Self-fulfilling Credit Market Freezes

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This article 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 firms are interdependent, where their success depends on the ability of other operating firms to obtain financing. In such an economy, an inefficient credit market freeze may arise in which banks abstain from lending to operating firms with good projects because of their self-fulfilling expectations that other banks will not be making such loans. Our model enables us to study the effectiveness of using alternative measures as a means of getting an economy out of an inefficient credit market freeze. In particular, we study the effectiveness of interest rate cuts, an infusion of capital into banks, direct lending by the government to operating firms, and the provision of government capital or guarantees to encourage privately managed lending. Our analysis provides a framework for analyzing and evaluating the standard and nonstandard instruments used by authorities during the 2008–2009 financial crisis. Our analysis also provides testable implications for how firms, banks, and economies can be expected to be affected by shocks to the banking system. (*JEL* C72, D21, E44, G01, G20)

An important aspect of the 2008–2009 economic crisis has been the contraction or "freezing" of credit to nonfinancial firms.[1] During the crisis, financial firms have displayed considerable reluctance to extend loans to nonfinancial firms (as well as households). Some observers attributed the reluctance of financial firms to lend to irrational fear, while others attributed it to a rational assessment of the fundamentals of the economy, which can be expected to reduce the number of operating firms with good projects worthy of financing.

We analyze in this article another factor that may contribute to the contraction of credit in such circumstances. In particular, we show how coordination

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[1] See Ivashina and Scharfstein (2010); Almeida et al. (2010). For a description of the crisis and the events leading up to it, see Brunnermeier (2009).

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failure among financial institutions 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. They do 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 primary contribution of the article is to analyze the effectiveness of various government policies that are meant to get the economy out of self-fulfilling credit freeze equilibrium. The analysis identifies the role and potential limitations of standard instruments, such as interest rate cuts and infusion of capital into the financial sector. It also considers less traditional forms of intervention and analyzes why and when they may be needed. These include direct intervention in lending to nonfinancial companies, provision of incentives to financial firms to lend to such companies, and supplying government capital to private funds dedicated to such lending. Our analysis provides a framework for understanding and assessing the range of instruments used by authorities to revive credit markets in the course of the financial crisis.

Our analysis is based on the premise (put forward in earlier work, such as Cooper and John 1988) that operating firms, or at least a significant fraction of such firms, benefit from the success of other operating firms in the economy, and the returns they will make on borrowed capital will thus increase if other operating firms are able to obtain financing. This interdependence can be generated by multiple channels. A firm’s success depends on the success of firms that use its products, of those who supply its inputs, and of those whose employees buy its products. As a result of this interdependence, the decision of any given financial institution of whether to lend to a given operating firm depends on the financial institution’s assessment of the firm’s project and on its expectations of whether other financial institutions will lend money to other operating firms. (For simplicity, from here we refer to financial institutions as banks.)

If fundamentals are sufficiently poor, it may be rational for banks not to lend, regardless of what they expect other banks to do. And if fundamentals are sufficiently good, it may be rational for banks to lend, regardless of what they expect other banks to do. However, given the positive spillovers among firms, there is an intermediate range of fundamentals that can give rise to multiple equilibria. In an efficient lending equilibrium, banks expect other banks to lend to operating firms with worthy projects, and these expectations are self-fulfilling. In inefficient credit freeze equilibrium, banks have self-fulfilling expectations that other banks will withdraw from the lending market and, as a result, they rationally avoid lending to operating firms. We use the global-games methodology, where banks observe noisy signals about the macroeconomic fundamentals—which affect the profitability of real projects—in order to identify when an inefficient credit freeze arises in equilibrium. We also analyze the effect of various government policies on the probability of an inefficient freeze and on the overall wealth in the economy.

One standard policy measure to encourage lending is interest rate reduction. During the recent financial crisis, the Federal Reserve and other central banks around the world slashed interest rates. In our model, interest rate cuts by the central bank help make inefficient credit market freeze less likely by reducing payoffs to banks that avoid lending and invest in government bonds. However, such cuts still leave a range of fundamentals, where the economy remains in inefficient credit freeze equilibrium and banks' self-fulfilling expectations (i.e., a bank will not lend if they think others will also not lend) lead them to avoid lending to firms that would otherwise be worthy of funding.

Another prominent course of government policy works via capital infusion. Our analysis indicates that a shock to the banking system, where the amount of capital banks have is depleted, makes inefficient credit market freeze equilibrium more likely. Such depletion in the financial sector's capital makes each bank more concerned that operating firms in the economy will not receive sufficient capital; therefore, they are more reluctant to lend capital to operating firms. As a result, intervention through the infusion of capital into banks, which governments in the United States, United Kingdom, and other countries did throughout the financial crisis, can be beneficial and reduces in our model the probability of a freeze. However, we again show that this measure has limited effectiveness. Even when banks know that the banking sector's capital is no longer depleted, there is still a range of macroeconomic fundamentals in which the economy remains in an inefficient credit freeze and banks avoid lending to operating firms that they would fund if other banks were expected to lend.

We then turn to examine the possibility of the government directly providing capital to operating firms. In macroeconomic circumstances in which an inefficient credit freeze arises, should the government serve as the "lender of last resort" to operating firms? That is, should the government directly provide capital to *Main Street*, rather than provide it to *Wall Street* with the hope that the banks will, in turn, lend to operating firms? This was attempted during the recent financial crisis, when the government bought the commercial paper of some firms. In our model, direct lending to operating firms is more effective in reducing the probability of a credit freeze, since it avoids the coordination problem among banks in lending the money. However, as long as the government does not have the same ability as banks do in distinguishing between operating firms with good and bad projects, governmental direct lending to unscreened operating firms can waste resources by channeling capital to firms with bad projects.

Thus, in some circumstances, providing the government's capital to banks will fail to break an inefficient credit freeze, but providing this capital directly to operating firms will fail to take advantage of the screening expertise of private parties and hence fail to allocate capital among productive operating firms. Therefore, our analysis devotes considerable attention to alternative mechanisms under which the government harnesses the screening expertise of financial firms but also provides them with incentives to lend. For example, during the recent financial crisis, the U.S. government used the Term Asset-Backed Securities Loan Facility (TALF) to provide government capital while limiting the downside risks of funds that extended certain types of credit to the nonfinancial economy. We analyze and compare the consequences of several alternative mechanisms. We identify their potential advantages and disadvantages, relative to standard policy instruments, as well as to each other. This analysis provides a rationale and framework for assessing and designing government-supported mechanisms that are intended to encourage lending, while also harnessing financial firms' expertise.

Although we shall explicitly discuss lending by financial firms to nonfinancial operating firms, it will be clear to the reader that the basic insights of our analysis also apply to some lending by the financial sector to other nonfinancial borrowers, namely, individuals and households. That will be the case whenever there is interdependence among borrowers (i.e., the ability of some nonfinancial borrowers to repay loans to a given bank is dependent on the ability of other nonfinancial borrowers to obtain financing from other banks). This might be the case, e.g., in the housing market, where the expected resale value of any given house for which a loan is sought from a bank depends on future housing prices and thus might depend on the willingness of other banks to finance house purchases.

Our analysis has implications not only for policy-making in economic or financial crises but also for empirical work. In particular, for any given deterioration in fundamentals or shocks to banks' capital, our model provides testable implications concerning the extent to which different firms, sectors, regions, and economies can be expected to suffer from credit contraction and the extent to which a given government intervention will spur lending. For example, following a shock to a banking sector, our model predicts that, other things equal, affected firms will have their credit contracted more when they are more dependent on each other (either on the demand or the supply side) and when the banking sector is less concentrated (and thus more prone to coordination failures). There is substantial empirical literature available on the effect of shocks to banks' capital on lending and investments, and our analysis can inform this line of work and provide additional dimensions and issues it can investigate. In the course of our analysis, we discuss in detail the empirical tests and work suggested by our model.

Our model 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 work on the subject (see, e.g., Allen and Gale 1998; Peck and Shell 2003; Goldstein and Pauzner 2005). The ideas in the bank-run literature have subsequently been applied to describe runs by investors on currencies (Morris and Shin 1998), financial markets (Bernardo and Welch 2004; Morris and Shin 2004a), and other contexts. Our article, 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. More importantly, our contribution is in analyzing alternative government responses that can be used in this context.

Several papers analyze policies of deposit insurance or "lender of last resort" to prevent runs on financial institutions, such as the papers by Rochet and Vives (2004), Corsetti, Guimaraes, and Roubini (2006), and Morris and Shin (2006). The policy problem we consider here is fundamentally different. In these papers, the analysis revolves around capital infusion to an institution that might be subject to a run because it lacks capital. In our model, on the other hand, coordination failures arise among financial institutions in their decision to lend to operating firms. Hence, capital infusion to financial institutions might not be sufficient to eliminate an inefficient credit market freeze, as they might fail to coordinate on lending this capital. This leads to our discussion on the role of direct government intervention in lending to operating firms and the various ways of implementing it without losing the informational advantage that banks have in lending to such firms.[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 macroeconomy were motivated in an influential paper by Cooper and John (1988) and have been used in other papers (e.g., Goldstein and Pauzner 2004). Our article complements this literature by showing how such complementarities can cause an inefficient credit freeze and analyze government policy in such context.

Models of strategic complementarities usually yield multiple equilibria and thus do not naturally lend themselves to policy analysis. To overcome this problem, we follow the 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). In particular, we build on the model in Morris and Shin (2004b).

