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A theory of failed bank resolution: Technological change and political economics

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ABSTRACT

We model the failed bank resolution process as a repeated game between a utility-maximizing government resolution authority (RA) and a profit-maximizing banking industry. Limits to resolution technology and political/economic pressure create incentives for the RA to bail out failed complex banks; the inability of the RA to credibly commit to closing these banks creates an incentive for bank complexity. We solve the game in mixed strategies and find equilibrium conditions remarkably descriptive of government responses to actual and potential large bank insolvencies during the recent financial crisis. The central role of the technology constraint in this model highlights a crucial determinant of failed bank resolution policy that has been overlooked in the theory literature to date; without improved resolution technologies, future bank bailouts are inevitable. The effects of political pressure in this model remind us that regulatory reform (e.g., Dodd-Frank) is only as good as the regulators that implement the reform.

1. Introduction

Government bailouts of large insolvent financial institutions was one of the most critical and controversial events of the recent international financial crisis. While the details of these bailouts differed, the underlying policy motivations were the same: to prevent the financial troubles at single institutions from spreading to other parts of the financial system, thus avoiding a collapse of credit markets and disastrous macro-economic consequences. By guaranteeing that creditors of these institutions suffered few if any losses, policymakers struck an implicit bargain with the financial system: preserve financial market liquidity today at the cost of increasing the moral hazard incentives of financial market participants in the future. In other words, policymakers traded market discipline in exchange for market liquidity.

We explore the implications of this policy tradeoff for the risk composition of the banking industry. In our theory model, we stress a crucial determinant of policy that has received scant attention in the previous literature: the limited set of failed bank resolution technologies that can leave regulators with little choice but to bail out systemically important banks. Our study is timely, as the technology sets of bank resolution authorities—most notably the Federal Deposit Insurance Corporation (FDIC)—are in the process of expanding. For example, the Wall Street Reform and Consumer Protection Act of 2010 (a.k.a. the Dodd-Frank Act) expands the FDIC's resolution authority beyond insolvent banks, and gives the agency "orderly liquidation authority" to place systemically important financial companies of all types into receivership and liquidate them. Dodd-Frank also mandates that financial institutions perform more of their derivatives trading through centralized clearing houses and requires systemically important financial firms to file "living wills" with the FDIC—changes that improve the FDIC's ability to accurately value the assets, and better understand the production processes, of troubled complex banking firms.

But having authority to resolve insolvent banks is not equivalent to actually wielding that authority. Our model also emphasizes the likelihood that mounting political and/or economic pressure during a financial crisis can lead even a well-armed regulator to bailout systemically important banks. The public relations message that accompanied Dodd-Frank was clear and seemingly unequivocal. At bill's signing, President Obama said "The American people will never again be asked to foot the bill for Wall Street's mistakes. There will be no more taxpayer-funded bailouts. Period." Like most declarative statements, this one contains some wiggle room: ruling out "*taxpayer-funded* bailouts" does not rule out bailouts funded by some other third party and hence does not by itself reduce moral hazard incentives. Dodd-Frank provides a resolution mechanism

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in which losses are borne by stockholders and unsecured creditors at the insolvent firm, with losses larger than this shared across the entire banking industry. But this new structure is untested, and regulatory credibility will not be established until a firm previously considered "too big to fail" is closed and liquidated without creating a crisis in financial markets.

Our model is a straightforward, repeated game between a utility-maximizing resolution authority that chooses between closing and bailing out failed banks, and an expected profit-maximizing banking industry that chooses between simple (transparent, easy to unwind) and complex (opaque, difficult to unwind) loan production processes. The regulator values resolutions that generate both market discipline and market liquidity, but it is forced to trade the former for the latter (i.e., choose a bail out) when its resolution technology is insufficient to close a failed complex bank without imposing spillover costs on the macro-economy. The key innovation in our model is the inclusion of a technology constraint—a realistic condition not considered in previous models of bank resolution—and tightening or loosening this constraint provides key results. In equilibrium, insufficient resolution technology, combined with short-run political or economic pressure, support a too-complex-to-fail (TCTF) resolution policy; this inability of regulators to credibly commit to closing failed complex banks encourages continued or increased bank complexity. These conditions are remarkably descriptive of government responses to actual and potential large bank insolvencies before and during the recent financial crisis. Improvements in resolution technology have over time allowed the FDIC to close increasingly large and complex banks, but economic and political pressures during the financial crises resulted in resolution choices (e.g., allowing already TCTF banks to acquire insolvent TCTF banks) that exacerbated the gap between bank complexity and the ability of regulators to close failed complex banks. In the end, a deeper technological toolbox can be useless if regulators favor preserving short-run liquidity over imposing long-run discipline.

It is important to state what our model is *not* about. The banks in our model *do not* choose to be risky or safe; rather, they choose to be either complex or simple, where complexity is unrelated to the probability that a bank fails, but makes a bank difficult for regulators to unwind should it fail. Thus, the regulator in our model is *not* choosing its strategy in order to minimize moral hazard incentives that make banks more prone to take pre-failure risks, but rather to reduce the post-failure complexity that makes it necessary to bail out failed banks. These distinctions set our paper apart from most of the theoretical literature on bank failure regulation.

Because the U.S. has the longest history of deposit insurance and failed bank resolution, we couch our discussion of bank resolution authority in terms of the FDIC; nevertheless, our findings have clear implications for bank failure resolution outside the U.S. The remainder of the paper unfolds as follows. Section 2 reviews the historical tradeoff between preserving liquidity and imposing discipline in failed bank resolution policy in the U.S. Section 3 describes the techniques used by the FDIC to resolve failed banks and how this technology set has evolved over time, including during and after the financial crisis. (A substantially more detailed discussion of the material in Sections 2 and 3, along with an historical appendix, are available in the longer working paper version of this study.) Section 4 presents our theory model and analyzes its main results. Section 5 discusses the implications of our analysis for bank resolution policy.

2. Market liquidity versus market discipline

Commercial banks play a central role in our economy, but their inherent fragility requires special regulatory attention. Absent appropriate regulation, depositors and short-term creditors may withdraw their funds from banks experiencing declines in asset quality, prompting reductions in economic liquidity beyond the troubled banks themselves. Bank failures can also reduce liquidity by disrupting borrower access to credit (e.g., Ashcraft, 2005). Depending on the size and/or number of the affected banks, these disruptions to market liquidity can be debilitating for the economy at large.[1] Repeated banking panics in the United States during the nineteenth and early twentieth centuries led to the creation of the FDIC in 1934, a new federal agency with the mandate to insure bank deposits and the power to seize and quickly resolve failed banks. Deposit insurance reduced incentives for small depositors to run and precipitate bank failure, and bypassing lengthy bankruptcy proceedings for failed banks reduced disruptions to depositor liquidity, borrower liquidity and payments.

The potential cost of preserving liquidity in this fashion is the creation of moral hazard incentives and the resulting loss of market discipline. Like all regulatory solutions to market failure, deposit insurance protections and bank resolution procedures are second-best arrangements that result in incentive incompatibilities. Knowing (or suspecting) their deposits are protected from loss, insured (and to a lesser extent, uninsured) depositors have little incentive to monitor the financial condition of their banks, and have the perverse incentive to make deposits at troubled banks paying above-market interest rates. The deposit insurance put option gives managers of troubled banks incentives to "gamble for resurrection" by paying above-market rates for deposits and investing those funds in risky loans. Extending deposit insurance protection to all bank creditors in failed banks, or providing financial assistance to keep insolvent banks open, reduces market discipline further and exacerbates the risk-taking behaviors of both bank depositors and bank managers.

2.1. Regulator incentives

As a first principle, one might reasonably presume that government deposit insurers strongly identify with their mission of protecting insured depositors and, when administratively possible, this culture can easily err on the side of protecting uninsured depositors and non-deposit creditors as well. Such predilections may be exacerbated when political and/or economic pressures arise to prevent illiquidity at all costs—for instance, during economic crises when numerous large banks become insolvent. Whether or not these predilections rise to the level of serious principle-agent problems is the subject of some debate (Kane, 1990; Mishkin, 1992). Kane and Klingebiel (2004) weigh in with an especially cynical assessment: Regulators exhibit a bias toward bailing out all depositors because they do not want to be blamed (rightly or wrongly) for the bank failure by disgruntled (unprotected) depositors. Looking from a different angle, Kane (1995) shows how existing legal and regulatory arrangements (including the prompt corrective action features of the Federal Deposit Insurance Corporation Improvement Act of 1991) create incentives for regulators to practice forbearance.

Regardless of regulator motive, making uninsured depositors whole reduces deposit market discipline: it reinforces the incentives for depositors to lend to risky banks, and it enhances the value of the deposit insurance put option. Numerous proposals have been made for preserving market liquidity while still imposing at least a modicum of discipline on depositors. Kaufman and Seelig (2002) proposed a combination of quick access to insured deposit funds

[1] Hoggarth et al. (2002) estimate that the economic costs of a systemic bank failure event could run as high as 15–20% of a nation's GDP.

and a partial "advance dividend payment" to uninsured depositors, the amount of the latter based on a first approximation of the value of the failed bank's assets.[2] Slight delays in paying depositors may have positive market discipline effects by imposing costs on depositors who knowingly provide funds to risky banks; under this line of thought, if authorities can credibly commit to such a practice, depositors will have incentives to monitor the banks and demand higher rates on funds they deposit in risky banks. A continuing line of policy proposals in this same vein is provided by Kaufman (2004), Mayes (2004), Kaufman and Eisenbeis (2005) and Harrison et al. (2007).

2.2. Resolution policy in practice

Fig. 1 briefly describes the main resolution techniques used by the FDIC since its inception; some of these techniques have only recently become available to the FDIC via legal changes or improved technologies, while others are no longer available or have fallen into disuse over time.[3] The various techniques are displayed in rank order based on the degree to which they preserve liquidity. Because there is a roughly inverse relationship exists between preserving market liquidity and enhancing market discipline among these techniques, Fig. 1 also illustrates the primary economic tradeoff (liquidity versus discipline) facing policymakers. Finally, the figure also shows that borrower liquidity and depositor liquidity tend to be positively correlated across these techniques—for example, when a receivership liquidates a failed bank's assets gradually over time, some depositors will be denied full access to their (uninsured) funds, and some borrowers will be denied full access to their lines of credit, until enough assets are sold to cover these obligations.

Over the past three-quarters of a century, bank resolution practices in the U.S. have swung between the extremes of Fig. 1 spectrum. Prior to the establishment of the FDIC in 1933, bank failures were typically resolved in a manner analogous to chapter 7 bankruptcies of non-bank corporations. This approach clearly favored imposing discipline over preserving liquidity. Insolvent banks were closed and a receiver was named to manage the resolution, usually the state banking authority for state chartered banks or the Office of the Comptroller of the Currency (OCC) for national banks. The receiver was responsible for liquidating the assets of the failed bank and repaying the depositors and other creditors of the bank. This process could take many years, during which depositors and other liability holders of the failed bank lost access to their funds.[4] Borrowers also faced large costs, having to establish new credit relationships at other banks while still having to pay off any existing loans from the closed bank. A number of studies have focused on the economic impact of bank failures during the 1920s and early 1930s; these studies find that bank failures by themselves, even if unaccompanied by an extended financial panic, had negative effects on the economy (e.g., Bernanke, 1983; Calomiris and Mason, 2003; Kupiec and Ramirez, 2009; Ramirez and Shively, 2012).

