

# **Lending Booms, Smart Bankers and Financial Crises**

**(Working Paper)**

by

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# Lending Booms, Smart Bankers and Financial Crises?

## Abstract

This paper develops a theory of financial crises that explains why crises should be expected to follow periods of sustained lending booms and high banking profitability. When the behavior of agents is affected by the availability heuristic and there is a long period of sustained banking profitability, *all* agents—banks as well as those who fund banks and those who regulate them—end up in an “availability cascade” in which they overestimate the skills of bankers in managing risks and underestimate the probability that the observed good outcomes are simply due to luck. All agents consequently become more tolerant of bank risk-taking, and banks invest in increasingly riskier assets. Further, as the number of banks entering this market grows, the liquidity of highly risky assets improves, making it more attractive for others to enter the market. The economy thus ends up with a large number of financial institutions investing in very risky assets that are traded in highly liquid markets. Subsequently, if some salient public signal reveals in some period that loan repayment probabilities are exogenous rather than skill-dependent, investors rush to withdraw funds, market liquidity dries up, and a crisis ensues. The model also explains why the economy may not recover even after the friction that precipitated the crisis has dissipated. Empirical predictions and policy implications of the analysis are discussed. The analysis suggests that the majority of regulations put in place in response to the crises of the last few decades, including the recent financial crisis, may do little to prevent future crises.

**Key words:** lending booms, availability heuristic, financial crises

**JEL classifications:** G21, G28

# Lending Booms, Smart Bankers and Financial Crises

*“Experience keeps a dear school, but fools will learn in no other”*

Benjamin Franklin

## I. INTRODUCTION

Boom and bust economic cycles have occurred throughout recorded history—although with a higher frequency in recent times—and financial crises typically follow economic booms with leverage-financed asset price bubbles (see Reinhart and Rogoff (2008), and Schularick and Taylor (2012)). Why do financial crises keep occurring, despite the increasing size of the economic rupture caused by each successive crisis? Given the significant economic disruption that is associated with financial crises<sup>1</sup> and the discernable *pre-crisis* conditions that seem to be recurring, there are three possibilities. One is that the economic benefits that are produced by the pre-crisis boom are valued sufficiently highly by society that the cost of the crisis that follows is considered an acceptable cost. The second possibility is that misaligned incentives lead to the pursuit of excessively risky growth by banks and lax oversight by regulators that permits such risk taking. The third is that we collectively do not engage in rational learning, so we experience a recurring pattern of events periodically, and the pattern culminates in a crisis.

While the first possibility is an intriguing one to ponder, the magnitude of the economic losses in the 2007-09 subprime crisis suggests that we should explore alternatives to an explanation based on a conscious collective choice to engage in or permit behavior that leads to an economic boom that will predictably be followed by a crisis. For example, Luttrell, Atkinson and Rosenblum (2013) estimate that the 2007-09 financial crisis cost the U.S. 40 to 90 percent of one year's output—a range of \$6 trillion to \$14 trillion.

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<sup>1</sup> See [Kupiec and Ramirez \(2013\)](#) for estimates of the costs of financial crises. See Luttrell, Atkinson and Rosenblum (2013) for an estimate of the cost of the 2007-09 subprime crisis to the U.S. economy.

The misaligned incentives story is perhaps the most popular explanation for crises. See, for example, Barth, Caprio and Levine (2012), Boot and Thakor (1993), Kane (1990), Stiglitz (2010), and Thakor (2014a). While conflicts of interest undeniably played a role in the most recent crisis and in previous crises, it is unlikely that these conflicts provide a complete story (see example, Lo (2012) on disagreement among experts on the causes of the subprime crisis). The conditions under which incentives become misaligned are, in most cases, identifiable *ex ante* and observable as well.<sup>2</sup> So one would think that the "watchdogs" of the financial system—regulators, rating agencies and investors—would take actions that would provide a more effective resolution of these conflicts and stave off a crisis.

This paper focuses on the third possibility and provides an explanation for financial crises in developed as well as developing economies that is based on a behavioral bias called the "availability heuristic" (Tversky and Kahneman (1973)). This is a behavioral bias induced by the propensity of individuals to take a mental shortcut that relies on immediate examples that come to mind in revising beliefs. That is, people often assess the probability of an event by the ease with which instances or occurrences can be remembered. Quite often, factors or events that individuals have been personally associated with become more salient in this recollection. And some events are perceived to be so unique that past history does not seem to be relevant to the evaluation of the likelihood of their occurrence. Tversky and Khaneman (1973) provide substantial experimental evidence in support of the existence of this bias in individuals.

In this paper I rely on this bias and argue that crises are caused by agents believing that outcomes are influenced by the *a priori* unknown skills of financial institutions in a setting in which there is a non-zero probability that these outcomes are actually purely exogenous.<sup>3</sup> This generates a particular form of

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<sup>2</sup> An example is the issuer-pays arrangement with credit ratings. Another example is the low capital level in many S&Ls prior to the S&L crisis in the 1980s.

<sup>3</sup> The reason for this may be that some agents are conditioning their beliefs based on observed compensation levels in banking, which may themselves be driven by beliefs about the importance of skills that are formed based on some memorable past experience that no longer applies. That is, they may observe banks hiring really smart people at high wages and also observe high profitability in banking, and arrive at a conclusion based on this correlation. I say more about this later.

bias in the revision of beliefs in that good outcomes lead to excess upward revision in beliefs about the skills of bankers. Thus, if there is a sufficiently long sequence of good outcomes, *all* agents—financial institutions as well as the investors who provide funding for these institutions—believe that there is a high likelihood that financial institutions are highly skilled and thus capable of managing risk. This then leads financial institutions and investors to underestimate the true risk in high-risk products, so many institutions rush in to invest in these high-return, high-risk products. In effect, risk is mispriced because risk-management ability is overestimated during such periods. The increased market entry resulting from this means that there are more institutions that are potential buyers of a bank’s loans; this provides enhanced liquidity to the market for high-risk assets and makes this market even more attractive for other institutions to enter. Eventually, there is a non-zero probability with which investors learn about the true risk in the high-risk products, and when this happens, liquidity dries up suddenly and a crisis commences with little warning.

This explanation for financial crises is consonant with many of the stylized facts related to the subprime crisis. More importantly, it illuminates the difficulty of avoiding crises in certain settings even if incentives are properly aligned, and points to how appropriate regulatory responses should be assessed.

In this model, agents have “experience-based” beliefs because the cognitive short-cut that they use to form beliefs about future events depends on the information they can recall from historical data, and the data that are most salient/memorable are those that are related to their own experiences.<sup>4</sup> These beliefs do not satisfy rational expectations. A prolonged period of favorable outcomes makes it increasingly difficult for individuals to construct scenarios in which the economy can go from the present situation to a major financial crisis. This will invariably lead financial institutions to invest in riskier, higher-return assets. This happens even if there is no moral hazard due to government safety nets. That is, this paper provides a theory of “crisis cycles”. Moreover, regulatory initiatives like attempting to control bank risk-taking through direct monitoring are unlikely to be effective in preventing crises

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<sup>4</sup> That is, people learn through “naïve reinforcement.” See [Chiang, Hirshleifer, Qian and Sherman \(2011\)](#).

because “watch dogs” like regulators and rating agencies also display the availability heuristic and are therefore also likely to underestimate risk subsequent to long periods of good performance.

The theory helps to understand the following additional stylized facts related to many financial crises:

- Why booms typically precede financial crises;
- Why banks tend to keep capital levels prior to crises that seem too low ex post after the crisis has occurred and why risk managers are often ignored prior to crises;
- Why bank CEOs are paid relatively high levels of compensation prior to crises and they appear to make risky bets that contribute to those crises; and
- Why bank regulators seem to be lax in monitoring banks prior to crises.

While it is easy to interpret these stylized facts as *prima facie* evidence of moral hazard of various sorts, I argue that there is a plausible alternative explanation, the one provided in this paper that leads to very different prescriptions about how to reduce the incidence of crises.

In addition to better comprehending the causes of crises, we also need to improve our understanding of the *after-effects*. Specifically, why does the economy fall to pieces after a financial crisis? In his paper with this question as the title, Hall (2010) observes that while existing macroeconomic models account successfully for the immediate effects of a financial crisis on output and employment, they cannot explain why GDP and employment failed to recover in this and past major financial crises as soon as the crisis-related financial frictions had returned to normal.<sup>5</sup> In an extension of the model, I show why bank lending and hence the real economy may not recover for a while even after the financing friction – sudden loss of liquidity for banks – that precipitated the crisis has subsided. The intuition for this result is that a crisis can lead banks to lower their assessments of their own abilities so much that they may be averse to even investing in relatively low-risk assets. Bank lending/investment

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<sup>5</sup> One possible explanation is that the crisis ruptures relationships between borrowers and banks who choose to ration them. This may then cause borrowers to revise their beliefs about the durability of relationship lending and cause a drop in demand for value-added relationship loans. See [Boot and Thakor \(2000\)](#) for a model of value-added relationship lending.

thus freezes up even though investors are willing to fund banks.

This paper is related to the large and growing literature on financial crises (e.g., Allen and Gale (2000), Boyd, Kwak and Smith (2005)), including papers on the causes of crises (e.g., DeJonghe (2010) and Wagner (2010), as well as the overview papers of Allen and Gale (2007), Rochet (2008), and Thakor (2014a)). Recent papers have focused on the role of complexity and innovation. Allen, Babus and Carletti (2012) develop a model in which networks arise because banks swap projects to diversify individual risks and thereby become interconnected. This can then generate systemic risk. Caballero and Simsek (2013) show that growth in financial networks causes endogenous complexity to increase. The increased complexity faced by banks may cause liquidity to vanish and a crisis may come about. Other papers have focused on the role of financial innovation. Gennaioli, Shleifer and Vishny (2012) have proposed that “neglected risk” in innovative financial products, when joined with limited supply of traditional safe products, results in excess demand for innovative products. When the neglected risks are realized, investors dump these innovative products, causing banks to be stuck with them. Shleifer and Vishny (2010) focus on securitization and argue that it leads to excessive leverage and lending. Thakor (2012) shows that potential disagreement about the profitability of an innovation acts as an endogenous barrier to entry and entices banks to pursue the innovation. However, this disagreement may also cause investors to withdraw funding, leading to a crisis.

While my focus is on how a particular behavioral bias can cause a financial crisis, one can also build a (more complicated) model with rationality in which everybody rationally recognizes *ex ante* that there is a (small) probability that outcomes are purely exogenous and a crisis occurs because sufficiently many bank failures cause agents to assign a higher posterior probability to outcomes being exogenous. I develop such a model in Thakor (2014b). The differences between the implications of this model and the implications of this paper are discussed in Section V.

