but uses the expertise of private financial firms to screen which operating firms will get credit and which will not.

Under one version of this approach, the government places capital in funds managed by private agents that will use them to extend loans to operating firms and will receive a reimbursement of their expenses and a cut of the profits (i.e., the returns above the riskless rate) generated by the funds. Under an alternative version of this approach, the government sells guarantees to financial institutions that extend new loans to operating firms: in return for a cut of the profits generated by a portfolio of loans held by a bank purchasing the guarantee, the government will bear the losses relative to the riskless rate generated by the portfolio. Under both versions, the government shares the profits generated by a portfolio of loans to operating firms with private players, and bears the risk in the event that the portfolio ends up in the red.

Under (either version of) this approach, the government commitment will ensure that capital will be deployed to fund operating firms. At the same time, choices as to which operating firms will get financing will be made by private parties with incentives to select for this purpose operating firms that have good projects. We show that the use of this approach can improve the government's ability to produce a credit thaw and study

the circumstances in which, and the extent to which, this is the case. But even though this approach can be most effective for dealing with an inefficient credit freeze, it is costly when the economy is in an efficient credit freeze caused by a sufficiently large deterioration in fundamentals.

Our paper is related to the large literature on bank runs, where depositors rush to demand early withdrawal from the bank because they believe that other depositors are going to do the same. The seminal paper on bank runs is by Diamond and Dybvig (1983), and it was followed by much subsequent work on the subject (see, e.g., Allen and Gale (1998), Peck and Shell (2003), and Goldstein and Pauzner (2005)). The ideas in the bank-run literature have subsequently been applied to describe also runs by investors on currencies (Obstfeld (1996), Krugman (1996), and Morris and Shin (1998))), financial markets (Bernardo and Welch (2004) and Morris and Shin (2004)), and sovereign debt (Detragiache (1996), Cole and Kehoe (2000)). Our paper, which builds on the analytical insights of this literature, focuses on a different context. We do not consider a run by depositors or investors on financial institutions, financial markets, or governments, but rather a run by financial institutions on the nonfinancial firms of the real economy. Furthermore, much of our focus is on analyzing alternative government responses that can be used in this context and that substantially differ from the policy responses to self-fulfilling crises in other contexts analyzed by the literature (such as deposit insurance in the context of runs on banks or IMF lending in the context of currency or sovereign debt runs).[2]

The source of coordination failures among banks in our model is the interdependence among firms in the real economy that makes the investment in a firm profitable only if other firms are able to invest and produce. Such strategic complementarities in the macro economy were motivated in an influential paper by Cooper and John (1988). Our paper complements this literature by showing how such complementarities can cause a credit freeze and analyze government policy in such context.

[2] See, e.g, Morris and Shin (2006) and Corsetti, Guimaraes, and Roubini (2006) for work on IMF lending to address runs on currencies and sovereign debt, Diamond and Dybvig (1983) for analysis of the role of deposit insurance in preventing runs on banks, and Rochet and Vives (2004) for analysis of a lender of last resort policy in bank runs.

Models of strategic complementarities usually yield multiple equilibria and thus do not lend themselves naturally to policy analysis. To overcome this problem, we follow recent work on self-fulfilling crises and rely on global-games techniques. The global-games literature has been pioneered by Carlsson and van Damme (1993) and Morris and Shin (1998) and is reviewed in Morris and Shin (2003)). The particular model used here is most similar to the one-country version of Goldstein and Pauzner (2004), where interdependence arises between real projects.

The remainder of this paper is organized as follows. Section 2 describes our framework of analysis. Section 3 provides an equilibrium analysis, identifying the conditions under which inefficient credit freeze equilibria will arise. Section 4 analyzes several governmental policies that may be used to produce a credit thaw, identifying their potential benefits and limitations. Section 5 concludes.

2. The Model

There is a continuum *[0,K]* of identical financial firms, which we call banks for simplicity. Each bank has 1 dollar of capital. Banks can choose whether to invest their capital in a risk-free asset, such as a deposit with the central bank, generating $1+r$ dollars next period, or lend it to operating (nonfinancial) firms. Banks are risk neutral and hence make their choices so as to maximize expected payoffs.

Operating firms have access to investment projects that require investment of 1 dollar, but do not have any capital to finance them. They rely on bank lending to invest in their projects. There are two types of operating firms. Some operating firms have bad projects, generating a gross return of 0. Others have good projects, generating a gross return of R (which is stochastic, and will be specified below) next period per one dollar invested this period. We assume that banks can tell the difference between firms with bad projects ("bad firms") and firms with good projects ("good firms"), and thus can choose to lend only to firms with good projects.[3] Moreover, we assume for simplicity

[3] The firms with bad projects will have an explicit role in the model later when we consider the possibility of the government extending direct loans to operating firms.

that the mass of firms with good projects is greater than the mass of banks K, and thus banks are able to extract the full surplus R from lending to good firms.[4]

We assume that the return R is an increasing function of two variables θ and n, and we therefore denote the return as $R(\theta,n)$. The first variable θ is a macroeconomic fundamental – exogenous to the model – that affects the strength of the economy and in turn the profitability of operating firms. It can represent various factors, such as firms' productivity, consumers' demand, the cost of imported oil, etc. The second variable n, whose value lies in the interval [0,1], is the proportion of banks that decide to lend to firms and finance their projects. Its value is determined endogenously in the model.

The dependence of R on n reflects the interdependence among operating firms in the economy. This interdependence can be due to several reasons. For example, many firms can prosper only when there are other firms in the economy that can provide them with adequate inputs. In addition, many firms sell some or all of their output to other firms, and thus depend on the operation of other firms. And even firms that sell their output solely to individuals might suffer from declining sales if other firms do not operate and thus are not able to employ these individuals. In sum, the success of the economy in our model requires the coordination among various operating firms and the banks that finance them. Such coordination issues in the macro economy were proposed before by other authors, e.g., by Cooper and John (1988).

The fundamental θ has the (improper) uniform prior over the real line. After it is realized (at the beginning of time in the model), θ is not publicly reported. Instead, each bank receives a private signal regarding the value of θ. More specifically, when θ is realized, bank i observes a signal $\theta_i=\theta+\sigma\varepsilon_i$, where $\sigma>0$ is a constant and the individual specific noise terms ε_i are independently distributed according to a smooth symmetric density function $g(\cdot)$ (the c.d.f. is denoted as $G(\cdot)$) with mean zero. Banks make their decisions whether to invest in the riskless asset or to lend to operating firms after observing these signals.