The creation of FDIC and the introduction of federal deposit insurance greatly mitigated the immediate ill effects of bank failure. Insured depositors (and often uninsured creditors as well) were made whole immediately when a failed bank was closed, and repeated application of this practice defused incentives for bank runs. Moreover, most borrowers retained access to their credit lines during FDIC failed bank resolutions. While over 10,000 banks had failed during the 1920s alone, only a handful of banks failed annually during the 1940s through the 1970s. But polices that favored depositor liquidity to the exclusion of market discipline created lax practices and moral hazard incentives. The extreme supervisory forbearance practices by regulatory authorities during the U.S. savings and loan crisis of the 1980s is the textbook example. Insolvent thrift institutions were permitted to continue operating, and in the most extreme cases of forbearance, authorities provided financial assistance to thrifts without removing thrift management and without a pledge of additional support from thrift owners.[5] As Kane (1989, 1995) has argued, allowing these "zombie" thrifts to operate, virtually without any safeguards, permitted thrift managers to gamble for resurrection by making risky loans with big financial upsides. Ultimately, these extreme practices cost $153 billion in resolution costs, with the U.S. taxpayers paying about $125 billion of this (Curry and Shibut, 2000).

Congress responded to the savings and loan crisis (and the wave of commercial bank failures that followed) with legislation designed to tilt failed bank policy away from blanket protection of liquidity and toward imposing at least some discipline on uninsured creditors and bank management. The Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991 constrained the decision-making latitude of bank supervisors and regulators. Among other changes, FDICIA established a "prompt corrective action" (PCA) regime that restricted the activities of troubled institutions before they became insolvent; mandated that the FDIC resolve failed banks in the "least costly" manner; increased the frequency and regularity of safety and soundness examinations; and took an initial step toward risk-based deposit insurance pricing. But these steps proved to be inadequate in the fall of 2008, when the FDIC was powerless to resolve failing financial institutions such as Lehman Brothers, Bear Stearns, Citigroup and Bank of America, where were either too large, too complex, or were organized as non-bank corporations beyond the legal reach of the FDIC. To avoid a massive reduction in economy-wide liquidity, the Treasury and the Federal Reserve now had no choice but to intervene, and it required a series of extraordinary and costly steps to stabilize credit markets, shore up the solvency of large financial institutions, and prevent the systemic crisis from spreading even further.[6]

After the events in the fall of 2008, policy makers sought to create a set of authorities that would allow an "orderly liquidation" of systemically important bank and non-bank financial firms, while

[2] There is an important difference between an uninsured depositor dividend based on *perfected* asset estimates and the "advance dividend" to uninsured depositors. The latter is based on a conservative estimate of the value of the failed bank in cases in which the resolution authority wishes to provide liquidity but lacks the time, information, or other resources necessary to complete a full insurance determination.

[3] Additional details concerning the resolution techniques listed in Fig. 1, as well as a short history of their use in the U.S., are contained in a companion Appendix A that is available upon request from the authors.

[4] Anari et al. (2005) showed that depositors and other creditors of national banks that failed in 1929 received only 66.12% of their funds; only about 20% of this amount (13.22 cents on the dollar) were returned during the first year, approximately double that amount was returned during the second year, and declining amounts were returned each year after that. The average liquidation period was about four years.

[5] The assistance came in the form of regulatory accounting adjustments that allowed thrifts to carry nonperforming loans at artificially high values, thus inflating their accounting capital and making the thrift "book solvent."

[6] A partial list of actions taken during September and October of 2008 includes: The Federal Reserve Board created hundreds of billions of dollars in special lending facilities and direct asset purchase programs, all aimed at providing increasing liquidity for suppliers of short-term credit. The Federal Reserve Bank of New York provided an $85 billion line of credit to American International Group (AIG), a large U.S. insurance company that also experienced a liquidity shortage, due to large losses in its sales of credit default swaps on subprime mortgage-backed securities. And the U.S. Treasury injected $115 billion of equity into eight of the largest U.S. banking companies (Bank of America, Bank of New York Mellon, Citigroup, JPMorgan Chase, Morgan Stanley, State Street, Goldman Sachs, and Wells Fargo) under the Troubled Asset Repurchase Program (TARP).

	Resolution Technique	A short description of each resolution technique
Most liquidity preserved ↑	Open bank assistance	Cash or in-kind assistance provided to bank, bank owners remain intact
	Forbearance	Allowing insolvent or undercapitalized bank to continue to operate, often with old management intact. No cash or in-kind assistance is provided.
	Bridge bank	A temporary National Bank created with FDIC in control. Assets and most liabilities of failed bank transferred to new bank. Old ownership, holding company creditors, and management are severed from bank.
	Purchase and assumption	Acquirer of failed bank purchases designated assets from the failed bank and assumes the liabilities.
	Partial payout	Acquirers of failed bank may only wish to bid on a sub-set of the failed banks deposits. Remaining depositors paid directly by FDIC.
↓ Least liquidity preserved	Asset liquidation	Failed bank assets are liquidated by the FDIC or its designees. Uninsured Depositor coverage is limited to the proceeds of the sale.

Fig. 1. A list of failed bank resolution techniques, in order by the amount of liquidity preserved.

maintaining market liquidity and forcing stockholders and debt holders to bear the losses in event of failure. Under the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, the FDIC is named as the receiver of such failed financial companies, and the Act provides the FDIC it with the necessary legal authority to resolve these firms. All assets, deposits, and other financial contracts would transfer to a temporary "bridge financial company" and the FDIC would provide the bridge company with the liquidity needed to continue all essential functions and maintain its ongoing asset values (funding made available *via* an FDIC line of credit with the U.S. Treasury). A new board directors would be appointed to run the temporary firm, which would hire new senior managers. The bridge structure would provide the FDIC with the time necessary to assess the true values of the failed firm's assets, and the FDIC would advance dividend payments to non-insured creditors as these assessments allowed. To support this orderly liquidation process, all large complex financial institutions are required to file resolution plans (so-called "living wills") with regulators on a regular basis. Ideally, the FDIC would sell the bridge company—now smaller, less complex, and solvent—to private investors within a short period of time.

3. The technology of failed bank resolution

A number of factors constrain the ability of banking authorities to efficiently resolve an insolvent financial firm—that is, to re-organize its ownership and management, re-allocate its assets, and at the same time preserve the liquidity of its depositors, creditors and borrowers. We characterize these constraints into three categories: legal limits that prevent the authorities from taking certain actions; asymmetric or missing information that retards the resolution process; and economic spillovers due to the shortcomings of the resolution process (systemic effects). The inefficiencies imposed by these constraints may cause banking authorities to abandon attempts to impose discipline on failed banks and their customers and instead "bail out" these banks. While in theory these constraints should be less binding under the Dodd-Frank Act, the constraints remain important for at least two reasons: the FDIC's new authorities under Dodd-Frank remain untested, and these new authorities are not generally available to banking authorities outside the U.S.

3.1. Legal limitations

The FDIC's special legal authority to take over insolvent banks and act as receiver differs materially from the regular bankruptcy procedures used to resolve insolvent non-banks. Bankruptcy laws protect the owners of insolvent firms from their creditors, and bankruptcy proceedings typically take weeks or months to conclude. In contrast, as receiver the FDIC steps in on behalf of the depositors and other creditors, and the owners never regain control of the firm. The FDIC can act quickly—generally overnight or over a weekend—to provide depositors with access to all or most of their funds, has broad discretion to sell the bank's assets, and can embark on such sales and other actions without waiting for a reorganization plan to be developed and approved by a bankruptcy judge.[7]

[7] Bliss and Kaufman (2011) argue that the U.S. bankruptcy practices could be tailored in a way that lessens or eliminates its inefficiencies when applied to banking companies; these changes would arguably allow insolvent banks to be reorganized

The FDIC has been granted these special powers because depositor illiquidity resulting from a slow, bankruptcy-like resolution process would cause disruptions to the payments system, financial markets, and the real economy. In countries where bank regulators lack these special powers, bankruptcy courts must be used to resolve insolvent banks, creating strong incentives for regulators to subsidize financially troubled banks rather than closing them.[8] But even in the U.S. these powers have been limited. As discussed above, the FDIC special resolution authority did not extend to the insolvent non-bank financial companies at the center of the 2008 financial crisis.

3.2. Information problems

Immediately after taking control of an insolvent bank, the FDIC begins the *insurance determination* process. The aim is to quickly determine how many of the bank's deposits are insured, how many of the deposits are uninsured, and to whom these deposits are owed. Insurance determination has historically been a manual process, working from depositor signature cards and other paper records kept at banks' branch offices. Over time, technological improvements—some as prosaic as requiring banks keep deposit records electronically and in uniform format, and equipping members of the government resolution team with laptop computers and wireless Internet—have automated this process and is usually completed overnight.[9]

Insured depositors have full and immediate access to the insured portion of their funds, either at the acquiring bank (for purchase and assumption, or P&A, resolutions) or by some form of a direct payout from the FDIC (for asset liquidation or partial payout resolutions). Uninsured depositors do not have immediate and full access to their funds, and are issued receivership certificates that represent their claims. The percentage of their funds they will eventually receive, and the delay in receiving those funds, is a function of the *asset valuation* process. Uninsured depositors usually receive a "partial dividend" payment relatively quickly, once the FDIC has an initial estimate of the value of the failed bank's assets. If the bank's assets are complex (e.g., structured asset-backed securities), illiquid (e.g., loans to small businesses), of questionable quality (e.g., derivatives contracts with troubled counterparties), international in scope, or otherwise difficult to value, then uninsured depositors will receive smaller initial dividends and will have to wait longer for any additional dividend payments.[10] This combination of immediate access to partial funds, delays in receiving additional funds, and a potential loss of some funds provides substantial liquidity for uninsured depositors while providing incentives under which depositors may better monitor bank risk-taking and potentially discipline the bank by requiring higher interest rates or withdrawing their funds.

Bank borrowers are also dealt a degree of discipline during this process. Borrowers may temporarily lose access to the undrawn portions of their credit lines and/or a portion of any compensating deposit balances. In a P&A resolution, borrowers retain access to their existing credit lines in the short-run, but the acquiring bank may or may not renew the credit relationship. In a liquidation resolution, the existing banking relationship dissolves, and borrowers incur the information costs necessary to establish entirely new financial relationships with other banks.

3.3. Systemic effects

The FDIC is able to impose delays and losses on uninsured depositors at small banks without causing systemic economic and financial disruptions. In contrast, large banks have hundreds of thousands of depositors, borrowers and other counterparties in markets throughout the country; imposing delays or losses when resolving a large insolvent bank can cause substantial financial and economic disruption. As banks grow larger and/or more systemically important, the external costs of imposing discipline on depositors, borrowers and bank decision-makers can increase dramatically.

As the FDIC attempts to resolve increasingly larger and/or more financially complex failed banks, completing an overnight insurance determination and a relatively complete initial asset valuation becomes more difficult, due to both the sheer number of deposit accounts to be administered and the large number and potential complexity of assets to be valued. Fig. 2 illustrates the potential scope of this problem. Prior to 2008, the largest FDIC insurance determination was First City Houston in 1992 with 322,983 separate deposit accounts; in sobering contrast, Bank of America currently has over 60 million separate deposit accounts. The disruption of such a large number of liquidity arrangements—on both sides of the balance sheet—could have significant macro-economic effects.

4. Modeling the impact of technology on bank resolution policy

We will now formalize much of the above discussion in a game-theoretic framework. The technology of failed bank resolution is central to our model, and this marks an innovation to the existing theory literature on bank failure policy. The model allows us to demonstrate how technological limits impact the choices available to the bank resolution authority, leading to increases in both bank bailouts and bank risk-taking.