The recent financial crisis has generated a surge of theoretical research. Let us mention a few papers that are more related to ours. Acharya, Gale, and Yorulmazer (2011) analyze the debt rollover problem, where the fact that debt needs to be rolled over frequently reduces the debt capacity of firms

[2] Sakovics and Steiner (2009) analyze a related question of subsidizing agents who participate in a coordination game. While their paper focuses on who should be subsidized, ours focuses on how to subsidize. Another related paper, Chamley (1999), analyzes a dynamic coordination game and discusses the effect of providing subsidies in different points in time when agents learn from recent aggregate outcomes.

with little credit risk. Diamond and Rajan (2011) argue that the possibility of future fire sales makes banks want to hoard on cash instead of extending new loans. Benmelech and Bergman (2009) analyze government policies in a model where credit traps evolve as a result of reduction in collateral value. Philippon and Schnabl (2009) analyze government policy in a model where credit does not flow because firms suffer from a debt overhang problem.

The remainder of this article is organized as follows: Section 1 describes our framework of analysis. Section 2 provides an equilibrium analysis, which identifies the conditions under which inefficient credit freeze equilibria will arise. Section 3 analyzes alternative governmental policies that may be used to produce a credit thaw and identifies their potential benefits and limitations. Section 4 concludes.

1. The Model

There is a continuum $[0, K]$ of identical banks. Each bank has US$1 worth of capital. Banks can choose to invest their capital in a risk-free asset, such as a deposit with the central bank, that generates $1 + r$ (>1) dollars next period, or lend it to operating (nonfinancial) firms. Banks are risk-neutral; hence, they make their choices based on their desire to maximize expected payoffs.

Operating firms have access to investment projects that require an investment of US$1 but do not have the capital to finance these projects. They rely on bank lending in order to invest in their projects. There are two types of operating firms: Some operating firms have bad projects that always generate a gross return of US$0. Others have good projects that generate a gross return of $1 + R$ $(>1 + r)$, when the macroeconomic fundamentals are strong and a sufficient number of operating firms get the required financing that they need to invest. Specifically, the return on a good project is assumed to take the following form:

$$\begin{cases} 1 + R & \text{if} \quad aL + \theta \geq b \\ 0 & \text{if} \quad aL + \theta < b. \end{cases} \tag{1}$$

Here, θ is a macroeconomic fundamental that can represent various factors, such as firms' productivity, consumers' demand, the cost of imported oil, etc. The variable L represents the mass of firms that received loans from banks in order to invest in their projects. In the basic model, $L = nK$, where $n \in [0, 1]$ (whose value is determined endogenously in the model) is the proportion of banks that decide to lend to firms. Hence, the macroeconomic fundamentals and the proportion of firms that are investing in their projects are together responsible for the profitability of good projects. a is a parameter that captures the importance of complementarities versus fundamentals in making projects profitable, and b is a parameter capturing the threshold needed to become profitable.[3]

The effect of L reflects the interdependence in payoffs 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. Even firms that solely sell their output to individuals might suffer from declining sales if other firms 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 macroeconomy were previously proposed by other authors, e.g., Cooper and John (1988). Note that there are some firms (e.g., firms providing services to firms in bankruptcy) that can become better off when other firms are hurting. Because our analysis focuses on complementarities, it should be viewed as applying to the universe of nonfinancial firms, where positive complementarities are the dominant force.

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. Firms with bad projects will have an explicit role in the model later on, when we consider the possibility of the government extending direct loans to operating firms. We assume for simplicity 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 return R from lending to good firms, whose projects were successful. Given this assumption, we will be able to show that inefficient 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.

We assume that the fundamental θ is not publicly known. It is normally distributed around a mean of y. We consider y to be public news about the strength of the economy that is available to everyone. The standard deviation of θ around y is σ_θ, and we use $\tau_\theta = \frac{1}{(\sigma_\theta)^2}$ to denote the precision of the distribution of θ. Each bank i receives a private signal with regard to the value of θ, given by $x_i = \theta + \varepsilon_i$. Here, the individual specific noise terms ε_i are independently normally distributed with mean 0 and standard deviation σ_ρ. We use $\tau_\rho = \frac{1}{(\sigma_\rho)^2}$ to denote the precision of banks' signals. After observing these signals, banks make the decision of whether to invest in the riskless asset or lend to operating firms.

Because the profitability of operating firms depends on macroeconomic conditions and the availability of financing to other firms, a bank's incentive

3 Note that we use a discontinuous return function (i.e., projects either succeed or do not succeed) for simplicity of exposition. Our results would hold in a model where the return on projects is a continuous function of θ and L.

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 that are willing to lend is high. While the optimal behavior of a bank usually depends on its belief that other banks will behave in a similar manner, there are ranges of macroeconomic fundamentals in which banks have a dominant strategy. More specifically, when the fundamental θ is above b, a bank will prefer to lend to an operating firm no matter what it believes other banks will do. This is because in this range the return on lending is guaranteed to be $1 + R$. Similarly, when the fundamental is below $b - aK$, the bank will invest in a government bond, even if it believes that all the other banks will lend to operating firms.[4]

Since θ is drawn from an unbounded distribution, there are signals in which banks choose, independent of their beliefs on other banks' behavior, to lend to operating firms; there are also signals in which banks choose, independent of their beliefs, not to lend. As for banks that receive a signal in the intermediate range, their optimal decision depends on their expectations with regard to the question of whether they believe other banks will lend to operating firms. This calls for an equilibrium analysis, to which we next turn.

2. Equilibrium Analysis

2.1 Credit freeze

We solve the model by using global-games techniques. In particular, we follow Morris and Shin (2004b). Proposition 1 states the basic equilibrium result.

Proposition 1. Suppose that the information in banks' signals is precise, relative to prior information, so that $\frac{\tau_\theta}{\sqrt{\tau_\rho}} \leq \frac{\sqrt{2\pi}}{aK}$. Then, there is a unique Bayesian Nash Equilibrium in which all banks lend to operating firms if they observe a signal above x^* and withdraw from lending if they observe a signal below x^*. Investment projects then succeed if, and only if, the fundamentals are above the threshold θ^*, between $b - aK$ and b, which is characterized by the following equation:

$$\theta^* = b - aK + aK\Phi\left(\frac{\tau_\theta}{\sqrt{\tau_p}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_p}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right), \quad (2)$$

where $\Phi(\cdot)$ is the cumulative distribution function for the standard normal.

Remarks:

(i) *Intuition:* Due to strategic complementarities, when banks do not know with high enough probability that the fundamentals are below $b - aK$ or above b, they do not have a dominant action to choose.

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[4] The idea that when below a threshold $b - aK$, lending to all firms would be unprofitable, applies more naturally if we think of our model as a description of a segment of the economy, rather than the economy as a whole.

In this case, they simply want to do what other banks do. In a model with common knowledge about the fundamental θ, this would result in multiple equilibria. The assumption that banks observe slightly noisy information about θ, combined with the presence of extreme regions where they have dominant actions, pins down the threshold equilibrium characterized by Equation (2) as the unique equilibrium. 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 and guarantees a range of signals below the upper dominance region, where banks choose to lend. Similarly, due in part 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-games techniques demonstrates that this procedure exactly separates the real line, so that banks lend above x^* and do not lend below it, which, in turn, leads to the success (failure) of real projects above (below) θ^*.

The condition in the proposition states that the private signals that banks observe are sufficiently precise, relative to their prior information. This is important for the above logic, as it guarantees that they place a large enough weight on their private information. In the remainder of the article, we assume that this condition holds. For tractability, in a large part of the analysis, we will consider the limit as the precision of banks' private signals approaches infinity, where the condition clearly holds.[5]

(ii) *The No-lending Threshold:* Equation (2) characterizes the threshold fundamental θ^* below which investment projects fail. To gain some intuition for what determines this threshold, it is useful to consider the limit, as banks' private signals become infinitely precise, i.e., as τ_ρ approaches infinity. In this case, x^* and θ^* converge to the same value, which is given by

$$\theta^* = b - aK + aK\frac{1+r}{1+R}. \tag{3}$$

Intuitively, a bank observing the signal θ^* is indifferent between lending to operating firms and investing in the risk-free asset under the belief that the proportion of other banks lending to operating firms is uniformly distributed between 0 and 1.[6] This implies that lending to

[5] It is known in the literature that even when the condition does not hold, comparative statics analysis can still be conducted considering the extreme equilibria. See Vives (2010).

[6] The rationale behind the uniform-distribution belief is that each 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.

operating firms will be profitable with probability $\left(1-\frac{b-\theta^*}{aK}\right)$, which yields the following indifference equation:

$$1+r=\left(1-\frac{b-\theta^*}{aK}\right)(1+R).$$

Rearranging this equation, we get Equation (3).

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 no-lending equilibrium.

(iii) *Efficient and Inefficient No-lending Equilibria:* When macroeconomic fundamentals are so bleak that we are below $b-aK$, the refusal of banks to lend is efficient because firms' projects will not produce payoffs that exceed the economy's riskless rate even if no banks withdraw from the lending market. When fundamentals lie between $b-aK$ and θ^*, the economy is in an inefficient no-lending equilibrium. In this interval, banks withdraw from lending even though, were banks all willing to lend, firms' projects would produce returns that exceed the riskless rate and the banks would all be better off, relative to the no-lending equilibrium. We refer to such an inefficient equilibrium as a *credit freeze*.

(iv) *Credit Freezes as a Coordination Failure*: When fundamentals lie between $b-aK$ and θ^*, the credit freeze can be viewed as having been caused by coordination failure. Here, banks do not lend to operating firms because they fear that other banks will not lend to operating firms. The fundamentals uniquely determine banks' expectations with regard to what other banks are going to do and thus (indirectly) uniquely determine whether a credit freeze will arise; however, the credit freeze is still inefficient. If the banks could have collectively concluded on an enforceable agreement on how they would act, they would have agreed on a coordinated strategy of lending to firms. However, as long as the banks separately make their decisions, based on their expectations on how other banks will act, inefficient credit freeze equilibrium may ensue. Interestingly, this inefficiency could have been avoided if the available capital was held by one large bank (or a few large banks) instead of many small ones. Thus, from the point of view of avoiding coordination failures, large financial institutions may be an advantage.