In contrast to these papers, the focus in this paper is not on complexity or innovation. The assets available to financial institutions are known at the outset and there is no disagreement over their profitability. Moreover, unlike the existing literature, the focus here is on explaining why financial crises

should be expected to follow economic booms and periods of sustained banking profitability and why risk tends to be underpriced just prior to the onset of crises. The central idea in this paper, and one that has not been previously examined as a *causal* factor in financial crises, is that the availability heuristic, whereby outcomes are attributed to skill but are generated largely by luck, lead to a “pretense of skill” or “expertise”.<sup>6</sup> That is, after a sequence of favorable outcomes, estimates of bank skill are elevated and their ability to manage risk is overestimated. The consequence is excessive risk-taking and crises.

The rest of the paper is organized as follows. Section II develops the model, Section III contains the analysis. In Section IV, I introduce a market in which banks can sell loans to each other. The main purpose is to show that this market is a double-edged sword. On the one hand, it increases the liquidity of the loans banks hold, thereby reducing the likelihood of a crisis *ex post* after a liquidity shock hits. On the other hand, it actually makes it more attractive for banks to invest in riskier assets, which increases the *ex ante* likelihood a crisis. Section V discusses how the model can be used to generate a theory of crisis cycles, and how it leads to an explanation of why the economy tends to fall to pieces after a crisis. This section also includes a discussion of the interpretations and regulatory policy implications of the analysis. Section VI concludes. All proofs are in the Appendix.

## **II. THE BASIC MODEL**

This section describes the basic model without a loan resale market. I begin with a description of agents and preferences. I then discuss the sequence of events, followed by the investment opportunity set. This is followed by a statement of the observability assumptions and description of how beliefs are revised. I conclude with a summary of the timeline.

### **A. Agents and Preferences**

The key players in the model are financial intermediaries and investors who provide financing for these intermediaries. The liabilities of the intermediaries are uninsured<sup>7</sup>, so even though I will refer to these

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<sup>6</sup> To borrow a term used by Caballero (2010).

<sup>7</sup> The model goes through with partially insured liabilities.



intermediaries as “banks” henceforth, it should be understood that they encompass a broad array of financial intermediaries that raise their funding in the capital market, including investment banks and commercial banks.

There is universal risk neutrality and the riskless rate of interest is zero.

## B. Sequence of Events

There are five payoff-relevant dates:  $t=0, 1, 2, 3$  and  $4$  that cover two time periods over which banks operate. At  $t=0$ , there are  $N_0$  banks in the market. Each bank can choose to invest \$1 at  $t=0$  in either a prudent loan ( $P$ ) or a risky loan ( $R$ ). Both loans mature at  $t=2$ . For simplicity, the entire \$1 is raised at  $t=0$  in the form of (uninsured) debt financing in the capital market. The debt is short-term in nature, so investors have the option to withdraw funding at  $t=1$  if they wish, or continue to keep their funding with the bank and be paid off at  $t=2$ . The repayment promised to investors differs based on whether they withdraw at  $t=1$  or  $t=2$ . This short-term (demandable) nature of debt financing, which creates a maturity mismatch on the bank’s balance sheet, is just taken as a given here, because the economic rationale for it is well known (see, for example, Calomiris and Kahn (1993)). If the bank survives until  $t=2$ , the bank makes its second-period loan, choosing again between  $P$  and  $R$ , and with investors having the option to withdraw at  $t=3$ .

## C. Investment Opportunities: P and R Loans

The bank chooses at  $t = 0$  and then again at  $t = 2$  between loans  $P$  and  $R$ , a mutually-exclusive set of loans.

**P Loans:** Loan  $P$  is either good ( $G$ ) or bad ( $B$ ) but no one can determine for sure *a priori* whether the loan is  $G$  or  $B$ . A loan of type  $G$  loan pays off  $X_p > 1$  w.p.  $1$ , and a  $B$  loan pays off  $X_p$  w.p.  $b \in (0,1)$  and  $0$  w.p.  $1-b$ .

There are two possible states of nature in any given period,  $\xi \in \{\xi_e, \xi_r\}$ . In state  $\xi_e$ , the probability that the loan is type  $G$  is purely exogenous and fixed at  $r \in (0,1)$ . In state  $\xi_r$ , the probability

that the loan is type  $G$  depends on the skill/talent of the bank in monitoring the loan after it is made.<sup>8</sup>

There are two possible types of banks: talented ( $\tau$ ) and untalented ( $u$ ). A type- $\tau$  bank monitors the  $P$  loan with perfect efficiency and is thus able to ensure that the loan is  $G$  w.p. 1. A type- $u$  bank, however, has no monitoring ability and thus ends up with a  $B$  loan w.p. 1.<sup>9</sup> The common prior belief at  $t=0$  is that the probability that any given bank is type- $\tau$  is  $r$ , and the probability that it is type  $u$  is  $1-r$ . The true probability of state  $\xi_e$ , is  $\lambda \in (0,1)$ , a small number. However, all agents believe at  $t=0$  that  $\lambda=0$ , i.e., they believe w.p. 1 that outcomes are driven by the skills of bankers.

At  $t=1$ , the realization of  $\xi$  occurs. However, this realization is *not* observed until  $t=3$ , at which date all agents receive a common signal that reveals the realization of  $\xi$  to them. The idea is to capture *lags* in learning. Some evidence may emerge at a particular date that the model investors have in mind is incorrect, but the evidence may not be viewed as compelling enough by sufficiently many economic agents to be of any consequence in moving prices or affecting bankers' access to funds. Thus, it is only at  $t=3$  that all agents have an opportunity to revise their beliefs about the true model of the world based on their observation of the common signal.<sup>10</sup> This signal is meant to represent a *completely unanticipated* shock to the system in the sense that all agents are unaware of the possibility of the signal until the signal arrives.<sup>11</sup>

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<sup>8</sup> Banks are experts in screening/monitoring borrowers (e.g. Ramakrishnan and Thakor (1984)). This specification attempts to capture "model uncertainty." In reality, investors can never be certain about the extent to which asset payoffs are influenced by the monitoring or screening skills of bankers. Moreover, they may be mistaken about the *true* state of the world because the true state cannot be reasonably inferred by building plausible "scenarios" based on historical experience.

<sup>9</sup> This assumption is merely to reduce notational clutter, and one could assume instead that a type- $u$  bank ends up with a  $B$  loan w.p. less than 1.

<sup>10</sup> If it is assumed that there is no delay and agents learn the realized value of  $\xi$  at  $t=1$ , then the analysis goes through if one assumes that the two periods are characterized by different (uncorrelated) models of the world, so agents can return to their prior beliefs regardless of what they learned at  $t=1$ . However, that version of the model is more complicated, without yielding additional insights.

<sup>11</sup> This assumption that "investors do not know what they do not know" is stronger than the *usual* Knightian uncertainty assumption (used, for example, in Cabellero and Simsek (2012)). With Knightian uncertainty, investors cannot accurately determine the odds of certain random future events, but they know that the uncertainty exists and they cannot determine these odds. Here investors believe that they know loan quality and do not recognize that a signal may arrive in the future that proves them wrong. Perhaps one could view this as an extreme (or special) form of Knightian uncertainty whereby everybody incorrectly computes the odds of receiving the future signal as zero when the (true) probability is  $\lambda$ .

This set-up is particularly relevant for understanding the role of the availability heuristic in generating financial crises. Even though there may be pre-crisis conditions that are encountered in most financial crises—such as high bank leverage and asset price bubbles—there are invariably circumstances that are unique to the crisis. For example, prior to the S&L crisis, we had high interest rates, high inflation, an inverted yield curve and no formal risk-adjusted capital requirements of the sort that are now in place. Prior to the subprime crisis, we had a different set of circumstances—the emergence of the CDS market, shadow banking and a broad set of mortgage-backed securities. These unique crisis-specific circumstances may be so salient and compelling that agents may view historical data as being quite useless in assessing the probability of a future crisis. Tversky and Kahneman (1973) note:

"Some events are perceived as so unique that past history does not seem to be relevant to the evaluation of their likelihood. In thinking of such events, we often construct *scenarios*, i.e., stories that lead from the present situation to the target event. The plausibility of the scenarios that come to mind, or the difficulty of producing them, then serve as a clue to the likelihood of the event. If no reasonable scenario comes to mind, the event is deemed impossible or highly unlikely."

This paper argues that in a bull market, when asset prices are high, banks have experienced low defaults, and there is consistent growth in profitability with little evidence of any adverse consequences of risk, it is difficult for agents to construct scenarios in which the economy can move from a state of economic "plenty" to one of a financial crisis. In other words, if it is believed that the high bank profitability and low defaults are attributable to the skills of bankers, and banks have continued to do well (further reinforcing these beliefs), it is difficult for agents to construct alternative scenarios in which the skills of bankers do not matter. Everybody thinks bankers are smart and this is reinforced by banks continuing to do well and bankers being paid highly, perhaps because pay is performance-contingent. The longer this goes on, the less likely it is that people imagine their beliefs to be untrue and a crisis to occur.

However, at some point, there may be so much evidence to the contrary that agents may be forced to change their view of the world. The common observability of the signal at  $t=3$  is a short-hand way to capture this.

At  $t=0$ , the prior belief about the probability of success of the  $P$  loan at  $t=2$  is

$$r_o^P \equiv r + [1-r]b \quad (1)$$

It is assumed that

$$r_o^P X_p > 1 \quad (2)$$

So  $P$  is a socially-efficient asset given these prior beliefs.

However,

$$bX_p < 1 \quad (3)$$

So a bank known to be type- $u$  almost surely would never be able to raise financing for a  $P$  loan.

**R Loans:** The  $R$  loan can be either good ( $\hat{G}$ ) or bad ( $\hat{B}$ ). No one can determine *a priori* whether a given loan is  $\hat{G}$  or  $\hat{B}$ . A loan of type  $\hat{G}$  pays off  $X_R$  w.p.  $q \in (0,1)$  and 0 w.p.  $(1-q)$ , whereas a  $\hat{B}$  loan pays off 0 w.p. 1. It is assumed that the  $\hat{G}$ -type  $R$  loan is better than the  $G$ -type  $P$  loan, i.e.,

$$qX_R > X_p \quad (4)$$

As in the case of the  $P$  loan, there are two possible states of nature with the  $R$  loan,  $\xi \in \{\xi_e, \xi_r\}$ . In state  $\xi_e$ , the loan is type  $\hat{G}$  with an exogenously fixed probability  $r$ . In state  $\xi_r$ , the probability that the loan is type  $\hat{G}$  is dependent on the bank's monitoring skill. In this case, the common belief is that a type- $\tau$  bank will be able to ensure w.p. 1 that it is a  $\hat{G}$  loan, whereas a type- $u$  bank will ensure w.p. 1 that it is a  $\hat{B}$  loan. As with the  $P$  loan, the probability of state  $\xi_e$  is  $\lambda$  and of state  $\xi_r$  is  $1-\lambda$ , and all agents believe at  $t=0$  that  $\lambda = 0$  even though  $\lambda \in (0,1)$ .