Our model contains many of the characteristics present in earlier theory models of failed bank resolution. Like much of the previous literature (e.g., Freixas, 1999; Goodhart and Huang, 2000; Cordella and Yeyati, 2003), the regulator in our model faces a tradeoff: it can close a failed bank, and by doing so impose market discipline that reduces moral hazard incentives, or it can bail out the bank, and by doing so preserve market liquidity and avoid potential systemic harm to financial markets and the macroeconomy. The banks in our model can choose to run a "complex" business strategy that is both highly prone to failure and, in the case of failure, imposes large reductions in market liquidity; given limited technologies for resolving failed banks, this can pose a too-complex-to-resolve (TCTR) problem for the resolution authority similar to the TBTF problem present in most of the extant literature (e.g., Ennis and Malek, 2005). Thus, as in a number of previous

rather than being closed or bailed out. These changes in the Bankruptcy Code, if successful, would represent a new resolution technique for banks within the meaning of our model.

[8] An international survey conducted by the FDIC in 2000 found that failed banks used the regular corporate bankruptcy process in 12 of 18 advanced economies, including Austria, Belgium, Germany, Spain, Sweden, Taiwan and the UK (Bennett, 2001), although the UK has since adopted legislation (Banking Act, 2009) creating FDIC-like bank resolution authority. A more recent World Bank study found that only 18% of 143 surveyed countries in 2008 had bank insolvency laws separate and different from regular bankruptcy laws (Marinč and Vlahu, 2011).

[9] For example, in 2008 the FDIC mandated that large banks establish electronic records containing all of their deposit account information, with the goal of transforming insurance determinations from a slow and manually intensive process to an automated overnight process.

[10] Cumming and Eisenbeis (2010) propose that complex banking companies adopt a simpler and more transparent form of corporate organization that would arguably make the asset valuation process faster and more accurate. In the same vein, requirements that banks conduct derivatives transactions through separately capitalized central exchanges could speed the process by reducing the valuation problems associated with counterparty default risk.

Largest Insured Institutions (as of June 2010)

	Domestic Deposits ($ billions)	Deposit Accounts (number)
Bank of America NA	$829	64,080,664
Wells Fargo & Company	$719	92,432,109
Citibank	$254	24,144,341
JPMorgan Chase Bank NA	$633	46,588,519
US Bank, NA	$169	12,395,340

Five Largest FDIC Insurance Determinations

	Deposits ($ billions)	Deposit Accounts (number)
IndyMac Bank, FSB	$28.5	301,878
First City Houston, NA	$2.5	322,983
NetBank	$2.3	191,194
ABN Financial NA	$1.8	27,209
Silver State Bank	$1.7	20,677

Fig. 2. Five largest U.S. commercial banks and five largest FDIC insurance determinations.

studies (e.g., Mailath and Mester, 1994; Acharya and Yorulmazer, 2007), the regulator in our model faces a time inconsistency problem which makes it difficult to credibly commit to a disciplinary resolution policy. Moreover, our model demonstrates how political pressure, macro-economic conditions, or herding by banks exacerbates the regulator's problem and leads to increased regulatory forbearance (e.g., Acharya, 2001; Acharya and Yorulmazer, 2008a,b; Brown and Dinc, 2009). We solve our game in random strategies, but unlike other studies that use this equilibrium concept to suggest a policy of "constructive ambiguity" (e.g., Freixas, 1999; Goodhart and Huang, 2000; Gong and Jones, 2010), our use of random strategies is merely a convenient equilibrium device and not a policy prescription. In contrast to previous studies that exploit the differences between solvency-driven and liquidity-driven bank failures (e.g., Diamond and Rajan, 2002; Freixas et al., 2003; Freixas and Parigi, 2010), we model failed banks as pure insolvencies and hence are concerned only with bank resolution policy, not with lender-of-last-resort policy.

4.1. Game set-up

We construct a multi-period game between a government resolution authority (RA) and a banking industry comprised of a non-trivially large number of identical investors who have to decide each period how to allocate their capital to a non-trivially large number of banks. The banks have access to two loan production processes: simple loan production and complex loan production. Simple loans are easy to value and the simple loan production process (e.g., originate and hold; core deposit funding; no off-balance sheet obligations) is transparent and easy to unwind in bankruptcy and hence generates relatively small social and/or macroeconomic externalities upon bank failure. Complex loans are difficult to value and the complex loan production process (e.g., originate, securitize and sell; financial market rather than deposit funding; off-balance sheet obligations) is opaque and difficult to unwind in bankruptcy and hence generates larger failure externalities. These two loan production processes are separable and both exhibit diminishing returns; banks can mix these processes, and it will be useful in some cases to refer to a bank as "mostly complex" or "highly complex" depending on its loan mix. We will also use the terms "investors" and "bank(s)" interchangeably below.

We emphasize that what we call "complexity" is not the same as "large size." While both of these characteristics will make failure resolution more difficult, the former is more likely than the latter to cause economy-wide externalities—i.e., one side of the central liquidity-versus-discipline tension facing the RA in our model. The assets created and held by complex banks are more difficult to value (e.g., deeply subordinated tranches of loan securitizations, loan servicing contracts, venture capital investments), complex banks are more likely to be interconnected with other financial institutions and hence exposed to their risks (loans or assets sold with recourse, trading positions in financial derivatives contracts), and complex bank funding is more apt to run (repos, purchased fed funds, commercial paper) and hence encourage runs at similarly funded banks. And although large banks do tend to be more complex than smaller banks, there is far from a one-to-one correspondence between these two characteristics among financial companies in the U.S. For example, MetLife is the sixth largest financial holding company in the U.S. with assets of around $800 billion, and under the provisions of the Dodd-Frank Act it is classified as a systemically important financial institution (SIFI). Despite its large size, however, MetLife resembles the easy-to-unwind simple banks from our model. Its main liabilities are insurance contracts backed largely by fixed income assets that are easy-to-value and sell, and its commercial banking affiliate issues only about $10 billion of deposits, has zero trading assets, and its derivatives positions are limited to vanilla interest rate swaps, forwards and futures (data from www.fdic.gov). Perhaps even more to the point, the FDIC was able to resolve the failed $300 billion savings bank Washington Mutual (WAMU) in September 2008 without any macro-economic disruption and without any cost to the taxpayer. The resolution imposed losses on WAMU's shareholders and uninsured creditors and transferred WAMU's retail deposit franchise to JPMorgan Chase. This clean resolution of such a large bank was possible WAMUs assets (mainly mortgage loans) were easy to value quickly. At the other extreme, the Federal Reserve and FDIC have been charged with identifying which non-bank financial firms with assets *less than* $50 billion should be classified as SIFIs.

Banks issue deposits at the beginning of the period, invest those funds (along with the investors' capital) in either simple loans L_S or complex loans L_C that mature at the end of the period, and use the loan proceeds to pay back depositors. If a bank's investment proceeds are greater than its deposit liabilities, the resulting profits are distributed to the investors who play the game again in the next period. Otherwise, if a bank's investment proceeds are too small to pay off its depositors, then the bank becomes insolvent, its investors leave the game, and an equal amount of new investors arrive at the start of the next period.[11]

Loans default with probability ρ_i ($i = C,S$) for complex and simple loans; each ρ_i follows a two-part stochastic process consisting of a macroeconomic (systematic) shock felt by all banks and a bank-specific (idiosyncratic) shock that is distributed independently across all banks. We place no constraints on the relative values of ρ_C and ρ_S, and we allow complex and simple loan defaults to be uncorrelated. Banks follow an internal (i.e., non-regulatory) value-at-risk (VaR) capital policy that protects the bank against default in all states of nature except for the tail-risk event in which both complex loans *and* simple loans default. Thus, a bank fails with probability $\varphi = \rho_C\rho_S$ and survives with probability $1-\varphi = (1-\rho_C)(1-\rho_S) + (1-\rho_C)\rho_S + \rho_C(1-\rho_S)$.

A failed bank generates a social externality, the costs of which are truly *external* to the banks in our model and hence we need not model them explicitly. Consistent with recent experience, we simply assume that the social externality increases in the amount of L_C at the failed bank. Within the context of our model, it is natural to consider an externality that manifests itself as macro-economic illiquidity. For example, if depositors at failed complex banks have to wait to receive access to their funds, then fewer deposits will be available in the next period of the game, reducing the supply of liquidity to all banks but more importantly reducing the amount of liquidity in the economy. Similarly, if assets at failed complex banks take time to be sold off (or if they can be sold off only at a discount), increased investor uncertainty about the value of similar financial assets can reduce the amount of available liquidity in financial markets in general.

4.2. Game without bank failure regulation

A game without a resolution authority (RA) lacks strategic interaction. Investors maximize profits each period as follows, as if they were playing a one-period game:

$$\begin{aligned} &\underset{L_C,L_S}{\text{maximize}} : \pi = (1-\rho_C)F_C(L_C) + (1-\rho_S)F_S(L_S) \\ &\text{subject to}: \mathbf{L} = L_C + L_S \end{aligned} \qquad (1)$$

where the $F_i(L_i)$ are increasing and concave profit functions for complex and simple loans satisfying the standard conditions $F_i(0) = 0$, $F'_i(0) = +\infty$ and $lim_{Li\to\infty} F'_i(L_i) = 0$. $\mathbf{L}$ is the fixed exogenous demand for loans, which the bank can satisfy using any combination of the simple and complex production processes. Given that both production processes exhibit diminishing returns and satisfy the above standard conditions, the solution L_C^* to this problem is interior and given by the first order condition:

$$(1-\rho_C)F'_C(L_C) - (1-\rho_S)F'_S(\mathbf{L} - L_C) = 0$$

where L_C^* is the amount of complex loans produced in a game without regulation. The solution is straightforward and is illustrated in Fig. 3.

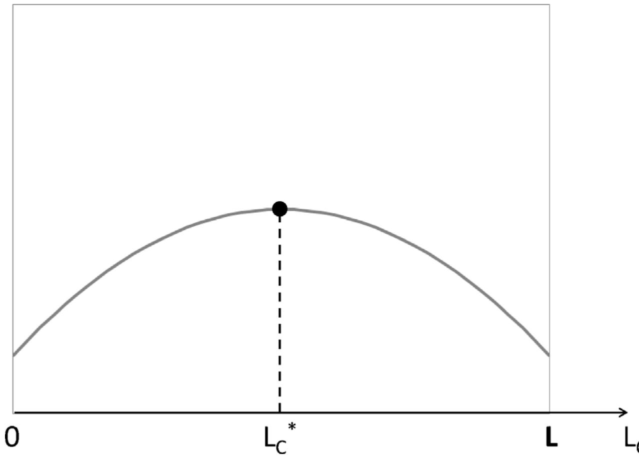

Fig. 3. Game without regulation.

Eq. (1) assumes additive separability between the profits generated by simple and complex banking; by definition, this means that there are no cost or revenue synergies between the two banking methods. While one can perhaps imagine synergies between these two banking approaches, cost and revenue synergies across banking lines of business have been notoriously difficult to quantity (Berger et al., 1999; Mester, 2008) and many banking researchers conclude that they limited at best. Nevertheless, in the face of either production or marketing synergies, each of the single-product profit functions would surely maintain their fundamental, well-behaved economic properties (increasing at a decreasing rate with output); hence, synergies would only serve to increase the height of the parabolic shape shown in Fig. 3 and consequently have no qualitative effect on the equilibra in the one-period and infinite horizon games described below. Similarly, we make no assumptions in Eq. (1) about the relative costs, revenues or profits of simple and complex loans. Again, so long as the two portions of (1) are each well-behaved profits functions (concave down in output), then the joint profit function in Fig. 3 will have an interior maximum regardless of the relative expenses and revenues of simple and complex loans. For example, scale economies for complex loan production (relative to smaller scale economies for simple loan production) would simply skew the inverted-U shape in Fig. 3 toward the right but maintain an interior optimum.