(v) *Credit Freeze and Deterioration in Fundamentals*: The above analysis indicates that an economy may fall into a credit freeze when fundamentals worsen, even if the fundamentals do not worsen to the point that not lending would be efficient in the absence of coordination failures. We note that the credit crunch of 2008–2009 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.

2.2 Can a reduction in banks' capital trigger a credit freeze?

The credit crunch of 2008–2009 was preceded by deteriorating macroeconomic fundamentals and a deterioration in the capital positions of financial institutions, resulting from losses in real estate mortgage assets. This subsection examines whether a reduction in the banks' capital can trigger a credit freeze, even holding the fundamental θ constant.

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 in part to bad past investments. For the simplicity of exposition, we assume that capital has been uniformly lost across banks, i.e., each bank in the economy lost a fraction l of its capital. With the introduction of this parameter into the model, the capital of a single bank $(1-l)$ no longer suffices in the financing of 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; hence, $L = n(1-l)K$.

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, investment projects succeed if, and only if, the fundamentals are above the threshold $\theta^*(l)$. The threshold $\theta^*(l)$ is characterized by the following equation:

$$\theta^* = b - aK(1-l) + aK(1-l)\Phi \times \left(\frac{\tau_\theta}{\sqrt{\tau_\rho}} \left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_\rho}}{\tau_\theta} \Phi^{-1} \left(\frac{1+r}{1+R} \right) \right) \right). \quad (4)$$

(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.

Remarks:

(i) *Intuition*: The result of proposition 2 indicates that a reduction in the banking sector's capital raises the threshold below that which banks elect to withdraw from lending. The intuition behind the result of this proposition is as follows: A reduction in the banking sector's capital makes each bank "less sure" that other banks will provide to operating firms enough capital needed to guarantee an adequate return from extending such loans to the 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 about the choice of providing credit to operating companies or investing in the riskless asset, which leads to an increase in the threshold θ^* and thus, in turn, leads to a larger range of fundamentals in 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. It is important to stress that operating firms are less likely to receive financing because of the direct and indirect effects that a reduction in capital has on lending. The direct effect is that some capital that could have been available for loans is no longer in place, while the indirect effect is that, as our result identifies, it might even deprive operating firms of the capital that remains in place. By influencing banks' expectations as to the number of operating firms that will be able to obtain financing, the disappearance of some capital can make banks more reluctant to lend the capital that still remains.

2.3 Empirical implications and predictions

The theoretical analysis of this section has shown how strategic complementarities and coordination failures can exacerbate problems that are the result of deteriorating fundamentals or a shock to banks' capital. Such strategic complementarities and coordination failures, we have shown, can lead banks to avoid lending out of their self-fulfilling fear that other banks will not lend. The insights generated by this analysis have empirical implications that can inform and guide future empirical work on economic and financial crises. Such work should seek to identify the role that strategic complementarities and coordination failures play.

In doing so, such work can build on recent empirical work that identifies the role of strategic complementarities and coordination failures in related contexts (see Goldstein 2011 for a recent review of the challenges in identifying such factors and how these challenges can be overcome). In particular, Chen, Goldstein, and Jiang (2010) identify the effect of strategic complementarities in outflows from mutual funds by showing that the sensitivity of outflows to bad performance is stronger in funds that exhibit stronger strategic complementarities. Hertzberg, Liberti, and Paravisini (2011) use a natural experiment from Argentina and show that the release of public information makes banks react to information they already had because they essentially expect other banks to react to it.

In the context we analyze, one expects strategic complementarities to be more prominent among firms whose prospects are more dependent on the prospect of other affected firms. Thus, our model predicts that, for any given deterioration in fundamental or any given reduction in banks' capital, the decline in borrowing and investment within an industry, sector, region, or economy is expected to be more severe in cases where firms' prospects are more dependent on the success of other affected firms. This will be the case, e.g., when firms trade more with each other or they have a dependence on their region or industry's infrastructure.

In addition, our analysis predicts that credit contractions can be expected to be influenced by the presence of circumstances that make coordination failures in the banking sector more likely. In particular, for any given shock to the banking system's capital, and other things equal, firms are less likely to suffer from a credit contraction when the banking sector on which they depend for financing is more concentrated (and thus less likely to be afflicted by coordination failures). Furthermore, our model shows why and when the release of information about capital problems to competing banks can affect the lending decisions of banks whose capital is not impacted.

The above predictions can be tested with data from the recent financial crisis, as well as data from other credit freeze episodes, such as the Great Depression, Japan's financial crisis in the 1990s, or other local events of shocks to bank capital. There is a substantial amount of work on borrowing and investments during such episodes, and our model can inform and guide such work.

For example, a substantial amount of ongoing empirical research focuses on how capital shocks affect banks' lending decisions in various episodes (see, e.g., Paravisini 2008; Schnabl 2011). Other papers in this literature focus on how shocks to banks' capital affect the market valuations, profits, and capital expenditures of firms that depend on these sources of capital (see, e.g., Lemmon and Roberts 2010; Chava and Purnanandam 2011). Recently, there has been a surge of papers in this literature that focuses on the recent credit freeze and demonstrates the effects of shocks to capital on firms' borrowing and investments (see, e.g., Almeida et al. 2010; Ivashina and Scharfstein 2010; Santos 2011). Our theoretical analysis suggests new dimensions for empirical investigation in this literature. In particular, data collected for such work can be used to test predictions that the effects on lending from the reduction in bank capital were more severe in sectors, types of firms, or geographical regions where firms' prospects were affected by network externalities and served by a large number of different banks. The results can shed light on the channel through which shocks to bank capital affected lending and investments.

To see how our model can potentially enrich empirical analysis in this literature, consider the recent paper by Paravisini et al. (2011). They show that a shock to the capital of certain banks in Peru led to a decrease in export by the firms in their dataset but that the effect was modest in magnitude. Our analysis suggests that the effect of a capital shock to Peruvian banks on the exporting activities of firms served by the banks may be smaller than the effect on sales to domestic firms. Because domestic firms—not foreign buyers—can be dependent on receiving lending from the Peruvian banks, banks that lend to exporting firms are subject to weaker strategic complementarities than are banks that lend to firms that produce for domestic sales. Thus, our model suggests that the effect identified by the authors might understate the effect of the shock to the Peruvian banks' capital on the firms served by these banks and suggests an examination of whether firms producing for the domestic market were more strongly affected than were firms engaged in exporting. Such predictions could be tested in any dataset where there are data available about both global and local sales.

Our model generates predictions across firms and sectors within a given economy, i.e., predictions that compare the effects of a banking crisis on different firms or sectors within an economy, and also across economies, i.e., predictions that concern the question of how economies will fare following a banking crisis. These predictions can be tested using datasets, such as that of Reinhart and Rogoff (2008), of the numerous financial crises taking place over time and around the world. Our model suggests that, for any given shock to its banking system, credit in the economy will contract less and recovery will be faster and less difficult when a large fraction of the economy's firms do not depend on the economy's other firms (say, because they export their products and services) and when the banking sector is more concentrated.

Finally, another route available for empirically assessing the importance of strategic complementarities and coordination failures would be to embed our model in a more elaborate macroeconomic model that could be calibrated and used to tell whether a crisis can be fully accounted for by a fundamental shock. This is a challenging task for future research.

Overall, our model highlights the need for and value of empirical research that identifies the role of strategic complementarities and coordination failures during the recent crisis and prior crises. We note that some of the responses to the recent crisis from governments around the world (including some of those analyzed in Section 3) seem to reflect a belief that the contraction in lending was not fully justified by fundamentals. Indeed, a recent paper by Tong and Wei (2011) shows that governmental policies in the recent crisis had a positive effect on firms, and similar evidence for the crisis in Japan is provided by Giannetti and Simonov (2009). The evidence in these papers is consistent with our analysis. We now turn to analyze such governmental policies and their effect in our model.

3. Government Policy

The focus of our article is on analyzing and comparing various government policies intended to reduce the inefficiency from credit freeze equilibria. This analysis, building on the setup and equilibrium analysis of the preceding two sections, is provided in this section.

3.1 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. In a series of moves, the Federal Reserve Board considerably cut the federal rate, bringing the federal funds rate down from 4.25% in January 2008 to 1% in October 2008. Similar steps were also taken by other central banks around the world. In October 2008, e.g., in the face of a worldwide contraction in lending, twenty-one countries around the world, including the United States and the United Kingdom, simultaneously cut interest rates.

Under normal market conditions, a cut in a country's interest rate can be expected to spur lending. However, to what extent can a cut in interest rate be relied upon to eliminate a coordination failure that results in inefficient credit freeze equilibrium? As we show below, a cut in interest rate (i.e., reducing r) may—but does not have to— produce a credit thaw. The proposition that follows summarizes the results.

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 that 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.

Remarks:

(i) *The Reduction in the Likelihood of Credit Freeze*: A reduction in r makes investment in the riskless asset less attractive and thus lowers the expected return that is necessary to induce banks to lend to operating firms. This, in turn, lowers the threshold θ^* above that 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 a 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.

(ii) *Empirical Implications:* This indirect effect is expected to be stronger in cases of stronger strategic complementarities. In the previous section, we provided examples of situations in which strategic complementarities are expected to be stronger. Future empirical research can test the differential effect of interest-rate cuts across sectors and geographical areas, with different degrees of strategic complementarities.

(iii) *Policy Implications—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 to 0 (or to a very low level that is just above zero), θ^* will remain above $b - aK(1 - l)$, which implies that inefficient credit freezes may occur in the interval between $b - aK(1 - l)$ 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 and banks expect other banks not to lend to operating firms, the banks will prefer to invest in riskless assets rather than lend the available capital to operating firms. Thus, while a 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 that is discussed in monetary economics.

