A Theory of 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 pressures 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.

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1. Introduction

In 2007, large cracks began to appear in the U.S. mortgage industry. Two leading non-bank mortgage originators, New Century Financial Corporation and American Home Mortgage Investment Corporation, filed for bankruptcy; Bear Stearns, a leading investment bank, suspended redemptions in one of its mortgage-backed investment funds and liquidated two hedge funds that invested in mortgage-backed securities. In September the cracks spread to Europe as losses in mortgage-backed securities led to a liquidity crisis at Northern Rock, the U.K's fifth largest thrift, prompting the first full-fledged bank run in the U.K. in over 100 years.[1] Subsequently, the U.S. Treasury, the Federal Reserve and the Bank of England took historic actions to prevent the collapse of troubled financial institutions deemed to be systemically important.[2] 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 the ensuing 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.

[1] The run on Northern Rock may have been exacerbated by the structure of the U.K.'s deposit insurance system, which imposed credit risk and liquidity risk on depositors. The system provided a full guarantee on the first £2,000 of deposits but only a 90 per cent guarantee on the next £33,000 of deposits; moreover, it could take several months for depositors to receive these payments.

[2] In February of 2008, the Bank of England effectively nationalized Northern Rock, after having extended over £50 billion in loans and guarantees to cover the firm's losses in subprime mortgage investments. In March, the Federal Reserve Bank of New York provided $29 billion of financing to assist J.P. Morgan Chase in its purchase of Bear Stearns, on the verge of financial collapse from real estate-related investment losses and impending inability to rollover its short-term debt. In September, the Federal Reserve Board gave an $85 billion line of credit to American International Group (AIG), the largest insurance company in the U.S., to offset losses related to its sales of credit default swaps on subprime mortgage-backed securities. In October, 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), some of which were facing insolvency due to large investment losses in subprime mortgage-backed securities. The notable exception was Lehman Brothers, a leading U.S. investment bank, which received no governmental aid and hence was forced to file for bankruptcy in September, an event that caused turmoil in short-term credit markets.

We explore the implications of this policy tradeoff for the risk composition of the banking industry. Our model stresses a crucial driver of this policy tradeoff which has received little or no attention in the previous theory literature: the limited set of failed bank resolution technologies that can leave regulators with little choice but to bail out systemically important (e.g., large, complex, and/or inter-connected) banks. In this way our study is timely. The Wall Street Reform and Consumer Protection Act of 2010 (here after, "Dodd-Frank") establishes "orderly liquidation authority" that allows U.S. bank regulators to place systemically important financial companies into receivership and liquidate them. Thus, Dodd-Frank expands the technology set available to the FDIC, which until now was permitted to resolve insolvent banks but not their (or other) financial or bank holding companies. These new powers will augment other recent efficiencies in the failed bank resolution process, such as improvements in the deposit determination process and the increased use of the FDIC's bridge bank authority.

The model also emphasizes the likelihood that political and/or economic pressure placed upon the regulator (which we model very generally as the regulator's time discount) during a mounting financial crisis can similarly force the regulator's hand and lead to bailouts. While Dodd-Frank has yet to be tested, the public relations message that accompanied Dodd-Frank was seemingly clear and unequivocal. At the signing of the bill, 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 that are funded by some other mechanism. Which third party gets stuck with the bill is a distributional issue, and this distributional concern is immaterial for the existence of moral hazard incentives. More importantly, Dodd-Frank provides for a resolution mechanism for large, complex financial firms, and this mechanism allows the losses in the firm to be borne by stockholders and unsecured creditors. However, this new structure is untested and bailouts will only truly be ended when a financial firm previously considered "too big to fail" is closed and liquidated without creating a crisis in financial markets.

The 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 complex (high risk) and simple (less risk) business strategies. The regulator (as does society) 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 the available resolution technology is insufficient to efficiently close a failed complex bank. Thus, the key innovation in our model is the inclusion of a technology constraint, a realistic condition not considered in previous models of bank resolution. The policy implications are intuitive. Legal, financial or technological advances that relax the technology constraint reduce the chance that the resolution authority will bail out complex banks, and also reduce the chance that banks will run complex business models, in equilibrium. But gains from improved technology can be dampened, offset or overwhelmed during times of financial turmoil, because increased political or economic pressure on the regulator increases the chance that banks will adopt complex business model in equilibrium.

The rest of the paper unfolds as follows. Section 2 provides a short review of the fundamental economics (and politics) of liquidity provision and market discipline in failed bank resolutions in the U.S. We give special attention to the bank failure policies exercised during the two most extreme episodes of bank insolvency in U.S. history: the pre-FDIC years in which failure resolution policy stressed market discipline with little concern for liquidity provision, and the thrift crisis of the 1980s-1990s in which failure resolution policy stressed liquidity provision with little concern for market discipline. (Because most of the academic attention to these issues has focused on the U.S. experience, and because the U.S. has the longest history of deposit insurance and failed bank resolution policy, we couch much of our discussion in terms of the FDIC.) Section 3 describes the "technology" used by the FDIC to resolve failed banks. Increased use of its bridge bank authority, as well as improvements in the process of insurance determination (the procedure by which the FDIC identifies whether and how many deposits at a failed bank are insured or un-insured), have yielded recent technological efficiencies for the FDIC; similarly, the "orderly liquidation authority" provisions of the Dodd-Frank legislation are expected to yield further technological efficiencies. In general, the special bank resolution powers in U.S. law allow the FDIC to deal with failed banks more efficiently than regulators in many other countries, where insolvent banks must be resolved according to standard bankruptcy processes. We present and analyze the results of our theory model in Section 4, and in Section 5 we discuss the implications of that analysis for bank resolution policy and the riskiness of the banking industry.

2. Market liquidity versus market discipline

Because commercial banks play a central role in our economy, their inherent fragility requires special regulatory attention. Banks finance risky, opaque and illiquid assets with large amounts of demandable debt. Absent appropriate regulation, banks that experience declines in asset quality become susceptible to liquidity risk, as depositors and other short-term creditors fearful of bank failure lose confidence and withdraw their funds from the bank. Bank failures also reduce borrower liquidity by disrupting the lending channel. Bernanke (1983), Calomiris and Mason (2003), and Ramírez (2007) have observed that the loss of banking relationship by borrowers caused significant economic damage after bank failures in the 20s and 30s. Ashcraft (2005) examined the regulatory closure of a large regional bank in Texas in the 1990s—the bank was solvent, but its parent bank holding company was insolvent, resulting in a natural experiment—and found a strong association between the bank's lending presence and declines in GDP in local Texas markets.

Depending on the size and/or number of the affected banks, these disruptions to market liquidity can be debilitating for the economy at large.[3] 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 the incentives for small depositors to run and precipitate bank failure; bypassing lengthy bankruptcy proceedings (i.e., the financial protections and available to non-bank

[3] Hoggarth and Saporta (2001) estimate that the economic costs of a systemic bank failure event could run as high as 15% to 20% of a nation's GDP.

corporations) reduced disruptions to depositor liquidity, borrower liquidity and payments in the case of bank failure.

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 to attract funds. 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. In both cases, these behaviors are enabled by the reduction in financial market discipline engendered by the presence of deposit insurance regulation. Extending deposit insurance protection to all bank creditors in a failed banks—or, the more extreme policy of providing financial assistance to keep an insolvent bank open—reduce market discipline further and exacerbates the risk-taking behaviors of both bank depositors and bank managers.

2a. Regulatory incentives

Much has been written about the incentives facing deposit insurers, the impact of these incentives on efficient failed bank resolution policy, and how to mitigate the socially inefficient regulatory behavior that can spring from these incentives.[4] 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 perhaps non-deposit creditors) as well. To the extent that these predilections exist, they may be exacerbated in certain circumstances when political and/or economic pressures arise to prevent illiquidity at all costs—for instance, during economic crises when numerous large banks become insolvent.

[4] A related line of inquiry concerns the incentives of the "lender of last resort" (the central bank) when faced with a bank that is illiquid but not (yet) insolvent. See Freixas and Parigi (2008) for a recent survey of these issues.