Because we assume that all investors are identical, all banks will have the same L_C^*. Some of these banks will fail—loan default is stochastic and contains an idiosyncratic component—but as stated above the failure probability is unrelated to L_C^*. In the absence of bank failure regulation, these failed banks enter the regular bankruptcy process, which (because it protects banks against creditors for some period of time) fosters macro-economic illiquidity (the social externality) in amounts that are positively related to L_C^*.

4.3. Bank failure regulation

We now introduce a bank failure resolution authority (RA). The resolution process works more quickly than bankruptcy

[11] The arrival of new investors is not technically necessary so long as the total number of solvent investors remains "non-trivially large." We could just as easily assume that the surviving banks proportionately absorb the deposits and remaining assets of the failed bank. Either assumption obviates modeling strategic interactions that occur as the industry becomes concentrated and market power develops (Enrico Perotti and Javier Suarez, European Economic Review, 2002). Moreover, this assumption simplifies the solving of the dynamic (repeated) version of the game. In any case, entry is relatively easy in U.S. banking markets, either via new (de novo) bank charters, geographic expansion by existing banks, or expansion by non-bank financial services firms into banking product markets.

proceedings, returns failed bank deposits to the banking system in time for the next round of the game, which mitigates the macroeconomic liquidity shock. The RA's technology set is finite, however, and it lacks the ability to quickly resolve banks with large amounts of complex loans. Letting L_T represent the limits of resolution technology (i.e., the lowest level of failed bank complexity that the RA is *unable* to resolve), the RA closes failed banks when $L_C < L_T$ and bails out failed banks when $L_C \geq L_T$.[12]

In a failed bank *closure*, the RA seizes the insolvent bank and pays off the depositors, using the bank's (insufficient) investment proceeds plus an insurance fund which is capitalized prior to the start of the game.[13] The bank's owners receive zero profit distribution (i.e., the bank fails with limited liability), are prohibited from playing the game again, and new investors enter the game at the start of the next period. In a *bailout*, the RA pays off the depositors (or, equivalently, gives the bank the funds necessary to pay off the depositors) and pays investors an amount *b* large enough so that they can play the game again in the next period (i.e., recapitalizes the bank).[14] Bailout in our model is similar in nature to the open bank assistance policy discussed above and used sparingly in the past by the FDIC, and is similar in spirit to the U.S. Treasury's TARP program and other ad hoc actions used to support insolvent and/or illiquid financial institutions during the recent financial crisis. Bank closure in our model is similar to the depositor payout policy discussed above and used often by the FDIC.

Faced with the task of resolving an insolvent bank, the RA maximizes its own utility by selecting a method of resolution that maintains some non-negative amount of liquidity (*LIQ*) and imposes some non-negative amount of market discipline (*DISC*). The RA's preferences for *LIQ* and *DISC* need not be exactly consistent with social welfare—for example, as discussed above in Section 2, the regulator may identify closely with depositors, hence favor

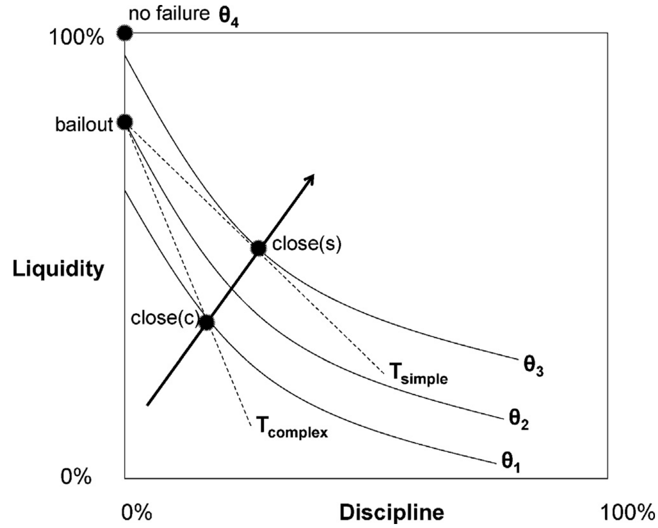

Fig. 4. The RA's problem.

somewhat more liquidity and somewhat less discipline than is welfare maximizing—but in any case we specify both *LIQ* and *DISC* as economic goods in the RA's utility function. The RA is constrained in its choices of *LIQ* and *DISC* by available resolution technologies *T*. With little loss of generality we specify this utility maximization problem as follows using a Cobb-Douglas utility function and a linear technology constraint *T*:

$$\underset{LIQ, DISC}{\text{maximize}}\; U = \alpha LIQ^{\beta} DISC^{\sigma} \tag{2}$$

$$\text{subject to:} \quad T \geq \upsilon LIQ + \omega DISC \tag{2a}$$

$$0 \leq LIQ < 1 \tag{2b}$$

$$0 \leq DISC < 1 \tag{2c}$$

where υ and ω are, respectively, the "prices" of maintaining a unit of liquidity *LIQ* or imposing a unit of discipline *DISC*. To emphasize the policy tradeoff between maintaining liquidity and imposing discipline, we arbitrarily set $\upsilon = 1$ and then rewrite the technology constraint as:

$$LIQ = T - \omega DISC \tag{2a'}$$

which allows the straightforward interpretation of the slope ω as the "liquidity price of discipline," that is, the marginal rate at which an efficient RA can transform one unit of sacrificed liquidity into additional discipline. Consistent with the discussion above, ω will decline with efficiencies in insurance determination, asset valuation, and other activities necessary to resolve a failed bank, and ω will increase with the size and complexity of the failed bank being resolved. The constraints (2b) and (2c) scale the problem so that the solution set lies within the unit square (see Fig. 4).[15] Maximizing (2) with respect to *LIQ* and *DISC* yields the RA's optimal resolution method:

$$LIQ* = \frac{\beta T}{\beta + \sigma}$$

[12] These two alternative resolution techniques, "closure" and "bailout," are meant to represent the two ends of the liquidity-discipline spectrum illustrated in Fig. 1. Limiting the RA's tradeoff to just two techniques keeps the model tractable with no real loss of generality.

[13] Imagine that the insurance fund is capitalized by charging each of the "non-trivially large number of investors" a small and identical entry fee at the beginning of the game. For the sake of simplicity, we characterize a flat-rate insurance premium; conceptually, including a risk-based deposit premium would make little difference because in our model bank insolvency risk is by assumption unrelated to bank complexity. Moreover, the central focus of our model is neither insolvency risk nor systemic risk; rather, we focus on how innovations in bank failure resolution technology can improve regulators' ability to resolve complex failed banks, and by doing so change bank incentives and result in an equilibrium with banks that are less complex and a regulator that is less likely to bail out complex banks should they fail. Of course, one can imagine a complexity-based (as opposed to a flat-rate) insurance premium large enough to deter banks from choosing to be complex in the first place—however, such a solution requires that the RA monitor *all banks* (in our model, the RA takes no actions until a bank fails), can accurately detect (without Type I and II errors) complexity at non-failed banks and in non-crisis situations, and can do this at a reasonable cost. We choose to avoid these complications to keep our model tractable, and further note that none of this matters unless in the end the RA has both the technology and the political will to actually close complex failed banks, which is the main lesson from our model. Other studies have focused on innovations in deposit insurance pricing. For example, Acharya et al. (2010) explore the relationships between systemic risk and deposit insurance pricing, and show that charging higher premiums to large banks with correlated insolvency risks can mitigate systemic risk and minimize costs to the insurance fund.

[14] We make the simplifying assumption that the bailout payment *b* is unrelated to loan complexity L_C. If complexity makes it difficult for the RA to value a bank's assets, it should also make it impossible to determine the size of *b* needed to recapitalize the bank. The RA could easily deal with this problem by including loan guarantees along with *b*. Issuing these guarantees would be costless to the RA in the short-run. As the value of the complex loans are revealed in the long-run, the RA could pay out extra capital above *b* to banks that incur larger than expected loan losses, and fund these payments by collecting capital back from banks that incur smaller than expected loan losses. This only requires the RA to be able to estimate *b* in an unbiased fashion across multiple banks.

[15] The RA cannot maintain maximum liquidity (*LIQ* = 1) because failed bank resolutions require the bank to be shut down for a short period of time (typically over the weekend). The RA cannot impose maximum discipline (*DISC* = 1) because deposit insurance will shield some creditors from the costs of bank failure.

$$DISC* = \frac{\sigma T}{\omega(\beta+\sigma)}$$

The results are economically intuitive. Discipline increases with the RA's strength of preference for discipline σ, decreases with the RA's strength of preference for liquidity β, and decreases with the liquidity price of discipline ω. Liquidity increases with the RA's strength of preference for liquidity β and decreases with the RA's strength of preference for discipline σ. Both liquidity and discipline increase, proportionate with their strength of preferences β and σ, with efficiencies that relax the technology constraint T.

The solution is illustrated in Fig. 4. The indifference curves are drawn with a relatively shallow slope, indicating an RA with a strong preference for maintaining market liquidity and a weak preference for imposing market discipline ($\beta > \sigma$).[16] (For our Cobb-Douglas utility function this policy tradeoff is given by $-\sigma_U(1/\beta)DISC(\beta-\sigma/\beta)/\beta\alpha(1/\beta)$ which shows a diminishing willingness by the RA to substitute *DISC* for *LIQ*.) The four indifference curves correspond to ordered utility levels $\boldsymbol{\theta}$ where $\theta_4 > \theta_3 > \theta_2 > \theta_1$. The technology constraint T has linear slope ω (the liquidity price of discipline) and runs between "bailout," which generates high liquidity (depositors are fully paid off) and low discipline (investors play again next period), and "close," which generates lower levels of liquidity (some depositors receive haircuts) but higher levels of discipline (investors are wiped out).

The RA clearly prefers insolvent banks that are mostly simple. When a relatively simple bank fails, the RA has access to the more efficient resolution technology T_{simple} with a low liquidity cost of discipline, and will prefer closure (utility = θ_3) over bailout (utility = θ_2). When a relatively complex bank fails, then the RA has access only to a less efficient resolution technology $T_{complex}$ with a high liquidity cost of discipline, and will prefer bailout (utility = θ_2) over closure (utility = θ_1). To make the model easier to solve we include the "quiet life" utility θ_4 which the RA consumes when there are no bank failures in a given period. The arrow suggests a technology expansion path: As the resolution technology improves (i.e., as L_T increases), the RA will close, rather than bail out, increasingly complex banks.[17]

The investor maximization problem changes with the introduction of the RA and the possibility of being bailed out. Investors now maximize profits as follows:

$$\max_{L_C,L_S}\begin{cases}(1-\rho_C)F_C(L_C)+(1-\rho_S)F_S(L-L_C), & \text{if } L_C < L_T\\ (1-\rho_C)F_C(L_C)+(1-\rho_S)F_S(L-L_C), \varphi b, & \text{if } L_C \geq L_T\end{cases} \quad (3)$$

where banks that choose $L_C \geq L_T$ and hence are too complex to resolve (TCTR) gain access to the expected bailout subsidy φb. Hence, the solution to the game with bank failure regulation will depend on the technology L_T that is available to the RA. There are three cases. In the first case, illustrated in Fig. 6a, the resolution technology is *very imperfect*, such that $L_T \leq L_C^*$ and does not constrain investors' choices. Investors choose $L_C = L_C^*$ and the bank gets bailed out if it fails. In the second case, illustrated in Fig. 6b, the resolution technology is only *weakly imperfect*, such that $L_C^* < L_\pi \leq L_T$, where L_π is defined by the condition

$$\pi(L_C > L_C^*) = \pi(L_C^*)$$

$$(1-\rho_C)F_C(L_C^*)+(1-\rho_S)F_S(L-L_C^*) = (1-\rho_C)F_C(L_\pi)+(1-\rho_S)F_S(L-L_\pi)+\varphi b.$$

Investors are once again unconstrained and choose $L_C = L_C^*$, but in this case the bank gets closed if it fails. In the third case, illustrated in Fig. 6c, the resolution technology is *moderately imperfect*, such that $L_C^* < L_T < L_\pi$. In this case the investors are constrained by the resolution technology, choose $L_C = L_T = L_C^{**}$, and the bank gets bailed out if it fails. Thus, we have the first main implication from our model: the presence of a resolution authority with imperfect resolution technology can increase the amount of complexity in the banking system (i.e., $L_C^{**} > L_C^*$).