It will also be assumed, for later use, that the difference in loan repayment (success) probabilities across the good and bad loans is greater for the  $R$  loan than the  $P$  loan, i.e.,

$$q > 1 - b \quad (5)$$

This is motivated by the observation that  $R$  is a more complex loan for which the importance of the bank's skill/talent is greater for such a loan than for  $P$ .

At  $t=0$  then, the prior probability of success of the type  $R$  loan at  $t=2$  is:

$$r_o^R \equiv rq \quad (6)$$

and it is assumed that

$$r_o^R X_R < 1, \quad (7)$$

so the  $R$  loan is socially inefficient given the prior beliefs.

If either a  $P$  or an  $R$  loan is prematurely liquidated (i.e., at  $t=1$  in the first period or  $t=3$  in the second period), there is a loss of non-pledgeable rent  $K > 0$ . Absent premature liquidation, the borrower of the bank would enjoy this rent.

A summary of these loans and payoffs is provided in the table below.

**Table 1: Loan Payoffs**

<b>Exogenous Loan Payoff Distribution (Probability <math>\lambda</math>)</b>				
		<b>Loan Type</b>	<b>Date 2 payoff:</b>	
$P$		$G$ w.p. $r$	$X_p > 1$ w.p. 1	
		$B$ w.p. $1-r$	$X_p$ w.p. $b$ 0 w.p. $1-b$	
$R$		$\hat{G}$ w.p. $r$	$X_R > 1$ w.p. $q$ 0 w.p. $1-q$	
		$\hat{B}$ w.p. $1-r$	0 w.p. 1	
<b>Endogenous Loan (Bank-Type-Dependent) Payoff Distribution (Probability <math>1-\lambda</math>)</b>				
	<b>Bank Type</b>	<b>Probability of Bank Type</b>	<b>Loan Type, conditional on bank type</b>	<b>Date 2 Payoff:</b>
$P$	$\tau$	$r$	$G$ w.p. 1	$X_p > 1$ w.p. 1
	$u$	$1-r$	$B$ w.p. 1	$X_p$ w.p. $b$ 0 w.p. $1-b$
$R$	$\tau$	$r$	$\hat{G}$ w.p. 1	$X_R > 1$ w.p. $q$ 0 w.p. $1-q$
	$u$	$1-r$	$\hat{B}$ w.p. 1	0 w.p. 1

## D. Observability and Knowledge Assumptions

Each bank's loan choice at any given date is commonly observable. So, investors know the bank's choice ( $P$  or  $R$ ) before providing financing. Also publicly observable is whether the bank's loan repaid or defaulted at the end of the period ( $t=2$  for the first period and  $t=4$  for the second period). Moreover, at  $t=3$ , all agents observe a common signal that reveals the true model about whether the loan success probability is exogenous or dependent on bank skill.<sup>12</sup>

## E. Capital Market Financing

Investors provide financing in a competitive capital market, so that bank debt is priced to yield investors an expected return of zero. If investors liquidate a loan at  $t=3$ , they collect  $L \in (rqX_R, 1)$ . It is assumed that  $L < rqX_R + K$ .

## F. Summary of Timeline

At  $t=0$ , there are  $N_0$  banks. Each bank chooses to invest \$1 in either a prudent ( $P$ ) loan or a risky ( $R$ ) loan. Each loan is entirely funded by short-term, uninsured debt and each matures at  $t=2$ .<sup>13</sup> Activity at  $t=1$  occurs only if there is a loan resale market. At  $t=2$ , the bank collects its loan payment (if available) and pays off investors. Assuming the bank is able to continue for another period, the lending cycle then restarts at  $t=2$  and the bank makes a new choice of loan and funds it entirely with new (short-term) debt. Any positive profit at  $t=2$  on the first-period loan is paid out as a dividend to the bank's shareholders.<sup>14</sup> The signal about the true model of the world (i.e., whether the success probability of the loan is skill-dependent or purely exogenous) is realized and observed by all at  $t=3$ . At this date, investors may decide to withdraw funding, and if they do so, the bank is forced to liquidate. The terminal payoff is realized at  $t=4$ .

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<sup>12</sup> The analysis is qualitatively unaffected by whether this signal arrives w.p. 1 or with a probability lower than 1.

<sup>13</sup> It makes little difference to the analysis if the bank was partly financed with equity, as long as it is not predominantly financed with equity. Non-trivial amounts of debt financing are essential for fragility.

<sup>14</sup> This is for simplicity. If the bank could use its first-period profit to fund part of its second-period loan, it would reduce the reliance on outside debt. However, the analysis is qualitatively unchanged if the bank has to fund the loan even partly from outside debt.

A summary of the sequence of events is provided in *Figure 1*. In *Figure 2*, there is a pictorial summary of the probability distributions of the projects.

Figure 1 goes here

Figure 2 goes here

### III. ANALYSIS OF THE BASIC MODEL

My main goal in this section is to analyze the model developed in the previous section to show how financial crises – that have many of the features discussed in the previous section – can arise.

#### A. Analysis of Outcomes at $t=2$

In the usual backward induction manner, I start by analyzing the second period, beginning at  $t=2$ , first and then the first period beginning at  $t=0$ .

**Default/Repayment on First-Period Loan:** Suppose the bank made a  $P$  loan at  $t=0$ . There are now two possible states for the bank at  $t=2$ ; (i) its loan defaults at  $t=2$ , or (ii) its loan pays off.

**State (i): Repayment Failure ( $P$  loan defaults at  $t=2$ ):** In this case, the common posterior beliefs about the bank's type is

$$\begin{aligned} r_2^f &= \Pr(\tau \mid \text{default on first-period loan}) \\ &= 0. \end{aligned} \tag{8}$$

Using (8), the posterior belief that agents have at  $t=2$  about the probability of second-period success for a  $P$  loan (at  $t=4$ ) is:

$$\hat{r}_2^P(f) = b \tag{9}$$

and the posterior belief about the probability of second period success for an  $R$  loan (at  $t=4$ ) is:

$$\hat{r}_2^R(f) = 0. \tag{10}$$

Recall that  $bX_p < 1$  (by (3)), which implies that if the bank's first-period  $P$  loan does not repay at  $t=2$ , it cannot make either a  $P$  loan or an  $R$  loan in the second period.

**State (ii): Repayment Success ( $P$  loan repaid at  $t=2$ ):** Now, the common posterior belief about the bank's type is:

$$\begin{aligned} r_2^s &= \Pr(\tau \mid \text{first-period loan repaid}) \\ &= \frac{r}{r + b[1-r]} > r. \end{aligned} \quad (11)$$

The posterior belief that all agents have at  $t=2$  about the probability of second-period success for a  $P$  loan (at  $t=4$ ) is:

$$\hat{r}_2^P(s) = r_2^s + [1 - r_2^s]b \quad (12)$$

and the posterior belief at  $t=2$  about the probability of second period success for an  $R$  loan (at  $t=4$ ) is:

$$\hat{r}_2^R(s) = qr_2^s. \quad (13)$$

It will be assumed that:

$$\hat{r}_2^R(s)X_R = qX_R \left[ \frac{r}{r + b[1-r]} \right] > 1 \quad (14)$$

The implication of this is that a bank that experienced repayment success on a first-period  $P$  loan at  $t=2$  will have such a high posterior probability of success in the second period that an  $R$  loan will be socially efficient given those beliefs.

**Second-Period Lending Choice:** Now consider the second-period lending choice for a bank whose first-period  $P$  loan was repaid. If it makes a  $P$  loan at  $t=2$ , its expected profit is:

$$\bar{\pi}_2^P = \hat{r}_2^P(s) \{X_P - \bar{D}_P(\hat{r}_2^P(s))\} \quad (15)$$

where  $\bar{D}_P$  is the promised repayment on the debt financing raised by the bank at  $t=2$  to finance its loan.

The bank views the posterior probability at  $t=2$  as  $\hat{r}_2^P(s)$ , so the bank's expected payoff is

$$\hat{r}_2^P(s) \{X_P - \bar{D}_P(\hat{r}_2^P(s))\}.$$

The bank's repayment obligation to debt investors should be such that the amount raised from these investors at  $t=0$  (\$1) equals the expected payoff to them at  $t=2$ , i.e.

$$\bar{D}_P(\hat{r}_2^P(s)) = \frac{1}{\hat{r}_2^P(s)} \quad (16)$$



I now turn to the  $R$  loan. An obvious but useful result to note is the following:

**Lemma 1:** *If the bank makes an  $R$  loan at  $t=2$  and it is discovered at  $t=3$  that the loan repayment probability is purely exogenous ( $\xi = \xi_e$ ), then debt investors will demand immediate repayment at  $t=3$  and force the liquidation of the bank.*

The reason for this result is that the liquidation value of the  $R$  loan exceeds its expected terminal value under prior beliefs. However, since the shock is unanticipated at  $t=2$ , the bank's expected profit from an  $R$  loan is computed at  $t=2$  to be:

$$\bar{\pi}_2^R = qr_2^s \{X_R - \bar{D}_R(qr_2^s)\} \quad (17)$$

The following result can now be proved:

**Proposition 1 (Bank's Second-Period Lending):** *In the second period, the bank will: (i) exit the market if its first-period loan defaults at  $t=2$ , and (ii) if its first-period loan repays, then the bank prefers to make an  $R$  loan at  $t=2$  if  $r_2^s > r_2^s$  (cut-off) and a  $P$  loan otherwise. If it invests in the  $R$  loan, its repayment obligation to debt investors is  $\bar{D}_R(qr_2^s)$  given by (16) and its expected profit is  $\bar{\pi}_2^R$  given by (17).*

To see the intuition, note that first-period failure lowers the expected second-period repayment probability so much that even a  $P$  loan is not viable, whereas first-period success raises the posterior belief about the bank being talented sufficiently to ensure that the expected second-period repayment probability with an  $R$  loan is high enough to make it more attractive than the  $P$  loan.