3.2 Infusion of capital into the banking system

During the 2008–2009 financial crisis, governments around the world infused very large amounts of capital into banks in order to shore up banks' capital positions, which had eroded due in part to losses from real estate mortgage assets and other investments. In the fall of 2008, e.g., the U.S. Troubled Asset Relief Program (TARP) provided about US$250 billion in capital to banks, and the United Kingdom invested about US$90 billion in several major banks.

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 situations in which depositors seek to withdraw their deposits en masse from a bank. When a solvent bank faces the problem of a bank run, providing the bank with capital through infusion may ensure to the bank's depositors that their money is safe and ultimately 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 that such banks can meet their obligations to depositors is necessary in order to prevent a contagion effect that would lead to runs by depositors on other banks.

The subject we examine with our model is different because it does not involve potential runs by depositors on banks (or, more generally, financial institutions). Rather, it is the banks that may "run on the economy" by not extending loans to operating firms. Therefore, in our context, 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 straightforward 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, that will not normally elect to lend in the absence of a capital infusion, to lend the capital they already have.

To analyze the effect of 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 $Z = \alpha l K$ that enables it to inject a proportion α of the lost capital l to all banks in the economy. If the government injects the capital, then each bank will have a total capital of $1 - (1 - \alpha)l$.

Banks will again make the decision of whether to lend to operating firms or invest in the riskless asset. The first option yields a gross return of $1 + R$ if firms' investment projects succeed. Success happens as long as the proportion of banks lending to firms is above $\frac{b-\theta}{a(1-(1-\alpha)l)K}$, while the second option yields a certain gross return of $1 + r$. To focus on capital infusion, we will assume from now on that $r = 0$, so that the government has already reduced the interest rate as much as possible. The proposition that follows analyzes the effect of injecting capital into the banking system.

Proposition 4.

(a) The threshold θ^*, below that which a credit freeze occurs when the government covers proportion α of bank losses, is implicitly determined by

$$\theta^* = b - aK(1 - (1 - \alpha)l) + aK(1 - (1 - \alpha)l) \times \Phi\left(\frac{\tau_\theta}{\sqrt{\tau_\rho}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_\rho}}{\tau_\theta}\Phi^{-1}\left(\frac{1}{1+R}\right)\right)\right). \quad (5)$$

(b) The threshold θ^* decreases in α. Yet, for every $\alpha \leq 1$, there are realizations of the fundamental θ at which an inefficient credit freeze will occur.

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 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. Importantly, the effect of capital infusion is not merely due to the fact that the government's capital flows to operating firms; rather, it is mostly caused by the fact that the availability of this capital makes banks more likely to lend capital that they already have. This is thus the mechanism behind the effect of TARP if the underlying problem was indeed a coordination problem.

(ii) *Empirical Implications:* Recent empirical research has documented the real effects of the provision of government capital to banks (see Giannetti and Simonov 2009; Tong and Wei 2011). The fact that they find a positive effect suggests that there was an underlying inefficiency that the government was able to correct. This is consistent with our model. A sharper test of our model should analyze the differential effect across different industries or geographical areas, with different degrees of strategic complementarities (that could be measured as we suggested in Section 2). Related to this, an important policy implication of our article is that the government can achieve better results by intervening in sectors where strategic complementarities and coordination failures are most prevalent.

(iii) *Policy Implications—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 the capital that they have for lending purposes. Hence, capital infusion might not be sufficient to eliminate an inefficient credit market freeze.

3.3 Direct lending to operating firms

As previously explained, the difficulty faced by the government, in breaking a credit freeze through providing capital to banks, is that banks might take the capital and not lend it to operating firms due in part to the fear that other banks will not lend. An alternative to having the government provide capital to banks is for the government to forgo the intermediation by banks and lend directly to operating firms. This approach could be viewed as extending the government's role as a lender of last resort from the financial sector to the nonfinancial sector. During the financial crisis of 2008–2009, governments provided some direct financing to operating firms. In the United States, e.g., the government made an unprecedented entry into the market for commercial paper and purchased the commercial paper of some nonfinancial firms.

While such an approach avoids the coordination problems that might impede banks from lending, it suffers from a disadvantage because the government does not have the ability that banks have in screening operating firms. Thus, if the government were to extend capital to firms without using the intermediation services of banks, such a move would lead the government to lending to some firms that have bad projects and should not get financing.

To formally examine the efficiency of direct lending, we have to explicitly describe bad operating firms within our model. 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 $Z = \alpha l K$ (as in Section 3.2) and has to decide whether to directly inject the capital in to operating firms or in to the banks. 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 firms (as firms with bad projects do purchase inputs from other firms, etc.); 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.

We begin the analysis by comparing the likelihood of a credit freeze under direct lending to operating firms versus under infusion of capital in to banks. The result is summarized in the proposition that follows.

Proposition 5. If the government directly lends $\alpha l K$ to operating firms, there is a credit freeze equilibrium if, and only if, the fundamental θ is below the threshold θ^*, which is implicitly defined by

$$\theta^* = b - aK(1-(1-\alpha)l) + aK(1-l) \times \Phi\left(\frac{\tau_\theta}{\sqrt{\tau_\rho}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta+\tau_\rho}}{\tau_\theta}\Phi^{-1}\left(\frac{1}{1+R}\right)\right)\right). \quad (6)$$

Denoting the threshold under capital injection in to banks (defined in Equation (5)) as θ^*_{Bank} and the one under direct lending to firms (defined in Equation (6)) as θ^*_{Direct}, we get that for every α and l, $\theta^*_{Bank} > \theta^*_{Direct}$, which implies that the probability of a credit freeze is higher under capital injection to banks than it is under direct lending to operating firms.

Remark: The intuition behind the question of why directly lending the government's capital reduces the lending threshold more than it does by infusing the capital into banks is simple. When the government injects capital in to banks, some of this capital might remain "stuck" in the banking system, as banks fail to coordinate in lending the capital 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, directly lending to operating firms more effectively increases a bank's return from lending, encouraging banks to lend, and thus creating a situation that is more likely to bring the economy to a credit thaw.

Focusing attention on the limit case, where banks' private signals become infinitely precise, i.e., as τ_ρ approaches infinity, the comparison between the two cases becomes very transparent. Following Equation (3), we can express the thresholds under the two regimes in the limit case as

$$\theta^*_{Bank} = b - aK(1-(1-\alpha)l) + aK(1-(1-\alpha)l)\frac{1}{1+R} \tag{7}$$

$$\theta^*_{Direct} = b - aK(1-(1-\alpha)l) + aK(1-l)\frac{1}{1+R}. \tag{8}$$

Equations (7) and (8) clearly reveal that $\theta^*_{Bank} > \theta^*_{Direct}$.

But, as previously noted, the fact that direct lending is more likely to generate a credit thaw is not enough to make this policy measure more efficient. We now carry out a full comparison between the two measures. For a sharp comparison, we focus attention on the limit case just described. This is easier to work with because at the limit either all banks lend or none of them do, and we do not have to consider cases where some banks lend but projects fail and vice versa. The following proposition characterizes which policy ends up producing better results for different levels of the fundamentals.

Proposition 6.

(a) When the fundamental θ is below θ^*_{Direct} or above θ^*_{Bank}, the overall wealth in the economy is higher under injection of capital in to the banking system than it is under direct lending to operating firms.
(b) 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 and/or small R, the wealth is higher under injection of capital in to the banking system.
(c) Ex ante, when choosing the policy, the government should choose to inject capital in to the banking system when β is sufficiently high, R is sufficiently low, and y is either sufficiently high or sufficiently low (i.e., outside an intermediate range).

Remarks:

(i) *When θ Is Below θ^*_{Direct} or Above θ^*_{Bank}*: In these circumstances, direct lending is clearly undesirable, as it does not turn a credit freeze into a thaw but still generates the costs of lending by the government. In particular, when θ is above θ^*_{Bank}, a credit thaw is produced under both policies but direct lending involves lending money to bad borrowers. When θ is below θ^*_{Direct}, there is a credit freeze under both policies but direct lending involves lending to bad borrowers and also to good borrowers, whose projects fail because there is a credit freeze.

(ii) *When θ Is Between θ^*_{Direct} and θ^*_{Bank}*: In these circumstances, infusion of capital into the banks will fail to induce banks to lend efficiently. Accordingly, direct lending by the government will have two benefits: First, it will provide financing to some operating firms with good projects; and second, 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—i.e., when the government's screening ability is sufficiently poor—this cost of a direct lending program may make it overall undesirable. The same is true when the return on successful good projects R is sufficiently low.

(iii) *Ex Ante Choice Between the Two Policy Measures*: As previously noted, the government does not know the realization of θ. Hence, it should make its decision between the two policy measures based on the characterization previously provided regarding what will happen for different realizations of θ and on the prior distribution of θ. Clearly, based on the previous, we can see that for sufficiently high β and/or low R, the government should not choose direct lending. In addition, y—the mean of the fundamentals, which can be interpreted as public news—matters for the decision. Given that direct lending may only be desirable at an intermediate range of the fundamentals, the government should not choose it when y is either too high or too low, only when it is in an intermediate range.

This result can be tied to the policy debate that arose in the recent crisis, regarding the question of whether the government should bail out *Wall Street* or *Main Street*. Infusing money to banks can be interpreted as helping Wall Street, while lending directly to operating firms can be interpreted as helping Main Street. Our results suggest that the latter is desirable when public news about the fundamentals of the economy is in some intermediate range and is not desirable when it is too bad or too good.

(iv) *Empirical Implications:* The previous analysis can inform future empirical work. To the extent that governments are sophisticated and follow the optimal course of intervention, our model predicts that they will provide capital to banks when the fundamentals are either low or high and to operating firms when the fundamentals are intermediate. In the past, such predictions have been difficult to test because government interventions in lending markets were not very common. However, the recent dataset collected by Tong and Wei (2011) that covers the interventions in various countries and industries during the recent crisis can be potentially extended to considering the determinants of the type of intervention.