We now solve two versions of the game with regulation: a one-period game in which the RA's response to a bank failure marks the end of the game, and an infinite horizon game in which banks can change their loan mixes after each RA response. In what follows, we assume the most interesting case (illustrated in Fig. 6c) in which the RA's resolution technology is *moderately imperfect*. Consistent with this case, we assume that "simple" banks choose L_C^* and earn expected profits $\pi_S(L_C^*)$, and we assume that "complex" banks choose L_C^{**} and earn expected profits $\pi_C(L_C^{**}) = \pi_C + \varphi b$, where π_C is the non-governmental part of its expected profits.[18] (As discussed above, it may be instructive to think about two same-sized banks, one of which chooses L_C^{**} and hence is a SIFI whose insolvency will create systemic external costs, and one that chooses L_C^* and hence is a non-SIFI.) Because the resolution technology is moderately imperfect, it holds that $\pi_C(L_C^{**}) > \pi_S(L_C^*) > \pi_C$. The last inequality holds because L_C^* is the optimal solution without bailouts.

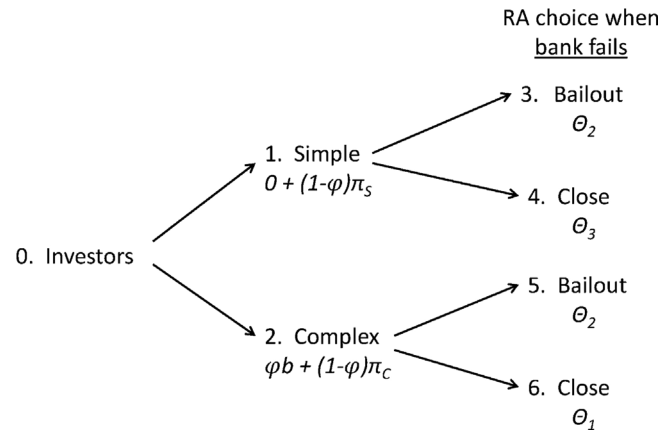

Fig. 5. Game tree with payoffs.

4.4. One-period game

The solution of the one period game is straightforward, and is easy to see in the game tree illustrated in Fig. 5. The RA always closes failed simple banks (node 4) because $\theta_3 > \theta_2$ and it always bails out failed complex banks (node 5) because $\theta_2 > \theta_1$. Banks will

[16] Preferences such as these are plausible in a number of scenarios: (a) the RA and/or elected officials who influence the RA identify strongly with depositors and hence prefer liquidity over discipline; (b) the RA and/or economic authorities that influence the RA feel that an illiquidity shock would harm the macro-economy and hence prefer liquidity over discipline; and/or (c) the RA and/or bank supervisors who influence the RA wish to conceal the financial deterioration of a bank or the banking system, and the regulatory forbearance that results naturally generates liquidity rather than discipline. As illustrated at length in Appendix A, the resolution choices made by FDIC during the post-deposit insurance era have been largely consistent with a strong preference for liquidity over discipline.

[17] Improvements in the insurance determination process, improved asset valuation techniques, and other efficiencies in bank resolution would relax the technology constraint by reducing the liquidity price of discipline; in contrast, greater bank size or increased bank complexity would make the resolution process more difficult, tightening the constraint by increasing the liquidity price of discipline.

[18] We note that each of the production options available to the bank in this set-up (L_C^* and L_C^{**}) include both simple loans and complex loans. This implies that banks already know how to produce both types of loans at the beginning of the game.

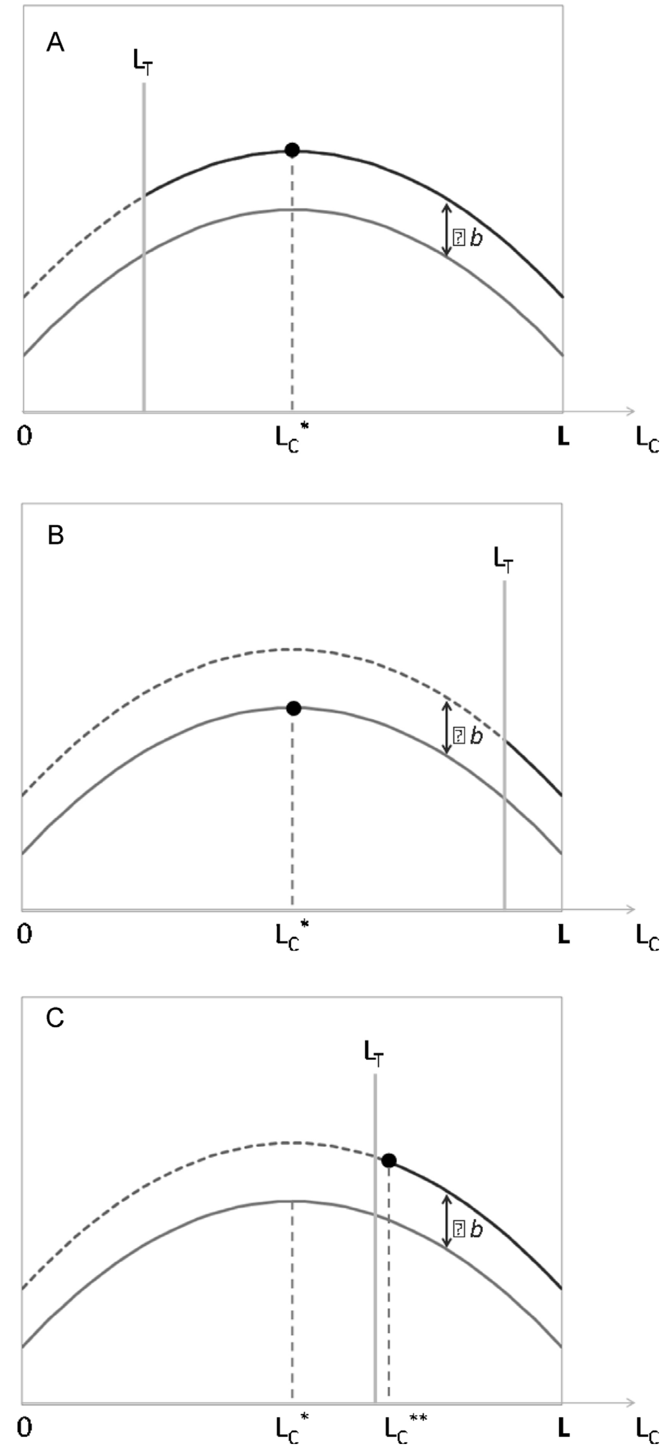

Fig. 6. Game with regulation. Panel A: very imperfect resolution technology. Bank optimizes at L_C^* and failed banks are bailed out. Panel B: weakly imperfect resolution technology. Bank optimizes at L_C^* and failed banks are closed. Panel C: moderately imperfect resolution technology. Bank optimizes at L_C^{**} and failed banks are bailed out.

always choose to be complex (node 2), due to the RA's TCTR policy that introduces the regulatory wedge b that makes expected complex profits $\pi_C(L_C^{**})$ exceed expected simple profits $\pi_S(L_C^*)$. Thus, in the subgame perfect equilibrium of the one-period game, all of the banks are complex because this strategy promises unambiguously higher expected returns, and the RA will always choose to bail them out should they become insolvent. Without a history of past actions, or the promise of future actions, the RA will not close an insolvent complex bank, because it cannot consume the expected future benefits (i.e., fewer complex banks) that would derive from imposing discipline today.

4.5. Infinite horizon game

In the one-period game, the RA's current policy decisions cannot influence the industry's future business model decisions. Specifically, the RA might choose to forfeit some short-run utility (by closing insolvent complex banks and suffering reduced liquidity today) in order to establish a credible reputation that makes the industry less likely to choose complexity in the future. In order to study this interplay between banks' and RA's actions we study an infinitely repeated version of the one-period game described above. We add the assumption that all players weight future payoffs with positive discount factors: $\delta < 1$ for the RA and $\gamma < 1$ for the banks. Although our objective is to characterize the strategic interplay between the RA and the *banking industry*, in what follows we analyze a repeated version of the one-period game described above between the RA and a *single bank*.[19]

In what follows, we derive the conditions that support an equilibrium in which a bank repeatedly chooses to be simple with certainty. We focus on Markov strategies in which the past influences current decisions only through its effect on the state variables (Fudenberg and Tirole, 1991, chapter 13; Maskin and Tirole, 2001). There are two possible states of the world at the beginning of each stage of the game, defined by whether there was a bailout at time $t-1$ (denoted by $s_t = \text{B}$) or there was no bailout at $t-1$ ($s_t = \text{NB}$). If $s_t = \text{NB}$, then the game repeats with the successful bank (i.e., when there was no bank failure at $t-1$) or with the new replacement bank (i.e., when there was a failure at $t-1$ and the RA closed the bank). Otherwise if $s_t = \text{B}$, the game repeats with the bailed out bank.[20]

The desired equilibrium upon which we focus has only simple banks that are always closed when they fail. The banks and the RA play one set of strategies when the desired equilibrium obtains, and a different set of strategies when the desired equilibrium does not obtain. We consider the following profile of strategies for the RA:

- *The equilibrium path strategy RA_e*: The RA closes insolvent simple banks with certainty.
- *The off-equilibrium path strategy RA_o*: The RA closes insolvent complex banks with probability q and bails them out with probability $1-q$.

and we consider the following profile of strategies for the banking industry:

- *The equilibrium path strategy B_e*: If $s_t = \text{NB}$, the bank chooses to be simple with certainty.

[19] There is no inconsistency here: one can think of the RA playing the same repeated game simultaneously with each bank in the industry. This merely requires us to assume that the RA's preference ordering ($\theta_4 > \theta_3 > \theta_2 > \theta_1$) is invariant to the number of banks that fail in any given period. Nevertheless, in our comparative statics analysis below, we analyze the impact that political pressure or macro-economic circumstances may have on the RA's policy choices during times of multiple and/or large bank failures.

[20] This 'one-period memory' makes sense for our problem. The history of bank failure and resolution in the U.S. has been marked by discrete episodes of bank failures (e.g., the 1930s; the late 1980s and early 1990s; and the late 2000s) followed by clear policy shifts in response to those episodes (e.g., the creation of the FDIC and the Glass-Steagall Act; the FDIC Improvement Act; and the Dodd bill). Enough time passed between these events for both banks and regulators to 'forget' the past, and focus only on the new episode.