Since first-period loan success leads to the posterior belief about the bank being talented rising above the prior belief, and this higher posterior belief leads to higher expected second-period repayment probabilities for both  $P$  and  $R$  loans, one may wonder why the  $R$  loan is preferred in the second period in this case. The reason is that the difference in repayment probabilities across talented and untalented banks is higher for the  $R$  loan than for the  $P$  loan. For the  $P$  loan, this difference is  $1-b$ , whereas for the  $R$  loan it is  $q$ . By (5) we know that  $q > 1-b$ . Hence, an upward revision in the belief about the bank's skill increases the attractiveness of the  $R$  loan relative to the  $P$  loan. It will be assumed, henceforth, that  $r_2^s > r_2^s$  (cut-off) following repayment of the first-period  $P$  loan.

## B. Analysis of Outcomes at $t=0$

The following result is immediate, given our earlier analysis.

**Proposition 2 (Bank's First-Period Lending):** *At  $t=0$ , all banks invest in  $P$  loans. Investors are promised a repayment of  $D_p(r_o^P)$  at  $t=2$ , where*

$$D_p(r_o^P) = 1 / r_o^P \quad (18)$$

and the bank's expected profit is

$$\pi_1^P = r_o^P [X_p - D_p(r_o^P)] \quad (19)$$

## C. Financial Crises

Given Propositions 1 and 2, one can now readily see how financial crises can arise.

**Proposition 3 (Financial crisis):** *There is no financial crisis in the first period. In the second period, all banks that experience first-period repayment success make  $R$  loans in the second period at  $t=2$ . A financial crisis occurs in the sense that all these banks fail at  $t=3$  if investors learn at that time that the loan repayment probability is purely exogenous. Otherwise, there is no financial crisis and investors wait until  $t=4$  to be repaid.*

The sequence of events is that banks initially make prudent loans, and nothing is revealed at  $t=1$ , so there is no crisis.<sup>15</sup> The banks that are successful in the first period invest in  $R$  loans in the second period. Even if  $\lambda$  is small, there is a positive probability that at  $t=3$  investors will learn that the loan repayment probability in the second period is exogenous. This makes it preferable for them to demand immediate repayment at  $t=3$ , forcing liquidation of banks and precipitating a crisis. A key aspect of this result is that with a positive probability, a financial crisis *follows* good performance by banks, since it is only good first-period performance that induces banks to invest in  $R$  loans, and a crisis can occur only when they do.

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<sup>15</sup> Even if revelation of the true model of the world were to occur at  $t=1$  and the true model turned out to be  $\xi = \xi_e$ , there would be no crisis since the  $P$  loan is efficient even in this case.

#### IV. ANALYSIS OF THE MODEL WITH A LOAN RESALE MARKET

While the basic model delivers the central result related to financial crises, it does not permit an examination of why asset market liquidity dries up during a crisis. This is because asset markets have no liquidity in the model. If investors withdraw funding at  $t=3$ , the bank is forced to liquidate the loan. So in this section I introduce a loan resale market.

##### A. Additional Structure to Accommodate Loan Resale Market

Analyzing the loan resale market requires additional structure, which is provided below.

**Liquidity Shocks and Investor Actions:** with probability  $\theta \in (0,1)$  investors of a given bank experience an idiosyncratic liquidity shock at  $t=1$  that creates for them an urgent demand for liquidity. We assume that these liquidity shocks are *i.i.d.* in the cross-section of banks. Investors respond to this shock by demanding immediate repayment by the bank.<sup>16</sup>

**The Bank's Response to Investor Actions:** When investors demand immediate repayment, the bank has two choices. One is to repay investors by liquidating its loan prematurely and realizing a liquidation value of  $L \in (0,1)$ . The other is to sell its loan to another bank and pay investors from the loan sale proceeds.<sup>17</sup> What price the loan can be sold at depends on the competitive structure of the loan resale market, which is endogenous. Potential buyers of the loan act as *Bertrand competitors* in this market, so the loan resale price depends on the number of banks that are willing and able to buy the loan. We assume that only a bank that has not suffered a withdrawal of funding by its investors and has already invested in that type of loan previously on its own, is in a position to buy another bank's loans.<sup>18</sup> There

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<sup>16</sup> This can be viewed as a "dark side" of (uninsured) wholesale funding, as in Huang and Ratnovski (2011). Thus, while the information about whether loan repayment probabilities are exogenous or skill dependent can be viewed as a systematic shock, this is an idiosyncratic shock.

<sup>17</sup> The difference between liquidating and selling a loan can be thought of as follows. When a bank liquidates a loan, it may either force the borrower to repay early by selling off real assets prematurely at a loss or it may transfer the loan to a non-bank lender at a heavy discount since that non-bank lender can realize only a fraction of the loan value that the bank can. When a bank sells a loan, it transfers ownership to another specialized lender, a bank. The purchasing bank can realize the full value of the loan that the selling bank could have if it had not sold it.

<sup>18</sup> Thus, for example, a bank that invested in a prudent loan would not be in a position to buy risky loans.

are no capacity limits on how many loans such a bank can buy at  $t=1$ .<sup>19</sup> Whether the bank that suffers a liquidity shock sells its loan in the secondary market or liquidates the loan depends on the (endogenously-determined) loan resale price at  $t=1$ .

The debt contract with these investors, set at  $t=0$ , stipulates that the investors receive the *market price* of their debt if they withdraw at  $t=1$ , subject to the limited liability constraint governing the bank's ability to repay. Thus, investors receive the *minimum* of the proceeds the bank receives from the loan sale (or liquidation if the loan cannot be sold) and the expected value (determined at  $t=1$ ) of the date-2 repayment amount owed to the investors.<sup>20</sup> A bank that suffers a liquidity shock at  $t=1$  can continue to exist only if it can pay investors the market price of their debt at  $t=1$ . Otherwise it ceases to exist. If it survives, then it has no loan in its portfolio until  $t=2$ , but investors revise their belief about the bank's type based on whether the loan it sold to another bank eventually repaid or defaulted at  $t=2$ .

**The Purchasing Banks:** For the banks that purchase loans from other banks at  $t=1$ , it is assumed that the purchasing bank pays the selling bank a price for the loan, but does not assume any of the seller's liabilities against that loan.<sup>21</sup> The purchase price will be financed by the purchasing bank with new debt issued at  $t=1$ . Every purchased loan is put by the buying bank into a legally-separate (bankruptcy-remote) trust or organization set up for the purchased loan, so that the repayments on the purchased loans are unavailable to repay the investors who funded the purchasing bank at  $t=0$ , and these investors are also not liable for any of the defaults on the purchased loans. That is, investors who fund loan  $i$  in a given bank are paid only from repayment on loan  $i$  and do not receive any of the repayment on loan  $j$  ( $\neq i$ ) if loan  $i$

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<sup>19</sup> This is not very realistic, and ideally one would like a capacity limit—say each loan buyer can buy at most one loan—but this complicates the model without adding insight.

<sup>20</sup> Conditional on the loan sale proceeds being sufficient, paying investors less than the expected value of what is owed to them (market price) would imply an “early withdrawal” penalty that would simply be reflected in the *ex ante* pricing of debt at  $t=0$ , and paying them more would induce investors to demand repayment at  $t=1$  even if not hit with a liquidity shock.

<sup>21</sup> Recall that the bank that sells its loan uses the proceeds to pay off its liabilities.

defaults. This assumption corresponds to the standard practice in securitization to segregate the collateral pool (against which asset-backed securities are issued) in a legally distinct, bankruptcy-remote entity.<sup>22</sup>

**Expertise to Manage R Loan:** The  $R$  loan is a more complex asset than the  $P$  loan, so it requires the bank to acquire special expertise to manage the loan. The cost of acquiring this expertise varies in the cross-section and is  $C_i \geq 0$  for bank  $i$ , with  $C_i \in [0, \bar{C}] \subset \mathbb{R}_+$ .

**Banks that are not Hit by Liquidity Shocks at  $t=1$ :** If the bank is not hit by a liquidity shock at  $t=1$ , then investors who provided funding at  $t=0$  are repaid at  $t=2$  an amount equal to the face value of the debt conditional on the bank receiving repayment from the borrower. Any surplus left over is paid as a dividend to the bank's shareholders at  $t=2$ . The bank then makes a new loan at  $t=2$  if it is able to raise financing for it. The cycle then repeats. Once again, the choice is between two mutually-exclusive assets: the prudent loan and the risky loan. At  $t=3$ , investors receive a signal about the bank's true success probability at  $t=4$ , which says *w.p.*  $\lambda$  that the success probability is exogenous. The bank-specific liquidity shock is also realized *w.p.*  $\theta$  at  $t=3$ . There are then loan sales and possibly liquidations at  $t=3$ . A bank hit with a liquidity shock at  $t=3$  essentially ceases to exist regardless of whether it liquidates or sells its loan, since it no longer has a loan on its books and  $t=4$  is the terminal date. If the bank survives, it continues until  $t=4$ , at which time loan repayments are collected and investors are paid off if possible.

## B. Second-Period Analysis with a Loan Resale Market

The previous analysis does not deal with the ability of a bank to offset the loss of liquidity on the liability side by selling assets. Being able to do this may reduce (or even eliminate) the probability of a crisis.

This is examined next.

Suppose there are  $N$  banks that can raise financing and operate at  $t=2$ . To examine the effect of the loan resale market, note that there are three possible scenarios facing a bank that wishes to sell its loan

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<sup>22</sup> Specifically, the standard practice in securitization is to use SPVs (Special Purpose Vehicles) to segregate the securitized assets from the bank's other assets. This assumption is made to eliminate unnecessary analytical complexity related to the commingling of the cash flows from the purchased loan with the purchasing bank's existing assets. Relaxing this assumption is unlikely to qualitatively affect the results.

at  $t=3$ : (i) there are no potential buyers for the loan; (ii) the number of potential buyers for the loan is equal to one; and (iii) there are two or more potential buyers.

In case (i), with no banks available to buy the bank's loan, it is forced to liquidate and realize a value of  $L$  for the loan. In case (ii), with only one potential buyer, the buyer can act as a monopolist and pay a price equal to the seller's reservation price, which is the liquidation value,  $L$ . Thus, cases (i) and (ii) are identical for the bank wishing to sell the loan.

If there are two or more potential buyers (case (iii)), then Bertrand competition among them ensures that the expected return on the loan purchase for the buyer is zero and the selling bank receives the same expected value that it would have if it had retained the loan.