[4] We are thus able to show that a credit freeze equilibrium may arise even when the competitive conditions enable banks to extract the full surplus from lending and are thus as favorable to lending activity as possible.

Because the profitability of operating firms depends on macroeconomic conditions and the availability of financing to other firms, a bank's incentive to lend to a given operating firm with a good project is higher when the economy's fundamentals are favorable and when the number of banks who are going to lend is high. While the optimal behavior of a bank usually depends on its belief regarding the behavior of other banks, we assume that there are extreme ranges of macroeconomic fundamentals in which banks have a dominant strategy. More specifically, when the fundamentals are very good, a bank will prefer to lend to an operating firm no matter what it believes other banks will do. Similarly, when the fundamentals are very bad, the bank will invest in a government bond even if it believes that all the other banks will lend to operating firms. Formally, we assume that there exist $\underline{\theta} < \overline{\theta}$ such that:

$$R(\underline{\theta},1) = R(\overline{\theta},0) = 1 + r\,. \tag{1}$$

Thus, when the level of fundamentals is below $\underline{\theta}$ (in the lower dominance region), a bank is always better off not lending to operating firms, no matter what other banks are going to do, given that the fundamentals of the economy are so weak. Similarly, when the level of fundamentals is above $\overline{\theta}$ (in the upper dominance region), a bank is always better off lending to operating firms. Thus, since θ is uniformly distributed on the real line, there are signals at which banks choose to lend to operating firms independently of their beliefs regarding other banks' behavior, as well as signals at which they choose not to lend independently of their beliefs. As to banks that receive a signal in the interval between $\underline{\theta}$ and $\overline{\theta}$, however, their optimal decision depends on their expectations about whether other banks will lend to operating firms. This calls for an equilibrium analysis to which we turn next.

3. Equilibrium Analysis

3.1. Credit Freeze

We solve the model using global-games techniques. To get familiarized with these techniques, we refer the interested reader to the review article by Morris and Shin

(2003). To simplify the exposition of the results, we consider the case where banks observe macroeconomic fundamentals with infinitesimally small noise, that is, the case where σ approaches 0. Proposition 1 states the basic equilibrium result.

Proposition 1: *There is a unique Bayesian Nash Equilibrium in which all banks lend to operating firms if they observe a signal above* θ^* *and withdraw from lending if they observe a signal below* θ^*. *The threshold* θ^* *falls between* $\underline{\theta}$ *and* $\overline{\theta}$, *and is characterized by the following equation:*

$$\int_0^1 R(\theta^*, n)dn = 1 + r. \qquad (2)$$

Proof: We show that there is indeed an equilibrium, where banks lend to operating firms if and only if they observe a signal above θ^*, as defined in equation (2). Under this equilibrium, a bank observing the signal θ^* is indifferent between lending and not lending. Given the structure of information, this yields the following equation:

$$\int_{-\infty}^{\infty} R\left(\theta, 1 - G\left(\tfrac{\theta^* - \theta}{\sigma}\right)\right)\frac{1}{\sigma} g\left(\tfrac{\theta^* - \theta}{\sigma}\right)d\theta = 1 + r.$$

Here, conditional on the signal θ^*, the posterior density over θ is $\frac{1}{\sigma} g(\frac{\theta^* - \theta}{\sigma})$. Then, given the state θ, the proportion of banks that lend is $1 - G(\frac{\theta^* - \theta}{\sigma})$. Changing the variable of integration, we can get the following equation that implicitly characterizes θ^*:

$$\int_0^1 R\left(\theta^* - G^{-1}(1-n)\sigma, n\right)dn = 1 + r.$$

Then, taking the limit as σ approaches 0, we obtain equation (2).

To complete the proof of equilibrium, we need to show that banks that observe signals above (below) θ^* indeed prefer to lend (not to lend) given the equilibrium behavior of all other banks. This follows directly from the fact that a bank observing θ^* is indifferent and from the fact that banks observing higher (lower) signals have higher (lower) expectations about the fundamental θ and about the percentage of banks n lending in equilibrium, both of which increase the return $R(\theta, n)$ from lending. Finally, the proof of uniqueness of the equilibrium we just characterized is straightforward given

standard global-game results, which are discussed in Morris and Shin (2003), and thus omitted. **QED**. ■

Remarks: (i) *Intuition:* The intuition behind the result of Proposition 1 can be explained as follows. Due to strategic complementarities among banks, when the fundamentals are between $\underline{\theta}$ and $\overline{\theta}$, banks do not have a dominant action to choose. They simply want to do what other banks do: in that interval, each bank will be better off lending to operating firms if other banks do so, and will be better off withdrawing from the lending market if other banks do so. In a model with common knowledge about the fundamental θ, this would result in multiple equilibria, as both the case where all banks lend to operating firms and the case where none of them does so can be supported by equilibrium beliefs. The assumption that banks observe slightly noisy information about θ combined with the presence of extreme regions where banks have dominant actions (below $\underline{\theta}$ and above $\overline{\theta}$) pins down the threshold equilibrium characterized by equation (2) as the unique equilibrium here.

Intuitively, with noisy information, banks that observe a signal slightly below the upper dominance region know that the fundamental may well be higher than their signal and thus choose to lend. Knowing this, banks with even lower signals will also choose to lend. This rationale can be repeated again and again, guaranteeing a range of signals below the upper dominance region, where banks choose to lend. Similarly, due to the noisy information, there will be a range of signals above the lower dominance region, where banks will choose to invest in government bonds. The proof of equilibrium with global-game techniques demonstrates that this procedure exactly separates the real line, so that banks lend above θ^* and do not lend below it.

(ii) *The Credit Freeze Threshold:* Equation (2) that characterizes the threshold signal θ^* is based on the idea that a bank that observed θ^* has to be indifferent between lending to operating firms and investing in government bonds given the equilibrium behavior of other banks. The bank then knows that investing in government bonds will generate a return of $1+r$, while lending to operating firms will generate $R(\theta, n)$, where $\theta = \theta^*$ (recall that the noise in the signal about the fundamental approaches 0), and n is

uniformly distributed between 0 and 1. This latter result is due to the fact that the bank perceives a uniform distribution on the proportion of banks getting lower signals than its own. Given that the bank observed θ^* and that other banks lend if and only if they obtained a signal above θ^*, the bank perceives a uniform distribution on *n*. Because banks' signals have infinitesimally small noise, the equilibrium result is that all banks lend when the fundamental is above θ^* and do not lend when the fundamental is below θ^*. Hence, below θ^*, the economy ends up in a *credit freeze*.