- *The off-equilibrium path strategy* B_o: If s_t = B, the bank chooses to be simple with probability p and complex with probability $1-p$.

The following proposition provides the conditions under which this profile of strategies constitutes an equilibrium in which banks choose the simple business model and the RA always closes failed banks:

Proposition: There exists a non-negative value $\underline{\delta}$ such that for any $\delta \in (\underline{\delta}; 1)$ there also exists the following "disciplinary equilibrium" in the infinitely repeated game:

- The RA always closes a failed simple bank. Furthermore, the RA is indifferent in expected payoffs between closing or bailing out a failed complex bank and chooses closure with probability $q* = 1-\frac{(1-\gamma(1-\varphi))}{\varphi[\gamma\pi_S+(1-\gamma(1-\varphi))b]}(\pi_S-\pi_C)$.
- When s_t = NB, banks always choose the simple business model. But when s_t = B, banks are indifferent in expected payoffs between the simple and complex business models and choose the simple model with probability $p* = 1-\left(\frac{1}{\delta}-1\right)\frac{\theta_2-\theta_1}{\varphi(\theta_3-\theta_2)}$.

The proof of this proposition appears in Appendix A.

The first important insight of the proposition is that, in order to credibly establish a disciplinary mechanism that encourages the bank to make mostly simple loans, the RA should randomize between closing and bailing out failed complex banks.[21] The RA mixes its response to complex bank failure proportionately (i.e., q^*) so that the banks are just indifferent between being complex and simple—in other words, banks cannot increase their expected profits by deviating from the simple bank strategy. More explicitly, the RA is indifferent between bailing out and closing a failed complex bank if and only if

$$\theta_1+\delta\frac{(1-\varphi)\theta_4+\varphi\theta_3}{1-\delta}=\theta_2+\delta\frac{(1-\varphi)\theta_4+\varphi\theta_3-(1-p)\varphi(\theta_3-\theta_2)}{1-\delta}. \tag{4}$$

The left-hand side is the value of playing closure to the RA. The first term is the immediate utility θ_1 from closing the failed complex bank. The second term is the discounted utility arising from the replacement bank choosing the mostly simple loan model in future periods, i.e., the future returns from imposing discipline today. The right-hand side is the value of playing bailout to the RA. The first term is the immediate utility θ_2 from bailing out the complex bank. The second term is the discounted utility arising from the bailed out bank randomizing between the complex and simple lending strategies in future periods. It is instructive to rewrite this equation to compare the RA's immediate utilities to its future utilities:

$$\theta_2-\theta_1=\frac{\delta}{1-\delta}(1-p)\varphi(\theta_3-\theta_2), \tag{5}$$

where the left-hand side is the immediate utility from bailing out the complex failed bank relative to closing it (illiquidity avoided), and the right-hand side is the expected future utility from closing the complex failed bank relative to bailing it out (moral hazard avoided). When a bank chooses to be simple after a bailout with very high probability (p close to 1) then the future gain of today's closure becomes negligible and the RA will prefer to bail out the banks.[22] Similarly, when a bank chooses to be complex after a bailout with very high probability (p close to 0) then the future gain of today's closure becomes larger than the immediate gain from a bailout. By this logic we obtain the RA's best response function, which stipulates that the RA closes failed complex banks if $p < p^*$, bails out such banks if $p > p^*$, and is indifferent between these two actions if $p = p^*$.

The second important insight of the proposition is that the disciplinary equilibrium exists only if the discount factor δ is sufficiently high—that is, only when the future matters for the RA. A disciplinary equilibrium requires $\delta > \underline{\delta}$; otherwise, the RA prefers always bailing out failed complex banks, as the future utility consequences associated with this action will get deeply discounted. By re-arranging the above expression for p^* we can derive a boundary condition for this cutoff threshold, $\underline{\delta} = 1/1+(\varphi(\theta_3-\theta_2)/(\theta_2-\theta_1)$. We can gain some intuition by rewriting the boundary condition as

$$(\theta_2-\theta_1)\left(\frac{1}{\delta}-1\right)<\varphi(\theta_3-\theta_2). \tag{6}$$

The disciplinary equilibrium requires that the expected marginal utility from avoiding moral hazard in the future (right-hand side) exceeds the marginal utility from avoiding illiquidity by bailing out a complex bank today (left-hand side) by a factor of $(1/\delta-1)$.

4.6. Comparative statics

Explicit expressions for the comparative static results (i.e., the partial derivatives of $\underline{\delta}$, q^*, and p^* with respect to model parameters θ_1, θ_2, θ_3, θ_4, φ, π_s, π_c, b, γ and δ) are shown in Appendix B.[23] We report the signs of the comparative static tests here, along with logical interpretations of these results that are consistent with the structure of our model. The relevance of these findings for the current debate on failed bank resolution policy is discussed in the section that follows.

The threshold $\underline{\delta}$ identifies the discount factor that separates the disciplinary equilibrium from the non-disciplinary equilibrium. When $\delta > \underline{\delta}$ (i.e., the future is relatively important), the RA accepts illiquidity today in exchange for reducing moral hazard incentives in the future; when $\delta < \underline{\delta}$ (i.e., the future is unimportant), the RA accepts moral hazard incentives in the future in exchange for reducing illiquidity today. Changes in the values of the model parameters influence the sensitivity of this inter-temporal tradeoff. *Ceteris paribus*, increases in θ_1, θ_3 and φ make the disciplinary equilibrium more attractive to the RA, and thus push $\underline{\delta}$ lower. Higher utility from closing failed complex banks (θ_1) makes bailouts relatively less attractive to the RA; higher utility from closing failed simple banks (θ_3) makes simple banks relatively more attractive to the RA. A higher probability of the bank default state φ increases the RA's expected marginal utility from avoiding moral hazard and/or decreases its expected marginal utility of avoiding illiquidity (see the discussion that accompanies Eq. (5) above). In contrast, an increase in θ_2 makes the disciplinary equilibrium less attractive to the RA, and thus pushes $\underline{\delta}$ higher. Obviously, higher utility from bailing out failed banks (θ_2) makes discipline less attractive to the RA.

The RA's off-the-equilibrium-path behavior is given by q^*, the probability that the RA will close a failed complex bank. *Ceteris*

[21] Note that an RA threat to *always* close a failed complex bank is not a solution and outside our real world experience: if the RA could credibly commit to always closing failed complex banks, then banks would never choose to be complex, and establishing this credibility would be unimportant for the RA.

[22] This is why a RA announcement that it will always close failed complex banks is not credible.

[23] Although π_s, π_c and φ are functions, we treat them as parameters in the comparative statics section in order to provide some additional intuition behind our results.

paribus, increases in b and π_c make complex lending more attractive to banks by increasing its expected returns; an increase in the probability of bank failure φ makes complex lending more attractive by creating greater possibilities for bailouts that extend the expected life of the bank; and an increase in γ makes a longer expected life more valuable to the bank. In response, the RA becomes more likely to impose discipline, thus increasing q^*. In contrast, an increase in π_s makes simple lending more attractive to banks. In response, the RA becomes less likely to impose discipline, thus decreasing q^*.

The bank's off-the-equilibrium-path behavior is given by p^*, the probability that the bank chooses to make mostly simple loans. *Ceteris paribus*, increases in θ_1 and θ_3 directly strengthen the RA's preferences to establish discipline, making banks more likely at the margin to make simple loans; an increase in θ_2 obviously has the opposite effect. A higher probability of bank failure φ increases the future chances of illiquidity and moral hazard behavior while an increase in δ makes the RA care more about these future states of the world, both of which make the RA more likely to impose discipline and hence the bank becomes more likely to make simple loans.

Two of these results bear special attention: (1) An increase in θ_1 (holding θ_2 constant) is equivalent to a reduction in the liquidity price of imposing discipline on failed complex banks (see Fig. 4). Thus, the comparative static results $\partial\underline{\delta}/\partial\theta_1 < 0$ and $\partial p^*/\partial\theta_1 > 0$ indicate that more efficient failed bank resolution technologies *alone* will make the disciplinary equilibrium more likely to obtain. An RA that can close a failed complex bank more efficiently—that is, preserving more liquidity and generating more discipline—will impose the disciplinary equilibrium more often ($\partial\underline{\delta}/\partial\theta_1 < 0$) and banks facing this RA will have a higher probability of making simple loans ($\partial p^*/\partial\theta_1 > 0$).[24] (2) A decrease in the RA's discount factor δ (holding constant the banks' discount factor γ) means that the RA increasingly values current liquidity and/or discipline at the expense of future liquidity and/or discipline. This is most likely to occur during an economic downturn or financial crisis, when preserving current liquidity becomes relatively more important than preventing future moral hazard incentives. Such a time revaluation could be triggered if, for example, multiple complex banks become insolvent within months or weeks, the threat of contagion increases due to herding or inter-connectedness, the government or central bank pressures the RA to keep banks open, and/or the bank supervisory authority pressures the RA to forebear to cover up gross supervisory mistakes. Thus, in a world where bailouts are possible, the comparative static result $\partial p^*/\partial\delta > 0$ indicates that systematic developments or political events can create incentives for banks to make complex loans.

5. Implications and conclusions

When a bank fails in the U.S., the FDIC is assigned as a receiver for the insolvent bank and has special powers to take immediate and unilateral action to resolve the situation. These special resolution powers yield potential macro-economic efficiencies: depositors and line-of-credit customers can have immediate access to their funds, thus avoiding illiquidity problems in the local, regional or nationwide economies in which failed bank operates. But these protections make bank depositors and borrowers passive counterparties, reducing banks' exposure to market discipline and encouraging bank managers to take greater insolvency risk. This policy tradeoff—which we refer to here as the liquidity price of discipline—is the underlying motivation for much of the debate over how we should regulate financial institutions. We construct a theory model of failed bank resolution policy that is centered on this tradeoff.

We model a repeated game between a utility maximizing bank resolution authority (RA) and profit maximizing banks that can generate negative externalities should they fail. In our model, banks choose to be either complex or simple, where complexity is unrelated to the probability that a bank fails, but makes a bank difficult for regulators to unwind if it does fail. Thus, our model does not focus on the positive relationship between risk-taking and the probability of bank failure; rather, it focuses on the positive relationship between failed bank complexity and the propensity of regulators to bail out insolvent banks. In equilibrium, the degree of complexity chosen by banks and the propensity of regulators to bailout failed banks are dependent on two exogenous conditions: (1) the technology set available to the RA and (2) the political and economic pressures under which the RA must operate.

We define resolution technology set as the tradeoff the RA must make between preserving liquidity for the customers of a failed bank (and by extension, liquidity in the macro-economy) and imposing market discipline on the bank's other stakeholders, i.e., the liquidity cost of discipline. A positive (liquidity increasing) shock to the resolution technology set generates two important results. First, improved technology makes the RA more likely to pursue a disciplinary resolution policy, closing failed banks rather than providing them with financial assistance. Second, an improvement in the RA's technology makes banks less likely to pursue complex business strategies that make them difficult for the RA to efficiently resolve in the case of failure. We specify the political and/or economic pressure facing the RA even more simply as the RA's value of time. The logic is straightforward: in an environment in which bank closures create negative externalities that threaten the current health of the macro-economy, policymakers will discount the long-run consequences of bank bailouts (increased moral hazard incentives) relative to the short-run social and political benefits of bank bailouts (preventing financial disruptions, avoiding bank failures and the blame that goes with them). In our model, when the RA increasingly discounts future consequences, banks become more likely to pursue risky business strategies that make them difficult to efficiently resolve.