The probability that there are two or more potential buyers for the loan at  $t=3$ , given that  $N$  banks made  $P$  or  $R$  loans at  $t=2$ , is 1 minus the probability that one or no bank avoided getting the liquidity shock (i.e., the probability that the liquidity shock hit all banks or all but one):

$$\delta \equiv 1 - \{\theta^{N-1} + \theta^{N-2}[1-\theta]\} \quad (20)$$

**Analysis when all banks make second-period P loans:** Suppose every bank made a  $P$  loan at  $t=2$ , after having been repaid on  $P$  loans made at  $t=0$ , as before, banks that experienced defaults on first-period loans exit the market. Combining cases (i), (ii) (iii), yields the following result:

**Lemma 2:** *With a loan resale market, if the bank invests in a  $P$  loan at  $t=2$ , it must promise investors a repayment of  $\hat{D}_p(z)$  to raise  $\$1$ , where:*

$$\hat{D}_p(z) = \frac{\{1-\theta[1-\delta]L\}}{[1-\theta+\theta\delta][z]} > 1 \quad (21)$$

where  $z = \hat{r}_2^P(s)$ ,  $\hat{r}_2^P(s)$  by (12). The bank assesses its expected profit as:

$$\hat{\pi}_2^P = [1-\theta]\{Y_p + [N-1]\theta^{N-1}[TV_p - L]\} + \theta\delta Y_p \quad (22)$$

where:

$$Y_p = z[X_p - \hat{D}_p(z)] \text{ and } z = \hat{r}_2^P(s) \quad (23)$$

$$TV_p = \hat{r}_2^P(s)X_p \text{ and} \quad (24)$$

$$\bar{Y}_p = r_o^p [X_p - \hat{D}_p(z)] \quad (25)$$

To interpret the expressions in Lemma 2, let us begin with a discussion of how the face value of debt,  $\hat{D}_p(z)$ , in (21) is arrived at. With a loan resale market, when investors experience a liquidity shock and demand repayment at  $t=3$ , the bank does not necessarily have to liquidate and pay  $L$  to investors. It may be able to sell the loan to another bank. If the loan resale market is competitive (the probability of which is  $1-\theta+\theta\delta$ ), then the bank will receive a price that is equal to the expected value of the loan to the buyer, which is  $TV_p$ , the total market value of the loan. From this amount, investors who provided funding at  $t=0$  can be paid the market price of their debt,  $z[\hat{D}_p(z)]$ . But, if there is only one buyer, then this buyer will pay only  $L$  (the probability of this is  $\theta[1-\delta]$ ), for the loan, since this liquidation value is the seller's reservation price. Similarly, if the bank has to liquidate the loan because there are no buyers, it will receive  $L$ . In both cases, whether there is no buyer or only one buyer, investors will have to take a haircut and will get paid only  $L$ , and the bank's profit is zero. The expression in (21) results from this calculation to ensure that investors set the face value of the debt,  $\hat{D}_p(z)$ , such that its expected value at  $t=0$  is \$1, the amount of initial financing provided.

Turning to the bank's expected payoff in (22), it can be seen that it consists of two parts. One part is when it experiences no liquidity shock (probability  $1-\theta$ ). In this case, the bank earns an expected profit of  $Y_p$  on its loan and it is also able to earn a profit of  $TV_p - L$  on purchased loans if all the other banks  $N-1$  suffer liquidity shocks (probability  $\theta^{N-1}$ ), and this bank is able to act as a monopolist and purchase all of these loans at  $L$  each (it would need to borrow  $L$  for each loan, but the expected value of its promised repayment to debt investors is  $L$  per loan). If  $N-2$  or fewer banks suffer liquidity shocks, then there are two or more potential loan buyers (including this bank), so the loan resale market is perfectly competitive and the bank's expected profit from buying a loan is zero. The other part of the bank's expected payoff refers to the event when it experiences a liquidity shock (probability  $\theta$ ), in which the case the bank's expected profit is  $Y_p$  if the loan resale market is competitive (probability  $\delta$ ) and zero otherwise.

**Analysis when all banks make second-period  $R$  loans:** Next assume that every bank made an  $R$  loan at  $t=2$ . Then we have the following result.<sup>23</sup>

**Lemma 3:** *With a loan resale market, if the bank invests in an  $R$  loan at  $t=2$ , it must promise investors a repayment of  $\hat{D}_R(qr_2^s)$  to raise \$1, where:*

$$\hat{D}_R(qr_2^s) = \frac{1 - \theta[1 - \delta]L}{r_2^s q \{1 - \theta + \theta\delta\}} > 1 \quad (26)$$

and the bank's expected payoff is:

$$\hat{\pi}_2^R = \left\{ [1 - \theta] \left[ Y_R + [N - 1]\theta^{N-1}[TV_R - L] \right] + \theta\delta Y_R \right\} - C_i \quad (27)$$

$$Y_R \equiv r_2^s q \left[ X_R - \hat{D}_R(qr_2^s) \right] \quad (28)$$

$$TV_R = r_2^s q X_R \quad (29)$$

The interpretation of the lemma is similar to that of Lemma 2. We now have another result:

**Lemma 4:** *The existence of the loan resale market: (i) increases the bank's second-period expected payoffs on both the  $P$  and  $R$  loans; and (ii) it increase the number of banks that can offer the  $R$  loan in the second period, but does not affect the number of banks that can offer the  $P$  loan in the second period.*

It is intuitive that the existence of the loan resale market increases the bank's expected profits on both types of loans. Without a loan resale market, a bank hit with a liquidity shock must liquidate its loan and collect  $L$ , all of which goes to the creditors, leaving nothing for the bank's shareholders. With a loan resale market, there is a positive probability that the bank can sell its loan at a price sufficiently higher than  $L$  to generate a positive expected profit for its shareholders even in the state in which there is a liquidity shock. In short, the existence of a secondary market makes both types of loans more liquid, enhancing their profitability to the bank.

The loan resale market does not affect the number of banks that can offer  $P$ , because  $P$  is profitable for banks even at the prior belief  $r$  and without a loan resale market. Loan  $R$ , however, is

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<sup>23</sup> Note that we can use  $\delta$  here as well since no one in this economy expects the information signal about the true loan value until it actually arrives. Hence, the calculation of  $\delta$  does not reflect  $\lambda$ .



profitable for banks only if the posterior belief,  $r_2^s$ , is high enough and the cost of acquiring expertise,  $C_i$ , is low enough. Since the loan resale market increases the profitability of  $R$  to the bank, the cut-off  $C_i$  such that banks with  $C_i$ 's below that cut-off can participate in  $R$  goes up. As a consequence, the emergence of the loan resale market increases the number of banks that can offer  $R$ .

This is an interesting result because it shows that the loan resale market, whose primary purpose is to increase bank liquidity and thereby lower the probability of a crisis when investors are hit ex post with a liquidity shock, induces banks to invest in *riskier* assets *ex ante*. This contributes to an increase in the probability of a crisis.

This lemma also allows us to establish a result that is important for the subsequent analysis. Before establishing that result, it is useful to simplify the specification of the cost. Assume that  $C_i \in \{0, \underline{C}, \bar{C}\}$ , with  $0 < \underline{C} < \bar{C}$ , and prior to the opening of the loan market at  $t=2$ , each bank randomly draws  $C_i$  equal to 0,  $\underline{C}$  or  $\bar{C}$ . Let  $\Pr(C_i = 0) = \gamma_0 \in (0, 1)$ ,  $\Pr(C_i = \underline{C}) = \gamma_1 \in (0, 1)$ , and  $\Pr(C_i = \bar{C}) = 1 - \gamma_0 - \gamma_1$ .

Further, it will be assumed that

$$qX_R - \bar{C} > X_P \quad (30)$$

which is a stronger version of (4) with the introduction of the maximum cost,  $\bar{C}$ , of acquiring the skills to manage  $R$ .

Some additional notation is also necessary. Let  $n_0$ ,  $n_1$ , and  $n_2 \equiv N - n_0 - n_1$  be the number of banks at  $t=2$  that had success on their first-period loans and realized  $C_i = 0$ ,  $C_i = \underline{C}$ , and  $C_i = \bar{C}$ , respectively. We can now state a result that is important for the subsequent analysis.

**Proposition 4 (date-2 lending choice with a loan resale market):** *There exists a cut-off value of the posterior belief of making a good loan,  $r_2^s$ , call it  $\hat{r}_2^s$  (cut-off)  $\in (0, 1)$  such that banks that experienced repayment success on their first-period loans prefer  $R$  over  $P$  at  $t=2$  if  $r_2^s > \hat{r}_2^s$  (cut-off), and they prefer  $P$  over  $R$  if  $r_2^s < \hat{r}_2^s$  (cut-off).*

Moreover,  $\hat{r}_2^s$  (cut-off) is an increasing function of  $C_i$ , with a distinct cut-off for each  $C_i$ , and

$$(1) \hat{r}_2^s(0, n_0) < \hat{r}_2^s(\underline{C}, n_0) < \hat{r}_2^s(\bar{C}, n_0); \quad (31)$$

$$(2) \hat{r}_2^s(C_i, n_0) > \hat{r}_2^s(C_i, n_0 + n_1) > \hat{r}_2^s(C_i, N). \quad (32)$$

The expected number of successful banks at  $t=2$  that will prefer  $R$  over  $P$  for their second-period loans is a non-decreasing function of  $N$ , the number of banks that are successful at  $t=2$ , and for values of  $N$  high enough, a majority of banks prefer  $R$  over  $P$ .

The intuition for the cut-off is that the bank's profitability in lending for both  $P$  and  $R$  loans increases with the posterior belief that the bank is type  $\tau$ , but it increases at a faster rate with the  $R$  loan. It is also clear why the cut-off is increasing in  $C_i$ , since higher values of  $C_i$  make  $R$  less attractive to banks. The intuition for why the expected fraction of successful banks preferring  $R$  over  $P$  goes up with  $N$ , the number of successful banks, is as follows, and here the loan resale market plays a role. As  $N$  increases,  $\gamma_0 N$ , the number banks with  $C_i = 0$  goes up, and we know from the previous analysis that these banks prefer  $R$ , so the number of banks above the cut-off increases. The more banks opt for  $R$ , the larger is the loan resale market for this loan and the greater is the liquidity of this loan. This increases the expected profits of banks offering  $R$ , and banks with higher values of  $C_i$  switch over from  $P$  to  $R$ . While it is true that an increase in  $N$  increases the potential liquidity of  $P$  as well, the marginal benefit of higher liquidity in the loan resale market is higher for  $R$  than for  $P$ .