(iii) *Efficient and Inefficient Credit Freezes:* When macroeconomic fundamentals are so bleak that we are below $\underline{\theta}$, the refusal of banks to lend is <u>efficient</u> because firms' projects will not produce payoffs exceeding the economy's riskless rate even if no banks withdraw from the lending market. In this case, funding the operating firms' project would be inefficient and reduce social wealth. Outside this set of circumstances, however, there exists a range of circumstances, when fundamentals lie between $\underline{\theta}$ and θ^*, that the economy will be in an <u>inefficient</u> credit freeze equilibrium. In this interval, banks will withdraw from lending even though, were banks all willing to lend, firms' projects will produce returns exceeding the riskless rate and the banks will be all better off relative to the credit freeze equilibrium.

(iii) *Inefficient Credit Freezes as a Coordination Failure*: When fundamentals lie between $\underline{\theta}$ and θ^*, the inefficient credit freeze can be viewed as due to coordination failure. Here, banks do not lend to operating firms just because they fear that other banks will not lend to operating firms. The fundamentals uniquely determine banks' expectations regarding what other banks are going to do and thus (indirectly) uniquely determine whether a credit freeze will arise, but the credit freeze is still inefficient. If the banks could have concluded among themselves an enforceable agreement on how they will act (or otherwise acted in a concerted fashion), they would have agreed on a coordinated strategy of lending to firms. However, as long as the banks make their decisions separately, based on their expectations as to how other banks will act, an inefficient credit freeze equilibrium may ensue. This raises the question, which section 4 will study in detail, what policy measures by the government could get the economy out of a credit freeze equilibrium.

(iv) *The 2008 Credit Crunch:* The credit crunch of 2008 was preceded by the arrival of bad economic news about macroeconomic fundamentals. For one thing, the substantial decline in housing prices considerably reduced the wealth of households, and such a reduction could have been expected to produce a subsequent decrease in consumer spending and thus the demand for firms' output. Our model indicates that the arrival of bad macroeconomic news might trigger a credit freeze that will lead to the refusal of banks to lend to firms even though the firms would still be worth financing notwithstanding the deterioration in macroeconomic fundamentals absent a self-fulfilling withdrawal of banks from the lending market. Such triggering of a credit freeze will of course further reinforce and exacerbate the effects of the deterioration in fundamentals that triggered it in the first place.

3.2. Can Reduction in Banks' Capital Trigger A Credit Freeze?

The credit crunch of 2008 was preceded by a perceived deterioration in the capital positions of financial institutions as a result of losses from real estate mortgage assets. This subsection examines whether a reduction in the banks' capital can trigger a credit freeze. To be sure, the decline in housing prices, which caused the losses from real estate mortgage assets, can directly produce a deterioration in the macroeconomic fundamentals represented by θ in our model, and such deterioration may by itself trigger a credit freeze. Our interest in this section, however, is whether, holding θ constant, a reduction in banks' capital can lead to, or make more likely, a credit freeze equilibrium. Our model indicates that a negative shock to the capital of the banking sector can indeed shift the economy to an inefficient credit freeze.

To study this issue, let us introduce the parameter l (between 0 and 1), which denotes the proportion of capital lost by banks in the economy due to bad past investments (say, because capital has been invested in "toxic" real estate paper). For simplicity of exposition, we assume that capital has been lost uniformly across banks, that is, each bank in the economy lost a fraction l of its capital. With this parameter introduced into the model, the capital of a single bank $(1-l)$ does no longer suffice to finance a firm's project. Hence, each firm will have to pool resources from more than one bank. Eventually, if a fraction n of banks decide to lend the capital they have to operating firms, the

total capital that will be provided as loans to such firms will be only a fraction *n(1-l)* of *K*, and the return of each project will thus be $R(\theta, n(1-l))$.

Proposition 2 characterizes the new equilibrium results and the effect that the parameter *l* may have on the realization of a credit freeze.

Proposition 2: *(a) In the unique Bayesian Nash Equilibrium, all banks withdraw from lending to operating firms if they observe a signal below* $\theta^*(l)$ *, and all banks lend to operating firms if they observe a signal above* $\theta^*(l)$*. The threshold* $\theta^*(l)$ *is characterized by the following equation:*

$$\int_0^1 R(\theta^*(l), n(1-l))dn = 1+r. \qquad (3)$$

(b)The threshold $\theta^*(l)$ *is an increasing function of the parameter l; hence, an increase in the fraction of bank capital that was lost, l, with no change in the fundamental θ, can shift the economy from an efficient lending equilibrium to an inefficient credit freeze.*

Proof: Proving the first part of the proposition is straightforward given the proof of Proposition 1. The proof just replaces $R(\theta, n)$ with $R(\theta, n(1-l))$ to reflect the fact that when a proportion *n* of the banks lend, only a proportion *n(1-l)* of potential capital makes its way to operating firms.

The second part is proved with the implicit function theorem. Denote

$$F(\theta^*, l) \equiv \int_0^1 R(\theta^*, n(1-l))dn - (1+r) = 0.$$

Then,

$$\frac{d\theta^*}{dl} = -\frac{dF(\theta^*, l)/dl}{dF(\theta^*, l)/d\theta^*}.$$

Since $\frac{dF(\theta^*, l)}{dl} < 0$ and $\frac{dF(\theta^*, l)}{d\theta^*} > 0$, it follows that $\frac{d\theta^*}{dl} > 0$. **QED**. ■

Remark: The intuition behind the result of Proposition 2, which indicates that a reduction in the banking sector's capital raises the threshold, below which banks elect to

withdraw from lending, is as follows. A reduction in the banking sector's capital makes each bank "less sure" that other banks will provide enough capital to operating firms to guarantee adequate return from the bank's using its capital to extend loans to operating companies. Hence, such a reduction makes each bank more concerned that, in the event it provides a loan to a given operating company, the firm will nonetheless suffer from the inability of many other operating companies to obtain financing. Technically, in equilibrium, a higher fundamental θ is required to make banks indifferent between providing credit to operating companies and investing in the riskless asset, which leads to an increase in the threshold θ^* and thus in turn to a larger range of fundamentals at which an inefficient credit freeze ensues.

