Does Increased Shareholder Liability Always Reduce Bank Moral Hazard?

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Abstract

Scholars and regulators have long maintained that increased shareholder liability mitigates banks' excessive risk-taking. Prior to the Great Depression, regulators imposed double liability on bank shareholders to constrain moral hazard and protect depositors. Under double liability, shareholders of failing banks lost their initial investment and had to pay up to the par value of the stock in order to compensate depositors. In this paper, we examine whether increased shareholder liability in the double-liability framework was effective at moderating bank risk-taking. We first develop a model that demonstrates two competing effects of increased shareholder liability: a direct effect that constrains bank risk-taking due to increased skin in the game, and an indirect effect that promotes risk-taking due to endogenously weaker monitoring by better-protected depositors. We then test the model's predictions using a novel identification strategy that compares state Federal Reserve member banks and national banks in New York and New Jersey. We find no evidence that double liability reduced risk-taking prior to the Great Depression. However, we do find evidence that deposits in double-liability banks were stickier during the Great Depression, suggesting that shareholders of double-liability banks faced less risk of bank runs. The empirical evidence that shareholder liability did not effectively mitigate bank risk-taking is consistent with the shifting of losses from depositors to shareholders weakening market discipline, and attenuating the effects of increased skin in the game.

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1 Introduction

The size and severity of the 2008 financial crisis has been tied to excessive risk-taking by banks, in part enabled by the poor incentives that arise under limited liability. Under limited (single) liability, bank shareholders may take excessive risks because they receive all upside gains from risky projects but their downside exposure is limited. Policymakers have responded to this moral hazard problem in financial intermediation by imposing regulatory and supervisory requirements designed to induce prudent bank investments and increasing disclosure requirements to facilitate market discipline.[1]

When the crisis subsided, attention turned to financial regulatory reforms. A number of measures were introduced to reduce systemic vulnerability.[2] This was in part due to the substantial increase in safety nets implemented during the crisis, which could make the financial system more prone to future crises (Demirgüç-Kunt and Detragiache (2002)). Yet, the debate over what interventions are appropriate continues because current reform efforts do not fully address the fundamental moral hazard problem. Academics and various policy organizations have advocated achieving financial stability through alternative policies directly focused on bank incentives rather than through complex regulatory and supervisory controls.[3]

One such proposal is to eliminate the limited liability protection and increase shareholder liability.[4] By increasing shareholder liability, regulators institutionally force shareholders to absorb greater losses in the event of a bank failure with the goal of inspiring more prudent risk-taking. Such an approach is not new. Prior to the Great Depression, regulators imposed *double liability* on bank shareholders to constrain excessive risk-taking and enhance the safety of deposits. Under double liability, if a bank fails and closes with negative net worth, shareholders can be forced to pay an assessment up to the par value of the stock in order to compensate depositors and other creditors.

In this paper, we analyze whether increased shareholder liability always reduces banks' moral

[1] For instance, Basel II guidelines are based on a "three pillars" concept, consisting of minimum capital requirements, supervisory review, and market discipline.

[2] See Basel Committee on Banking Supervision (2011) for the list of major reforms under Basel III.

[3] See, e.g., Kashyap, Rajan, and Stein (2008), Diamond and Rajan (2009), Hart and Zingales (2011), Admati, DeMarzo, Hellwig, and Pfleiderer (2014), and Acharya, Mehran, and Thakor (2016).

[4] See, e.g., Dowd (2009), Buiter (2008), and Conti-Brown (2012). In fact, Brazilian law has eliminated limited liability for financial institutions (Pargendler (2018)).

hazard to constrain excessive risk-taking, and if not, what the mitigating factors are. We focus on the double-liability framework around the Great Depression. While previous studies generally argue that double liability discourages bank risk-taking, some find empirical evidence of greater risk. For instance, Macey and Miller (1992) show that banks with double liability appear to have been able to operate with lower capital ratios than banks without double liability. Evans and Quigley (1995) and Bodenhorn (2016) find similar results. One potential source of this inconsistency is that empirical tests of the effectiveness of increased shareholder liability are fraught with challenges. Furthermore, an important but often overlooked confounding factor is the endogenous response of creditors. That is, increased shareholder liability may also reduce creditors' incentives to monitor and constrain bank risk by shifting losses to equity holders in the event of a bank failure.

We begin by providing a simple model that characterizes two competing effects of increased liability on bank risk-taking. The first is a reduction in moral hazard that results from shareholders' increased skin in the game (Esty (1998), Grossman (2001), Mitchener and Richardson (2013), Koudijs, Salisbury, and Sran (2018)), the conventional channel considered to constrain excessive risk-taking. However, double liability also reduces market discipline by depositors, who receive more protection from losses in the event of a bank failure.[5] All else equal, this weakened market discipline incentivizes bankers to take more risks.

Our model analyzes the effect of liability structure on excessive risk-taking in the presence of potential deposit withdrawals (i.e., bank runs). If depositors monitor their banks and react to negative information by withdrawing funds, banks are incentivized to avoid excessive risks (Calomiris and Kahn (1991), Diamond and Rajan (2001)). Depositors, however, have fewer incentives to respond to information if their funds are protected from losses (Gorton and Pennacchi (1990)). Double liability, therefore, makes deposits "stickier," weakening market discipline and potentially promoting greater risk-taking. The model predicts that while double liability unambiguously makes deposits stickier when negative information is revealed (i.e., less *ex post* deposit outflow), its overall effect on *ex ante* risk-taking is unclear. To our knowledge, this trade-off between the direct effect of better incentive alignment and the indirect effect of weaker market discipline has not been explored in the literature.

[5] Relatedly, see Billett, Garfinkel, and O'Neal (1998), Demirgüç-Kunt and Huizinga (2004), and Ioannidou and Penas (2010) on how deposit insurance affects market discipline.

This theoretical ambiguity suggests that the relationship between increased shareholder liability and bank risk-taking is ultimately an empirical question. However, obtaining credible estimates of this effect is challenging because differences in local economic conditions, regulation, supervision, and other unobservable characteristics all pose threats to inference. To overcome these issues, we use a novel identification strategy based on the unique regulatory environment in the United States prior to the Great Depression.

Ideally, we would like to compare banks that simultaneously face (i) identical regulatory requirements (e.g., capital and reserve requirements and branching restrictions), (ii) identical supervisory agencies, and (iii) identical local economic conditions, but (iv) different liability rules. To achieve this, our identification strategy is to compare national banks and state Federal Reserve member banks (Fed-member) in neighboring states within the same Federal Reserve District (2nd District), but with different liability rules.[6] While all national banks operated under double liability throughout the 1920s and early 1930s, state banks operated under the liability rules of the state.[7] Specifically, our identification strategy exploits that state banks operated under double liability in New York but under single (limited) liability in New Jersey.