Thus, the larger the number of banks that experience success in the first period, the higher is the expected number of banks that invest in the risky loan, i.e., the risky loan market in the second period becomes larger and more liquid as a consequence of greater success experienced by banks with the prudent asset in the first period. This result sheds light on the high liquidity in the asset markets in which banks operated prior to the crisis. This leads to the next result:

**Proposition 5:** *Investors demand immediate repayment from a bank with a  $P$  loan at  $t=3$  only if they experience a liquidity shock. The bank will be liquidated only if it cannot find a buyer for its loan.*

*Investors demand immediate repayment from a bank with an  $R$  loan at  $t=3$  if they experience a liquidity shock or if they receive a signal that the true success probability of  $R$  is exogenous. In the former case, the bank is liquidated only if it cannot find a buyer for its loan, but in the latter case, all banks that have made  $R$  loans are liquidated. The higher is the posterior belief of the bank being talented following first-period loan repayment,  $r_2^s$ , at  $t=2$ , the larger is the expected number of banks that are liquidated at  $t=3$  due to investors receiving a signal that the true success probability of  $R$  is exogenous and not skill-dependent.*

For banks that have either  $P$  or  $R$  loans in their portfolios, when investors experience a liquidity shock, the bank is liquidated if there is no loan resale market, but there may be *no* liquidation with a loan resale market. Hence, ex post the likelihood of bank liquidation is diminished due to the liquidity provided by the loan resale market. Moreover, as in the case without a loan resale market, investors do not demand repayment from banks that made  $P$  loans if they learn its true success probability is exogenous.

The reason why banks with  $R$  loans are liquidated at  $t=3$  in the event investors receive a signal that the true success probability of  $R$  is exogenous is that the expected value of the  $R$  project in this case is less than  $L$ , the liquidation value of the loan. Since all banks invested in  $R$ , they are all affected by this market-wide signal and are liquidated. Consequently, there is no solvent bank that is available to buy  $R$  in the secondary market. As  $r_2^s$  increases, we know from Proposition 4 that the expected number of banks opting for  $R$  goes up as well. Thus, in the event that investors learn that the true probability of success of the loan is exogenous, the expected number of banks that are liquidated is higher when  $r_2^s$  is higher.

### **C. First-Period Analysis With a Loan Resale Market**

Given (3), we know that no bank can make an  $R$  loan at  $t=0$ . Thus, all banks invest in  $P$  loans. The following result is immediate, given our preceding analysis:

**Lemma 5:** *At  $t=0$ , all banks invest in  $P$  loans. Investors are promised a repayment of  $\hat{D}_P(r_o^p)$  at  $t=2$  in order for the bank to raise \$1 at  $t=0$ , where*

$$\hat{D}_p(r_o^p) = \frac{\{1 - \theta[1 - \delta]L\}}{[1 - \theta + \theta\delta][r_o^p]} > 1 \quad (33)$$

and the bank's expected payoff is:

$$\hat{\pi}_1^p = [1 - \theta] \left\{ Y_p(r_o^p) + [N - 1] \theta^{N-1} [TV_p(r_o^p) - L] \right\} + \theta \delta Y_p(r_o^p) \quad (34)$$

where

$$Y_p(r_o^p) = [r_o^p] [X_p - \hat{D}_p(r_o^p)] \quad (35)$$

$$TV_p(r_o^p) = [r_o^p] X_p \quad (36)$$

The probability that the bank will survive until the second period beginning at  $t=2$  is  $[1 - \theta] + \theta\delta$ .

The bank's survival probability is the probability there is no liquidity shock (which is  $1 - \theta$ ) plus the probability of the liquidity shock ( $\theta$ ) times the probability,  $\delta$ , that the loan can be sold at its expected value,  $Y_p(r_o^p)$ . If the loan can only be sold at  $L$ , the bank has to pay investors  $L$  and it has to shut down at  $t=1$ .

## V. WELFARE IMPLICATIONS, CRISIS CYCLES, TRANSITORY VERSUS PERMANENT SHOCKS, INTERPRETATION OF THE RESULTS AND POLICY IMPLICATIONS

This section discusses a number of issues. First, I interpret the findings of the model and compare its implications with those of the model with rationality developed in Thakor (2014b). Then, I discuss the welfare implication of the model. This is followed by a discussion of what the model says about why the U.S. has witnessed so few banking crisis in the last few decades, and what has changed. The role of transitory versus permanent shocks related to whether loan repayment probabilities are exogenous is discussed next.

### A. Interpreting the Model

Because a crisis occurs only after banks invest in  $R$  loans, and these investments occur only for banks that have experienced first-period success, the preceding analysis sheds light on why financial crises follow booms. Moreover, to the extent that both capital requirements as well as the amount of capital banks

choose to keep voluntarily are higher when perceived risk in banking is higher, the model also explains low capital levels in the booms that precede financial crises. After all, it is during these booms that everybody thinks bankers are highly skilled and capable of managing risks effectively. It is also precisely for this reason that bank CEOs are highly paid prior to crises and bank regulators do not feel compelled to engage in costly and intrusive monitoring of banks.

Although some of these implications can also be derived in a model in which all agents are rational, as I do in Thakor (2014b), an exercise of that nature comes with substantially greater modeling complexity. Moreover, there are many differences between the implications of that model and the analysis here that are discussed below. First, the model with rational agents involves numerous additional restrictions on exogenous parameters that are unnecessary here, so the range of circumstances in which the implications of the model apply is much broader here. Second, in Thakor (2014b), a crisis only occurs if sufficiently many banks fail and cause agents to arrive at sufficiently adverse posterior beliefs about  $\lambda$  to induce them to pull funding from banks. In the model here, a crisis can come about with no such pre-crisis “warnings”. Third, in Thakor (1984b),  $\lambda > 0$  is common knowledge, so regulators know when  $\lambda$  is low and the price of risk is low as a consequence. Knowing that  $\lambda > 0$  also means that they recognize the possibility of a crisis, and can take preventive action, such as raising capital requirements to retard risk-taking. Such countercyclical measures do *not* arise as an optimal regulatory response in the model here because *no one*, including regulators, thinks *ex ante* that there is any likelihood of loan repayment probabilities being unaffected by the skills of bankers. Fourth, the availability heuristic in this paper works through the mental shortcuts agents take based on their own recent experiences. This generates the implication that having people who have personally experienced financial crises serve on bank boards, as bank CEOs and as officials in bank regulatory agencies can help to generate beliefs that may be conducive to reducing the likelihood of a crisis. No such implications arise in a model with full rationality. Finally, the analysis here can explain why the economy falls to pieces after a crisis and may not recover even though the friction that caused the crisis has dissipated (this analysis appears later in this section); the model with full rationality does not explain this.

## B. Efficiency

A natural question that arises is whether a financial crisis in this model is efficient. Because information is symmetric, a crisis occurs only when banks invest in  $R$  loans, and the liquidation value of such a loan exceeds the expected value conditional on loan value being purely exogenous (i.e.,  $L > rqX_R$ ). However, since  $L < rqX_R + K$ , a crisis is indeed inefficient.<sup>24</sup>

## C. Why There Have Been So Few Banking Crisis in the U.S. and What Has Changed

The model suggests that two factors may have been at work in explaining why the U.S. has experienced so few banking crises since the Great Depression. One is that  $\lambda$ , the probability of a shock that loan success probabilities are exogenous, may have been low. The other, more interesting, possibility is that financial innovation in U.S. banks was historically low, partly due to the Glass-Steagall separation between commercial and investment banking (see Boot and Thakor (1997)). This means that opportunities for banks to invest in riskier  $R$  loans were limited. However, that has now changed. Along with changing perceptions of the skills of bankers, there is also a greater availability of increasingly risky and innovative financial instruments to invest in. Thus, the analysis in this paper implies an increasing learning-based incidence of banking crises in the future.

## D. Why the Economy Falls to Pieces Following Credit Crises

The preceding analysis can also be used to understand why recessions seem to follow major financial crises, such as the financial crisis of 1929 leading to The Great Depression, and the subprime crisis leading to the recession we witnessed recently. The essence of the explanation is that a crisis may lower bankers' beliefs about their own skills, and if this downward revision is sufficiently large, bankers will appear to become excessively conservative in lending, possibly causing all lending to dry up. To see this, consider a modified version of the model.

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<sup>24</sup> Another potential source of inefficiency—outside the scope of this analysis—is that a crisis shuts down many banks that are experts in credit screening (e.g., Ramakrishnan and Thakor (1984)) and this causes a loss of screening expertise.

**A Modified Model:** The focus of the modified model is on what happens after a majority of banks succeed at  $t=2$  and invest in  $R$  loans, and then a crisis occurs at  $t=3$ . In the base model, there is no analysis of post-crisis events at  $t=3$ . In order to examine post-crisis events, suppose that *only* the bank's debt investors *privately* learn at  $t=3$  whether the loan repayment probability is exogenous (*w.p.*  $\lambda$ ) or skill-dependent (*w.p.*  $1-\lambda$ ). In case they learn that the probability is skill-dependent, they also come to observe the bank's type: whether it is  $\tau$  or  $u$ . All that the bank learns at  $t=3$  is that the true model of the world may have changed and that loan success probabilities may be independent of the skills of bankers (the bank recognizes at  $t=3$  that the probability of this is  $\lambda$ ) but it does not know if that is indeed true. As before, let us focus on banks that made  $P$  loans in the first period that repaid, so that these banks have made  $R$  loans in the second period.

**How a Crisis Arises:** The situation of interest is one in which there is a financial crisis. This occurs when investors withdraw funding at  $t=3$  after having learned: (i) that the true success probability of the  $R$  project is exogenous and equal to  $r q$  (which has a probability of  $\lambda$ ); or (ii) that the true success probability is skill-dependent and that the majority of banks are type- $u$ . While investors withdraw funding, in case (i), banks could return to the market with  $P$  loans and obtain funding, since investors would assign a success probability of  $r + b[1-r]$  to these loans.

**What Banks See:** It is assumed that *only* investors observe whether loan repayment probabilities are exogenous or skill-dependent, and in the latter case the bank's type. Banks cannot observe this, but can observe the decision of investors to renew or terminate funding.