Thus, our results indicate that banking losses can drive the economy into a credit freeze even without any accompanying change in other macroeconomic fundamentals. What is important to stress is that such reduction in capital will make operating firms less likely to receive financing not only because of the direct effect that some capital that could have been available for loans is no longer in place but also because of the indirect effect, which our result identifies, that it might deprive operating firms even of the capital that remains in place. By influencing banks' expectations as to how many operating firms will be able to obtain financing, the disappearance of some capital can make banks more reluctant to lend the capital that still remains.

4. Government Policy

4.1. Interest Rate Reduction

One governmental measure that is natural to examine as an instrument for addressing a credit freeze is a cut in interest rates. During the credit crisis of 2008, governments around the world have made substantial use of interest rate cuts. During 2008, in a series of moves, the Federal Reserve Board cut the federal rate considerably, bringing the Federal funds rate down from 4.25% in January to 1% in October. Similar steps have been taken by other central banks around the world. In October 2008, facing a worldwide contraction in lending, twenty one countries around the world, including the US and the UK, simultaneously cut interest rates.

Under normal market conditions, a cut in a country's interest rate can be expected to spur lending. To what extent can a cut in interest rate, however, be relied on to eliminate a coordination failure that results in an inefficient credit freeze equilibrium? Can any self-fulfilling credit freeze crisis be prevented by a sufficiently large interest rate cut? This section uses our model to consider these questions. As we explain below, a cut in interest rate may – but does not have to – produce a credit thaw. Such a cut may move the economy from a credit freeze equilibrium to a lending equilibrium in some circumstances, but there are circumstances in which a credit freeze will persist despite an interest rate cut however large.

In the language of our model, a reduction in interest rate amounts to reduction in the parameter *r*. Inspection of Equation (3) reveals the potential of this policy measure to help banks coordinate on a desirable credit thaw. The result is summarized in the following proposition.

Proposition 3: *(a) For every level of bank losses l, a decrease in the interest rate r on government bonds reduces the threshold* θ^**, below which a credit freeze occurs, and hence reduces the likelihood of a credit freeze.*
(b) Yet, for every $r \geq 0$ *and l (between 0 and 1), there are realizations of the fundamental* θ*, at which an inefficient credit freeze occurs.*

Proof: Proving the first part of the proposition is again done using the implicit function theorem. Denote:

$$F(\theta^*, r) \equiv \int_0^1 R(\theta^*, n(1-l))dn - (1+r) = 0.$$

Then,

$$\frac{d\theta^*}{dr} = -\frac{dF(\theta^*, r)/dr}{dF(\theta^*, r)/d\theta^*}.$$

Since $\frac{dF(\theta^*, r)}{dr} < 0$ and $\frac{dF(\theta^*, r)}{d\theta^*} > 0$, it follows that $\frac{d\theta^*}{dr} > 0$.

To see why the second part holds, compare the equations that define $\underline{\theta}$ and θ^*:

$R(\underline{\theta},1-l)=1+r$ and $\int_0^1 R\left(\theta^*, n(1-l)\right)dn = 1+r$, respectively.[5] Comparing the two equations, it is clear that for every $r \geq 0$, $\underline{\theta}$ is strictly smaller than θ^*. Since a credit freeze happens for every fundamental below θ^* and credit freezes are always inefficient when the fundamental is above $\underline{\theta}$, it follows that for every $r \geq 0$, there are realizations of θ, at which an inefficient credit freeze occurs. **QED**. ■

Remarks: (i) *The Reduction in the Likelihood of Credit Freeze*: The intuition behind the first part of Proposition 3 is as follows. A reduction in r makes investment in the riskless asset less attractive and thus lowers the expected return that will be necessary to induce banks to lend to operating firms, which in turn lowers the threshold θ^* above which banks will lend to such firms rather than withdraw from the lending market. It is interesting to note that the effect of the reduction in r on the decision of an individual bank is more than just the direct effect on this bank's payoff. Because the reduction in interest rate can be expected to affect other banks' decisions, it also affects the individual bank's decision through its effect on the bank's expectation concerning how other banks will act. Thus, the coordination aspect remains important when thinking about the effect of interest-rate policy in this model.

(ii) *The Limits of Interest Rate Cuts*: The second part of the proposition says that interest rate reductions cannot eliminate all inefficient credit freezes. Even if the government reduces r all the way to 0 (or to a very low level just above zero), θ^* will remain above $\underline{\theta}$, which implies that inefficient credit freezes may occur in the interval between $\underline{\theta}$ and θ^*. The intuition goes back to the coordination-failure aspect of credit freezes in our model. Even if the net return on the riskless asset is close to zero, banks will prefer to invest in it rather than lending to operating firms when they expect that other banks will all do so. When all other banks are expected to withhold funds from operating firms, a

[5] Note that the definition of $\underline{\theta}$ here is different than in equation (1). This is because this lower threshold, below which banks do not wish to lend even if they expect all other banks to lend, is also affected by the fact that banks lost proportion l of their capital.

bank may conclude that lending to a given operating firm will produce a loss and thus will be dominated by a safe investment yielding no positive return.

Thus, while governmental reduction in interest rates can shift the threshold that triggers coordination failure and credit freezes, it cannot completely eliminate such coordination failures. This result might be thought of as similar in spirit to the well-known liquidity trap in monetary economics. When the economy finds itself in a liquidity trap, even if the government reduces the interest rate all the way to 0, such rate cuts will fail to provide sufficient stimulus to the economy to bring it back to the desired level of activity. Similarly, the result indicates that there exists a range of circumstances in which interest rate cuts, however large, will fail to produce a credit thaw.

4.2. Infusion of Capital to the Banking System

During the financial crisis of 2008, governments around the world infused a large amount of capital into banks to shore up banks' capital positions, which have eroded due to losses from real estate mortgage assets and other investments. In the US, following the adoption of legislation in October 2008, the US Treasury infused into financial firms about $250 billion in additional equity capital. During the same period, the UK invested about $90 billion in several major banks. In addition to providing additional equity capital to financial firms, the Federal Reserve Board also provided additional capital to financial intermediaries by purchasing large amounts of their commercial paper.[6]

Infusion of capital into banks is a policy measure that is natural to consider in financial crises. Infusion of capital, e.g., in the form of a lender of last resort, has been used to prevent or stop bank runs in which depositors seek to withdraw their deposits en masse from a bank. When a solvent bank faces a problem of a bank run, providing the bank with capital may ensure depositors that their money is safe and prevent a run on the bank. Infusion of capital has also been used in the case of insolvent banks when governments felt that making sure such banks can meet their obligations to depositors is necessary to prevent a contagion effect that would lead to runs by depositors on other banks.