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) characterizes the relationship between the deposit insurer, taxpayer, and depositor as a surety bond. He shows how existing legal and regulatory arrangements (including the prompt corrective action features of the Federal Deposit Insurance Corporation Improvement Act of 1991) represent an incomplete market that creates 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) and Kaufman (2003) proposed a combination of quick access to insured deposit funds and a partial "advance dividend payment" to uninsured depositors (the amount based on a first approximation of the value of the failed bank's assets). Slight delays in paying depositors may have positive market discipline effects by imposing costs on depositors who decided to 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, Anderson, and Twaddle (2007). Much earlier, Rosengren and Simon (1992) suggested that transferable put options—whereby banks purchasing failed assets could return those loans to the FDIC in the case of future default—would reduce failed bank resolution costs by increasing the marketability of failed bank assets.

2b. Resolution policy in practice

The FDIC has used a wide variety of resolution techniques during its 75 year history. Some resolution 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. Figure 1 provides a brief definition of each of the major resolution techniques that have been used by the FDIC, displaying them in rank order based on the degree to which they preserve liquidity. Note that, since there is a roughly inverse (though not necessarily monotonic) relationship between preserving market liquidity and enhancing market discipline among these techniques, the figure also illustrates the economic tradeoffs facing policymakers. Also note that the degree of borrower liquidity and depositor liquidity associated with each of these resolution techniques tend to be correlated. For example, if a receivership liquidates a failed banks' loans and other assets only gradually over time, then at least some depositors will be denied full access to their (uninsured) funds until the receiver sells enough assets to cover their deposits, and some borrowers will have to delay further draw-downs of their lines of credit until the receiver sells their existing loan to another bank. Similarly, if a bank is liquidated, then both borrowers and lenders will need to establish new banking relationships. Hence, the rank ordering in Table 1 captures both depositor and borrower liquidity.

As political, economic, legal, and technological conditions have shifted over time, the FDIC's preferred resolution choices (or the choices imposed upon it by Congress) have switched between and among these various techniques.[5] We now focus briefly on two discretely different and polar opposite approaches to the failed bank resolution from U.S. history. At one extreme is a strategy of liquidating failed banks without any special depositor protections. At the other extreme is a strategy of complete regulatory forbearance that keeps liquid but insolvent banks operating.

U.S. bank failures prior to the FDIC: Stressing discipline over liquidity. 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. 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

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

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. Anari, Kolari and Mason (2005) showed that depositors and other creditors of national banks that failed in 1929 received only 66.12 percent 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. Borrowers also faced potentially large costs, having to establish new banking relationships, pay off their loan from the closed bank, and losing the liquidity associated with any deposit accounts they may have held at the closed bank.

Today, in a time when failed banks are closed in orderly and rapid fashion and most bank deposits are protected by insurance, it is easy to underestimate the frequency and depth of U.S. financial crises during the pre-FDIC era. Crises and widespread banking panics occurred at least eight times between 1819 and 1929—in 1819, 1837, 1848, 1873, 1893, 1907, 1921, and 1929-1933 (Kindleberger, 1978). During these crises, reduced liquidity was the primary concern of all of the interested groups, especially so in the banking and financial center of New York City. Amid the uncertainty, nervous depositors faced incentives to withdraw their funds from banks to preserve their liquidity. Banks responded by building up their reserves in order to withstand demands by depositors, thus depriving borrowers of needed funds. Whenever borrowers and/or depositors were denied funds by their banks, the banking panics intensified and spread.

The Panic of 1907 is particularly instructive. For banks and trusts that were closed down but eventually proved to be solvent, the Panic and its effects were relatively short-lived. For example, Knickerbocker Trust, the first trust company on which depositors ran during the Panic, failed on October 22, 1907 but resumed business on March 26, 1908; the Hamilton Bank failed on October 24, 1907 but resumed business even faster, on January 20, 1908. The panic was followed by a sharp, but short contraction with industrial production falling over 15% in 1908 and rising by a similar amount in 1909. Davis (2004). But outright bank failures had much deeper economic impacts, as the liquidation of these banks caused significant delays for payments to depositors and other creditors. 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, Ramirez, 2007).

The savings and loan crisis: Stressing liquidity over discipline. The creation of FDIC and the introduction of federal deposit insurance eliminated or at least mitigated many of the ill effects of bank failures. Insured depositors were made whole immediately after failed banks were closed, and the certainty with which this liquidity was provided defused bank runs, the biggest catalyst for the banking panics of the past century. While over 10,000 banks failed during the 1920s alone, only a handful of banks failed annually during the half century following the Great Depression, and none of these failures were associated with a banking panic. Given the apparent success of this new regulatory regime—and remembering the severe macroeconomic effects of past banking panics—it is not surprising that going forward banking authorities would lean toward resolution policies centered on maintaining depositor liquidity rather than policies centered on market discipline of banks and depositors.

Unfortunately, this new approach can create moral hazard incentives at both banks and bank supervisors. Knowing that their funds are fully or substantially protected, depositors and other creditors will continue to lend to troubled banks, even when the bank's condition is known. Similarly, businesses that borrow from troubled banks are less likely to establish multiple alternative credit lines, knowing that in the case of bank failure a seamless resolution process will most likely prevent their credit access from being badly disrupted. Managers of troubled banks are likely to make increasingly risky loans, knowing that the entire upside risk of the loans accrues to the bank while a large portion of the downside risk of the loans will be absorbed by the insurance fund. Knowing that the responsibility for monitoring banks' financial condition has passed largely from bank depositors (i.e., market discipline) to bank supervisors, bank insolvencies are now interpreted by some as evidence of supervisory failure; to avoid stigma, banking authorities are more likely to keep insolvent institutions open and operating in the short-run.

Nonetheless, the term moral hazard was rarely heard in conjunction with deposit insurance during the first fifty years of the FDIC's existence. The regulatory forbearance practiced by U.S. bank regulators during the thrift debacle of the 1980's would change that. The unexpected surge in inflation and short-term interest rates during the late 1970's, and the deleterious effects of these developments on the financial soundness of U.S. thrift institutions during the 1980s, is a well-known story. These firms financed portfolios of long-term, fixed-rate mortgage loans with short-run deposit liabilities, and the sudden spike in deposits rates generated massive operating losses. Tangible capital in the thrift industry fell from $32 billion in 1980 to just $4 billion in 1982; at least 415 thrifts reported negative tangible accounting capital at the end of 1982, and it is roundly believed that a much larger number of thrifts were insolvent on a market value basis. The Federal Home Loan Bank Board closed only a small portion of these thrifts: only 103 thrifts insured by the Federal Savings and Loan Insurance Corporation (FSLIC) were declared officially insolvent and closed between 1980 and 1982, and only 131 additional closures were performed between 1983 and 1985.

In the most extreme cases of supervisory forbearance, authorities actually provided financial assistance to thrifts without removing thrift management and without a pledge of additional support from thrift owners.[6] 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. With neither market discipline nor regulatory discipline in place, already troubled thrifts continued to hemorrhage and fell deeper into insolvency. Moreover, when these thrifts were finally declared insolvent and were closed, the most common resolution method protected both the insured and the uninsured creditors, and in addition guaranteed the thrift or banking institution that acquired the remaining assets against loss. Ultimately, these extreme supervisory and resolution practices, motivated initially by a desire to maintain liquidity, cost $153 billion in resolution costs, with the U.S. taxpayers paying about $125 billion of this (Curry and Shibut 2000).

[6] 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."