By limiting our focus to national and state Fed-member banks — which faced the same regulatory requirements as national banks — we control for (i).[8] However, national and state Fed-member banks are not directly comparable because the Office of the Comptroller of the Currency (OCC) supervised the former, while the Federal Reserve Bank of New York (NY Fed) supervised the latter. Further, observed differences between banks in New York and New Jersey could result from different economic conditions rather than liability structure. Instead, our approach is to follow a differences-in-differences style specification in which we compare differences between national and state Fed-member banks in New York (with the same liability structure) to differences between national and state Fed-members banks in New Jersey (with a different liability structure); this con-

[6]Using banks from the same Federal Reserve district is important for studying the banking system in the 1920s and 30s. This is because each regional bank was allowed to implement independent discount window policy, which affected local monetary and economic conditions (Richardson and Troost (2009), White (2015)).

[7]When the Federal Reserve System was established in 1913, it permitted state-chartered banks to become Federal Reserve members if they met the standards of the Federal Reserve System. Because the Federal Reserve Act never specified the liability rules of its state Fed-member banks, they were subject to liability rules of the state.

[8]State Fed-member banks followed Federal Reserve Act bank regulations instead of following state bank regulations. This fact is important because there were large regulatory changes for banks under the Federal Reserve System following the Banking Act of 1927. The changes applied to both national and state member banks (White (2014)).

trols for both (ii) and (iii). Our identification assumption is that differences in bank risk or deposit outflows that result from differences in bank charter types are the same in these two neighboring states. In an alternative specification, we compare national and state Fed-member banks within the same local market (i.e., county) to more tightly control for local economic conditions.

We construct semi-annual bank balance sheet data on national and state Fed-member banks from December 31, 1925 to December 31, 1932 in New York and New Jersey, spanning the boom and bust cycles of the Great Depression. Using bank-level balance sheet data from a historical period attenuates biases that arise when using modern institutional balance sheet data because the unit banking system ensured banks in the same local market likely had similar business models and faced similar demand. We augment this data with deposit rate information from national bank examination reports and state bank reports. This allows us to examine depositors' behavior through price as well as quantity.

Our empirical analysis begins by comparing the risk-taking behavior of single- and double-liability banks. We examine banks' ratios of cash to assets and equity to assets, broadly conceived as measures of liquidity and capital buffers, for the expansion period of December 1925 – June 1929. We find no statistically significant differences between single- and double-liability banks before the Great Depression. In fact, our point estimates, while not statistically significant, indicate that double-liability banks had fewer liquidity and capital buffers than single-liability banks. These results suggest that double liability did not lead to a reduction in risk-taking along these two dimensions.

Next, we examine deposit outflows during the Great Depression to test whether deposits in double-liability banks were stickier than in single-liability banks, conditional on banks' risk characteristics. Our empirical results indicate that single-liability banks faced a 2.75 percentage point larger deposit outflow on average *per six months* than double-liability banks during the Great Depression. This estimate is statistically significant and economically large compared to the median deposit growth rate of -2.79 percent over the same period. Results from a linear probability model also indicate that single-liability banks were nearly 8 percent more likely to experience a net deposit outflow during the Great Depression. Conversely, we find no evidence of a relationship between double liability and deposit growth rates during the boom period, when the risk of bank failure was low.

We also examine deposit rates for national and state fed members in New Jersey for years 1926, 1928, 1930, and 1932. We show that single-liability banks offered higher deposit rates throughout the entire period, suggesting the depositors required a risk premium from single-liability banks to compensate for the lack of protection for their deposits. We also show that *real* deposit rates were high and increasing for both national and state Fed-member banks during the Great Depression. This suggests that deposit outflows in the banking sector were not driven by banks' desire to induce deposit outflows by offering lower rates. Lastly, we find that single-liability banks actually increased deposit rates by more (in real terms) during the Great Depression, even though they experienced greater outflows. Hence, our finding that single-liability banks experienced greater outflows appears to be driven by depositors' decisions to withdraw rather than banks' decision to induce deposit outflows.

Our results imply that double liability failed to resolve the agency problem effectively due to the conflict between shareholder incentive alignment and depositor market discipline. By shifting losses from depositors to shareholders, double liability changed the incentives of both stakeholders. More specifically, the depositor protection feature of double liability may have undermined its effectiveness on constraining excessive risk-taking because of its indirect, offsetting effect of weaker market discipline.

Our findings are relevant for current policy discussions, even in today's banking system with deposit insurance. While deposit insurance may limit the incentive of insured depositors to monitor bank risk, previous research has demonstrated that insured deposits are still sensitive to bank stress (Iyer and Puri (2012)) and may provide a source of market discipline (Davenport and McDill (2006)). One mechanism employed by most counties to preserve market discipline is the use of coverage limits on deposits. For instance, the coverage limit is $250,000 in the U.S. and, as a result, over 40% of deposits are uninsured.[9] The importance of monitoring by non-insured depositors and potential runs on non-insured deposits has been explored in a new wave of academic research (see, e.g., Iyer, Puri, and Ryan (2016), Iyer, Jensen, Johannesen, and Sheridan (2016), Egan, Hortaçsu, and Matvos (2017), and Martin, Puri, and Ufier (2018)). Furthermore, the effectiveness of deposit insurance is intimately tied to the credibility of the government providing the guarantees (Mar-

[9]FDIC Quarterly, Volume 13, Number 1: https://www.fdic.gov/bank/analytical/quarterly/2019-vol13-1/fdic-v13n1-4q2018.pdf.

tinez Peria and Schmukler (2001)). In economies lacking fiscal capacity, the market discipline of depositors may serve as the primary constraint on bank risk even if deposits are nominally insured. Our results suggest that the effect of increased shareholder liability on discouraging excessive risk-taking may be weaker than anticipated if it simultaneously affects the incentives of depositors (or any unsecured creditors) to monitor and respond to negative information about bank fundamentals.

Additionally, post-crisis regulatory reforms introduced various measures to reallocate liability, including bail-in, contingent convertible (CoCo) bonds, and clawback provisions. These policies can affect the distribution of liability among different stakeholders by shifting losses from some creditors to shareholders (or other junior creditors). Our findings suggest that while such redistribution directly aligns incentives of certain stakeholders, it may also reduce the monitoring incentives of other stakeholders. This is consistent with the Basel Committee's three pillar concept that recommends market discipline to complement capital requirements and supervisory review.

This paper is related to several strands of literature. First, it contributes to the long-standing but active literature on the role of bank equity capital in promoting prudent investment (see, e.g., Kim and Santomero (1988), Furlong and Keeley (1989), Gennotte and Pyle (1991), Rochet (1992), Besanko and Kanatas (1996), Laeven and Levine (2009), Aiyar, Calomiris, and Wieladek (2015), and Greenwood, Stein, Hanson, and Sunderam (2017)). While previous studies generally focus on the direct effects of bank capital on shareholders' incentives, our study suggests that a simple shift of liabilities can also affect creditors' incentives, which may introduce unanticipated but important offsetting effects.