[6] The Fed established the Commercial Paper Funding Facility in October 2008, and it purchased during the subsequent several weeks hundreds of billions of dollars worth of commercial paper from financial intermediaries such as Morgan Stanley, GMAC, and American Express.

The subject we examine using our model is different because it does not involve potential runs by depositors on banks (or financial institutions more generally). Rather, it is the banks that may "run on the economy" by not extending loans to operating firms. In our context, therefore, capital infusion will not be designed to enable banks to meet their obligations toward their creditors. Rather, in our context, capital infusion may be used to facilitate lending by banks to operating firms in two ways: first, the direct and straight-forward way of providing banks with additional capital that they may use for the purposes of extending loans; and, second, the indirect effect, which our model highlights, of encouraging banks to lend to operating firms capital that they already have but that they might elect not to lend in the absence of the capital infusion to the banking sector and the shift in expectations produced by it.

To analyze governmental infusion of capital into the banking sector, let us assume that the government has or can obtain capital that would be sufficient to cover part of banks' losses. In particular, let us assume that the government has an amount $Z \equiv \alpha l K$, enabling it to inject a proportion α of the lost capital l to all banks in the economy. If the government injects the capital, each bank will have a total capital of $(1-l+\alpha l)$. In return, the government will get a share of $\alpha l/(1-l+\alpha l)$ in the banks. It can be shown that banks will not object to receive such capital infusion from the government. With the allocation of shares mentioned here, banks maintain the claim on the proceeds of their original capital. They now have to make an investment decision on the sum of their original capital and the government's injected capital. This does not change the return on their capital, aside from the (positive) indirect effect that investing more capital has on the returns in the economy.

Banks will again make a decision whether to lend to operating firms or invest in the riskless asset. The first option yields a stochastic gross return of $R(\theta, n(1-l+\alpha l))$, where n is the proportion of banks that decide to lend, while the second one yields a certain gross return of $1+r$. To focus on capital infusion, we will assume from now that $r=0$, so that the government has already reduced the interest rate as much as possible. The following proposition analyzes the effect of injecting capital to the banking system.

Proposition 4: *(a) The likelihood of a credit freeze* θ^* *when the government covers proportion* α *of bank losses is implicitly determined by*:

$$\int_0^1 R\left(\theta^*, n\left(1-l+\alpha l\right)\right)dn = 1. \qquad (4)$$

(b) This likelihood decreases in α *.Yet, for every* $\alpha \leq l$*, there are realizations of the fundamental* θ *at which an inefficient credit freeze will occur.*

Proof: The proof is analogous to the proof of Proposition 3, and thus omitted. **QED** ■

Remarks: (i) *The Reduction in the Likelihood of Credit Freeze*: By providing capital to the banking system, the government creates externalities that make the projects of operating firms more profitable. This is because banks have more capital to lend to operating firms, and so when they decide to lend, operating firms will produce greater returns. This encourages banks to lend to operating firms, making a credit thaw more likely to occur. Technically, at the threshold, below which a credit freeze occurs, banks will require a lower fundamental θ to be indifferent between lending and not lending to operating firms when the government injects more capital to the banking system (α is higher). This is because a higher α implies that under a uniform distribution of banks that decide to lend, the returns from lending increase. This pushes the threshold θ^* lower and increases the likelihood of a credit thaw.

(ii) *The Limits of Capital Infusion:* Even when the government covers all the losses that banks accumulated, banks will be reluctant to lend if they believe other banks are not going to lend. Hence, this policy of the government cannot fully eliminate coordination-based credit freezes. This sharpens the difference between infusion of capital to banks in our model, where crises reflect a run of banks on operating firms, and infusion of capital in a model of a run on the bank. Because, in our model, coordination failures arise among banks in their decision to lend to operating firms, banks end up not using capital that they have for lending purposes. Hence, capital infusion might not be sufficient to eliminate an inefficient credit market freeze. It should be noted, however, that, while capital infusion might not eliminate all inefficient credit freeze equilibrium, it

will leave intact efficient credit freeze equilibria, as it will never lead banks to lend when the economy is below $\underline{\theta}$.

4.3. Accompanying Infusion of Capital with Lending Commitments

In a standard financial crisis, where the problem is the ability of banks to meet their obligations, there is no need to accompany the infusion of capital into banks with requirements that the banks use the additional capital or other capital they have for the purpose of extending loans.

In our model, what the government would like is to have the banks commit to lend to operating firms upon the receipt of capital from the government. Achieving this, however, is not so simple. Consider, for example, the situation where the government conditions the infusion of capital to a given bank on a (perfectly enforceable) commitment from the bank to lend the injected capital, and possibly also the bank's original capital, to operating firms. The problem is that the banks might decide to forgo the injection of capital in order to avoid making such a commitment. If the other banks do not extend loans, and the bank follows through on the commitment to lend, the bank will make a loss on the capital lent to operating firms. The same coordination problem that came up in Section 4.2 in the lending decision will come up now in the decision on whether to get capital from the government and make the required commitment. In fact, the equilibrium in such a game will be identical to the one described in Section 4.2: Banks will choose to get the government's capital and make the commitment in and only in the cases where in Section 4.2 they chose to lend to operating firms.

In circumstances in which banks would otherwise not lend due to an inefficient credit freeze equilibrium, banks will agree to make a commitment requiring them to lend only if they expect that a sufficient large number of other banks will also make such a commitment. Consider the following mechanism: Let the government offer capital to banks under a condition that (i) the bank will make a 'contingent" commitment to lend the injected capital (and the bank's own capital) to operating firms, and (ii) that the commitment will become binding in the contingency in which at least a fraction of x of other banks also entered agreements with such a contingent commitment. The following proposition analyzes the result of applying such a mechanism.

Proposition 5: *Providing banks capital and having them commit to lend all of it (and their own capital) if at least a fraction x of other banks commit to do the same eliminates inefficient credit freezes above a certain threshold of the fundamental θ. This threshold approaches* $\underline{\theta}$*, leading to complete elimination of almost all inefficient credit freezes, as x approaches 1.*

Proof: When they decide whether to get the capital from the government and sign the conditional commitment agreement, banks only have to evaluate the desirability of lending in case *x* other banks lend. This is because if *x* banks do not get into conditional commitment with the government, the commitment of an individual bank is not binding, and thus having signed the agreement has no consequences.