FDICIA and Dodd-Frank. Congress responded to the savings and loan crisis and the wave of commercial bank failures that followed with two major pieces of legislation, the Financial Institutions Reform, Recovery and Enforcement Act of 1989 (FIRREA) that created the Resolution Trust Corportion (RTC) and the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991. FDICIA constrained the decision-making latitude of bank supervisors and regulators, and by doing so tilted bank resolution policy away from protecting the liquidity of uninsured creditors and toward imposing discipline on both uninsured creditors and bank management. Among other changes, the law established a "prompt corrective action" regime (PCA) aimed at restricting the activities of troubled institutions before they became insolvent (e.g., replenish lost capital, reduce asset growth, cancel dividends); mandated the FDIC to resolve failed banks in the "least costly" manner (i.e., as opposed to the manner that maximized liquidity); increased the frequency and regularity of bank and thrift safety and soundness examinations; and took an initial step toward risk-based deposit insurance pricing (i.e., basing deposit insurance premiums on banks' capital levels and examination ratings).[7]

FDICIA took an important set of steps toward increased reliance on supervisory discipline (if not market discipline) for troubled banks. But these steps proved to be inadequate in the fall of 2008. At that time (i.e., pre-Dodd-Frank), the FDIC's resolution authority extended only to federally or state chartered banks—not to their bank holding companies, or to insurance companies or investment banks, all of which at the time of the crisis were subject to federal bankruptcy laws.[8] For example, Lehman Brothers, a leading U.S. investment bank, suffered a liquidity crisis and was effectively out of cash by the weekend of September 13-14, 2008. The U.S. Treasury and the Federal Reserve Bank of New York attempted but were unable to find a viable buyer for Lehman, and without a viable buyer Lehman sought the protection of Chapter 11 Bankruptcy on Monday, September 15.

[7] Prior to FDICIA the FDIC was required to use resolution methods that were *less costly than liquidation.* For a discussion of the evolution of the cost see Federal Deposit Insurance Corporation (1984).

[8] If the brokerage portion of an investment bank fails, the failure is handled through the Securities Investor Protection Corporation (http://www.sipc.org/). If an insurance company fails, the failure is handled by the state insurance guarantee fund in the state where the company is headquartered (http://www.ncigf.org/).

To explain why the government did not intervene to save Lehman, then-Secretary of the Treasury Henry M. Paulson stated "Moral hazard is something I don't take lightly" and followed with "I never once considered it appropriate to put taxpayers' money on the line in resolving Lehman Brothers." (Paulson, 2010). Effectively, this decision resulted in the insolvency of Lehman and imposed large losses on its creditors. Investors in credit markets viewed this decision as a potential precedent for future policy and reacted accordingly. On September 16, the Reserve Primary Money Fund "broke the buck," primarily due to losses on Lehman Brothers commercial paper and medium term notes. The commercial paper market quickly collapsed. Earlier that day, the Federal Reserve authorized the Federal Reserve Bank of New York to lend AIG $85 billion under section 13(3) of the Federal Reserve Act. On Friday, five days after Lehman declared bankruptcy, the Federal Reserve acted to support the commercial paper market. Other interventions followed, including the enactment of TARP and the subsequent support programs. In the aftermath of the financial crisis, Congress passed the Dodd-Frank Act (2010) that contained extensive new powers to allow the FDIC to plan for and effect the orderly liquidation of systemically important firms to help avoid a repeat of the bail-outs of 2008.

The legal and financial consequences of the abrupt bankruptcy of Lehman Brothers have implications for failed bank resolution policy. First, the firm's value as a going concern was lost. Lehman Brothers Holdings Inc. (the parent company) could no longer provide liquidity to its subsidiary operations and Lehman's major foreign subsidiary, the London broker/dealer Lehman Brothers International Europe, entered into U.K. bankruptcy proceedings. Most other foreign and domestic subsidiaries followed. Second, when a debtor files for bankruptcy protection or becomes insolvent, counterparties can terminate agreements, liquidate positions and set off claims against margin or other collateral posted by the debtor in accordance with the terms of their contracts. Thus, Lehman's derivatives counterparties invoked their rights under Chapter 11, causing a massive unwinding of Lehman's derivatives book. Third, the inability of the Chapter 11 entity to quickly obtain debtor-in-possession financing meant that Lehman's U.S. broker/dealer, Lehman Brothers Inc., rapidly became illiquid and had difficulty executing trades. It entered liquidation on the Friday after Lehman's Chapter

11 filing. Forth, unsecured creditors lost access to their funds and hence suffered reduced liquidity. There has still not been a distribution to unsecured creditors of Lehman Brothers. Finally, the unexpected and hence unplanned nature of the Lehman bankruptcy exacerbated uncertainty in financial markets.

After the events in the fall of 2008, policy makers sought to create a set of authorities that would force stockholders and debt holders at systemically important non-bank financial firms to bear the losses in event of failure, effecting an orderly liquidation of the firm while maintaining market liquidity. Dodd-Frank names the FDIC as the receiver of such failed financial companies, and provides it with five important powers:

(i) to maintain the going concern value of a firm by continuing key, systemically important operations, through the formation of bridge financial companies if needed.[9] In addition, the FDIC is required to replace the covered financial company's board of directors and the most senior management responsible for the company's failure;[10]

(ii) to transfer all qualified financial contracts with a given counterparty to another entity (such as a bridge financial company), thus avoiding immediate termination and liquidation;[11]

(iii) to provide immediate liquidity to the firm in order to affect an orderly liquidation, which allows continuation of essential functions and maintains asset values; [12]

[9] See Section 210(h) of the Dodd-Frank Act. There are statutorily imposed limitations on the transfer of assets and liabilities from the receiver to the bridge financial company. including a prohibition against transfering liabilities that exceed the assets transferred.

[10] This may be contrasted with a typical Chapter 11 resolution, in which the management of the pre-insolvency institution will continue to manage the operations of the debtor institution.

[11] Under the Bankruptcy Code, counterparties to QFCs with the debtor company are permitted to terminate the contracts and liquidate and net out their positions. The debtor company or trustee has no authority to transfer these contracts to a third party so that the contracts can continue according to their terms notwithstanding the debtor company's insolvency. A complex, systemically important financial company can hold very large positions in QFCs, often involving numerous back-to-back trades, some of which may be opaque and incompletely documented. Generally, qualified financial contracts are financial instruments such as securities contracts, commodities contracts, forwards contracts, swaps, repurchase agreements, and any similar agreements. *See* section 210(c)(8)(D)(i) of the Dodd-Frank Act, 12 U.S.C. § 5390(c)(8)(D)(i).

[12] In Section 204(d), the Dodd-Frank Act provides that the FDIC may borrow funds from the Department of the Treasury to provide liquidity for the operations of the receivership and the bridge financial company and may make those funds available to the receivership for the orderly liquidation of the covered financial company. Those funds are to be given a priority either as administrative expenses of the receiver or as amounts owed to the United States when used for the orderly liquidation of the covered financial company. See also Section 210(n) of the Dodd-Frank Act.

(iv) to provide market liquidity, by making advance dividend payments and prompt distributions to creditors based upon expected recoveries while still imposing losses on their holdings (if applicable); and importantly,

(v) to require systemically important financial firms to file (and regularly update) resolution plans, or living wills, for purposes of advance resolution planning.[13] Within this process Dodd-Frank permits regulators "by order, to divest certain assets or operations identified by the Board of Governors and the Corporation to facilitate an orderly liquidation of such company…"

These powers—which are analogous to the FDIC's extant powers for banks—along with other parts of Dodd-Frank give regulators significant new tools to resolve large systemically important insolvent financial firms.

3. The technology of failed bank resolution

As a first approximation, the larger an insolvent bank, the more difficult it is for the FDIC to close it without imposing illiquidity on its depositors, its other creditors, its borrowers, or on the market activities conducted by these agents. We characterize these difficulties as *scale diseconomies of resolution.* Five separate phenomena contribute substantially to these scale inefficiencies: limits to the FDIC's legal authority, the deposit determination process, the asset valuation process, spillovers from the failed bank to the macro-economy (systemic effects), and political pressures. Any or all of these inefficiencies could lead policymakers to abandon attempts at imposing discipline on failed banks and their customers, and instead "bail out" these banks.