Second, our paper adds to the literature on the relationship between double liability and financial stability. Previous studies find that double liability was generally effective in constraining bank risk during the National Banking era (Esty (1998), Grossman (2001), Mitchener and Richardson (2013), and Koudijs, Salisbury, and Sran (2018)), but became less effective during the economic boom of the 1920s (Macey and Miller (1992), Kane and Wilson (1998)). We contribute to this literature by adopting the novel identification strategy to isolate the effect of double liability. We also incorporate its indirect effects on depositor incentives that are previously overlooked. We provide evidence that double liability was an incomplete regulatory tool to address moral hazard due to the inevitable conflicts of interest between shareholders and depositors.

Third, our paper is also related to the literature on bank funding stability. Specifically, Gorton and Pennacchi (1990) and more recently Dang, Gorton, and Holmström (2015) examine the role of information insensitivity on bank funding stability, and Calomiris and Kahn (1991) and Diamond and Rajan (2001) analyze the role of bank funding risks as a discipline device. We combine these two channels into a simple unified setup to have testable predictions, and provide empirical supports.

Lastly, this study contributes to the literature on banking panics during the Great Depression. Examining the cause of widespread bank failures, a number of previous studies find that bank runs reflected a rational and predictable process of market discipline.[10] Others examine how regulations affected bank failures during the Great Depression (e.g., Mitchener (2005), Mitchener (2007)). We contribute to this literature by analyzing the role of double liability on bank risk and bank runs during this period.

The remainder of the paper is organized as follows. Section 2 gives a historical background. Section 3 provides a theoretical framework that explains the relationship between double liability, bank risk-taking, and market discipline. Section 4 introduces the data and provides summary statistics. Sections 5 and 6 describe empirical specifications and present results. Section 7 discusses potential biases from bank charter selection and heterogeneous deposit rates. Section 8 concludes.

2 Historical Background

2.1 Double Liability and Bank Risk-Taking

Double liability was an important bank regulation prior to the Great Depression. Under double liability, shareholders were liable up to the par value of their shares in addition to their initial investment when a bank failed. For example, under double liability, the owner of a single share of stock with a face value of $100 could be called upon to pay up to an additional $100 in the event the bank's assets were insufficient to meet its obligations. The National Banking Act of 1863 made double liability common by requiring all national banks to organize under double liability. Many states also imposed double liability on bank shareholders. Double liability was repealed following the Great Depression due to the political resentment toward assessment of shareholders and its inadequacy to protect depositors. Figure 1 shows liability rules across U.S. states in 1930. At the

[10] See, e.g., Calomiris and Mason (1997), Calormiris and Wilson (1998), Calomiris and Mason (2003a), and Calomiris and Mason (2003b).

time, state banks in 34 states plus all national banks were subject to double liability (Grossman (2001), Vincens (1957)).

Double liability remained an important feature of bank regulation into the 1930s. Regulators expected that double liability would incentivize shareholders to control bank risk-taking and mitigate agency problems between shareholders and depositors. Depositors face a natural informational disadvantage relative to shareholders and owner-managers, who know more about the quality of bank assets.[11] Because double liability imposes post-closure losses on bank stockholders, it was expected to incentivize banks to hold capital and decrease the incidence of moral hazard, thereby limiting excessive risk-taking (e.g., a "go-for-broke" strategy). By reining in moral hazard, double liability potentially reduces the incidence of bank failures and the size of losses incurred by depositors and unsecured creditors. Additionally, double liability was intended to provide greater protection for depositors in the event of a bank failure. Recall that during this period, there was no federal deposit insurance. In the absence of deposit insurance, double liability represented the only form of protection available to creditors of insolvent banks.

Yet, empirical studies examining the relationship between double liability and bank risk-taking show mixed results. Some studies find that double liability reduced bank risk-taking. Based on cross-sectional studies, Grossman (2001) and Mitchener and Richardson (2013) find that banks operating in multiple-liability states held more capital and liquid assets. Esty (1998) finds that banks in states with stricter liability rules had balance sheets with lower equity and asset volatilities. More recently, Koudijs, Salisbury, and Sran (2018) find that banks with managers that had more exposure to their bank's downside risk took less risk.

In contrast, other studies document that double liability actually increased bank risk-taking. For instance, Macey and Miller (1992) show that banks with double liability appear to have been able to operate with lower capital ratios than banks without double liability. Similarly, Bodenhorn (2016) finds that banks increased their leverage after they adopted double liability rules. These studies argue that extended liability allowed banks to engage in greater risk-taking because it offered off-balance sheet protection for bank depositors.

[11] The regulatory requirement that bank managers hold bank stocks further aligned the incentives of bank shareholders and managers. At the time, a bank's top corporate officers had to sit on the board of directors. Federal law required all members of the board of directors to own a minimum of $1,000 dollars in stock (at par value), and most state laws had similar provisions. Laws in some states required directors to hold larger stakes (Mitchener and Richardson (2013)). These laws made bank managers liable for losses as well.

These inconsistencies in empirical findings may arise due to the identification challenges discussed in the introduction, i.e., confounding effects from differential regulation, supervision, and economic conditions. Additionally, as our model shows, double liability can also change the incentives of depositors, which indirectly affects banks' risk-taking. For instance, depositors in double-liability banks can become less likely to run even when their banks become more fragile (i.e., deposits become stickier), which exacerbates bankers' agency problem (Calomiris and Kahn (1991), Diamond and Rajan (2001)). Double liability can further weaken market discipline by enabling banks to attract a wider pool of local savers who are less able to monitor their banks. These depositors tend to be less sophisticated and would not have held bank deposits if they had been information-sensitive (Gorton and Pennacchi (1990), Gorton and Ordonez (2014), Dang, Gorton, Holmström, and Ordonez (2017)). We study the relationship between liability structure and bank risk taking behavior in the presence of deposit outflows in Sections 3 and 6.

2.2 Banking Environment in the 1920s and 30s

During the 1920s and 1930s, the U.S. banking system operated under a dual banking system where banks could choose either a national or state charter. All national banks had to become members of the Federal Reserve System. In contrast, state banks could choose to become members of the Federal Reserve System. In 1926, there were 7,972 national banks, 1,403 state banks with Federal Reserve membership, and 17,591 state banks without Federal Reserve membership. In total, roughly 30 percent of banks in the U.S. were supervised under the regulatory requirements of the Federal Reserve System, and 64 percent were liable to the regulatory requirements of the state (Board (1932)).

The choice of bank charter had implications for bank regulation and supervision. National banks and state Fed-member banks were subject to the same capital and reserve requirements and branching restrictions. For non-member state banks, these requirements differed from state to state, although generally national and state Fed-member banks were subject to stricter regulatory standards than their state non-member counterparts. National banks were supervised by the OCC. State bank and trust company Fed-members were supervised by the local Federal Reserve Bank. Lastly, state bank and trust company non-members were supervised by state banking departments (White (2011)).

Federal Reserve member banks faced some other restrictions as well. There were restrictions on permitted investments, including real estate investments and investments in the stock of safe deposit companies. Member banks could not make large loans to single borrowers, nor could they make large mortgage loans. They were also constrained from making risky loans or engaging in the business of selling and buying investment securities, which non-member banks found to be increasingly profitable (White (2014)).