Defining θ_x by $R(\theta_x, x(1-l+\alpha l))=1$, banks will always want to get into agreement observing a signal above θ_x because they know that at such fundamentals a proportion *x* of other banks choosing to lend guarantees that lending to operating firms is profitable.[7] Inspecting the equations that define θ_x and $\underline{\theta}$, one can see that the former converges to the latter, as *x* approaches 1. **QED**. ■

Remarks: To understand the intuition, consider the case where the government asks banks to commit to lend as long as all other banks commit to lend. When deciding whether to get into agreement with the government, each bank will have to evaluate whether lending is optimal, conditional on all the other banks lending. This is because if this condition is not fulfilled, the bank is not committed to do anything, in which case having signed the agreement is meaningless. Then, each bank will get into agreement with the government as long as its signal is above $\underline{\theta}$ (recall that the noise in the signal approaches 0). This would imply that when the fundamental is above $\underline{\theta}$, all banks will

[7] Note that this commitment program will enable the government to eliminate inefficient credit freezes even at some range below θ_x since banks will take into account that some banks who did not sign the agreement will choose to lend knowing that a proportion *x* signed the agreement, and thus will be willing to sign the agreement even below θ_x. Specifying the exact range where this happens is not central for the purpose of our paper.

sign the agreement with the government and be committed to lend, eliminating inefficient credit freezes altogether.

Getting the whole universe of banks to sign on such commitment might be deemed to be unrealistic. After all, it is possible that some banks suffer conditions that are particularly adverse or that some of them are not sophisticated enough to understand the terms of the agreement. Hence, it is more realistic to consider a policy that conditions the commitment to lend on a proportion x of other banks agreeing to do so. The proposition shows that this will eliminate inefficient credit freezes above a certain threshold and that this threshold converges to $\underline{\theta}$ as x converges to 1.

4.4. Direct Lending to Operating Firms

As explained above, the difficulty that the government faces in breaking the credit freeze by providing capital to banks is that banks might take the capital and not lend it to operating firms due to the fear that other banks will not lend. Hence, the success of the provision of capital by the government requires the government to demand the banks to commit to lend to operating firms. We showed that getting such a commitment is also not straightforward, and a rather complicated mechanism of conditional commitment is needed to achieve the optimal lending equilibrium. While in theory the conditional commitment mechanism we described enables the government to eliminate inefficient credit freeze, some would argue that such a simultaneous commitment mechanism may be difficult to implement in the real world.

An alternative to providing capital to banks is for the government to lend directly to operating firms. This would be the truly equivalent policy to a traditional lender of last resort, as it would have the government directly providing capital to those that need it, who in our model are the operating firms.

The problem with such policy is that the government does not have the ability that banks have to identify good firms from bad firms. Thus, providing capital to firms without using the intermediation services of banks would lead to lending to some firms that have bad projects and should not get financing.

To examine the efficiency of direct lending formally, we have to explicitly describe the bad operating firms in our model. So far, there was no need to consider them

and how many of them exist, as the assumption was that banks can tell good firms from bad firms, and thus bad firms would always be avoided. If the government attempts to lend to operating firms directly, however, it will have to consider the consequences of not being able to tell good firms from bad firms.

For the formal analysis, let us denote the mass of bad (good) operating firms in the economy as B (G). Recall that G is greater than K (the mass of banks). Suppose that the government has capital at the amount of $Z \equiv \alpha l K$ (as in Section 4.2) and it has to decide whether to inject it directly to operating firms or to the banks (without getting any lending commitment from them). When the government lends capital to operating firms, the capital is randomly allocated between good or bad firms. We denote the proportion of the capital that finds its way to bad firms as $\beta \equiv B/(B+G)$. For simplicity, we assume that the government does not know the realization of the fundamental θ (and does not get any signal about it). Initially, we will assume that the operation of firms with bad projects, while producing no returns for the lending bank, still provides a positive externality for other operating firm (as firms with bad projects do purchase inputs from other firms etc.); below we will discuss how our conclusions will change if we were to assume that such externalities flow only from the operation of firms with good projects.

Below we show that using the government's capital for direct lending to operating firms is more effective, compared with infusing this capital into the banks, in lowering the threshold θ^* above which banks will lend to operating firms toward $\underline{\theta}$. Thus, there are circumstances in which direct landing would produce a credit thaw where a capital infusion into the banks would not. Even in these circumstances, however, direct lending might be overall less efficient due to the waste associated with lending to bad firms. Furthermore, outside these circumstances, direct lending would produce worse results.

Proposition 6: *(a) If the government lends $\alpha l K$ directly to operating firms, the banks are in a credit freeze equilibrium if and only if the fundamental θ is below the threshold θ^*, which is implicitly defined by:*

$$\int_0^1 R\left(\theta^*, n(1-l)+\alpha l\right)dn = 1. \qquad (5)$$

Denoting the threshold under capital injection to banks (defined in equation (4)) as θ^*_{Bank} *and the one under direct lending to firms (defined in equation(5)) as* θ^*_{Direct}*, we get that for every α and l,* $\theta^*_{Bank} > \theta^*_{Direct}$*, implying that the probability of a credit freeze is higher under capital injection to banks than under direct lending to operating firms.*

(b) When the fundamental θ *is below* θ^*_{Direct} *or above* θ^*_{Bank}*, the overall wealth in the economy is higher under injection of capital to the banking system than under direct lending to operating firms.*

(c) When the fundamental θ *is between* θ^*_{Direct} *and* θ^*_{Bank}*, the comparison between the two regimes yields ambiguous results. For a sufficiently large β, the wealth may be higher under injection of capital to the banking system.*

Proof: See the appendix.

Remarks: (i) *The Effect on the Lending Threshold*: The intuition behind part (a) of the Proposition, which indicates that directly lending the government's capital will reduce the lending threshold more than infusing the capital into banks is simple. When the government injects capital to banks, some of this capital might remain "stuck" in the banking system as banks fail to coordinate on lending it to operating firms. When the government lends the capital directly to operating firms, banks know that it will generate the desired externalities. As a result, lending directly to operating firms more effectively increases the returns to banks from lending and encourages banks to lend, and thus is more likely to bring the economy to a credit thaw.