The FDIC has special legal authority to take over insolvent banks and act as receiver. This is very different from the regular bankruptcy procedures used to resolve insolvent non-banks. First, bankruptcy laws protect the owners of insolvent firms from their creditors; in contrast, as receiver the

[13] *See generally* section 165 of Title I of the Dodd-Frank Act, 12 U.S.C. § 5365 and "The Orderly Resolution of Covered Financial Companies—Special Powers under Title II—Oversight and Advanced Planning,"

FDIC steps in on the behalf of creditors (depositors) and the owners never regain control of the firm. The fact that the *firm* files for bankruptcy, while it is the *regulator* that files for receivership, is an important and telling distinction. Second, regular bankruptcy proceedings typically take weeks or months to conclude; the automatic stay that protects the firm from creditor claims has no set limit. In contrast, in its role as receiver the FDIC can act fast—generally overnight—to provide depositors with access to all or most of their funds. The FDIC 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.

The FDIC has been granted these special powers because, unlike the liabilities of non-banks, deposit liabilities are crucial to the payments system; the depositor illiquidity resulting from a slow resolution process causes 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.[14] But even in the U.S. these powers are limited. The FDIC's special resolution authority historically has been constrained to depository institutions that hold federal or state charters; it has lacked the authority to seize and resolve the parent (financial or bank) holding companies that own insolvent banks or thrifts. (As noted above, the Dodd-Frank Act grants federal regulators broader "orderly liquidation authorities" that extend to the bank holding company level similar in nature to the FDIC's authorities over insured depository institutions; as discussed below, however, these new authorities have not yet been used and as such the efficacy of these new authorities in application are not yet known.)

The bank closure process in the U.S. begins when the relevant chartering authority (the OCC for federally chartered banks, or the relevant state banking authority for state-chartered banks) revokes a

[14] 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). The UK has since adopted legislation (Banking Act 2009) creating FDIC-like bank resolution authority.

bank's operating charter and names the FDIC as the receiver of the failed bank. The FDIC dismisses top management and takes over control of the bank. In contrast to the ousted managers, the FDIC represents the interests of the depositors rather than the interests of the owners. Immediately after taking control, the FDIC begins the insurance determination process, the details of which are displayed in Figure 2. The normal procedure is to close the bank on a Friday afternoon just prior to the end of the business day. The objective of the insurance determination process is to determine how many of the bank's deposits are insured, how many of the deposits are uninsured, and to whom these deposits are owed. This has historically been a manual process, working from depositor signature cards and other paper records which may be located at the main bank office or at any of the bank's branch offices. However, due to recent improvements and uniformities in electronic record-keeping, this is now a mostly automated process and is usually completed overnight; by Saturday morning the depositors have full access to their (insured) funds either at the acquiring bank (if the failed bank is being resolved through a purchase and assumption (P&A) transaction) or by some form of a direct payout from the FDIC (if the failed bank is being resolved through a payout and liquidation of the failed bank's assets).[15]

In contrast, the uninsured depositors are issued a receivership certificate that represents their claim. The percentage of their funds that the uninsured depositors receive, and the delay in receiving these funds, is a function of the asset valuation process. As time passes and FDIC is able to more accurately determine the total losses of the failed bank, partial "dividends" can be paid to the uninsured depositors. The size of these dividends depends on the FDIC's 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), or otherwise difficult to value, then the initial dividends paid to uninsured depositors will be smaller and their wait for any additional dividend payments will be longer.

[15] Direct payouts from the FDIC can be accomplished a number of ways, ranging from using another insured bank as a pay agent to mailing out checks to the insured depositors. One notable exception to this process described here is brokered deposits, which are not always assumed by an acquiring bank and in such cases are handled separately. For details, see http://www.fdic.gov/deposit/deposits/brokers/01overview.html.

Importantly, even if an uninsured depositor eventually receives all of her funds, any delay represents a loss of liquidity and hence provides at least a modicum of discipline.[16]

On the one hand, this gradual process of asset valuation and partial dividend payouts provides uninsured depositors with some initial degree of liquidity. On the other hand, by imposing appropriate delays and in some cases losses on uninsured depositors, this process imposes market discipline and by doing so may reduce the moral hazard incentives among uninsured depositors at other banks. 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, and will incur the informational and administrative costs of re-establishing a credit relationship at the post-closure bank. In a P&A transaction, borrowers retain credit in the short-run but must re-establish their banking relationship with new loan officers at the acquiring bank. In a liquidation transaction, the loans are retained and eventually sold by the receiver (the FDIC), dissolving the existing banking relationship and forcing borrowers to establish entirely new financial relationships with other banks.

Most U.S. banks are small, both in absolute size and relative to the size of the local economy, and thus most failed U.S. banks are small. In recent years the FDIC has been able to impose a degree of discipline when closing small insolvent banks by imposing losses and/or delays on some uninsured depositors. Because these banks are small, the illiquidity resulting from these policies causes little financial disruption in local markets. And because these banks are not systemically important, any local loss of liquidity does not spill over to the regional or national economies. In contrast, large banks are comprised of hundreds of thousands of depositors and borrowers operating in markets throughout the country; incurring delays and imposing losses when resolving a large insolvent bank can cause substantial financial and economic disruption. Thus, as banks grow larger and/or more systemically important, the

[16] We note that there is an important difference between an uninsured depositor dividend based on *perfected* asset estimates and the "advance dividend" to uninsured depositors proposed by Kaufman (2003) and Kaufman and Seelig (2002) that is based on a conservative estimate of the value of the failed bank in cases in which the resolution authority lacks the time, information, or other resources necessary to complete a full insurance determination. Nevertheless, the goal of both policies is to reduce economy-wide illiquidity effects while avoiding a full bail-out of uninsured depositors.

economic cost of imposing discipline on depositors, borrowers and bank decision-makers increases dramatically.

As the FDIC attempts to resolve increasingly larger and/or more financially complex failed banks, completing the insurance determination over a single weekend becomes operationally 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. Temporarily freezing the funds of insured or uninsured depositors (as would happen in a regular bankruptcy) is not an option. Table 3 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 64 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. In other words, when an insolvent bank is large and/or complex, the benefits from imposing market discipline are more expensive in terms of lost depositor and borrower liquidity.

In recent years, a number of innovations have reduced, though far from eliminated, the scale diseconomies of failed bank resolution. 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.[17] In the midst of the liquidity crisis in October 2008, Congress passed the Emergency Economic Stabilization Act of 2008 which temporarily increased basic FDIC deposit insurance coverage from $100,000 to $250,000.[18] "This temporary increase in deposit insurance coverage should go far to help consumers maintain confidence in the banking system and the marketplace," said FDIC Chairman Sheila C. Bair. "And clearly the public's confidence is key to a healthy and stable economy."[19] The “temporary” increase in coverage to $250,000 has since been made permanent in the Dodd-Frank Act.

[17] Federal Register: July 17, 2008 (Volume 73, Number 138) Page 41169-41180.
[18] The Act is best known for authorizing $700 billion Troubled Assets Relief Program (TARP).
[19] Press release following passage of TARP.

While the objective of this increase was to quell bank insolvency fears of depositors (and of money market investors whose funds were invested in commercial paper issued by banks), a by-product of this change is that most uninsured deposits have been eliminated, which simplifies the insurance determination process. In 2008, the FDIC used its "bridge bank authority" to resolve Indy Mac Bank, which at the time was the largest insolvent bank ever resolved by the agency.[20] By setting up a temporary bank to "bridge" the time between seizure of the bank and disposition of its assets, the FDIC was able to effect an insurance determination while continuing the operation of the bank until a resolution plan could be developed. Later in 2008, the FDIC facilitated the resolution of an even larger (pending) bank failure when it negotiated the sale of Washington Mutual, with $307 billion in assets, to JPMorgan Chase. In 2010, the "orderly liquidation authority" provisions of the Dodd-Frank Act gave the FDIC (in consort with other federal regulators) the ability to seize the assets of insolvent parent financial companies.