Importantly, state Fed-member banks were subject to liability rules of their states. After the passage of the National Banking Act, double liability became one of the most prominent features of bank regulation in the United States. However, there was no provision in the Federal Reserve Act imposing double liability on the stockholders of state banks or trust companies that became members of a Federal Reserve Bank. From the Federal Reserve Bulletin, vol 1, September 1915, p.273:

> "...it is clear that state banks or trust companies located in a State the laws of which do not provide that the stockholders shall be subject to double liability, may become members of the Federal reserve system without subjecting their stock holders to this liability."

The competitive inequalities between state and national banks created a tension in the 1920s when rapid economic expansion offered the banking sector new business opportunities. This served as a catalyst for easing some of these federal bank regulations. The McFadden Act was passed in 1927 to give national banks competitive equality with state-chartered banks. The Act gave national banks charters of indeterminate length, allowing them to compete with state banks for trust business. It removed many investment restrictions. It allowed the par value of shares to be less than $100, allowing small shareholders to own bank stocks. The most important change was the removal of branching restrictions, permitting national bank branching to the extent that branches could be established by state banks under state law.

The Roaring 20s ended with the stock market crash in 1929, which became a harbinger of the Great Depression of the 1930s. During this period, the total number of banks shrank by 30 percent from the number at the end of 1929. During the crisis, the degree of bank distress differed between states. Bank failure rates ranged from 6 percent to 25 percent (Mitchener (2005)).

Two major factors contributed to the differences in bank failures between states. One factor was differences in bank regulation and supervision. Federal regulations tended to be stricter than state regulations. In double-liability states, national banks enforced double liability more strictly than state banks. Mitchener (2005) studies differences in regulatory and supervisory environments across states and finds that states with higher capital requirements and branching experienced fewer failures.

Another factor was the monetary policy decisions of the regional Reserve Bank. Before the Banking Act of 1935 was passed, each bank implemented open-market operations in its own district. Although regional banks agreed to coordinate open-market transactions, the agreement was voluntary, with individual banks retaining the legal right to engage in open market operations on their own initiative or to decline to participate in system-wide actions. In addition, each Federal Reserve Bank had different views regarding discount-window lending policies. Different monetary operations across Federal Reserve Districts resulted in different monetary and lending conditions.

The panic ended when President Franklin D. Roosevelt declared a national bank holiday just one day after he took office in March 1933. Roosevelt ordered all banks closed, including the Federal Reserve banks. He permitted them to reopen only after each bank received a government license. In addition, the federal government created federal deposit insurance. Roosevelt's policies restored confidence in the banking system and bank runs ended.

Differences in the regulatory, supervisory, and monetary environment make it difficult to identify the effect of double liability on bank risk-taking and depositor behavior. Large changes in these regulations and monetary policies in the late 20s and early 30s make the identification exercise even more challenging. In Section 5, we describe how our identification strategy overcomes these challenges.

3 Model

In this section, we develop a simple model to analyze the relationship between double liability, bank risk-taking, and market discipline by depositors. For simplicity, we abstract away from a full general equilibrium setting, and instead focus on a partial equilibrium setup where certain aspects of banks' and depositors' decisions are considered outside the model. The goal of the model is to formally demonstrate that while double liability reduces banks' risk-taking incentives, all else being equal, double liability also reduces depositors' monitoring incentives, which attenuates (or may altogether eliminate) the reduction in risk-shifting due to banks' greater skin in the game.

We begin with a benchmark model of excessive risk-taking (risk-shifting) caused by single liability. We then discuss the partial equilibrium effect of (i) double liability on risk shifting; (ii) depositor withdrawals (market discipline) on risk shifting; and (iii) double liability on depositor withdrawals (market discipline).

3.1 Benchmark Model of Excessive Risk-taking

In the benchmark model, we consider a three-period economy with $t = 0,1,2$ as in a typical Diamond and Dybvig (1983) setup, and where banks are governed by single liability. The bank is endowed with equity E owned by "bankers" and deposits D owned by "depositors", and invests these funds in a long-term asset with the scale of $A\ (= D+E)$. We assume $D > E$ such that double liability does not provide full protection of deposits.

In period $t = 1$, depositors can choose to either roll over their deposits to period $t = 2$, in which case they are paid $r\ (> 1)$ if the bank is solvent, or they can withdraw their deposits and are paid 1 per unit of deposit. In this benchmark setup, we turn off market discipline and assume that depositors always roll over their deposits; we introduce the possibility of deposit withdrawals in the following section. We assume that all agents are risk neutral and only consume at $t = 2$, having access to a storage technology with the rate of return equal to 1.

The banker chooses the type of risky asset at $t = 0$, denoted by $j \in \{G,B\}$.[12] The choice of asset is unobservable to the depositors. Risk neutrality implies that the banker's objective is to maximize the equity's expected payoff at $t = 2$. At $t = 2$, the type G ("good") asset produces R per unit of investment with probability p_G, and 0 with probability $1 - p_G$; the type B ("bad") asset produces R' per unit with probability p_B, and 0 with probability $1 - p_B$. We assume the following:

$$(A1):\ p_G > p_B;\ \ (A2):\ p_G R > 1 > p_B R';\ \ (A3): p_B(R'-r) > p_G(R-r) > 0.$$

As (A1) and (A3) imply $R' > R$, these assumptions imply that asset B has negative net present value (NPV) and is also riskier (higher failure rate) than asset G. If there is no agency problem, the

[12] While we refer to j as different "assets" for the expository purpose, it is meant to capture risk shifting incentives, i.e., different risk management strategies to avoid bank failure. Hence, the choice of asset G (B) implies the adoption of a strategy with lower (higher) insolvency risk.

bank should always choose to invest in G because it has both higher NPV and lower risk. However, (A3) also incentivizes levered banks to take excessive risks (risk-shifting) because bankers do not bear any downside risks under single liability.

The banker's expected payoff with asset G, denoted by π_G^E, is

$$\pi_G^E = p_G R(D+E) - r p_G D.$$

When the asset has a positive payoff (probability p_G), the bank earns the return on the asset, pays depositors the offered deposit rate, and pockets the difference. When the asset pays zero and the bank becomes insolvent (probability $1-p_G$), both the banker and depositors earn zero. Similarly, the payoff for asset B, denoted by π_B^E, is

$$\pi_B^E = p_B R'(D+E) - r p_B D.$$

The banker will choose riskier asset B if $\pi_G^E < \pi_B^E$, which implies

$$\frac{E}{D} < \frac{(p_G - p_B)r}{p_G R - p_B R'} - 1 \implies \frac{A}{E} > \frac{p_G R - p_B R'}{(p_G - p_B)r} \equiv \overline{Lev}. \tag{1}$$

Equation (1) defines $\overline{Lev}$, the maximum amount of leverage under single liability for which the bank would still choose asset G. Any leverage A/E greater than $\overline{Lev}$ would lead to risk shifting and to the bank choosing asset B with higher likelihood of insolvency. Simply put, sufficiently leveraged banks will take excessive risks due to limited skin in the game