(ii) *The Costs of Direct Lending*: Of course, the fact that direct lending is more effective in encouraging banks to lend does not imply that this policy measure is worth using. To begin with, even when the economy is above $\underline{\theta}$ and financing firms with good project is efficient, direct lending by the government will also provide "wasteful" financing to operating firms with bad projects. Moreover, when the economy is below $\underline{\theta}$ even the provision of funding to operating firms with good projects is inefficient.

(iii) *When* θ *is below* θ^*_{Direct} *or above* θ^*_{Bank}: Part (b) of the Proposition indicates that in these circumstances, direct lending is clearly undesirable. In these circumstances,

direct lending does not have an advantage over capital infusion into banks in terms of inducing banks to lend to operating firms, but the costs of direct lending are still borne. When θ is above θ^*_{Bank}, direct capital infusion into banks will be sufficient to produce a credit thaw, as would direct lending program, and thus there is no reason to bear the costs of lending to firms with bad projects the latter involves. When θ is below θ^*_{Direct}, direct lending by the government will not induce banks to do their own lending to operating firms, and, given this, the government will produce returns lower than 1 not only on loans to operating firms with bad projects but also on operating firms with good projects.

(iv) *When* θ *is between* θ^*_{Direct} *and* θ^*_{Bank}: In these circumstances, which are the focus of part (c) of the Proposition, direct infusion of capital into the banks will fail to induce them to lend even though lending to operating firms with good projects is efficient. Direct lending by the government will accordingly have two benefits in these circumstances: first, it will provide financing to some operating firms with good projects that should receive financing; second, to the extent that θ *exceeds* θ^*_{Direct}, direct lending will induce banks to lend to operating firms. On the other hand, direct lending by the government will involve the wasteful provision of financing to firms with bad projects. If β is sufficiently large – that is, when the government's screening ability is sufficiently poor that it will not be able to provide financing to operating firms with good projects without providing financing also to a sufficiently large number of firms with bad projects – this cost of a direct lending program may make it overall undesirable.

(iv) *The Case in which only Operating Firms with Good Projects have Beneficial Spill-over Effects*: Finally, it should be noted that our analysis in this section was conducted under the assumption that capital that is lent to bad firms still creates positive externalities to other firms even though it generates no direct return. It might be argued, however, that some bad projects create no or lower spill-over benefits for other firms. To examine the consequences of this factor, let us assume that the payoffs of operating firms do not depend on the number of other firms in operation but on the number of other firms in operation with good projects. Making this assumption weakens the attractiveness of direct lending to operating firms by the government.

To see this, note that if only good firms getting capital from the government created synergies to other firms, than the equation that determined the threshold θ^*_{Direct}, below which a credit freeze occurs in a regime of direct lending, would change from equation (5) to the following:

$$\int_0^1 R\left(\theta^*_{Direct}, n(1-l)+(1-\beta)\alpha l\right)dn = 1. \qquad (6)$$

Using the logic used thus far in the paper, it is then easy to show that this would increase the likelihood of a credit freeze under direct lending, making this regime overall less desirable.

4.5. Government Funds Managed by Private Firms

While the direct lending program analyzed in the preceding section could ensure that the government's capital will flow to operating firms, it is disadvantaged by the government's inability to distinguish between operating firms with good and bad projects. Accordingly, a direct lending program could benefit if it were designed to utilize the expertise of private parties in screening operating firms with good projects from operating firms with bad projects.

Consider the following mechanism. The government places the capital αlK in a number of funds dedicated to lending to operating firms, with any amounts not so invested placed in the economy's riskless asset. The funds will be managed by banks or by other private agents that have the same expertise. The managers of the funds will be paid, in addition to reimbursement of the expenses of processing loans which for simplicity are assumed to be zero in our model, a proportion γ on any profit that they generate on the capital invested by the fund they manage – that is, the excess of the return they generate over the riskless return i. Note that, whereas the managers will capture a share of the profits if any that the fund will generate, they (like hedge fund managers) will not bear

any share of the losses generated, if any, and such losses will be borne by the government.[8] The following proposition characterizes the consequences of this mechanism.

Proposition 7: (a) *If the government invests αlK in funds dedicated to lending to operating firms, and managed by private agents promised a proportion γ on any return they generate above 1, then (i) the funds' capital will be fully lent to operating firms with good projects, and (ii) the threshold defining whether banks will lend to operating firms will be* θ^*_{Direct}*, as characterized in equation (5).*

(b) Compared with infusing the capital αlK directly into banks, the setting of such government funds will (i) produce the same total wealth if θ *exceeds* θ^*_{Bank}*, (ii) produce a higher total wealth if* θ *is between* θ^*_{Direct} *and* θ^*_{Bank}*, and produce a lower total wealth if* θ *is lower than* θ^*_{Direct}*.*

Proof: (a) When choosing whether to lend the government's capital to operating firms or not, banks always prefer to lend. This is because their only chance to get a return above 1, on which they are compensated, is when they lend. Moreover, given that the noise, with which the banks observe the fundamentals is unbounded (even though very small), they always perceive some probability that lending will generate a return above 1, which will provide compensation for them, while they know that there is no cost in generating a return below 1. Hence, the government's capital always flows to operating firms, generating the threshold θ^*_{Direct} characterized in equation (5). Finally, it is straightforward that banks lend to good firms and not to bad firms, as a positive return only comes from the former and the banks can distinguish between the two types.

(b) The second part of the proposition can be proven along the same lines used in the proof of Proposition 6. **QED**. ■

[8] For a fuller discussion of the institutional details involved in implementing this mechanism, see Bebchuk (2008b).The mechanism is similar to the one proposed by Bebchuk (2008a) for the government's purchase of troubled assets through funds using governments fund and run by private agents compensated with a cut of the profits generated by the funds.

Remarks: (a) *The Decisions of the Government Funds' Managers*: The design of the mechanism ensures that the government's capital invested in the funds will be fully provided to operating firms with good projects. Because the government will fully bear the losses, the managers will have no reason to avoid lending the funds given to them. Furthermore, because the managers will be promised a cut of the profits, they will have an incentive to screen operating firms with good projects from operating firms with bad projects, and their dominant strategy will be to lend funds only to firms with good projects.

(b) *The Effect on Bank's Lending Threshold*: Because the government funds program, like the direct lending program, will ensure that an amount of αlK will be lent to operating firms, the threshold for banks' lending to operating firms will be the same as the threshold, defined in equation (5), that would result from the direct lending program under the assumption that all operating firms have positive externalities for other operating firms. Indeed, when the positive externalities from the operation of firms with bad projects are non-existent or smaller in magnitude than the positive externalities from the operation of firms with good projects, the government funds program, which will channel all of its capital to firms with good projects, will perform better in terms of lowering the banks' lending threshold than the direct-lending program.