We can use our model as a prism for viewing the policy solutions imposed on insolvent banking companies during the recent financial crisis. In some cases, extant laws and regulations simply prevented authorities from applying their existing resolution technologies to insolvent financial institutions. For example, the FDIC had the legal authority to resolve insolvent banks, but lacked this authority over parent bank holding companies (e.g., Citigroup, the financial holding company that owns Citibank) or non-bank financial firms (e.g., Bear Stearns, AIG). Outside the U.S., the FSA had even less legal authority, so effectively policymakers in the UK had to choose between nationalizing Northern Rock or letting it enter normal commercial bankruptcy. In other cases, the size and/or complexity of insolvent financial firms (e.g., some of the initial TARP recipients) simply outstripped the technological ability of the FDIC to close them down without inducing large losses in liquidity for bank customers, for counterparties of bank customers exposed

[24] These comparative static results are based on a shock in the technology available to the RA at the beginning of the repeated game, and assumes that the technology remains static after that. Technically, a change in L_T (or any of the other parameters) during the game would invalidate our equilibrium solution. As discussed at length in Section 3 above, resolution technology does change over time, often unpredictably, with changes in laws and regulations and with advances in information technology. For a change in L_T to materially influence either the banks' or the RA's actions today—and hence the comparative static results—then (a) the players would have to *expect* the future change in L_T and (b) because these expected changes would occur in the future, their effects would be discounted in the players' decisions.

to contagion-like effects, and for investors potentially exposed to increased uncertainty in financial markets. Pressure was felt by decision makers to provide *immediate* assistance to large complex financial firms to prevent further disruptions to financial markets and the macro-economy.

While it is generally agreed—though ultimately not provable—that government assistance prevented a larger meltdown, the decisions to provide this assistance were made with little thought of the longer term consequences for bank risk-taking.[25] Absent the technological ability to close the very largest insolvent banking companies, federal bank regulators encouraged/facilitated the purchase of these banks by other large banks (Wells Fargo purchased Wachovia in October 2008; Bank of America purchased Merrill Lynch in September 2008), actions that substantially increased the size and complexity of the surviving acquirers.[26] Even if we experience continuous improvements in resolution technology that allow regulators to close increasingly larger banks, allowing the largest banks to grow even larger nullifies these technological gains. In our model, in which such scenarios correspond to a higher rate of time discount for the RA, increased focus on the present relative to the future (i.e., the discounting of future moral hazard consequences) makes banks more likely to choose high-risk business models.

The seeming inconsistency of U.S. regulators' treatment of Bear Stearns and Lehman Brothers—providing assistance for JP Morgan-Chase to purchase the former investment bank, but several months later standing by and forcing the latter investment bank to enter bankruptcy—can also be interpreted within the framework of our model. McDonald and Robinson (2009) argue that Lehman Brothers CEO Richard Fuld falsely believed that the United States government would save the company, and with this put option in hand Fuld played a game of brinksmanship, engaging in unnecessarily risky behavior and rejecting as too low private sector offers to purchase controlling interest in the firm (e.g., an $18 per share from the Korea Development Bank in August 2008). Assuming this characterization is an accurate one, the behavior of Lehman is consistent with a departure from the desired simple equilibrium strategy, and the seeming reversal of regulatory policy is consistent with the random strategy necessary to support the desired equilibrium in the future.

The "orderly liquidation authority" provision in the Dodd-Frank Act of 2010 represents a positive technological shock for U.S. bank regulators. The ability to place systemically important financial companies (not just banks) into receivership provides an alternative to *ad hoc* policy interventions necessary to avoid the economy-wide reductions in liquidity that could result if these firms gained corporate bankruptcy protections. The legislation also gives regulators the authority to force a decrease in the operational and/or financial complexity of large systemic financial firms. In the context of our model, this new authority expands the technology set available to the RA, reduces the liquidity cost of discipline, makes the closure of large insolvent bank more likely, and reduces the incentives for banks to choose high-risk business models. These theoretical effects, of course, are conditional on the RA's rate of time discount (i.e., pressures to act in the short run) remaining low. The success of the Dodd-Frank provisions may ultimately depend on whether regulators can invoke their new authority to close large, complex financial firms without succumbing to the inevitable political and economic pressures to do otherwise during a financial crisis.

At the other end of the policy spectrum lie proposals that would greatly, or even completely, reduce the probability of bank insolvency. Indeed, a world in which banks do not fail is a world in which bank failures do not need to be resolved. Various examples are mentioned in Dodd-Frank, most notably: the co-called Volcker Rule that would eliminate proprietary trading at banks; "skin-in-the-game" provisions that would require banks to hold a portion of risky assets they create and sell off; and contingent capital schemes that would keep failed banks operating by converting the claims of junior creditors to an ownership stake. Such policies are not magic bullets: while they may reduce the number of failed banks that regulators must resolved, they come with attendant costs of their own. Eliminating proprietary trading surely does not eliminate credit risk, the underlying cause of bank insolvency during the financial crisis. Reductions in credit risk large enough to substantially reduce bank failures can only be accomplished by greatly curtailing lending (by definition, loans are risky), which in our economic system is the central purpose of banks. Similarly, holding back some portion of loan securitization tranches (the skin) may change bank incentives but reduces the total amount of risk in the system only by reducing securitizations, which in the end allocates less capital to loans (the game). Finally, bail-ins leave in place the fundamental deficiencies of failed banks—that is, the organizational, behavioral, geographic, and product mix inefficiencies that caused poor bank performance in the first place—rather than reallocating bank assets to more efficient and sounder financial firms. Simply stated, we must not forget that bank failures, like bankruptcies of inefficient non-banking firms, are essential phenomena for efficient reallocation of society's resources in the long run. This calls for a regulatory regime that not only expects and allows banks to fail, but also improves our capacity for resolving those failed banks.

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Appendix A. Proof of the proposition

We derive conditions under which the strategies described in the proposition constitute a subgame perfect equilibrium of our infinitely repeated game. We use the concept of the Markov Perfect Equilibrium, i.e., we derive conditions under which the Markov strategies mentioned in the paper constitute a subgame perfect equilibrium.

The RA's strategy on the equilibrium path (RA_e). First, we show that the RA always prefers to close failed "simple" banks. If the RA sticks to its strategy RA_e and closes the banks, the closure yields

[25] In a September 19, 2008 address, President George W. Bush said that TARP "should be enacted as soon as possible" because "our entire economy is in danger" and that "the risk of not acting would be far higher." These remarks were made shortly after Federal Reserve Chairman Ben Bernanke and U.S. Treasury Secretary Henry Paulson lobbied the White House to provide large and immediate assistance to financial markets and troubled financial firms.

[26] In September 2008, the FDIC seized and closed Washington Mutual Bank—at the time, the largest U.S. thrift institution with assets of about $300 billion—and sold its assets and most of its liabilities to JPMorgan Chase. The parent company, Washington Mutual Corporation, stripped of its major asset, declared bankruptcy the following day.

the immediate utility θ_3. Moreover, the closure in period t implies that s_{t+1} = NB and the "simple" strategy by the new investors in the future. Thus, the RA receives from period $t+1$ on the present value of future utility from closing the failed "simple" banks, which is equal to $PV(RA_e) = ((1-\varphi)\theta_4 + \varphi\theta_3)/(1-\delta)$. $PV(RA_e)$ takes into account that in each period the RA receives θ_4 with probability $1-\varphi$ (the "simple" banks survives) or θ_3 with probability φ (the RA closes the failed "simple" banks). Formally, $PV(RA)_e$ is derived using the following equation:

$$PV(RA_e) = (1-\varphi)(\theta_4 + \delta PV(RA_e)) + \varphi(\theta_3 + \delta PV(RA_e)).$$

Hence the utility from closing the failed "simple" banks at period t is:

$$\theta_3 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3}{1-\delta}.$$

Now consider the situation in which the RA makes a one-time deviation and bails out the failed "simple" banks. It receives the immediate utility θ_2. However, the bailout results in s_{t+1} = B, and the bailed-out investors and the new investors (should the existing investors be banned from the banking banks in the future) play the strategy B_o, i.e., they randomize between the "simple" and "complex" business strategy. This alters the present value of the RA's future utility, which is denoted by *PV(BOS)*. *PV(BOS)* is a solution to the following equation:

$$PV(BOS) = p[(1-\varphi)\theta_4 + \varphi\theta_3 + \delta PV(BOS)] + (1-p)[(1-\varphi)\theta_4 + \varphi q\theta_1 + \varphi(1-q)\theta_2 + \delta PV(BOS)].$$

This equation takes into account that after a bailout both the RA and the investors randomize between their pure strategies. With probability p the banks become "simple". With probability $1-p$ the banks become "complex". The RA receives θ_4 with probability $1-\varphi$ if the banks succeed. Otherwise, the RA receives either θ_1, when it closes the failed "complex" banks with probability φq, or θ_2 with probability $\varphi(1-q)$ when it bails out such banks. After solving the last equation with respect to *PV(BOS)* the utility from the RA's one-time deviation is

$$\theta_2 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3 - (1-p)\varphi[\theta_3 - (q\theta_1 + (1-q)\theta_2)]}{1-\delta}.$$

The RA sticks to its strategy of closing down the failed "simple" banks if and only if

$$\theta_3 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3}{1-\delta} \geq \theta_2 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3 - (1-p)\varphi[\theta_3 - (q\theta_1 + (1-q)\theta_2)]}{1-\delta}$$

This can be rewritten as

$$\theta_3 - \theta_2 \geq -(1-p)\delta\varphi\frac{\theta_3 - (q\theta_1 + (1-q)\theta_2)}{1-\delta}.$$

This expression holds always because $\theta_3 > \theta_2 > \theta_1$ implies that the LHS of the last expression is positive and the RHS negative. Hence, the RA will never deviate from RA_e under the stated assumptions.

The investors' strategy on the equilibrium path (B_e). Second, we study the investors' decision to choose the "simple" bank when there was no bailout in the previous period. Assume that s_t = NB (observe that in this state both the existing investors that succeeded in the period $t-1$ and the new investors after closure of the old bank at $t-1$ decide about its strategy for period t). When the investors choose the "simple" bank, their payoff is:

$$V_s = \pi_s + \gamma(1-\varphi)\pi_s + \cdots + \gamma^{t-1}(1-\varphi)^t\pi_s + \cdots = \frac{\pi_s}{1-(1-\varphi)\gamma'}$$

where the bank succeeds with probability $1-\varphi$ and is closed with probability φ.

If the investors deviate and choose the "complex" bank, this has the following consequences for their payoff. When the "complex" bank succeeds, the investors return to choosing a "simple" bank in the next period and its payoff is $(\pi_c + \gamma(1-\varphi)V_s)$. When the bank fails while being "complex", the RA starts to play RA_o. RA_o prescribes that a failed "complex" bank is closed with probability q (implying s_{t+1} = NB and the "simple" strategy by the new investors), or otherwise it is bailed out (which implies that the investors will play B_o from s_{t+1} = B on). Denote the investors' continuation payoff from playing B_o as V_{B_0}. Then V_{B_0} is given by the following equation:

$$V_{B_0} = p(\pi_s + \gamma(1-\varphi)V_{B_0}) + (1-p)(\pi_c + \gamma(1-\varphi)V_{B_0}) + (1-p)\varphi(1-q)(b + \gamma V_{B_0}),$$

where the bank is "simple" with probability p or "complex" with probability $(1-p)$. In the latter case the failed "complex" bank receives b and is allowed to continue with probability $(1-p)\varphi(-q)$. Then:

$$V_{B_0} = \frac{p\pi_s + (1-p)\pi_c + (1-p)\varphi(1-q)b}{1-\gamma(1-\varphi+(1-p)(1-q)\varphi)}.$$

Hence the payoff from deviating from B_e is:

$$(\pi_c + \gamma(1-\varphi)V_s) + \varphi(1-q)(b + \gamma V_{B_0}).$$

Because the last expression depends on p and q, we have to find mixed strategies played by the both parties out of the equilibrium path in order to check under which conditions the investors do not deviate from B_e.