These and other technological innovations are allowing the FDIC to resolve increasingly larger failed banks without "bail outs" of uninsured creditors, shareholders, bank managers and other stakeholders. But scale diseconomies of resolution still exist. Perhaps most importantly, the potential for macro-economic spillovers inherent in the closure of a systemically important bank gives rise (perhaps rightly) to risk-averse policies—especially when multiple large banks are approaching insolvency simultaneously. The orderly liquidation authority in the Dodd-Frank Act remains to be tested, and there remains the important question of whether the political will exists to execute this authority in the face of systemic risk. These issues lie at the center of our theory model.

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

[20] IndyMac was a thrift institution, and at the time of its failure the FDIC did not have authority to create a "bridge thrift." Instead, the FDIC was named as "conservator" of IndyMac, an authority similar to, but legally different from creating a bridge bank. The TARP legislation gave the FDIC bridge thrift authority.

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 1999; Cordella and Yeyati 2002), 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 macro-economy. 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-fail (TCTF) 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 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 2006, 2008; 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 1999; Gong, Hwa and Jones 2010), our use of random strategies is merely a convenient equilibrium devise and is not as 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, Parigi and Rochet 2003; Freixas and Parigi 2008), we model failed banks as pure insolvencies and hence are concerned only with bank resolution policy, not with lender-of-last-resort policy.

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 different but non-mutually exclusive 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. 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.

Banks issue deposits at the beginning of the period, invest those funds in either simple loans L_S or complex loans L_C that mature at the end of the period, and then uses the 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.[21]

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

[21] 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.

loans default. Thus, a bank fails with probability $\varphi = \rho_C\rho_S$ and survives with probability $1\text{-}\varphi = (1\text{-}\rho_C)(1\text{-}\rho_S) + (1\text{-}\rho_C)\rho_S + \rho_C(1\text{-}\rho_S)$.

A failed bank generates a social externality in the form of macro-economic illiquidity. We do not model explicitly the impact of this illiquidity—in this sense the costs are truly *external* to the banks in our model—but, consistent with recent experience, we assume that the illiquidity is positively related to the magnitude of L_C at the failed bank. In the context of our model, one can think of the externality-generating process as follows: In all bank failures, a "local" externality occurs because depositors at the failed bank experience delays in gaining access or all of their funds, resulting in illiquidity for these depositor. (If depositors suffer losses, fewer deposits will be available in the next period of the game, resulting in a system-wide reduction in liquidity.) In mostly complex bank failures, a "macro" externality occurs because of increased investor uncertainty about the value of complex loans and assets at *other* banks, resulting in a more general illiquidity in credit markets and asset markets.

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:

$$\underset{L_C}{\text{maximize:}} \;\; \pi \;=\; (1\text{-}\rho_C)A_C(L_C)^{\alpha} + (1\text{-}\rho_S)A_S(\boldsymbol{L}\text{-}L_C)^{\alpha} \tag{1}$$

$$\text{subject to: } \boldsymbol{L} \;=\; L_C + L_S$$

where the $A_iL_i^{\alpha}$ are concave profit functions (i.e., $0<\alpha<1$) for complex and simple loans and $\boldsymbol{L}$ is the exogenous demand for loans. The solution L_C^* to this problem is given by the first order condition:

$$(1\text{-}\rho_C)\alpha A_C(L_C)^{\alpha\text{-}1} + (1\text{-}\rho_S)\alpha A_S(\boldsymbol{L}\text{-}L_C)^{\alpha\text{-}1} \;=\; 0 \tag{2}$$

where L_C^* is the amount of complex loans produced in a game without regulation. Given that both the simple and the complex loan production processes exhibit diminishing returns, both L_C^* and its complement $L_S^* = \boldsymbol{L}$ - L_C^* are interior solutions (i.e., $0 < L_C^* < \boldsymbol{L}$) given by:

$$L^*{}_C = L\left[1 + \left(\frac{(1-\rho_C)A_C}{(1-\rho_S)A_S}\right)^{\frac{1}{1-\alpha}}\right]^{-1} \in (0; L) \quad (3)$$

and illustrated in Figure 3.

Because investors are identical, all banks 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 banks enter the regular bankruptcy process, which fosters macro-economic illiquidity in amounts that are positively related to L_C^*.

Bank failure regulation. We now introduce a bank failure resolution authority (RA). The resolution process works more quickly than bankruptcy proceedings, returns failed bank deposits to the banking system in time for the next round of the game, which (fully or partially) 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_C^{**} represent the limits of resolution technology, the RA "closes" failed banks when $L_C < L_C^{**}$ and "bails out" failed banks when $L_C \geq L_C^{**}$.[22]

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.[23] 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 makes the bank solvent with a direct payment B large enough for the bank to pay off its depositors and play the game again in the next period. It is natural to assume $B'(L_C)>0$, as the loss given default for complex loans is uncertain relative to the loss given default for simple loans; this short-run asset valuation problem requires that complex loans be priced at a discount, which requires a

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

[23] Imagine that the insurance fund is capitalized by taxing each of the "non-trivially large number of investors" a small and identical entry fee at the beginning of the game. Because this funding mechanism is not risk sensitive, it will not affect banks' risk choices. Because it is industry-funded, it will not affect the RA's resolution choices. We note that exploring optimal deposit insurance pricing is not an objective of this model.

larger bailout payment to refloat the bank. 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.

We motivate the RA's actions with the constrained optimization problem illustrated in Figure 4.[24] The RA exhibits a strong preference for resolutions that maintain market liquidity, a weaker preference for resolutions that impose market discipline, and is willing to substitute liquidity for discipline in well-behaved fashion.[25] The RA is constrained in its choice of resolution technique by the available resolution technology T_{simple}. For simplicity, we assume that this constraint runs linearly between a bailout which generates high liquidity (depositors are fully paid off) and low discipline (investors play again next period) and a closure which generates lower levels of liquidity (some depositors receive haircuts) but higher levels of discipline (investors are wiped out). Thus, the slope of T_{simple} is the "liquidity price of discipline." T_{simple} is anchored on the vertical axis because we know that a resolution technique with full liquidity and zero discipline does exist (open bank assistance) and been used by U.S. regulators in both the 1980s and in the more recent past.[26] The RA's payoffs are the ordered utility levels in Figure 4, where $\theta_4 > \theta_3 > \theta_2 > \theta_1$. The RA clearly prefers 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

[24] An earlier version of this paper contained multiple variations of the Figure 4 framework (DeYoung and Reidhill 2008). Beck (2009) exploits some of those variations to analyze cross-border issues in bank resolution.

[25] 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 the Appendix, the resolution choices made by FDIC during the post-deposit insurance era have been largely consistent with a strong preference for liquidity over discipline.

[26] Note that anchoring T on the horizontal axis would be inappropriate in a world with deposit insurance, which precludes any resolution outcome with zero liquidity.

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_C^{**} increases), the RA will close, rather than bail out, increasingly complex banks.[27]

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

$$max_{L_C,L_S}\begin{cases}(1-\rho_C)(A_C L_C{}^{\alpha}) + (1-\rho_S)(A_S L_S{}^{\alpha}), \text{if } L_C < L_C{}^{**} \\ (1-\rho_C)(A_C L_C{}^{\alpha}) + (1-\rho_S)(A_S L_S{}^{\alpha}) + \varphi B(L_C), \text{if } L_C \geq L_C{}^{**}\end{cases} \tag{3}$$

where banks that choose $L_C \geq L_C^{**}$ and hence are "too complex to fail" (TCTF) gain access to the expected bailout subsidy φB. Hence, the solution to the game with bank failure regulation will depend on the technology L_C^{**} that is available to the RA. First, if $L_C^{**} > \boldsymbol{L}$ then the resolution technology is so good that the RA can close even the most complex banks. In this case, the bailout subsidy B will never be paid out, banks have no incentive to become TCTR, and the game reverts to the solution L_C^{*} characterized by equations (1) through (3) above and illustrated in Figure 3. Second, if $L_C^{**} \leq \boldsymbol{L}$ and investors were to choose $L_C < L_C^{**}$, then the solution would again be the unconstrained optimum L_C^{*}. While this is a local optimum and hence is trivial a one-period game, this sub-optimal "simple" choice may be part of a mixed strategy for investors in a multi-period game. Third, if $L_C^{**} \leq \boldsymbol{L}$ and investors were to choose $L_C \geq L_C^{**}$, then L_C is determined by the first order condition:

$$(1-\rho_C)\alpha A_C L_C{}^{\alpha-1} - (1-\rho_S)\alpha A_S(L-L_C)^{\alpha-1} + \varphi B'(L_C) = 0 \tag{4}$$

[27] 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.

which (together with the upper bound constraint $L_C \leq \boldsymbol{L}$) implicitly defines the solution L_C^{***}, which we illustrate in Figure 5. Thus, we have the first main implication from our model: the presence of a resolution authority with imperfect resolution technology increases the amount of complexity in the banking system (i.e., $L_C^{***} > L_C^*$).