3.2 Double liability and Risk Shifting

We now analyze risk-shifting incentives under double liability. Under the double-liability structure, the banker pays up to E when the bank fails, and the expected equity payoff when investing in asset B, denoted as $\pi_{G,double}^E$, becomes

$$\pi_{G,double}^E = p_G R(D+E) - r p_G D - (1-p_G)E.$$

The additional term arises because the bank now must pay E to depositors even when the asset pays zero. Similarly, the payoff when investing in asset B, denoted as $\pi^E_{B,double}$, is

$$\pi^E_{B,double} = p_B R'(D+E) - r p_B D - (1-p_B)E.$$

In the case of double liability, the bank chooses asset B and risk shifting arises if $\pi^E_{G,double} < \pi^E_{B,double}$, which implies

$$\frac{E}{D} < \frac{(p_G - p_B)(r+1)}{p_G(R+1) - p_B(R'+1)} - 1 \implies \frac{A}{E} > \frac{p_G(R+1) - p_B(R'+1)}{(p_G - p_B)(r+1)} \equiv \overline{Lev}_{double}, \tag{2}$$

where $\overline{Lev}_{double}$ is the maximum amount of leverage for which the bank will choose asset G. Note that under the assumption $A3$, a condition incentivizing risk shifting, it follows that $\overline{Lev}_{double} > \overline{Lev}$; risk shifting arises less frequently under double liability. This result is because bankers have greater skin in the game under double liability, as they are responsible for paying depositors even when the asset pays zero.

3.3 Depositor Withdrawals, Market Discipline, and Risk Shifting

Having established the conditions under which risk shifting occurs for both single- and double-liability structures, we now introduce depositors' withdrawal decisions at $t = 1$ in order to analyze how the possibility of a "bank run" affects the banker's risk shifting incentives. For brevity, we only present the case of a single-liability bank, but the same mechanism holds for double-liability banks.

At $t = 1$, depositors receive a signal $s \in \{s_G, s_B\}$ containing information on the bank's asset type $j \in \{G, B\}$. After observing this signal, depositors decide whether to roll over their deposits to $t = 2$ or withdraw immediately.[13] Both assets B and G generate ℓ per unit when liquidated early at $t = 1$, and we assume $D/A < \ell < 1$ for simplicity.

The possibility of *ex post* deposit outflows at $t = 1$ after the arrival of negative information can induce the bank to avoid excessive risk-taking *ex ante* at $t = 0$, similar to Calomiris and Kahn (1991) and Diamond and Rajan (2001) where ex-post liquidity risk prevents ex-ante agency prob-

[13]We assume that all depositors receive the same signal and can perfectly coordinate their actions to rule out self-fulfilling runs. Alternatively, under the assumption of independently distributed signals, we could derive the fraction of depositors that choose to withdraw early.

lems. To see this, first suppose that the depositors' signal is noisy, such that

$$Pr(s = s_G \mid j = G) = 1; \;\; Pr(s = s_B \mid j = B) = \alpha,$$

where $\alpha \in [1/2, 1]$. In other words, depositors at a bank that invests in asset G learn the asset type with certainty (and therefore never receive negative news), whereas depositors at a bank that invests in asset B only receive a noisy signal about the type of asset being held by the bank (and therefore receive negative news stochastically). We assume that, as of $t = 0$, α follows a random variable $\tilde{\alpha}$ with a C.D.F. $F_{\tilde{\alpha}}(\alpha)$ and that depositors learn both α and s at $t = 1$ prior to making their withdrawal decision. The signal accuracy α reflects, for instance, depositors' financial literacy or sophistication.

We solve the model backwards, beginning with the depositors' decision at $t = 1$ given α and then the bank's risk-taking decision at $t = 0$ given the depositor's strategy. For a given α, the expected payoff for a depositor who receives s_B and rolls over, denoted by $\pi^D_{s_B}$, is

$$\pi^D_{s_B} = (1 - \alpha) p_G r + \alpha p_B r,$$

because $j = G$ with probability $1 - \alpha$ and $j = B$ with probability α. The depositors withdraw if $\pi^D_{s_B}$ is less than the early withdrawal payoff of 1.[14]

To make further progress, we impose the following parametric restrictions:

$$(A4): \; r(p_G + p_B) > 2; \;\; (A5): \; p_B r < 1.$$

Under these restrictions, depositors always withdraw upon receiving s_B if they are certain that their bank's asset is type B ($\alpha = 1$, from $A5$) and never withdraw if the signal is maximally noisy ($\alpha = 1/2$, from $A4$).

Now, $\pi^D_{s_B} < 1$ can be written as

$$\alpha > \frac{p_G r - 1}{p_G r - p_B r} \; (\equiv \alpha^*), \tag{3}$$

[14]Our assumption of $\ell A > D$ guarantees this full early-payment.

which implies that depositors, when receiving s_B, withdraw if and only if the signal is sufficiently informative, $\alpha > \alpha^*$. Hence, at $t = 0$, the bank will face bank runs at $t = 1$ with probability $\int_{\alpha^*}^{1} \alpha dF_{\tilde{\alpha}}(\alpha)$ $(\equiv \beta^*)$ if the bank takes excessive risks and chooses asset B.

The possibility of $t = 1$ depositor withdrawals changes the banker's risk-shifting incentives at $t = 0$. In this case, the bank's expected payoff with asset B, denoted by $\pi_B^{E,run}$, becomes

$$\pi_B^{E,run} = \Big(\underbrace{F_{\tilde{\alpha}}(\alpha^*)}_{\substack{\text{Probability that} \\ \text{signal too noisy}}} + \underbrace{\int_{\alpha^*}^{1} (1-\alpha) dF_{\tilde{\alpha}}(\alpha) \Big)}_{\text{Probability of } s_G|B} \times \underbrace{\Big(p_B R'(D+E) - r p_B D \Big)}_{\text{Payoff with no bank run}} + \underbrace{\int_{\alpha^*}^{1} \alpha dF_{\tilde{\alpha}}(\alpha)}_{\text{Probability of } s_B|B} \times \underbrace{(\ell A - D)}_{\text{Payoff with bank run}} . \quad (4)$$

The sum of the first two terms is the probability that, given that the bank has chosen asset B, depositors choose to roll over deposits to period $t = 2$. It is the probability that the signal is too noisy plus the probability that the signal is sufficiently precise but indicates (incorrectly) that the bank holds G rather than B. This sum is multiplied by the expected payoff of the bad asset when investors do not withdraw. The last term characterizes the expected payoff under a bank run; when α is greater than α^*, depositors withdraw with probability α, and the bank liquidates the asset to collect ℓA and pay D to depositors, keeping the difference. Hence, using the ex ante run likelihood denoted by β^*, we get

$$\pi_B^{E,run} = (1-\beta^*) \times \Big(p_B R'(D+E) - r p_B D \Big) + \beta^* \times (\ell A - D). \quad (5)$$

Because early liquidations are costly ($\ell < 1$), $\pi_B^{E,run}$ is less than π_B^E, the payoff from asset B with no possibility of depositor withdrawal in the benchmark setup. That is, the potential for depositor withdrawals lowers the bank's expected payoff from excessive risk-taking. Note that depositors never withdraw when the banker invests in asset G because they always receive s_G. The bank's payoff in the case of potential depositor withdrawal, denoted by $\pi_G^{E,run}$, is therefore equal to π_G^E, the payoff in the benchmark setup.