The mixed strategy of the RA. Third, we have to find the off-equilibrium response of the RA to the failed "complex" banks. If the RA plays a mixed strategy once it deals with the failed "complex" banks, it has to be indifferent between closure and bailout. The RA's utility from closing the failed "complex" banks amounts to the immediate utility θ_1 and the future continuation value $\delta PV(RA_e)$ (the closure implies s_{t+1} = NB). The RA's utility from bailing out the failed "complex" banks amounts to the immediate utility θ_2 and the future continuation value $\delta PV(BOC)$. *PV(BOC)* is the RA's utility after the investors play B_o following the bailout and is the solution to the following equation:

$$PV(BOC) = p[(1-\varphi)\theta_4 + \varphi\theta_3 + \delta PV(BOC)] + (1-p)[(1-\varphi)\theta_4 + \varphi\theta_2 + \delta PV(BOC)].$$

Solving out for *PV(BOC)* the RA's indifference condition reads:

$$\theta_1 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3}{1-\delta} = \theta_2 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3 - (1-p)\varphi(\theta_3 - \theta_2)}{1-\delta}$$

or

$$\frac{\delta}{1-\delta}(1-p)\varphi(\theta_3 - \theta_2) = \theta_2 - \theta_1.$$

Both sides of the last equality are positive because of $\theta_3 > \theta_2 > \theta_1$.

The last equality describes the RA's reaction to the investors' behavior. The RA's payoff from bailouts is increasing in p: the higher the probability p that the investors play "simple", the higher the expected utility of bailouts of the "complex" banks because they occur less frequently. From this expression we can derive the RA's best response given the strategy played by the investors:

$$\begin{cases} \text{close the "compelx" banks for } p < p* \\ \text{indifferent between closing and bailing out the "complex" banks for } p = p* \\ \text{bail out the "complex" banks for } p > p* \end{cases}$$

where

$$p^* = 1 - \left(\frac{1}{\delta} - 1\right)\frac{\theta_2 - \theta_1}{\varphi(\theta_3 - \theta_2)}.$$

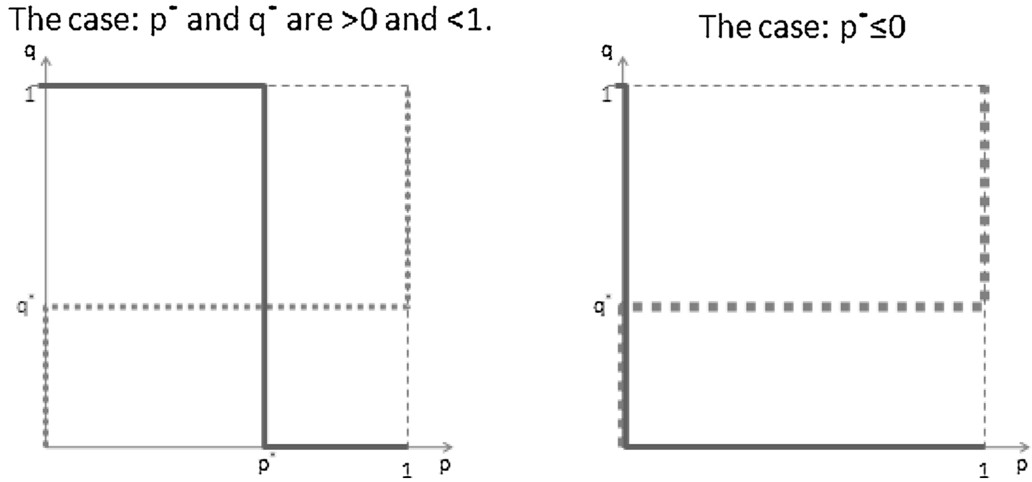

Fig. A1. The best responses of the RA (solid line) and the investors (dashed line).

The mixed strategies of the investors. Fourth, we derive the off-equilibrium mixed strategy for the investors. After the investors observe s_t = B, they will randomize according to B_o, which requires that the investors are indifferent between the "simple" and "complex" bank. Being "simple" delivers V_s to the investors. Denote as V_c the investors' payoff from the "complex" bank. If the "complex" bank is successful, the investors' expected profit is π_c and the future continuation value is γV_c with the probability $1-\varphi$. If the "complex" bank fails with probability φ, it is closed with probability q, but with probability $1-q$ it is allowed to continue and receives $b+\gamma V_c$. Formally V_c comes from the following equation:

$$V_c = \pi_c + \gamma(1-\varphi)V_c + \varphi(1-q)(b+\gamma V_c)$$

and it is equal to

$$V_c = \frac{\pi_c + \varphi(1-q)b}{1-(1-q\varphi)\gamma}.$$

The investors are indifferent between the "complex" or "simple" bank after a bailout, when $V_s = V_c$. Solving this equation for q delivers that the investors are indifferent for

$$q^* = 1 - \frac{(1-\gamma(1-\varphi))}{\varphi[\gamma\pi_s + (1-\gamma(1-\varphi))b]}(\pi_s - \pi_c) \in (0;1).$$

$q^* < 1$ follows because of $\pi_s > \pi_c$. $q^* > 0$ follows because of $\pi_s < \pi_c + \varphi b$. Indeed, $q^* > 0$ is equivalent to $\tau_s - (\gamma\varphi)/(1-\gamma(1-\varphi))\pi_S < \pi_C + \varphi b$, which is weaker than $\pi_s < \pi_c + \varphi b$. The reaction function of the investors is as follows. Hence, the investors' best response is to set up the "complex" bank for $q < q^*$, the "simple" for $q > q^*$, and they are indifferent for $q = q^*$.

Finding the mixed strategies. Fifth, we combine the best responses of the RA and the investors to find the optimal off-equilibrium strategies. q^* is always between 0 and 1. p^* is always lower than 1. The following two figures summarize the potential cases depending on the parameters of the model (Fig. A1).

The solid line represents the best response of the RA, $q(p)$, and the dashed line the one of the investors, *p(q)*. Now we will show that the only case which supports an equilibrium, in which the investors choose to the "simple" industry, is the case in which p^* is between 0 and 1. When $p^* \le 0$, the RA always bails out the "complex" industry. This cannot lead to a desired equilibrium because the investors would always choose to the "complex" industry and deviate from B_e.

Now, we will check if for parameters such that $p^* > 0$ the resulting out-of-equilibrium mixed strategies can support the desired equilibrium. First, $p^* > 0$ holds for

$$\delta > \frac{1}{1+(\varphi(\theta_3-\theta_2)/(\theta_2-\theta_1)} = \underline{\delta} \in (0;1).$$

Second, in order to check whether the investors do not deviate from B_e, we insert p^* and q^* in the condition

$$V_s \ge (\pi_c + \gamma(1-\varphi)V_s) + \varphi(1-q)(b+\gamma V_{B_0}),$$

derived when checking the one-time deviation from B_e.

It turns out that the investors are indifferent between deviating or not. This is intuitive because the investors are indifferent between the "simple" and "complex" industry out of the equilibrium, so the same has to hold on the equilibrium path. This finalizes the proof of the claim in the proposition that the above mentioned mixed strategies support the disciplinary equilibrium for any $\delta \in (\underline{\delta}; 1)$.■

Appendix B. Comparative static results

Comparative statics for $\underline{\delta}$:

$$\frac{\partial\delta}{\partial\varphi} = \frac{-(\theta_3-\theta_2)/(\theta_2-\theta_1)}{(1+(\varphi(\theta_3-\theta_2))/(\theta_2-\theta_1))^2} < 0$$

$$\frac{\partial\delta}{\partial\theta_1} = -\frac{\varphi(\theta_3-\theta_2)/(\theta_2-\theta_1)}{(1+(\varphi(\theta_3-\theta_2))/(\theta_2-\theta_1))^2} < 0$$

$$\frac{\partial\delta}{\partial\theta_2} = -\frac{\varphi(\theta_3-\theta_2)/(\theta_2-\theta_1)^2}{(1+(\varphi(\theta_3-\theta_2))/(\theta_2-\theta_1))^2} < 0$$

$$\frac{\partial\delta}{\partial\theta_3} = -\frac{\varphi}{(\theta_2-\theta_1)(1+(\varphi(\theta_3-\theta_2))/(\theta_2-\theta_1))^2} < 0$$

Comparative statics for q^*:

$$\frac{\partial q*}{\partial\gamma} = \frac{\pi_s(\pi_s-\pi_c)}{\varphi[\gamma\pi_s + (1-\gamma(1-\varphi))b]^2} > 0$$

$$\frac{\partial q*}{\partial b} = \frac{(1-\gamma(1-\varphi))^2\varphi}{\varphi[\gamma\pi_s + (1-\gamma(1-\varphi))b]^2} > 0$$

To derive the next three results, we treat φ, π_C, and π_S as parameters that freely vary rather than as functions. Doing so provides some additional intuition.

$$\frac{\partial q*}{\partial \pi_c} = \frac{1-\gamma(1-\varphi)}{\varphi[\gamma\pi_s + (1-\gamma(1-\varphi))b]} > 0$$

$$\frac{\partial q*}{\partial \pi_S} = \frac{-(1-\gamma(1-\varphi))(\gamma\pi_C + (1-\gamma(1-\varphi))b)}{\varphi[\gamma\pi_s + (1-\gamma(1-\varphi))b]^2} < 0$$

$$\frac{\partial q*}{\partial \varphi} = \frac{(\pi_s - \pi_c)(\gamma(1-\gamma)\pi_s + (1-\gamma(1-\varphi))^2 b)}{[\varphi[\gamma\pi_s + (1-\gamma(1-\varphi))b]]^2} > 0$$

Comparative statics for p^*

$$\frac{\partial p*}{\partial \delta} = \frac{1}{\delta^2}\frac{\theta_2 - \theta_1}{\varphi(\theta_3 - \theta_2)} > 0$$

$$\frac{\partial p*}{\partial \theta_1} = \frac{(1/\delta) - 1}{\varphi(\theta_3 - \theta_2)} > 0$$

$$\frac{\partial p*}{\partial \theta_2} = \left(\frac{1}{\delta} - 1\right)\frac{\theta_3 - \theta_1}{\varphi(\theta_3 - \theta_2)^2} < 0$$

$$\frac{\partial p*}{\partial \theta_3} = \left(\frac{1}{\delta} - 1\right)\frac{\theta_2 - \theta_1}{\varphi(\theta_3 - \theta_2)^2} > 0$$

Unlike $\partial q^*/\partial\varphi$ above, the following derivative $\partial p^*/\partial\varphi$ is a comparative static result because $\varphi = \rho_C\rho_S$ increases equally with both ρ_C and ρ_S and that we impose no restrictions on the relative magnitudes of ρ_C and ρ_S.

$$\frac{\partial p*}{\partial \varphi} = \left(\frac{1}{\delta} - 1\right)\frac{\theta_2 - \theta_1}{\varphi^2(\theta_3 - \theta_2)} > 0$$

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