**Analysis of Modified Model:** The question is: what will be the posterior beliefs of banks about their own type after the crisis has occurred? If banks could observe that investors have withdrawn funding because they believe the  $R$  loan is too risky, bankers would *not* lower their assessments of their own skills and may be willing to invest in  $P$  loans and investors would be willing to fund them. But banks do not know what investors know. All banks can observe is the crisis at  $t=3$ . This makes it possible that banks may erroneously lower their probability assessments of their own abilities (case (ii))

even when the crisis was triggered by investors lowering their belief about the success probability of the  $R$  loan (case (i)). The posterior probability a bank will assign to the event that it is type- $\tau$  after experiencing withdrawal of its funding at  $t=3$  is (referring to “funding withdrawal” as “f.w.”):

$$\Pr(\tau|f.w. \text{ at } t=3) = \frac{\Pr(f.w.|\tau)\Pr(\tau)}{\left\{\Pr(f.w.|\tau)\Pr(\tau) + \Pr(f.w.|\tau)\Pr(u) + \Pr(f.w.|\text{success probability exogenous})\lambda\right\}} = 0$$

$$\Pr(u|f.w. \text{ at } t=3) = \frac{[1-\lambda][1-r_2^s]}{\{[1-\lambda][1-r_2^s] + \lambda\}} \quad (37)$$

Thus, after having observed funding withdrawal at  $t=3$ , the bank will have the posterior belief that the probability of loan repayment on a  $P$  loan it can make at  $t=4$  will be

$$\lambda[r + [1-r]b] + [1-\lambda]b \quad (38)$$

since it assigns a zero probability to being of type  $\tau$ . If  $\lambda$  is small, the above posterior will be close to  $b$ .

Assume now that the bank must incur a cost (possibly arbitrarily small)  $\Psi > 0$  of investing in a  $P$  loan.

Thus, we have:

**Proposition 6:** *There exists a  $\lambda \in (0,1)$  small enough such that no bank that suffers a withdrawal of funding at  $t=3$  and fails during a crisis will wish to invest in any loan at  $t=4$  even though investors are willing to fund  $P$  loans at that time.*

The intuition is as follows. The expression in (37) is decreasing in  $\lambda$ , so for  $\lambda$  low enough, the observation of funding withdrawal will cause the bank to believe that it is relatively highly likely that investors received a signal that indicated that the bank was type- $u$ . This makes even a  $P$  loan unattractive to the bank if there is even a miniscule cost of engaging in such lending.

Since banks do not lend, this economy falls to pieces. This continues even when the financing friction that investors will not fund banks has disappeared. The reason is not a lack of availability of funds. Rather, it is the banker’s lack of confidence in his own ability to make profitable loans.

## VI. CONCLUSION

This paper has proposed a theory of financial crises based on a combination of the availability heuristic and learning that leads to revisions in inferences of banking skills. In such a setting, a sufficiently long



sequence of favorable outcomes for banks leads *all agents*—banks themselves, their investors, rating agencies, and regulators—to assign relatively high probabilities to the abilities of banks to manage their own risks. This provides banks with access to low-cost funding. Consequently, if it is revealed in the future that outcomes are skill-independent and purely exogenous, a crisis occurs as debt investors withdraw their funding from banks and the loan sale market dries up.

This theory of financial crises can explain a substantial pre-crisis build-up of liquidity, and then a sudden collapse of the system, with a rapid drying up of liquidity. The theory developed here also predicts that such financial crises will be cyclical, and likely to follow booms.

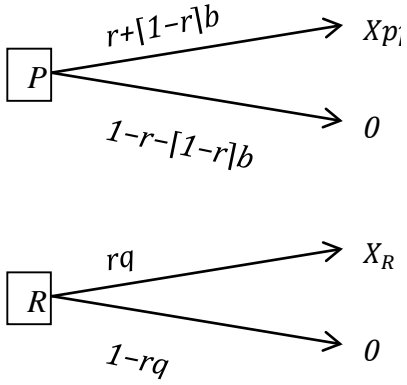
The analysis in this paper also sheds light on why the real economy falls to pieces even after the financial-market frictions that precipitated the crisis have subsided. The reason is that the crisis is accompanied by a downward revision in ability perceptions *within* banks, so banks become “gun shy” and cut back on investments even though investors are willing to resume funding banks.

**FIGURE 1. SEQUENCE OF EVENTS**

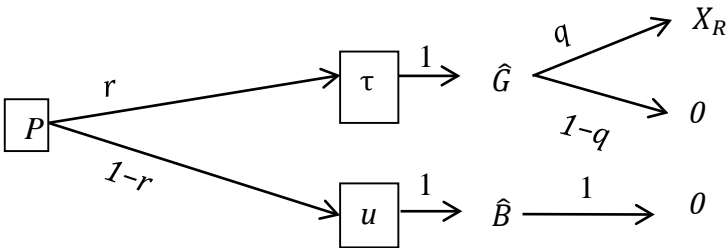
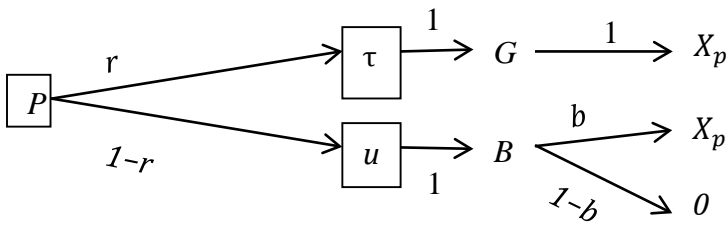
0	1	2	3	4
<ul style="list-style-type: none"> <li>• Banks choose between prudent (<math>P</math>) and risky (<math>R</math>) loans and invest \$1 in the chosen loan.</li> <li>• The loan is entirely debt financed, and financing is raised from investors.</li> <li>• The common prior belief is that the loan repayment probability is almost surely skill-dependent, and in this case the probability is <math>r \in (0,1)</math> that the bank is talented (type <math>\tau</math>) and <math>1-r</math> that it is untalented (type-<math>u</math>). The true model of the world is that there is a probability <math>\lambda \in (0,1)</math> that the loan repayment probability is purely exogenous.</li> </ul>	<ul style="list-style-type: none"> <li>• Activity at this date occurs only if there is a loan resale market.</li> </ul>	<ul style="list-style-type: none"> <li>• Loans made at <math>t=0</math> pay off.</li> <li>• Investors revise their beliefs about the bank's type based on whether the loans pay off or not.</li> <li>• Banks make new loans financed with new debt.</li> </ul>	<ul style="list-style-type: none"> <li>• The realization of state <math>\xi</math> is commonly observed by investors who learn whether the repayment probability of the loans chosen by banks is exogenous or skill-dependent.</li> <li>• Investors decide whether to demand immediate repayment from the bank.</li> <li>• If the bank can fully pay off investors their promised amount, it survives until <math>t=4</math>. Otherwise, it ceases to exist.</li> </ul>	<ul style="list-style-type: none"> <li>• Loans pay off and new investors paid off if bank not liquidated at <math>t=3</math>.</li> </ul>

**FIGURE 2: Pictorial Depiction of Project Success Probabilities**

*Exogenous Project Success Probabilities*



*Skill Dependent Project Success Probabilities*



## APPENDIX

### Proof of Lemma 1:

If the loan repayment probability is exogenous, then this probability is  $r_o^R X_R < 1$ . Thus, investors withdraw funding.

■

### Proof of Proposition 1:

Now, default on the first-period loan leads to expected second-period repayment probabilities of  $\hat{r}_2^P(f)$  (given by (9)) and  $\hat{r}_2^R(f)$  (given by (10)) on the  $P$  and  $R$  loans respectively. From this, it follows that second-period financing can be raised for neither the  $P$  nor the  $R$  loan. The bank thus exits the market. If the first-period loan repays, then the bank's expected profit on the second-period loan is (see (15)):

$\bar{\pi}_2^P = \hat{r}_2^P(s)\{X_P - \bar{D}_P(\hat{r}_2^P(s))\}$  with a  $P$  loan, where  $\hat{r}_2^P(s)$  is given by (17). Substituting for  $\hat{r}_2^P(s)$ , using (16) and simplifying yields:

$$\bar{\pi}_2^P = \hat{r}_2^P(s)X_P - 1 \quad (\text{A-1})$$

Similarly, using (17), and recognizing that  $\bar{D}_R(\hat{r}_2^R(s)) = 1/qr_2^S$ , the bank's second-period expected profit with an  $R$  loan is:

$$\bar{\pi}_2^R = qr_2^S X_R - 1 \quad (\text{A-2})$$

The rest of the proof requires comparing (A-1) and (A-2). At  $r_2^S = r$ , it is clear that  $\bar{\pi}_2^P > \bar{\pi}_2^R$ . To see this, note that the bank cannot raise financing for  $R$  if the posterior belief is that the probability of the bank being of type  $\tau$  is  $r$ . Thus,  $\bar{\pi}_2^R = 0$  at  $r_2^S = r$ . However, given (2), it is clear that  $\bar{\pi}_2^P > 0$  at  $r_2^S = r$ .

Now, consider  $r_2^S = 1$ . By (12), we know  $\hat{r}_2^P(s) = r_2^S + [1 - r_2^S]b = 1$ . Thus, using (A-1) and (A-2),

we have

$$\bar{\pi}_2^P = x_p - 1 \quad (\text{A-3})$$

$$\bar{\pi}_2^R = qX_R - 1 \quad (\text{A-4})$$

Given (4) and (5), (A-3) and (A-4) show that  $\bar{\pi}_2^R > \bar{\pi}_2^P$  at  $r_2^s = 1$ . Since  $\bar{\pi}_2^P$  and  $\bar{\pi}_2^R$  are continuous functions of  $r_2^s$ , with  $\bar{\pi}_2^P > \bar{\pi}_2^R$  at  $r_2^s = r$  and  $\bar{\pi}_2^R > \bar{\pi}_2^P$  at  $r_2^s = 1$ , it follows that the two functions intersect at least once in  $[r, 1]$ . It will now be shown that they intersect only once. Now, for  $r_2^s \in (r, 1)$ , using (A-1) and (A-2), we have:

$$\partial \bar{\pi}_2^P / \partial r_2^s = [1-b]X_p > 0 \quad (\text{A-5})$$

$$\partial \bar{\pi}_2^R / \partial r_2^s = qX_R > 0. \quad (\text{A-6})$$

Given (4), it follows that  $\partial \bar{\pi}_2^R / \partial r_2^s > \partial \bar{\pi}_2^P / \partial r_2^s$ . Thus,  $\bar{\pi}_2^P$  and  $\bar{\pi}_2^R$  will intersect only once for  $r_2^s \in [r, 1]$ .