Define $\overline{Lev}^{run}$ as the maximum leverage for which $\pi_B^{E,run} < \pi_G^{E,run}$. It follows that $\overline{Lev}^{run} > \overline{Lev}$; the amount of leverage necessary to incentivize excessive risks is larger under double liability than it is under single liability.

Note that $\overline{Lev}^{run}$ changes as the underlying distribution of $\tilde{\alpha}$ changes. Consider another distribution H such that H FOSD F meaning that under H depositors tend to receive a more accurate signal. Intuitively, this would be the case if depositors were more financially sophisticated and better informed. Because under H depositors would be more likely to withdraw when the bank chooses asset B, market discipline would increase and further mitigate risk shifting incentives (lower $\pi_B^{E,run}$ and higher $\overline{Lev}^{run}$).

3.4 Double Liability and Depositor Withdrawals

Lastly, we examine the extent to which double liability reduces depositors' incentives for early withdrawals, thereby counteracting the incentive alignment shown in the previous section that reduces bank risk-taking *ex ante*. Specifically, we focus on how double liability affects the withdrawal threshold α^* defined in equation (3).

When receiving s_B, a depositor's expected payoff from rolling over in the case of double liability, denoted by $\pi^D_{s_B,double}$, is

$$\pi^D_{s_B,double} = (1-\alpha)[p_G r + (1-p_G)E/D] + \alpha[p_B r + (1-p_B)E/D],$$

because even if the bank fails, the banker pays E, which gets divided evenly among depositors (with deposits equal to D). Hence, $\pi^D_{s_B,double} < 1$ if

$$\alpha > \frac{p_G r - 1 + (1-p_G)E/D}{p_G r - p_B r - (p_G - p_B)E/D} \ \ (\equiv \alpha^*_{double}), \tag{6}$$

which is larger than α^* in (3). We have already shown that a higher α^* implies a lower likelihood of *ex post* depositor withdrawals; thus, all else being equal, depositors in double-liability banks are less likely to withdraw their deposits than depositors in single-liability banks.

3.5 The Indeterminacy of the Effect of Double Liability on Risk-Taking

The preceding result shows that double liability weakens the threat of depositor withdrawals. This result has important implications for the total effect of double liability on *ex ante* risk-taking and *ex post* withdrawals. While double liability reduces bank risk-shifting due to increased skin in the game, double liability also reduces the risk-mitigation effect of the threat of depositor withdrawals. The size, and even sign, of the combined effect is therefore theoretically ambiguous in this model. Said differently, the weakened threat of withdrawals under double liability may be so large that double liability actually *increases* bank risk-shifting incentives.[15] In the Appendix, we derive one set of conditions under which such an effect would arise.

However, an unambiguous result of this model is that, *conditional on banks' ex ante risk choices*, double liability will reduce the likelihood and severity of depositor withdrawals. The confounding effect of double liability's weakening of *ex ante* bank risk has no additional bearing on *ex post* withdrawal decisions by depositors. For any constant level of bank risk characteristics, depositors at double-liability banks will always run on the bank less frequently than depositors at single-liability banks. In the following sections, we test this idea with data from the period around the Great Depression.

4 Data and Summary Statistics

4.1 Data Sources

We collect data from various sources. First, we collect balance sheet information from the *Rand McNally Bankers' Directory* from December 31, 1925 to December 31, 1932. The *Directory* published semi-annual balance sheets for all financial institutions every January and July. The January edition provided information for the preceding December and the July edition provided information for the preceding June. Table 1 lists asset and liability categories reported in the book. In addition, we consult the Annual Report of the Federal Reserve Board to determine whether a bank was a member of the Federal Reserve. The report lists all state Fed-member banks for the year by district.[16]

[15]This offsetting effect could be amplified if double liability enabled banks to appeal to a more diverse depositor pool, for example if less sophisticated savers valued the additional "safety" or "information insensitivity" that double liability offered (see Gorton and Pennacchi (1990). Relatedly, Limodio and Strobbe (2018) find that liquidity requirements stimulate deposit growths). This assumption would imply that the distribution of $\tilde{\alpha}$ shifts to the left for double-liability banks. This shift would further weaken the market discipline mechanism. See, for instance, Choi and Velasquez (2017) for the relationship between deposit stickiness and market discipline.

[16]It is worth noting that membership is stable in our dataset. The vast majority of banks in our sample that were members of the Federal Reserve at the end of 1925 remained Federal Reserve members for the entirety of the sample period, and very few became members that were not members at the beginning of the sample. We drop any banks from our sample that switched Federal Reserve membership status during our sample.

We augment this dataset with deposit rate information collected from national bank examination reports and state bank reports of New Jersey. The national bank examination reports provide the minimum and maximum deposit rates for each national bank.[17] The New Jersey state banking reports provide a range of deposit rates for each state bank, and therefore implicitly define a maximum and minimum rate.[18] We construct minimum and maximum deposit rates for each bank in New Jersey. We collect this data at four points in time: 1926, 1928, 1930, and 1932.

To eliminate potential confounding effects, we apply various restrictions to the raw data. First, we exclude banks in central reserve (New York) and reserve (Albany and Buffalo) cities, because they were larger in size and had a different business model. To compare banks that are similar in size, depositor and shareholder distributions, and business models, we focus on banks in rural areas that are not private banks, clearing banks, or savings banks (that are not also trust companies), and have a deposit to asset ratio greater than 10 percent. Second, because our main specification compares national and state Fed-member banks within a local market in order to control for local economic conditions (county fixed effects), we include only banks located in counties with at least one Fed-member state bank and one national bank in a given period. We also exclude all New Jersey banks that are in the Federal Reserve Bank of Philadelphia's district, as well as banks that switched Federal Reserve districts during our sample period. Finally, we drop observations that likely result from data errors.[19]

4.2 Bank Risk Variables and Summary Statistics

Our sample consists of data on 302 national and state Fed-member banks, 166 of which are banks in New York and 136 are banks in New Jersey. In New York, there were 89 national banks and 77 state Fed-member banks. In New Jersey, there were 78 national banks and 58 state Fed-

[17] National bank examination reports provide rich information relating to bank ownership and corporate governance, the composition and quality of the loan portfolio, dividend payments, the composition of deposits, and the use of different types of liabilities. See Calomiris and Carlson (2018) for more information on national bank examination reports. In recent years, several studies used examination reports, e.g., Calomiris and Carlson (2016), Calomiris and Carlson (2017), Paddrik, Park, and Wang (2018), and Koudijs, Salisbury, and Sran (2018). See Appendix Figure 8 for deposit rate information appearing in the national examination reports.