(v) *The Case in Which Only Operating Firms with Good Projects Have Beneficial Spillover Effects*: Finally, we remind the reader that our analysis 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 spillover 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.

Formally, 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 that which a credit freeze occurs in a regime of direct lending, would change from Equation (8) to the following (for simplicity, we consider the limit again):

$$\theta^*_{Direct} = b - aK(1 - (1 - \alpha(1 - \beta))l) + aK(1 - l)\frac{1}{1 + R}. \quad (9)$$

Clearly, this would increase the likelihood of a credit freeze under direct lending, making this regime less desirable overall.

3.4 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 versus bad projects. Accordingly, a direct lending program could be beneficial if it were designed to utilize the expertise of private parties to screen operating firms in order to determine good projects from bad projects.

Consider the mechanism that follows. The government places the capital $Z = \alpha l K$ in a number of funds that are managed by banks or by other private agents that have the same expertise. The managers of the funds will be paid a proportion γ on any profit that they generate on the capital invested by the fund they manage, i.e., the excess of the return they generate over the riskless return. However, like hedge fund managers, they will not bear any share of the losses generated, if any, and such losses will be borne by the government.[7] The following proposition characterizes the consequences of this mechanism.

Proposition 7.

(a) If the government invests $Z = \alpha l K$ in funds dedicated to lending to operating firms and managed by private agents who are 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 (6).

(b) Consider the case where τ_ρ approaches infinity: Compared with infusing the capital Z into banks, the setting of government funds proposed here 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 (iii) produce a lower total wealth if θ is lower than θ^*_{Direct}.

(c) Ex ante, when choosing the policy, the government should choose to inject capital in to the banking system, rather than place it with private funds, when R is sufficiently low and y is sufficiently low.

Remarks:

(i) *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.

(ii) *The Effect on Banks' Lending Threshold*: Because the government funds program, like the direct lending program, will ensure that an amount of $Z = \alpha l K$ will be lent to operating firms, the threshold for banks' lending to operating firms will be the same as the threshold that, defined in Equation (6), would result from the direct lending program under the assumption that all operating firms have positive externalities for other operating firms.

(iii) *Comparison with the Direct-lending Program*: Relative to the direct-lending program, the government funds mechanism has the advantage

[7] 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, 2009) for the government's purchase of troubled assets through funds using government funds and run by private agents compensated with a cut of the profits generated by the funds.

of not involving loans to operating firms with bad projects; as a result, the government funds program performs better in a comparison with 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 even funding good operating firms is inefficient (because not enough of them are being funded).

(iv) *Comparison with Infusion of Capital into Banks:* In circumstances in which θ exceeds θ^*_{Bank}, where infusion of capital will be sufficient to produce a credit thaw, the government funds mechanism will perform neither better nor worse than will the 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 does capital infusion into banks because it 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 the infusion of capital in to banks. In these circumstances, the 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 banks 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.

(v) *Ex Ante Choice Between the Two Policy Measures*: Given that the government funds mechanism is only worse than the infusion of capital to banks when the fundamental is relatively low, the government would prefer injecting capital in to banks only when y—its prior expectation about the fundamental—is sufficiently low.

3.5 Government guarantees

The problem with the mechanisms discussed in the previous two sections is that they create excessive waste by having capital lent to operating firms when their projects fail. Under direct lending by the government (Section 3.3), the problem is most severe because the government, who is uninformed about borrowers' type, blindly lends to firms that have no access to potentially successful projects. Under privately managed government funds (Section 3.4), the government uses the expertise of private agents in avoiding bad borrowers but the incentives for private agents to lend are so strong that they lend even in a credit freeze when good projects fail because of the lack of lending by banks. We consider now an alternative mechanism that attempts to encourage lending without wasting government resources. Here, the government provides banks with guarantees in case their loans to operating firms fail. During the financial crisis of 2008–2009, governments, such as those of the United States and the United Kingdom, used the mechanism of guarantees, though they primarily used it (as in the case of Citigroup) to limit the potential losses of banks on existing loan portfolios. In contrast, our focus is now on encouraging new lending by providing guarantees that limit the losses incurred from new loan portfolios.

Specifically, suppose that the government guarantees a proportion δ of a bank's losses. In this case, a lending bank will receive the return $1+R$ when projects succeed and $\delta < 1$ when projects fail. The following proposition characterizes the consequences of using this mechanism.

Proposition 8.

(a) Suppose that the government provides a guarantee to cover a proportion δ (between 0 and 1) of banks' losses, i.e., the government pays δ when a bank lends and real projects fail. Then, the threshold θ^*, below which a credit freeze occurs, is given by

$$\theta^* = b - aK(1-l) + aK(1-l) \times \Phi\left(\frac{\tau_\theta}{\sqrt{\tau_\rho}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta+\tau_\rho}}{\tau_\theta}\Phi^{-1}\left(\frac{1-\delta}{1+R-\delta}\right)\right)\right), \quad (10)$$

which is decreasing in δ.

(b) At the limit, as τ_ρ approaches infinity, the threshold (denoted as $\theta^*_{Guarantees}$) is given by

$$\theta^*_{Guarantees} = b - aK(1-l) + aK(1-l)\frac{1-\delta}{1+R-\delta}. \quad (11)$$

Then, when the government provides full guarantees ($\delta = 1$), all banks lend and projects fail only when they are inefficient ($\theta < b - aK(1-l)$). Otherwise, banks do not always lend and projects sometimes fail even though they are efficient ($\theta > b - aK(1-l)$).

Remarks:

(i) *The Nature of the Mechanism:* Government guarantees reduce the threshold below that in which crises occur, since they make it more attractive for banks to lend. Considering the case where banks' signals are very precise (consider the limit case of part (b)), the attraction in this mechanism is that the government essentially does not need to provide any capital. Above $\theta^*_{Guarantees}$, where banks lend, the government's guarantee of providing capital if loans fail is sufficient to get the economy out of a credit freeze. Hence, banks lend and loans do not fail, so the government does not need to provide the capital. Below $\theta^*_{Guarantees}$, where banks do not lend, there are no loans made, and hence no loans that fail. This implies that the government's guarantees again do not lead to any capital being spent. In sum, this mechanism leads to an improvement in the threshold below which a credit freeze occurs without any actual cost.

(ii) *Comparing This Mechanism with Previous Ones*: It is hard to provide a sharp comparison. Such comparison depends on the extent to which the guarantees can reduce the threshold θ^*. This, in turn, depends on the level of the guarantees δ. It would be tempting to conclude that the government should increase δ very close to 1,[8] but this is not so easy. While the mechanism does not lead to actual costs, its validity depends on the government's credibility in providing the guarantees. That is, banks have to believe that the government will indeed be able to pay back a proportion δ of the losses. Hence, there is a budget constraint in the background that has to be considered. The solution is for the government to increase δ (still below 1) until this budget constraint becomes binding. A reasonable case to consider is where the maximum guarantee provided by the government is equal to its available capital $Z = \alpha l K$. The maximum that the government will have to pay is when all banks lend and fail. This will cause a liability of $\delta(1-l)K$ and imply that δ cannot exceed $\frac{\alpha l}{(1-l)}$. The following proposition compares the government guarantees mechanism with the government funds mechanism (considered in the previous section) for this level of guarantees (assuming that $\frac{\alpha l}{(1-l)} < 1$, i.e., that the government's available capital is smaller than the capital left in the banking sector).

Proposition 9.

(a) Suppose that the government provides a guarantee $\delta = \frac{\alpha l}{(1-l)} < 1$ and that τ_ρ approaches infinity. Then, the threshold under the guarantee regime ($\theta^*_{Guarantees}$) is higher than it is under the funds regime (θ^*_{Direct}), which implies that the latter is a more effective method in preventing a credit freeze.

[8] There is a problem in setting $\delta = 1$ because at that level of guarantees, banks always lend and the government will have to bail them out sometime. Settings very close but still below 1 ensure that banks (which have infinitesimally precise signals) never lend when projects fail.

(b) Compared with the government funds regime, providing guarantees as proposed here will (i) produce a lower total wealth if θ exceeds $\theta^*_{Guarantees}$; (ii) produce a lower total wealth if θ is between θ^*_{Direct} and $\theta^*_{Guarantees}$; and (iii) produce a higher total wealth if θ is lower than θ^*_{Direct}.

(c) Ex ante, when choosing the policy, the government should choose to provide guarantees, rather than place capital with private funds, when y is sufficiently low.

Remark: The advantage of the guarantees regime over the funds regime is that it avoids the waste of government's capital when there is a credit freeze. This is because the government's capital does not get invested in the guarantees regime, while in the funds regime it gets invested in projects that end up failing because of coordination failure. The disadvantage, however, is that under the guarantees regime, there are more overall realizations of the fundamental with a credit freeze, since the government's investment is more efficient in breaking the coordination failure. Also, under a credit thaw in the guarantees regime, the government's capital does not get invested. Overall, government guarantees offer a better solution when y is relatively low. In that, the guarantees regime is closer to the injection of capital in to banks considered in Section 3.2. Direct comparison between the two (not reported here, for brevity) reveals that capital injection in to banks dominates the guarantees regime when $R > \delta$, while the guarantees regime may be preferred when $R < \delta$.

3.6 Government funds managed by private firms exposed to downside risk

In this section, we search for a mechanism that will combine the advantages of previously discussed mechanisms and thus achieve better results. Such a mechanism should make the government's capital available to the economy so as to incentivize banks to lend their capital above θ^*_{Direct} (like the mechanisms in Sections 3.3 and 3.4) and, at the same time, it should avoid lending the government's capital to bad projects or to good projects in a credit freeze (like the mechanisms in Sections 3.2 and 3.5).

Suppose that, like in Section 3.4, the government sets up a continuum $[0, K]$ of private funds, each one receiving αl of government capital, but unlike in that section the government imposes some downside risk on the managers of these funds. Assume, like in Section 3.4, that managers get $\gamma > 0$ on any dollar return they achieve above 1 but, unlike in Section 3.4, they are penalized by $c > 0$ on any dollar return they achieve below 1.