Note that we have drawn the "potential bailout profit function" in Figure 5 such that the solution L_C^{***} lies on the interior of the interval (L_C^*, $\boldsymbol{L}$). This bears some discussion. Regarding the lower bound of this interval, the condition $B'(L_C)>0$ clearly guarantees that L_C^{***} will lie above the lower bound L_C^*. The justification for why L_C^{***} will lie below the upper bound $\boldsymbol{L}$ of this interval is more subtle. Once a bank becomes complex (i.e., $L_C > L_C^*$), further increases in complexity require (given its internal VaR-based capital rule) that is hold increased capital. Thus, while we allow that increasingly complex failed banks can cause substantially larger externalities, the increases in the bailout payments are moderated by these increased capital cushions. We can formalize this logic by simply assuming that $B''(L_C)>0$.

Also note that we have drawn Figure 5 such that optimizing complex banks have access to a bailout, because L_C^{***} lies to the right of the resolution technology limit L_C^{**}. In this case, being a mostly complex bank is preferable to being a simple bank. But an improvement in resolution technology, *ceteris paribus*, can change the situation. If $L_C^{**} > L_C^{***}$, then investors must choose between running a simple bank at $L_C = L_C^*$ or running a more complex bank at $L_C = L_C^{**}$ that (just barely) has access to a bailout. In Figure 6A the complex choice is optimal; in Figure 6B the simple choice is optimal. Finally, note that in Figure 6B, L_C^{***} is a local optimum and hence is trivial a one-period game, but this sub-optimal "complex" choice may be part of a mixed strategy for investors in a multi-period game.

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, for simplicity we refer to banks that choose L_C^* as "simple banks" and banks that choose L_C^{***} as "complex banks."

One-period game. The solution of the one period game is straightforward. The RA always closes failed simple banks because $\theta_3 > \theta_2$ and it always bails out failed complex banks because $\theta_2 > \theta_1$.

Banks will always choose to be complex, because the RA's TCTF policy introduces a regulatory wedge *B* that makes expected complex profits $\pi_C(L^{***})$ always exceed expected simple profits $\pi_S(L^*)$. More formally, investors choose to be complex iff $(1-\rho_C)(A_C({L_C}^{***})^\alpha) + (1-\rho_S)(A_S(L-{L_C}^{***})^\alpha) + \varphi B({L_C}^{***}) > (1-\rho_C)(A_C({L_C}^{*})^\alpha) + (1-\rho_S)(A_S(L-{L_C}^{*})^\alpha)$, and this condition holds as a strict inequality under the TCTF policy. 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.

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*.[28] As above, the bank chooses to be either "simple" (chooses ${L_C}^*$) or "complex" (chooses ${L_C}^{***}$) in each period; we express the bank's expected profits in each case as π_S and π_C, respectively. Should the bank fail then the RA chooses to close the failed bank or bail out the failed bank.

[28] 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.

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=B) or there was no bailout at *t*-1 (s_t=NB). 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.

If s_t=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=B, the game repeats with the bailed out bank. 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*.

as well as the following profile of strategies for the banking industry:

- The equilibrium path strategy B_e: If s_t=NB, the bank chooses to be simple with certainty.
- 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:

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 the Appendix.

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.[29] 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, deviating from the simple bank strategy will not increase their expected payoffs. More explicitly, the RA is indifferent between bailing out and closing a failed complex bank if and only if

$$\theta_1 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3}{1-\delta} = \theta_2 + \delta\frac{(1-\varphi)\theta_4 + \varphi\theta_3 - (1-p)\varphi(\theta_3 - \theta_2)}{1-\delta}. \quad (5)$$

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

[29] 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.

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:

$$\theta_2 - \theta_1 = \frac{\delta}{1-\delta}(1-p)\varphi(\theta_3 - \theta_2), \tag{6}$$

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.[30] 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, $\underline{\delta} = \frac{1}{1+\frac{\varphi(\theta_3-\theta_2)}{\theta_2-\theta_1}}$. We can gain some intuition by rewriting the boundary condition as

$$(\theta_2 - \theta_1)\left(\frac{1}{\delta} - 1\right) \leq \varphi(\theta_3 - \theta_2). \tag{7}$$

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 $\left(\frac{1}{\delta} - 1\right)$.

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

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. 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 equation (6) 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 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^*. (Note that the derivatives of q^* with respect to B, π_C, π_S and φ are not in the truest sense comparative statics results, these four terms are not primary parameters in our model but are themselves functions of the primary parameters ρ_i, A_i and α.)

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 Figure 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 ($\partial p^*/\partial\theta_1>0$). (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., "regular" commercial bankruptcy procedures and protections do not apply; instead, 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 bank 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 if not most of the debate over how we should (and should not) regulate financial institutions. In this paper, we construct a theory model of failed bank resolution policy that is centered on this policy tradeoff. The model is highly stylized, but it reveals the fundamental influence of two primary (and often overlooked) elements of failed bank resolution policy: (1) the technology set available to the bank resolution authority and (2) political and economic pressures under which the bank resolution authority may have to operate.

We define resolution technology very broadly to include any determinant—physical, legal, informational, financial—that affects the efficiency with which the resolution authority (RA) operates. We characterize the limits of this technology as the tradeoff the RA must make between preserving liquidity for the customers of a failed bank (and by extension, economic-wide liquidity) *versus* imposing market discipline on the bank's other stakeholders (e.g., owners, junior creditors). A positive shock to the resolution technology set generates two important results in our model. 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 benefits of bank bailouts (preventing the collapse of financial markets) as well as the short-run political benefits of bank bailouts (avoiding blame for allowing too much bank risk-taking). Depending on the amount of autonomy enjoyed by the RA, the degree to which future consequences get discounted in favor of current bailouts could be due to the preferences of the RA or could be imposed on the RA by other policymakers. Regardless, in our model, greater discounting of future consequences by the RA makes banks 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. Large, complex, insolvent banking companies were not as a rule *closed* during the crisis; instead, these firms received various forms of financial and regulatory assistance that could easily be characterized as government *bailouts*. The limitations of failed bank resolution technology, as well as the economic/political pressures under which policymakers were operating, influenced the chosen policy solutions in a manner consistent with our theory model.

In some cases, extant laws and regulations simply prevented authorities from applying their existing resolution technologies to insolvent financial institutions. 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). 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 down without inducing large losses in liquidity—for bank creditors and customers, for counterparties of bank customers potentially exposed to contagion-like effects, or for investors potentially exposed to increased uncertainty in financial markets.

In our model, all of these examples are characterized as negative technology shocks resulting in a higher liquidity cost of discipline for resolving large, complex banks; in equilibrium, the RA becomes less likely to pursue discipline and banks become more likely to pursue high-risk business models.

Clearly, and especially in the wake of the Lehman Brothers insolvency, policymakers were unwilling to close (or otherwise let fail) large complex banks because of the risk that such actions would (further) disrupt financial markets and the macro-economy. Fear of a financial meltdown reached a zenith in September 2008, and the mounting pressures made government officials more receptive to bailout-like actions, such as an $85 billion Federal Reserve line of credit for AIG and large-scale government purchases of mortgage-related assets from troubled large banks (TARP). Pressure was felt by decision makers to provide *immediate* assistance to financial firms, and 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.[31] 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.[32] This policy solution can also be viewed through the short-run *versus* long-run prism: even as continuous improvements in resolution technology allow regulators to close increasingly larger banks, allowing banks to grow increasingly larger will nullify these technological gains. In our model, these scenarios correspond to a higher rate of time discount for the RA; in equilibrium, this increased focus on the present

[31] 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.