[18] See Appendix Figure 9 for deposit rate information appearing in the New Jersey state bank reports. Unfortunately, this information does not exist for the New York state banks.

[19] We drop pairs of observations with "large reversals" in deposits — observations for which a deposit growth rate of greater than 80 percent or less than -80 percent is immediately followed in the next period by a growth rate of equal or larger magnitude but of the opposite sign. Finally, because the Rand McNally data have instances of repeated observations, which likely result from a carry-over of the previous year's report when a new report wasn't submitted, we drop observations that have identical values for all assets and liabilities as the previous period.

member banks. This gives us a total of 3,724 bank-time observations. Tables 2 and 3 provide summary statistics separately for national and state Fed-member banks in New York and New Jersey for the periods December 1925 - June 1929 and December 1929 - December 1932, respectively. Because we are focusing on rural banks in both states, the banks in our sample are relatively small. In both New Jersey and New York, national banks were smaller than state Fed-member banks on average. New York national banks averaged around \$5.0 million in assets versus \$7.3-7.7 million in assets for state Fed-member banks. In New Jersey, national banks held \$6.6-7.3 million in assets while state Fed-member banks held \$11.5-13.0 million in assets.

Tables 2 and 3 also provide summary statistics of relevant bank characteristics. We adopt two measures of bank risk-taking: the ratio of cash reserves to total assets, which we call the "cash ratio," and the ratio of bank equity to total assets, which we call the "capital ratio."[20] Banks' cash reserves comprise two types of liquid assets: 'cash and exchanges' and 'due from banks and bankers.' 'Cash and exchanges' were gold coins and other cash items. 'Due from banks and bankers' was interbank deposits banks placed in other banks. Bank equity comprises 'paid-in capital' and 'surplus and profits'. Paid-in capital (also referred to as 'legal capital' or 'par capital') is the minimum amount of capital that stockholders were required to maintain as on-balance-sheet equity. 'Surplus and profits' (surplus capital) is the sum of additional paid-in capital and undistributed profits that have not been allocated to the par account. It provided banks with an extra capital buffer that could absorb losses on loans and other investments. The distinction was important because shareholders of double-liability banks were liable up to the par value of the paid in capital. Columns (3) and (6) in each table also show the t-value from a two-sample t test of mean differences between national and state Fed-member banks in that state.

Table 2 highlights the importance of our identification strategy that compares differences between national and state Fed-member banks within New York and New Jersey. Even in New York, where state banks were governed by double liability just as were national banks, many of our summary variables still differed by statistically significant margins. In particular, in New York during the period December 1925 - June 1929, national banks were smaller, held more cash, held fewer securities (bonds), and issued more loans than state Fed-member banks. Similarly, in New Jersey

[20] While we do not have information on bank loan quality, note that under the unit banking system, banks in the same local market likely had similar business models and faced similar demand.

national banks held more cash and more equity, but had similar levels of loans, securities (bonds), and surplus capital.

Table 3 shows the same summary statistics as Table 2, but for the period December 1929 – December 1932. Of particular interest is the difference in deposit growth rates; single-liability New Jersey state banks experienced substantially larger outflows than double-liability national banks in New Jersey (-2.17 vs. -4.20), while deposit outflows from state and national banks in New York, each of which were governed by double liability, were much smaller (-1.50 vs. -2.58). While these mean differences fail to account for important controls, such as bank risk characteristics and county and time fixed effects, they nonetheless preview the results we obtain from a more formal empirical analysis in Section 6.

Figure 2 plots the full time-series of the average cash ratio and capital ratio for national and state Fed-member banks in New York and New Jersey. Figure 3 plots the time-series of deposit growth rates for all four types of banks, separately for the boom and bust periods. For all three ratios, the time-series patterns are highly similar for each bank type, with rises and falls largely coinciding across state and Fed-membership status.

In total, Tables 2 and 3 and Figure 2 offer no immediately obvious pattern between double liability and risk-taking. Table 3 does, however, offer some preliminary evidence deposit outflows during the Great Depression were larger for single-liability New Jersey state Fed-member banks. This is visible in Figure 3 as well. In Section 6, we examine the statistical difference in cash and capital ratios and deposit outflows after controlling for economic conditions and other potentially important factors.

5 Estimation and Identification

In this section, we enumerate the potential threats to inference that motivate our identification strategy, and describe how we attempt to resolve them. We then describe our empirical specifications and highlight the economic importance of the coefficients of interest.

5.1 Supervision, Regulation, and Macroeconomic Conditions

Although liability structure differed across states and charter types, we cannot simply compare banks in different states because economic, regulatory, and monetary environments also differed.

Comparing banks with different liability structure (i.e., charter types) within a state also poses a challenge since differences in charters accompanied differences in bank regulation and supervision. All national banks were uniformly supervised and regulated by the Office of the Comptroller of Currency. State banks that were members of the Federal Reserve System were supervised and regulated by regional Federal Reserve Banks. State banks that were not members of the Federal Reserve System were supervised and regulated by state banking departments.

We attempt to overcome these issues by exploiting the fact that state Fed-member banks were subject to the liability rules of the state, but otherwise faced identical regulations as national banks.[21] Specifically, we employ a difference-in-difference style analysis in which we compare differences in bank risk and deposit growth rates between state Fed-member banks and national banks in New York, where state banks were governed by double liability, to differences between national and state Fed-member banks in New Jersey, where state banks were governed by single (limited) liability. All national banks, regardless of the state in which they operated, were governed by double liability.

This strategy provides three advantages. First, comparing Federal Reserve member banks within the same Federal Reserve district alleviates the concern that differences among them may have resulted from differential regulation and supervision. Federal Reserve member banks were subject to the same reserve, capital, and branching requirements, and state Fed-members were supervised and regulated by local Federal Reserve Banks. Comparing banks in the Federal Reserve System is particularly important for our sample period due to the major regulatory changes imposed under the passage of the McFadden Act in 1927. For instance, the act was intended to allow national banks (and state member banks) to compete with state non-member banks by permitting them to open branches within state limitations. Second, our strategy alleviates concerns arising from the fact that regional Federal Reserve banks set discount rates independently, which produced different monetary environments and led to different experiences for distressed banks (Richardson and Troost (2009), Jalil (2014)). Lastly, focusing on banks in neighboring states helps control for regional macroeconomic conditions.[22]

[21] See Appendix Figure 7 for the summary of regulatory requirements for banks in New York and New Jersey.

[22] During the Great Depression, bank failure rates in New York and New Jersey were 14.44 percent and 18.64 percent, respectively. These numbers are comparable, considering that the U.S. bank failure rate was 41.94 percent on average (Guglielmo (2011)).

The comparisons to national banks in the respective states aims to address potential biases related to systematic differences that originate from bank charter choices. Specifically, we control for common factors that differ between state and national banks, regardless of liability structure, by examining how *within-state* differences between national and state Fed-member banks vary between New Jersey (where state banks were governed by single liability but national banks were governed by double liability) and New York (where double liability applied to both state and national banks). The identification assumption is that differences in bank risk-taking or deposit growth rates that resulted from differences in bank charter types are the same in New York and New Jersey, after controlling for observable bank characteristics. If the assumption is valid, our empirical approach isolates the effect of liability structure on bank risk-taking and deposit outflows.