The mechanism examined in this section is similar to that of the Term Asset-Backed Securities Loan Facility (TALF) developed by U.S. authorities during the 2008–2009 crisis. Under this government program, public capital was provided to finance certain portfolios of new loans on a nonrecourse basis.

Under the terms of financing, the private manager was able to capture the upside in the event the loans turned out to be profitable and had to bear only part of the downside, with the remainder absorbed by the government's capital.

In the game we are now considering, there are effectively two types of players: banks and fund managers.[9] Banks face the same trade-off as before: If they lend to operating firms, they will get a net return of R if their projects succeed and -1 if they fail. For fund managers, lending to operating firms will yield a net return of γR if their projects succeed and $-c$ if they fail. The amount of capital managed by banks is $(1-l)K$, while the amount that is managed by the funds is αlK. Hence, denoting the proportion of banks that decide to lend to operating firms as n_B and the proportion of funds that decide to lend to operating firms as n_F, the mass of operating firms L that will receive lending is given by $L = n_B(1-l)K + n_F\alpha lK$.

The proposition that follows summarizes the equilibrium results under this policy mechanism.

Proposition 10.

(a) Suppose that the government invests $Z = \alpha lK$ in funds managed by private agents, who receive a proportion γ on any return they generate above 1 and a penalty of proportion c on any return they generate below 1, and consider the case where τ_ρ approaches infinity. Then, banks and funds will lend to (good) operating firms and projects will succeed when θ is above:

$$\theta^*_{RiskyFunds} = b - aK\left(\frac{R}{\frac{c}{\gamma}+R}\alpha l + \frac{R}{1+R}(1-l)\right). \tag{12}$$

(b) As the penalty c approaches 0, the threshold $\theta^*_{RiskyFunds}$ converges to θ^*_{Direct}, so the solution of setting privately managed government funds with downside risk dominates the solutions proposed in Sections 3.2–3.5.

Remarks:

(i) *Fund Managers' Incentive Structure*: Inspecting Equation (12), we can see that when the fundamental is at the threshold $\theta^*_{RiskyFunds}$, proportion $\frac{R}{1+R}$ of banks lend to operating firms. This is similar to the behavior

[9] Note that the same agent can act both as a bank and as a fund manager. His incentives to lend will be different between the two roles due to the compensation structure. Moreover, due in part to risk neutrality, lending decisions will be completely independent between the two roles; hence, we can effectively analyze the game as having two types of agents.

of banks in any of the previous mechanisms.[10] At the same time, the proportion of fund managers who lend when the fundamental is $\theta^*_{RiskyFunds}$ is $\frac{R}{\frac{c}{\gamma}+R}$. Hence, the ratio between the downside penalty c and the upside gain γ that fund managers are exposed to changes their incentive to lend relative to banks. Reducing this ratio makes fund managers more eager to lend, and this lowers the threshold $\theta^*_{RiskyFunds}$.

(ii) *Optimal Level of Downside Risk*: In general, there is a trade-off in setting the level of downside risk c (or more precisely, the ratio $\frac{c}{\gamma}$). Reducing the exposure of fund managers to downside risk makes credit freezes less likely but also increases the likelihood that fund managers will lend the government's capital to failing projects. Hence, reducing the downside risk gets us closer to the mechanisms discussed in Sections 3.3 and 3.4. Interestingly, in the limit of precise private information (as τ_ρ approaches infinity), it is optimal to set the downside risk to be infinitesimally small. Since fund managers have very precise information, they know almost surely when the economy is going to be in a credit freeze, and thus even a tiny downside risk is sufficient to deter them from lending in a credit freeze. At the same time, the incentive effect of cutting the downside risk to be infinitesimally small encourages banks to lend, so that the credit freeze threshold is pushed down to θ^*_{Direct}. Hence, in the limit of precise information, setting up government funds managed by private agents who are exposed to minimal downside risk emerges as the optimal solution combining the advantages of the mechanisms analyzed in previous sections. Away from the limit of precise private information, the cost of reducing downside risk is likely to have more effect, leading to an interim solution with regard to the optimal level of downside risk.[11]

(iii) *Equivalence to Direct Infusion with Certain Lending Commitment*: The key of the mechanism described here is that private agents with lending expertise get to lever up their profit from lending to operating firms by using government capital. An alternative way to achieve the same outcome is to have the government allocating its capital to banks under the condition that they lend this capital in addition to a

[10] This behavior stems from the fact that banks find it optimal to lend only if they think that the probability of success, i.e., the probability that the fundamental is above the threshold, is at least $\frac{1}{1+R}$, while at the threshold, the posterior probability that the fundamental is above the threshold is uniformly distributed across agents between 0 and 1.

[11] As is usually the case in global-games models, the expressions for the thresholds away from the limit do not lend themselves to tractable comparative-statics analysis (see the expression in the proof of Proposition 10).

certain specified amount of their own capital to operating firms. We analyzed this alternative mechanism and found that it can achieve the outcome in this section, no matter what the amount of banks' own capital that must be lent together with the government's capital. Essentially, increasing the amount required from banks ensures that more private money is lent when the government's money is lent but reduces banks' incentives to lend. These two effects cancel out with each other and always lead to the same outcome, which is the outcome in Proposition 10b. Details of this analysis are available upon request.

4. Concluding Remarks

This article develops a model of credit freezes that are inefficient but arise from the rational and self-fulfilling expectations of financial institutions. In this equilibrium, banks would be better off if they were all collectively 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 also avoid lending. Our model enables the identification of the circumstances in which an inefficient credit freeze can be expected to arise. In such circumstances, efficiency will be served by getting the economy out of the inefficient credit freeze equilibrium, and our model has been proven useful for studying and assessing government policies that can be considered for the purpose of doing so.

Our analysis shows that interest rate cuts and the infusion of capital into the financial sector can be expected to eliminate an inefficient credit freeze in certain circumstances but not in others. Even with ample capital and with low return on hoarded cash, banks may fail to 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, then governments may look beyond interest rate cuts and capital enhancement as a means of getting the economy out of the credit freeze.

Our analysis also provides a framework for analyzing supplemental or alternative measures, including ones used by authorities in the course of the recent financial crisis. While direct lending by the government to nonfinancial borrowers can address certain problems that result from coordination failure among banks, it forgoes the benefits that come from the expert screening of borrowers by private parties. We have accordingly analyzed mechanisms that harness the screening expertise of private agents and identified features that determine their effectiveness.

Another important policy implication is that the government may want to differentially intervene across different industries and geographical areas. In particular, the government's intervention is most powerful where strategic complementarities and coordination failures are most prevalent.

In addition to providing a framework for the assessment of policy responses with regard to credit contractions, our analysis also has substantial implications for empirical work. In particular, for any given deterioration in fundamentals or shocks to banks' capital, our model provides testable implications that concern the extent to which different firms, sectors, regions, and economies can be expected to suffer from credit contraction and the extent to which a given government intervention will spur lending. Future empirical work should investigate the role of strategic complementarities and coordination failures along the lines we have discussed.

On the theoretical side, our analysis opens several avenues for future research. Future work can further develop the policy implications in our article by exploring the optimal stake a bank should keep in its investment following government intervention (see Section 3.6). In addition, there is room for future work to extend our model and add other features that may shape government policies that are intended to fight credit freezes. For example, an important and additional element is the signaling role of government policy. If the government has information that is not available to financial institutions, it will consider how its steps will affect the beliefs that financial institutions have about the underlying state of the economy and the consequences this may have on the behavior of financial institutions.

Appendix

Proof of Proposition 1. The proof follows Morris and Shin (2004b). The arguments in their proof (which, for brevity, we don't repeat here) establish that there can only be a threshold equilibrium, where banks lend if, and only if, their signal is above some common x^*. Given this result, we now characterize the threshold equilibrium and show that it is unique.

Given x^*, there is a unique threshold fundamental θ^*, at which investment projects are on the margin between failure and success. This is given by

$$\theta^* = b - aK(1 - \Phi(\sqrt{\tau_\rho}(x^* - \theta^*))).$$

Here, $\Phi(\sqrt{\tau_\rho}(x^* - \theta^*))$ is the proportion of banks that receive a signal below x^* and hence withdraw from lending when the fundamental is exactly θ^*.