[32] 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.

relative to the future—i.e., the discounting of future moral hazard consequences—makes banks more likely to choose high-risk business models.

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.

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Table 1

Five Largest U.S. Commercial Banks and Five Largest FDIC Insurance Determinations

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

Figure 1

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

	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.

Figure 2

Typical FDIC Insurance Determination Process

1. Collect data on all deposit accounts, using manual data entry for official items, as needed.

2. Group accounts together, based on name, address, and tax ID (SSN) number.

3. Accounts in groups with balances at or below $250,000 are released.

4. Accounts in groups with aggregate balances above $250,000 are reviewed by agent.
   - The agent must collect all relevant account information that can be used to determine the account owner(s) and, if necessary, beneficiaries.
   - This step might include pulling the account holder's signature card that would detail the above information.
   - The agent then determines the insurance category.

5. Holds are then calculated. They may reflect uninsured balances estimated on the basis of the electronic records, but might also reflect the need for additional documentation.

6. Holds are manually input into the bank's system.

7. When the bank reopens there are meetings with depositors who have funds held back. Necessary documentation is collected, including:
   - Affidavits from depositors related to kinship requirements for trust accounts.
   - Trust documents.

8. After considering the additional documentation, holds are then adjusted, receivership certificates created, and funds are released as needed.

Figure 3

Game with no regulation. Bank optimizes at L_C^*.

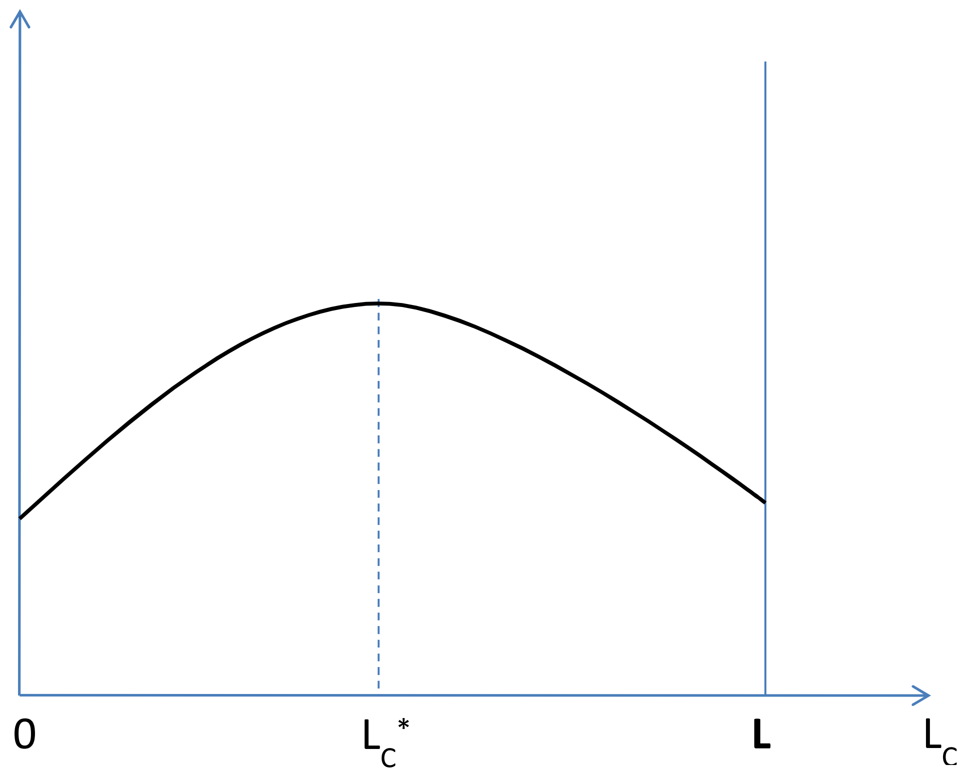


Figure 4

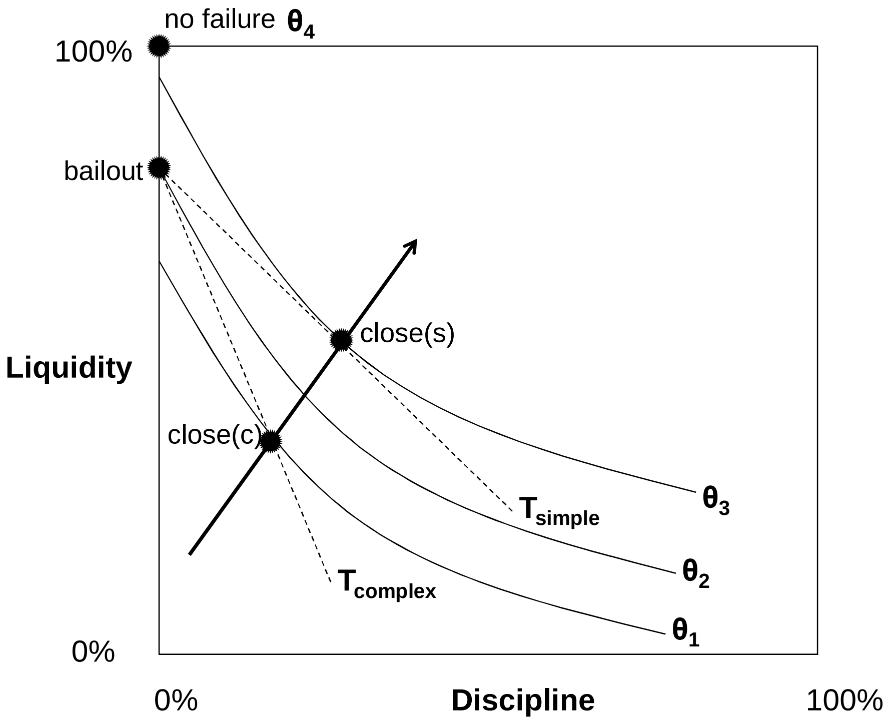

no failure θ4
100%
bailout
close(s)
Liquidity
close(c)
Tsimple
θ3
θ2
Tcomplex
θ1
0%
0%
Discipline
100%

Figure 5

Game with regulation. Bank optimizes at L_C^{***}.

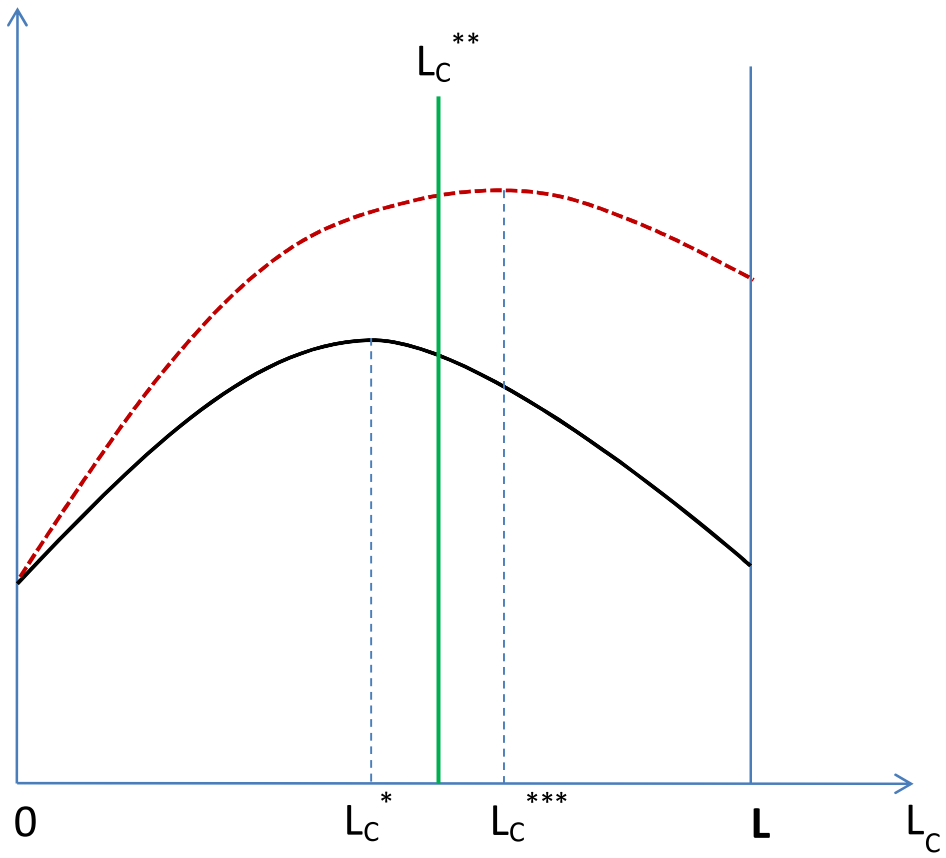


Figure 6A

Relatively inefficient resolution technology. Bank optimizes at L_C^{***}.