Thus, since  $\bar{\pi}_2^R > \bar{\pi}_2^P$  at  $r_2^s = 1$  and  $\bar{\pi}_2^P > \bar{\pi}_2^R$  at  $r_2^s = r$ , and  $\bar{\pi}_2^P$  and  $\bar{\pi}_2^R$  are strictly increasing in  $r_2^s$ , with  $\bar{\pi}_2^R$  having a steeper slope, we see that  $\exists$  a unique  $r_2^s$  (cut-off)  $\in (r, 1)$  such that  $\bar{\pi}_2^R = \bar{\pi}_2^P$  at  $r_2^s = r_2^s$  (cut-off) and  $\bar{\pi}_2^R > \bar{\pi}_2^P \forall r_2^s > r_2^s$  (cut-off) and  $\bar{\pi}_2^R < \bar{\pi}_2^P \forall r_2^s < r_2^s$  (cut-off). ■

### **Proof of Proposition 2:**

The proof is obvious given the earlier arguments. ■

### **Proof of Proposition 3:**

Since no information is revealed at  $t=1$ , the loans continue to be viewed as profitable, so investors never withdraw funding at  $t=1$  and there is no crisis. Now, if banks experience first-period success, then it follows from Proposition 1 (given that  $r_2^s > r_2^s$  (cut-off)) that the bank prefers an  $R$  loan to a  $P$  loan in the second period. So all banks experiencing first-period success invest in  $R$  loans. Clearly, if it is revealed at  $t=3$  that the loan repayment probability is exogenous, investors withdraw funding and a crisis ensues. ■

### **Proof of Lemma 2:**

If investors are promised a repayment of  $\hat{D}_p(z)$ , the debt pricing condition is:

$$[1 - \theta + \theta\delta]z\hat{D}_p(z) + \theta[1 - \delta]L = 1 \quad (\text{A-7})$$

where  $z$  is the loan repayment probability and  $\delta$  (given by (20)) is the probability that there are two or more buyers for the bank's loans. Now (21) follows from (A-7). The bank's expected payoff in (22) follows from the discussion in the text following the statement of the lemma. ■

**Proof of Lemma 3:**

The proof follows the same steps as the proof of Lemma 2. ■

**Proof of Lemma 4:**

Use (26) and (28) to write (27) as

$$\hat{\pi}_2^R = \{r_2^s q[1 - \theta + \theta\delta]X_R + \theta[1 - \delta]L - 1 + [N - 1][1 - 0]\theta^{N-1}[TV_R - L]\} - C_i$$

If there is no loan resale market, then the probability of there being two or more banks to buy the loan is zero, and the  $[N - 1]\theta^{N-1}[TV_R - L]$  terms drops out. Note that  $\partial \hat{\pi}_2^R / \partial \delta = \theta\{r_2^s qX_R - L\} > 0$ .

Thus, the loan resale market leads to a higher expected profit for the bank than when there is no loan resale market. A similar result can be established for the bank's profit with the  $P$  loan.

The fact that the loan resale market does not increase the number of banks making the  $P$  loan follows from the fact that the  $P$  loan is profitable for all banks, even without the loan resale market, i.e.,  $\hat{\pi}_2^P > 0$ . As for the  $R$  loan,  $\hat{\pi}_2^R \geq 0$  requires that:

$$[1 - \theta]\{Y_R + [N - 1]\theta^{N-1}[TV_R - L]\} + \theta\delta Y_R \geq C_i \quad (\text{A-8})$$

Let  $C_i^0$  be the cut-off value of  $C_i$  at which (A-8) holds as an equality. Similarly, the condition  $\bar{\pi}_2^R \geq 0$  requires that:

$$[1 - \theta]r_2^s q[X_R - \hat{D}_R(qr_2^s)] \geq C_i \quad (\text{A-9})$$

Let  $C_i^*$  be the cut-off value of  $C_i$  at which (A-9) holds as an equality. Then, it is clear that  $C_i^0 < C_i^*$ . Thus, the loan resale market increases the number of banks choosing the  $R$  loan. ■

**Proof of Proposition 4:**

Part of the proof is similar to that for Proposition 1. Using arguments similar to those used in the proof of that Proposition, it can be shown that  $\hat{\pi}_2^P$  and  $\hat{\pi}_2^R$  are continuously increasing in  $r_2^s$  with  $\hat{\pi}_2^P > \hat{\pi}_2^R$  at  $r_2^s = r$  and  $\hat{\pi}_2^R > \hat{\pi}_2^P$  at  $r_2^s = 1$ . From this it follows that  $\exists$  a unique  $\hat{r}_2^s$  (cut-off)  $\in (r, 1)$  such that  $P$  is strictly preferred if  $r < \hat{r}_2^s$  (cut-off) and  $R$  is strictly preferred if  $r > \hat{r}_2^s$  (cut-off).

The fact that  $\hat{r}_2^s$  (cut-off) is an increasing function of  $C_i$  follows from the observation that  $\hat{\pi}_2^P$  is decreasing in  $C_i$ . Moreover, the cost realization for a particular bank affects its cut-off since the cut-off depends on  $C_i$ . Since the cut-off is increasing in  $C_i$ , it follows that  $r_2^s(0, n_0) < \hat{r}_2^s(\underline{C}, n_0) < \hat{r}_2^s(\bar{C}, n_0)$  given that  $0 < \underline{C} < \bar{C}$ .

To show that, holding  $C_i$  fixed, the cut-off  $\hat{r}_2^s$  decreases as the number of successful banks with that cost realization increases, we need to show that the expected fraction of successful banks at  $t=2$  that will prefer  $R$  over  $P$  is non-decreasing in  $N$ , the number of successful banks at  $t=2$ . For this, we need to

show that  $\frac{\partial \hat{\pi}_2^R}{\partial N} \geq \frac{\partial \pi_2^P}{\partial N}$ , with strict inequality for  $N$  large enough. Note first that (22) can be simplified and

written as:

$$\hat{\pi}_2^P = \{[1 - \theta + \theta\delta]\hat{r}_2^P(s)X_p + \theta[1 - \delta]L - 1\} + [1 - \theta][N - 1]\theta^{N-1}\{TV_p - L\} \quad (\text{A-10})$$

Thus,

$$\frac{\partial \hat{\pi}_2^P}{\partial N} = \{\theta[\hat{r}_2^P(s)X_p - L]\}\left[\frac{\partial \delta}{\partial N}\right] + [1 - \theta]\{TV_p - L\}\frac{\partial\{[N - 1]\theta^{N-1}\}}{\partial N} \quad (\text{A-11})$$

Note that  $\frac{\partial\{[N - 1]\theta^{N-1}\}}{\partial N} = \theta^{N-1} + [N - 1]\ln(\theta)\theta^{N-1}$ ,  $\lim_{N \rightarrow \infty} \theta^{N-1}\{1 + [N - 1]\ln(\theta)\} = 0$  since  $\theta < 1$ , and  $\partial\delta / \partial N > 0$

(see (20)).

Similarly,

$$\frac{\partial \hat{\pi}_2^R}{\partial N} = \theta[r_2^s q X_R - L]\left[\frac{\partial \delta}{\partial N}\right] + \theta^{N-1}\{1 + [N - 1]\ln(\theta)\}[TV_R - L] \quad (\text{A-12})$$

Comparing (A-11) and (A-12), we see that for  $N$  large enough,  $\frac{\partial \hat{\pi}_2^R}{\partial N} > \frac{\partial \hat{\pi}_2^P}{\partial N}$ .

This shows that if  $N$  is sufficiently large, then an increase in  $N$  leads to a greater increase in the bank's expected profit from  $R$  than from  $P$ . Hence, the cut-off  $\hat{r}_2^s(C_i, N)$  decreases for any  $C_i$ , giving us  $\hat{r}_2^s(C_i, n_0) > \hat{r}_2^s(C_i, n_0 + n_1) > \hat{r}_2^s(C_i, N)$ .

This implies that for a particular realization of  $N$ , say  $N_1$ , we will have only banks that realized  $C_i = 0$  prefer  $R$  over  $P$  as  $r_2^s > \hat{r}_2^s(0, N_1)$ , but  $r_2^s < \hat{r}_2^s(\underline{C}, N_1)$ . In this case,  $n_0$  banks will invest in  $R$  at  $t=2$  and  $N_1 - n_0$  banks will invest in  $P$ . Relatively small increases in  $N$  beyond  $N_1$  will leave these inequalities unchanged. However, at a sufficiently higher  $N$ , say  $N_2 > N_1$ , we will have  $r_2^s > \hat{r}_2^s(\underline{C}, N_2)$ , so now  $n_0 + n_1$  banks will invest in  $R$  and the rest will invest in  $P$ . Then these inequalities will remain unchanged for small increases in  $N$  beyond  $N_2$ , but for a sufficiently large  $N_3 > N_2$ , we will have  $r_2^s > \hat{r}_2^s(\bar{C}, N_3)$ , and then all  $N_3$  banks will switch to  $R$  loans.

Thus, it has been proven that the expected number of banks investing in  $R$  is non-decreasing in  $N$ , and for  $N$  sufficiently high, all banks invest in  $N$ . ■

**Proof of Proposition 5:**

The proof is straightforward, given earlier results. With a  $P$  loan, if investors learn at  $t=3$  that the loan repayment probability is exogenous, they view the success probability as  $[r + [1-r]b]$  rather than  $[r_2^s + [1-r_2^s]b]$ , with  $r_2^s > r$ . However, it is still preferable for investors to continue funding  $P$  rather than liquidating. However, with  $R$ , the recognition that the true probability is  $rq$  rather than  $r_2^s q$  causes investors to liquidate.

It has already been shown earlier that an increase in  $r_2^s$  leads to an increase in the expected number of banks investing in  $R$  (see Proposition 4). Thus, if investors learn that the loan repayment probability of  $R$  is exogenous, then these banks are liquidated, implying that an increase in  $r_2^s$  leads to an increase in the expected number of banks that are liquidated. ■

**Proof of Lemma 5:** The proof is similar to that for Lemma 2 and therefore omitted for space reasons. ■

**Proof of Proposition 6:**

From (38) it follows that the probability of repayment on a  $P$  loan satisfies:

$$\lim_{\lambda \rightarrow 0} \{\lambda[r + (1-r)b] + [1-\lambda]b\} = b.$$



Since the probability of repayment on the  $P$  loan is continuous in  $\lambda$ , and  $bX_p < 1$ , it follows that the bank's expected profit on the  $P$  loan will be 0 ignoring  $\Psi$ , and  $-\Psi < 0$  if  $\Psi$  is included. Thus, the bank does not make a  $P$  loan. This is the case in which the bank is unwilling to invest in the  $P$  loan and investors are unwilling to fund it. For a higher value of  $\lambda$ , say  $\lambda^* > 0$ , repayment probability may satisfy  $\{\lambda^* [r + (1-r)b] + [1 - \lambda^*]b\} X_p = 1$ , in which case investors will be willing to fund the  $P$  loan. But the bank's expected profit at  $\lambda^*$  will be  $-\Psi < 0$ , so the bank will not lend even though investors are willing to fund it. The repayment probability on the  $R$  loan will be viewed by the bank as 0 at any  $\lambda \leq \lambda^*$ , so again, the bank's expected profit is  $-\Psi < 0$ . Thus, no lending occurs. ■

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