This gives us the first equation for the two unknowns x^* and θ^*. The second equation comes from the fact that at the threshold signal x^* a bank has to be indifferent in its decision to lend to firms or invest in the risk-free asset. When bank i observes signal x_i, his posterior distribution of θ is normal, with mean $\frac{\tau_\theta y + \tau_\rho x_i}{\tau_\theta + \theta_\rho}$ and precision $\tau_\theta + \tau_\rho$. He knows that lending to firms will yield $(1 + R)$ if, and only if, the fundamental is above θ^*, while not lending will yield $(1 + r)$, with certainty. The indifference condition is then given by

$$\left(1 - \Phi\left(\sqrt{\tau_\theta + \tau_\rho}\left(\theta^* - \frac{\tau_\theta y + \tau_\rho x^*}{\tau_\theta + \tau_\rho}\right)\right)\right)(1 + R) = 1 + r,$$

which can be developed as follows:

$$\theta^* - \frac{\tau_\theta y + \tau_\rho x^*}{\tau_\theta + \tau_\rho} = \frac{\Phi^{-1}\left(1 - \frac{1+r}{1+R}\right)}{\sqrt{\tau_\theta + \tau_\rho}},$$

leading to

$$\theta^* - x^* = \frac{-\tau_\theta(\theta^* - y)}{\tau_\rho} + \frac{\sqrt{\tau_\theta + \tau_\rho}\,\Phi^{-1}\left(1 - \frac{1+r}{1+R}\right)}{\tau_\rho}.$$

Plugging this in to the first equation, we get

$$\theta^* = b - aK\left(1 - \Phi\left(\sqrt{\tau_\rho}\left(\frac{\tau_\theta(\theta^* - y)}{\tau_\rho} - \frac{\sqrt{\tau_\theta + \tau_\rho}\,\Phi^{-1}\left(1 - \frac{1+r}{1+R}\right)}{\tau_\rho}\right)\right)\right),$$

which yields the equation in the proposition statement:

$$\theta^* = b - aK + aK\Phi\left(\frac{\tau_\theta}{\sqrt{\tau_\rho}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_\rho}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right).$$

The left-hand side is the 45-degree line with respect to θ^*, and the right-hand side is increasing in θ^* and is bounded between $b - aK$ and b. A unique solution for θ^* is guaranteed when the right-hand side has everywhere a slope of less than 1. The slope of the right-hand side is given by $aK\phi(\cdot)\frac{\tau_\theta}{\sqrt{\tau_\rho}}$, where $\phi(\cdot)$ is the density of the standard normal evaluated at the appropriate point. Since $\phi(\cdot) \leq \frac{1}{\sqrt{2\pi}}$, a sufficient condition for a unique solution is $\frac{\tau_\theta}{\sqrt{\tau_\rho}} \leq \frac{\sqrt{2\pi}}{aK}$. **QED** ■

Proof of Proposition 2. Proving the first part of the proposition is straightforward, given the proof of Proposition 1. The proof replaces K with $K(1-l)$ in order to reflect the fact that when a proportion n of the banks lend, only $nK(1-l)$ capital makes its way to operating firms. Note that the condition for uniqueness is now $\frac{\tau_\theta}{\sqrt{\tau_\rho}} \leq \frac{\sqrt{2\pi}}{aK(1-l)}$, which always holds when the condition in Proposition 1 holds.

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

$$F\left(\theta^*, l\right) = \theta^* - b + \alpha K\left(1-l\right)$$
$$-\alpha K\left(1-l\right)\Phi\left(\frac{\tau_\theta}{\sqrt{\tau_p}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_p}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right) = 0.$$

Then,

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

We know that

$$\frac{dF(\theta^*, l)}{dl} = -\alpha K\left(1 - \Phi\left(\frac{\tau_\theta}{\sqrt{\tau_p}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_p}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right)\right) \leq 0$$

$$\frac{dF(\theta^*, l)}{d\theta^*} = 1 - \alpha K\left(1-l\right)\frac{\tau_\theta}{\sqrt{\tau_p}}\Phi\left(\frac{\tau_\theta}{\sqrt{\tau_p}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_p}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right)$$

$$\geq 1 - \alpha K\left(1-l\right)\frac{\tau_\theta}{\sqrt{\tau_p}}\frac{1}{\sqrt{2\pi}} \geq 0.$$

It follows that $\frac{d\theta^*}{dl} \geq 0$. **QED** ■

Proof of Proposition 3. Proving the first part of the proposition is done using the implicit function theorem. Denote

$$F(\theta^*, r) = \theta^* - b + aK(1-l) -$$

$$aK(1-l)\Phi\left(\frac{\tau_\theta}{\sqrt{\tau_\rho}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta + \tau_\rho}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right) = 0.$$

Then,

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

Given that $\frac{dF(\theta^*,r)}{dr} \leq 0$ and $\frac{dF(\theta^*,r)}{d\theta^*} \geq 0$, it follows that $\frac{d\theta^*}{dr} \geq 0$.

Note that, given the capital available to banks $k(1-l)$, not lending to operating firms is efficient only when the fundamental θ is below $b - aK(1-l)$; this is why the second part holds. Since $\Phi\left(\frac{\tau_\theta}{\sqrt{\tau_\rho}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta+\tau_\rho}}{\tau_\theta}\Phi^{-1}\left(\frac{1+r}{1+R}\right)\right)\right) > 0$ (unless y approaches infinity), $\theta^* > b - aK(1-l)$. Hence, there is a range of fundamentals for which banks do not lend and projects fail, even though this is inefficient. **QED** ■

Proof of Proposition 4. The proof is analogous to the proof of Proposition 3 and is thus omitted. **QED** ■

Proof of Proposition 5. Equation (6) is based on the same principles that are behind the construction of equilibrium in Propositions 1 and 2. The only thing to note in Equation (6) is that all of the government's capital is lent and it generates the positive externality. Hence, investment projects fail when the proportion n of banks that decide to lend is below $\frac{b-\theta-aalK}{a(1-l)K}$. Having established Equation (6) and in comparing it with Equation (5) (using the implicit function theorem, as in Propositions 2 and 3), it is revealed that $\theta^*_{Bank} \geq \theta^*_{Direct}$. **QED** ■

Proof of Proposition 6. The overall wealth in the economy under injection of capital into the banking system is given by $(1-(1-\alpha)l)K$ when the economy is in a credit freeze and by $(1-(1-\alpha)l)K(1+R)$ when the economy is in a credit thaw.

The overall wealth in the economy under direct lending to operating firms is given by $(1-l)K$ when the economy is in a credit freeze and by $(1-l+\alpha l(1-\beta))K(1+R)$ when the economy is in a credit thaw. Note that in a credit thaw, the government cannot tell the difference between good and bad firms, so only $(1-\beta)$ of the projects financed by the government succeed. In a credit freeze, all the projects financed by the government fail, as even the good firms cannot succeed, given that too many of them do not receive financing (if this was not the case, then banks would lend and there would not be a credit freeze).

Based on these results, we now prove the different parts of the proposition.

(a) When the fundamental θ is below θ^*_{Direct}, we know that there is a credit freeze under both regimes. Then, since $(1-(1-\alpha)l)K > (1-l)K$, the wealth in the economy is higher under the infusion of capital into the banking system than it is under direct lending to firms. When the fundamental θ is above θ^*_{Bank}, there is a credit thaw under both regimes. Then, since $(1-(1-\alpha)l)K(1+R) > (1-l+\alpha l(1-\beta))K(1+R)$, the wealth in the economy is again higher under capital injection into banks than it is under direct lending to operating firms.

(b) 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: Capital injection into banks yields $(1-(1-\alpha)l)K$, and direct lending yields

$(1 - l + \alpha l(1-\beta))K(1+R)$. Overall, a high enough β and/or a small enough R makes capital injection better than does direct lending.

(c) For the choice of regime, the government should consider all possible realizations of θ, weighted by their prior probabilities and the difference in wealth they generate between the two policy measures. Based on the results above, the expected difference between wealth under capital injection and wealth under direct lending can be expressed as

$$\alpha l K \Phi\left(\frac{\theta^*_{Direct} - y}{\sigma_\theta}\right) + (\alpha\beta l - (1 - l + \alpha l(1-\beta))R)$$
$$\times K\left[\Phi\left(\frac{\theta^*_{Bank} - y}{\sigma_\theta}\right) - \Phi\left(\frac{\theta^*_{Direct} - y}{\sigma_\theta}\right)\right] + \alpha\beta l K(1+R)\left[1 - \Phi\left(\frac{\theta^*_{Bank} - y}{\sigma_\theta}\right)\right].$$

The statement in Proposition (6c) directly follows based on (6a) and (6b). **QED** ■

Proof of Proposition 7.

(a) When choosing whether to lend or not to lend the government's capital to operating firms, banks that manage the government's funds 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 it can be 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 and generates the threshold θ^*_{Direct} that is characterized in Equation (6). Finally, it is straightforward that banks lend to good firms and not to bad firms, since a positive return only comes from the former and banks can distinguish between the two types of firms.

(b) The second part of the proposition follows similar lines as those used in the proof of Proposition 6. The difference is that when the government sets private investment funds, as opposed to when it directly lends to operating firms, the government's capital does not go to bad firms. Hence, the overall wealth in the economy (when the government lends money via private funds) is given by $(1-l)K$, when the economy is in a credit freeze (here, the government's capital still gets wasted because even good firms fail to produce returns) and by $(1-(1-\alpha)l)K(1+R)$ when the economy is in a credit thaw. Then, in comparing this with the overall wealth levels under the infusion of capital in to the banks, we get the result stated in part (b) of the proposition.

(c) Based on the above results, the expected difference between wealth under capital injection in to banks and wealth under lending via private funds can be expressed as

$$\alpha l K \Phi\left(\frac{\theta^*_{Direct} - y}{\sigma_\theta}\right) - (1-(1-\alpha)\,l)\,RK\left[\Phi\left(\frac{\theta^*_{Bank} - y}{\sigma_\theta}\right) - \Phi\left(\frac{\theta^*_{Direct} - y}{\sigma_\theta}\right)\right].$$

The statement in (c) then directly follows. **QED** ■

Proof of Proposition 8. The proof follows similar steps to those in Propositions 1, 2, and 3. **QED** ■

Proof of Proposition 9.

(a) We need to show that

$$b - aK(1-(1-\alpha)l) + aK(1-l)\frac{1}{1+R} < b - aK(1-l) + aK(1-l)\frac{1-\delta}{1+R-\delta}.$$

This can be developed as follows:

$$-(1-(1-\alpha)l)+(1-l)\frac{1}{1+R} < -(1-l)+(1-l)\frac{1-\delta}{1+R-\delta}$$

$$-\alpha l+(1-l)\frac{1}{1+R} < (1-l)\frac{1-\delta}{1+R-\delta}$$

$$(1-l)\left(\frac{1+R-\delta-(1+R)(1-\delta)}{(1+R)(1+R-\delta)}\right) < \alpha l$$

$$\frac{\delta R}{(1+R)(1+R-\delta)} < \frac{\alpha l}{(1-l)}.$$

Plugging in $\delta=\frac{\alpha l}{(1-l)}$, we get

$$\begin{aligned} \mathrm{R} &< (1+R)(1+R-\delta) \\ 0 &< (1+R)(1-\delta)+R^2, \end{aligned}$$

which is always true.