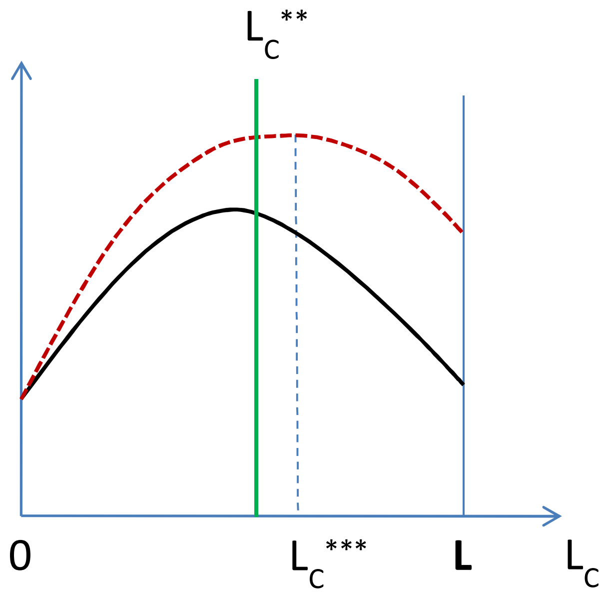
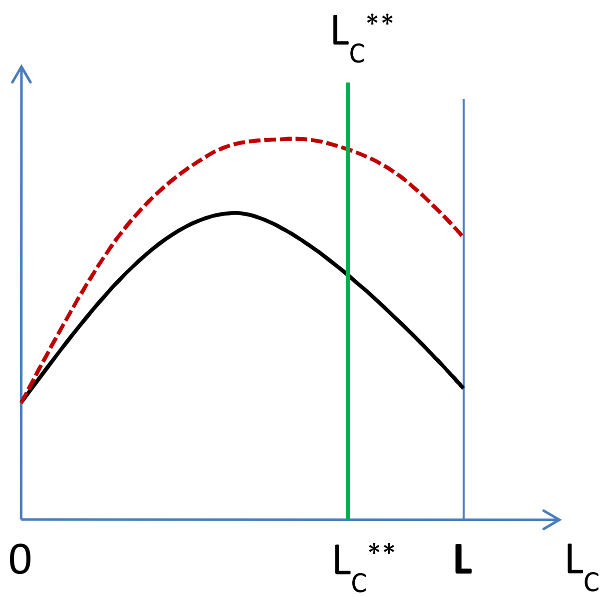


Figure 6B

Relatively efficient resolution technology. Bank optimizes at L_C^{**}.



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" industry. If the RA sticks to its strategy RA_e and closes the industry, the closure yields 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" industry, which is equal to $PV(RA_e) = \frac{(1-\varphi)\theta_4+\varphi\theta_3}{1-\delta}$. $PV(RA_e)$ takes into account that in each period the RA receives θ_4 with probability $1-\varphi$ (the "simple" industry survives) or θ_3 with probability φ (the RA closes the failed "simple" industry). Formally, this is captured by the following equation:

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

Hence the utility from closing the failed "simple" industry 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" industry. 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 industry 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 industry becomes "simple". With probability *1-p* the industry becomes "complex". In such a case the RA receives θ_4 with probability 1- φ. Otherwise, the RA receives either θ_1, when it closes the failed "complex" industry with probability φq, or θ_2 with probability $\varphi(1-q)$, when it bails out such a industry. 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" industry 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 the assumptions on the RA's preferences imply that the RHS of the last expression is always 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" industry 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 industry at t-1 decide about its strategy for period t). When the investors choose the "simple" industry, 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 industry succeeds with probability $1-\varphi$ and is closed with probability φ.

If the investors deviate and choose the "complex" industry, this has the following consequences for their payoff. When the "complex" industry succeeds, it returns to being "simple" in the next period and its payoff is $(\pi_c + \gamma(1-\varphi)V_s)$. When it fails while being "complex", the RA starts to play RA_o. RA_o prescribes that a failed "complex" industry 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_{Bo}. Then V_{Bo} 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 industry is "simple" with probability p or "complex" with probability *(1-p)*. In the latter case the failed "complex" industry receives B and is allowed to continue with probability $(1-p)\varphi(1-q)$. 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" industry. If the RA plays a mixed strategy once it deals with the failed "complex" industry, it has to be indifferent between closure and bailout. The RA's utility from closing the failed "complex" industry 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" industry 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

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

The term on the LHS is positive as has been shown above.

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" industry because they occur less frequently. From this expression we can derive the RA's best response given the strategy played by the investors:

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

where

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

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" industry. Being "simple" delivers V_s to the investors. Denote as V_c the investors' payoff from the "complex" industry. If the "complex" industry 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" industry 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

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

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

That holds follows from the fact that we have that . Observe that it holds that under our assumptions because the one period profits from being bailed out are higher than from running a “simple” industry, ie. . Indeed, holds for , which contradicts our assumption. Hence, the reaction function of the investors is as follows. Hence, the investors’ best response is to set up the “complex” industry 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.

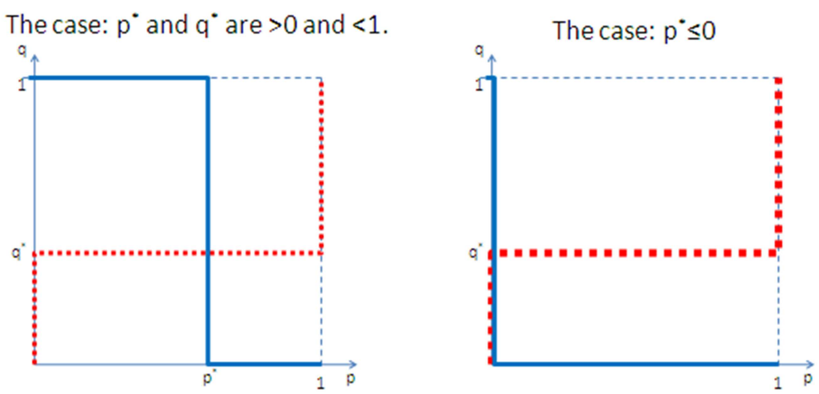


Figure A1. The best responses of the RA (solid line) and the investors (dashed line).

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 $p^* \leq 0$, 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

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

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

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

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 $\underline{\delta}$:

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

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

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

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

Comparative statics for q*:

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

The following four derivatives are not in the truest sense "comparative statics" results, because φ, π_C, π_S and B are not primary parameters in our model but are themselves functions of the primary parameters (ρ_i, A_i and α).

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

$$\frac{\partial q^*}{\partial\pi_C}=\frac{1-\gamma(1-\varphi)}{\varphi[\gamma\pi_s+\left(1-\gamma(1-\varphi)\right)B]}>0$$

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

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

Comparative statics for p*

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

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

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

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

Unlike $\frac{\partial q^*}{\partial \varphi}$ above, the following derivative $\frac{\partial p^*}{\partial \varphi}$ 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.

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