(c) *Comparison with the Direct-Lending Program*: Relative to the direct-lending program, the government funds mechanism has the advantage of not involving loans to operating firms with bad project; as a result, the government lending program performs somewhat better in a comparison with direct infusion of capital into banks. While the government funds program does not have this cost of the direct-lending program, it does, like the direct-lending program, provide capital to firms in circumstances in which θ *is below* θ^*_{Direct}, which are circumstances in which funding operating firms is inefficient. To be sure, this cost of the government funds program is lower than the cost of the direct-lending program, as the losses from lending to operating firms with good projects will be lower than the losses from lending to operating firms with bad projects. Still, this cost will make the government funds program inferior to direct infusion of capital when θ *is below* θ^*_{Direct}.

(d) Comparison with Infusion of Capital into Banks: In circumstances in which θ *exceeds* θ^*_{Bank} , where a direct infusion of capital will be sufficient to produce a credit thaw, the government funds mechanism will perform neither better nor worse than direct infusion of capital. In this case, both mechanisms will lead to providing *K* to operating firms with good projects. (In these circumstances, the direct-lending program performs worse than direct capital infusion into banks, but only because the former involves lending to operating firms with bad projects.)

In circumstances in which θ is between θ^*_{Direct} *and* θ^*_{Bank}, the government funds mechanism will be superior to direct infusion of capital. In these circumstances, the direct infusion of capital will not eliminate an inefficient capital freeze, and no funding will be provided to operating firms. In contrast, in these circumstances, under the government funds mechanism, both the capital in the government funds and the capital in the hands of the bank, totaling *K*, will be provided to operating firms.

Finally, when θ is lower than θ^*_{Direct}, the government funds mechanism will produce inferior results. In this case, the operation of government funds will not lead banks to lend to operating firms, and the lending by the government funds will produce losses: when θ is lower than $\underline{\theta}$, lending to operating firms will produce losses even if the banks were to lend to operating firms, and when θ is between $\underline{\theta}$ and θ^*_{Direct}, the lending to operating firms will produce losses due to the banks' failure to lend the capital in their hands to operating firms.

5. Concluding Remarks

This paper has developed a model of credit freezes that are inefficient but arises from the rational and self-fulfilling expectations of financial institutions. In this equilibrium, banks would be collectively better off if they were all willing to extend loans to a set of operating firms, but each of them avoids doing so out of self-fulfilling expectations that others will do as well. In such circumstances, efficiency will be served by getting the economy from the inefficient credit freeze equilibrium, and the developed model has

been seen to be useful for studying and assessing government policies that can be considered for this purpose.

Our analysis has shows that interest rate cuts, and infusion of capital into the financial sector might but also might not produce a credit thaw. Even with very low interest rates, and with ample capital, banks will not extend loans to operating firms when they believe that their projects, even though worthy in an environment in which other such firms obtain financing, will fail in an environment in which credit to other firms is frozen. If such circumstances arise, the government will have to look beyond interest rate cuts and capital enhancement to get the economy out of the credit freeze. The government's seeking commitments from banks to extend loans could help but would do so only if this approach could be used in a simultaneous and coordinated fashion with respect to a significant number of financial institutions.

When interest rate cuts and capital infusion into the financial sector cannot produce a credit thaw, an alternative or supplemental approach that may be considered would involve the government's getting more directly involved in assuming risks generated by portfolios of loans to operating companies. We have shown how a credit thaw could be facilitated by the government's investing in government-owned funds that will extend loans to operating firm and be run by private managers incentives by a profit cut, or, alternatively, the government's providing, in return to a share of generated profits, guaranteed floor for the returns of a portfolio of loans that a bank will extend to operating firms.

Our work has implications for the current economic crisis. With government intervention producing a substantial increase in the financial system's capital, some observers suggest that lack of expansion in the credit extended to operating firm will imply that the current economic environment has made such expansion no longer efficient. Our analysis indicates that this inference cannot be made. While banks' failure to extend additional credit may be efficient, it may also be an inefficient outcome due to coordination failure. Our paper provides a framework for examining this possibility and potential government responses to it.

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Appendix

Proof of Proposition 6:

(a) Equation (5) is based on the same principles behind the construction of equilibrium in Propositions 1 and 2. In equation (5), all the government's capital is lent and generates the positive externality. Then, using the implicit function theorem, as in Propositions 2 and 3, reveals then that $\theta^*_{Bank} > \theta^*_{Direct}$.

(b)The overall wealth in the economy under injection of capital to the banking system is given by:

$$(1-l+\alpha l)K,$$

when the economy is in a credit freeze, and by

$$R(\theta,1-l+\alpha l)\cdot(1-l+\alpha l)K,$$

when the economy is in a credit thaw.

The overall wealth in the economy under direct lending to operating firms is given by:

$$[R(\theta,\alpha l)\cdot\alpha l(1-\beta)+(1-l)]K,$$

when the economy is in a credit freeze, and by:

$$R(\theta,1-l+\alpha l)\cdot((1-l)+\alpha l(1-\beta))K.$$

when the economy is in a credit thaw.

Now, when the fundamental θ is below θ^*_{Direct}, we know that there is a credit freeze under both regimes. In this range, $R(\theta,\alpha l)<1$, otherwise banks (who receive signals with infinitesimally small noise) would have chosen to lend. Thus, given that $\beta>0$, the wealth under capital injection to banks is higher than under direct lending to operating firms.

When the fundamental θ is above θ^*_{Bank}, there is a credit thaw under both regimes. Then, it is easy to see that, given that $\beta>0$, the wealth under capital injection to banks is higher than under direct lending to operating firms.

When the fundamental θ is between θ^*_{Direct} and θ^*_{Bank}, the economy is in a credit thaw under the regime of direct lending and in a credit freeze under the regime of injection of capital to banks. Then, there is no obvious ranking between the levels of wealth in the two regimes. On the one hand, $R(\theta,1-l+\alpha l)>1$, as evident by the fact that banks choose to lend to operating firms when other banks do. This pushes the wealth under direct lending to be higher. On the other hand, the fact that $\beta>0$ causes waste in the direct-lending regime, pushing the wealth lower. Overall, a high enough β is more likely to generate again advantage to the regime where the government injects capital to banks. **QED**. ■