(b) The government guarantees regime generates an overall wealth of $(1-(1-\alpha)l)K$ when the economy is in a credit freeze (here, the government's capital doesn't get wasted) and of $((1-l)(1+R)+\alpha l)K$ when the economy is in a credit thaw (here, the government's money doesn't get invested in the real projects). Then, in comparing this with the overall wealth levels under the government funds program (in Proposition 7), we get the result stated in part (b) of the proposition.

(c) Based on the results above, the expected difference between wealth under the funds regime and wealth under the guarantees regime can be expressed as

$$-\alpha l K\Phi\left(\frac{\theta^*_{Direct}-y}{\sigma_\theta}\right)+(1-(1-\alpha)l)RK$$
$$\times\left[\Phi\!\left(\frac{\theta^*_{Guarantees}-y}{\sigma_\theta}\right)-\Phi\!\left(\frac{\theta^*_{Direct}-y}{\sigma_\theta}\right)\right]+\alpha lRK\left[1-\Phi\!\left(\frac{\theta^*_{Guarantees}-y}{\sigma_\theta}\right)\right].$$

The statement in (c) then directly follows. **QED** ■

Proof of Proposition 10.

(a) Based on the results in the global-games literature (e.g., Goldstein and Pauzner 2004), the equilibrium will be characterized by two threshold signals: Banks will lend to operating firms if, and only if, their signal is above x^*_B, while fund managers will lend if, and only if, their signal is above x^*_F. Then, there would be a unique cutoff θ^*, such that projects fail below the cutoff and succeed above it. Extending the logic in the proof of Proposition 1, the three thresholds x^*_B, x^*_F, and θ^* are determined by the following three equations:

$$\theta^*=b-aK\Big((1-l)\Big(1-\Phi\Big(\sqrt{\tau_p}\,(x^*_B-\theta^*)\Big)\Big)+\alpha l\Big(1-\Phi\left(\sqrt{\tau_p}\,(x^*_B-\theta^*)\right)\Big)\Big),$$

$$\left(1-\Phi\left(\sqrt{\tau_\theta+\tau_p}\left(\theta^*-\frac{\tau_\theta y+\tau_p x^*_B}{\tau_\theta+\tau_p}\right)\right)\right)=\frac{1}{1+R},$$

$$\left(1-\Phi\left(\sqrt{\tau_\theta+\tau_p}\left(\theta^*-\frac{\tau_\theta y+\tau_p x^*_F}{\tau_\theta+\tau_p}\right)\right)\right)=\frac{\frac{c}{y}}{\frac{c}{y}+R}.$$

Then, θ^* is implicitly determined by the following equation:

$$\theta^* = b - aK \begin{pmatrix} (1-l)\left(1 - \Phi\left(\frac{\tau_\theta}{\sqrt{\tau_p}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta+\tau_p}}{\tau_\theta}\Phi^{-1}\left(\frac{1}{1+R}\right)\right)\right)\right) \\ +\alpha l\left(1 - \Phi\left(\frac{\tau_\theta}{\sqrt{\tau_p}}\left(\theta^* - y + \frac{\sqrt{\tau_\theta+\tau_p}}{\tau_\theta}\Phi^{-1}\left(\frac{\frac{c}{y}}{\frac{c}{y}+R}\right)\right)\right)\right) \end{pmatrix}.$$

In the limit of precise information, denoting the threshold as $\theta^*_{RiskyFunds}$, we get

$$\theta^*_{RiskeyFunds} = b - aK\left(\frac{R}{\frac{c}{y}+R}\alpha l + \frac{R}{1+R}(1-l)\right).$$

(b) From (8) and (12), it is clear that as c approaches 0, $\theta^*_{RiskyFunds}$ approaches θ^*_{Direct}. Then, because this mechanism achieves the lowest threshold for lending and does not have government funds lent to failing projects, it maximizes wealth. **QED** ■

References

Acharya, V., D. Gale, and T. Yorulmazer. 2011. Rollover Risk and Market Freezes. *Journal of Finance* 66: 1177–1209.

Allen, F., and D. Gale. 1998. Optimal Financial Crises. *Journal of Finance* 53:1245–84.

Almeida, H., M. Campello, B. Laranjeira, and S. Weisbenner. 2010. Corporate Debt Maturity and the Real Effects of the 2007 Credit Crisis. Working Paper, University of Illinois.

Bebchuk, L. 2008a. A Better Plan for Addressing the Financial Crisis. *Economists' Voice:* 5.

———. 2008b. Unfreezing Credit Markets. Discussion Paper No. 622, Harvard Law School, John M. Olin Center for Law and Economics.

———. 2009. Buying Troubled Assets. *Yale Journal on Regulation* 26:343–58.

Benmelech, E., and N. Bergman. 2009. Credit Traps. Working Paper, Harvard University.

Bernardo, A., and I. Welch. 2004. Liquidity and Financial Market Runs. *Quarterly Journal of Economics* 119:135–58.

Brunnermeier, M. 2009. Deciphering the Liquidity and Credit Crunch of 2007–08. *Journal of Economic Perspectives* 23:77–100.

Carlsson, H., and E. van Damme. 1993. Global Games and Equilibrium Selection. *Econometrica* 61:989–1018.

Chamley, C. 1999. Coordinating Regime Switches. *Quarterly Journal of Economics* 114:869–905.

Chava, S., and A. Purnanandam. 2011. The Effect of Banking Crisis on Bank-dependent Borrowers. *Journal of Financial Economics* 99:116–35.

Chen, Q., I. Goldstein, and W. Jiang. 2010. Payoff Complementarities and Financial Fragility: Evidence from Mutual Fund Outflows. *Journal of Financial Economics* 97:239–62.

Cooper, R., and A. John. 1988. Coordinating Coordination Failures in Keynesian Models. *Quarterly Journal of Economics* 103:441–63.

Corsetti, G., B. Guimaraes, and N. Roubini. 2006. International Lending of Last Resort and Moral Hazard: A Model of IMF's Catalytic Finance. *Journal of Monetary Economics* 53:441–71.

Diamond, D., and P. Dybvig. 1983. Bank Runs, Deposit Insurance, and Liquidity. *Journal of Political Economy* 91:401–19.

Diamond, D., and R. Rajan. 2011. Fear of Fire Sales, Illiquidity Seeking, and Credit Freezes. *Quarterly Journal of Economics* 126:557–91.

Giannetti, M., and A. Simonov. 2009. On the Real Effects of Bank Bailouts: Micro-evidence from Japan. Working Paper, Stockholm School of Economics.

Goldstein, I. Forthcoming 2011. Fundamentals or Panic: Lessons from the Empirical Literature on Financial Crises. In C. J. Caprio (ed.), *Encyclopedia of Financial Globalization*. Amsterdam: Elsevier.

Goldstein, I., and A. Pauzner. 2004. Contagion of Self-fulfilling Financial Crises Due to Diversification of Investment Portfolios. *Journal of Economic Theory* 119:151–83.

———. 2005. Demand Deposit Contracts and the Probability of Bank Runs. *Journal of Finance* 60:1293–328.

Hertzberg, A., J. M. Liberti, and D. Paravisini. 2011. Public Information and Coordination: Evidence from a Credit Registry Expansion. *Journal of Finance* 66:379–412.

Ivashina, V., and D. Scharfstein. 2010. Bank Lending During the Financial Crisis of 2008. *Journal of Financial Economics* 97:319–38.

Lemmon, M., and M. Roberts. 2010. The Response of Corporate Financing and Investment to Changes in the Supply of Credit. *Journal of Financial and Quantitative Analysis* 45:555–87.

Morris, S., and H. S. Shin. 1998. Unique Equilibrium in a Model of Self-fulfilling Currency Attacks. *American Economic Review* 88:587–97.

———. 2003. Global Games: Theory and Applications. In M. Dewatripont, L. P. Hansen, and S. J. Turnovsky (eds.), *Advances in Economics and Econometrics*. Cambridge, UK: Cambridge University Press.

———. 2004a. Liquidity Black Holes. *Review of Finance* 8:1–18.

———. 2004b. Coordination Risk and the Price of Debt. *European Economic Review* 48:133–53.

———. 2006. Catalytic Finance: When Does It Work? *Journal of international Economics* 70:161–77.

Paravisini, D. 2008. Local Bank Financial Constraints and Firm Access to External Finance. *Journal of Finance* 63:2161–93.

Paravisini, D., V. Rappoport, P. Schnabl, and D. Wolfenzon. Dissecting the Effect of Credit Supply on Trade: Evidence from Matched Credit-export Data. Working Paper, Columbia University.

Peck, J., and K. Shell. 2003. Equilibrium Bank Runs. *Journal of Political Economy* 111:103–23.

Philippon, T., and P. Schnabl. 2009. Efficient Recapitalization. Working Paper, New York University.

Reinhart, C. M., and K. S. Rogoff. 2008. Banking Crises: An Equal Opportunity Menace. Working Paper 14587, NBER.

Rochet, J. C., and X. Vives. 2004. Coordination Failures and the Lender of Last Resort: Was Bagehot Right After All? *Journal of the European Economic Association* 2:1116–47.

Sakovics, J., and J. Steiner. 2009. Who Matters in Coordination Problems? Working Paper, Northwestern University.

Santos, J. 2011. Bank Corporate Loan Pricing Following the Subprime Crisis. *Review of Financial Studies* 24:1916–43.

Schnabl, P. Forthcoming 2011. The International Transmission of Bank Liquidity Shocks: Evidence from an Emerging Market. *Journal of Finance*.

Tong, H., and S.-J. Wei. 2011. Did Unconventional Interventions Unfreeze the Credit Market? Some International Evidence. Working Paper, Columbia University.

Vives, X. 2010. Strategic Complementarity, Fragility, and Regulation. Working Paper, IESE.