5.2 Bank Risk Prior to the Great Depression

Our first tests relate to bank risk-taking. The dependent variables are the cash ratio and the capital ratio, which capture bank failure risk along two important dimensions: liquidity buffers and loss-absorbing buffers.[23] Because these measures of bank risk may be mechanically affected by deposit outflows and other effects of bank distress, we do not investigate the relationship between bank risk-taking and liability structure during the Great Depression (December 1929 - December 1932). We do, however, use these risk characteristics as controls later in specifications of deposit outflows on liability structure.

Due to limitations associated with historical data, we face a fundamental trade-off between the power of our tests and the possibility of confounding unobservables. Our identification strategy, which limits our analysis to only national and state Fed-member banks in New York and New Jersey, seeks to constrain the critical confounding effects such as differential regulation, supervision, and economic conditions. Regardless, we estimate several specifications that trade-off potential bias with statistical power.

Our first specification is the simple linear regression

$$y_{i,t} = \beta_0 + \beta_{sb} SB_i + \beta_{nj} NJ_i + \beta_t T_t + \beta_{sb,nj} \times SB_i \times NJ_i + X_{i,t} + \varepsilon_{i,t}, \tag{7}$$

[23]Note that banks in same locality faced similar loan demand and lending opportunities during our sample period due to the branching restriction.

where $y_{i,t}$ is a measure of bank risk, either the cash ratio or capital ratio, SB_i is a dummy variable for whether the bank is a state Fed-member (rather than national) bank, NJ_i is an indicator variable for whether the bank is located in New Jersey (rather than New York), T_t is the time fixed effect (semi-annual), and $X_{i,t}$ is a vector of time-varying bank-specific controls that include the log of bank age and the log of total bank assets. The coefficient of interest in this specification is $\beta_{sb,nj}$, which measures the partial effect of being a state bank in New Jersey — the only single-liability banks in our sample — on our two measures of bank risk.

We estimate (7) only for the "boom period" immediately prior to the Great Depression, defined as December 1925 - June 1929. If double liability discourages risk-taking during this period, we should observe single-liability New Jersey state banks taking more risk. That is, they should hold less cash and capital relative to total bank assets. This effect would imply that $\beta_{sb,nj}$ should be negative and statistically significant.

While comparing only Fed-member state banks and national banks in New York and New Jersey mitigates issues related to regulatory requirements, supervision, and the state-level economic environment, differential local economic conditions may still be an important source of variation. The New Jersey indicator variable in specification (7) is likely too coarse if this is the case. To better control for local unobservables, we estimate a second specification that uses county-level fixed effects but retains the interaction between state Fed-member banks and the New Jersey indicator variable:

$$y_{i,t} = \beta_0 + \beta_{sb} SB_i + \beta_{cnty,i} County_i + \beta_t T_t + \beta_{sb,nj} \times SB_i \times NJ_i + X_{i,t} + \varepsilon_{i,t}, \tag{8}$$

where $County_i$ is a county-level indicator variable.

Specification (8) is likely to better control for geographic unobservables that may affect bank risk-taking. However, many of our counties have fewer than 10 banks. Thus, even if liability structure did have an effect on bank risk-taking, we might be under-powered to detect it empirically if the effect is economically small relative to other factors. Specification (7), which includes only a New Jersey indicator, better alleviates the problem of low power but may be exposed to biases resulting from local unobservables. To the extent that the coefficient $\beta_{sb,nj}$ differs across these specifications, keeping this difference between the two specifications in mind may be important.

5.3 Deposit Growth and Bank Runs

Next, we turn to the effect of double liability on deposit growth rates and bank runs. We estimate deposit growth rates separately for the "boom period" (December 1925 - June 1929) and the "bust period" (December 1929 - December 1932). Double liability may have affected deposit growth during the boom period if (i) the relative cost of deposit-based financing was lower for double-liability banks; (ii) double-liability banks had access to a wider pool of depositors; or (iii) double-liability banks attracted local deposits more aggressively. Double liability may have also mitigated deposit outflows during the "bust period" if depositors in double-liability banks monitored bank soundness less intensively or if the implicit guarantee of additional capital backing bank liabilities reduced the information sensitivity of depositors.

For both December 1925 - June 1929 and December 1929 - December 1932, we estimate the same specification as in (7), but include as the dependent variable the log-change in deposits $\Delta \log(Dep_t) = \log(Dep_t) - \log(Dep_{t-1})$:

$$\Delta \log(Dep_t) = \beta_0 + \beta_{sb} SB_i + \beta_{nj} NJ_i + \beta_t T_t + \beta_{sb,nj} \times SB_i \times NJ_i + X_{i,t} + \varepsilon_{i,t}. \tag{9}$$

Further, the bank controls $X_{i,t}$ now also include banks' cash and capital ratios (lagged by one period) to control for bank risk characteristics. The goal of specification (9) is to examine the change in deposits for banks with different liability rules, but the same risk of insolvency, which is likely to be an important determinant of deposit outflows in addition to liability structure. As before, the coefficient of interest is $\beta_{sb,nj}$. If double liability affected deposit growth either prior to or during the Great Depression, $\beta_{sb,nj}$ should be statistically significant; it will be positive if double liability reduced deposit growth and negative if double liability increased deposit growth.

As with our specifications on bank risk, local economic conditions that are more granular than state-level variation may have been an important determinant of deposit growth rates and bank runs. As with the bank risk model given by (8), we re-estimate (9) but replace the NJ_i indicator with county-level fixed effects. In this specification, we retain the interaction term between SB_i and NJ_i. We again do this for both December 1925 - June 1929 and December 1929 - December 1932 separately.

Finally, we note that the coefficient of interest in equation (9), $\beta_{sb,nj}$, is not only identified by the likelihood or intensity of deposit outflows, but is also affected by heterogeneity in deposit inflows. Our model, however, specifically predicts heterogeneity in depositor behavior in response to *negative* signals about bank health. We therefore estimate one final specification that explicitly examines net deposit outflows. Specifically, we estimate a linear probability model with an indicator variable for whether the bank experienced a deposit outflow as the dependent variable:

$$\mathbf{1}\{\Delta \log(Dep_t) < 0\} = \beta_0 + \beta_{sb} SB_i + \beta_{nj} NJ_i + \beta_t T_t + \beta_{sb,nj} \times SB_i \times NJ_i + X_{i,t} + \varepsilon_{i,t}. \tag{10}$$

where the function $\mathbf{1}\{\cdot\}$ is an indicator function equal to one if the condition is true, and all other variables are defined as previously.

As with the previous empirical models, our interest in is in the coefficient $\beta_{sb,nj}$. If the coefficient is positive, it indicates single-liability banks were more likely than double-liability banks to experience a deposit outflow conditional on bank risk characteristics.

6 Results

This section reports regression results obtained from estimating specifications (7) - (10) above. Section 6.1 reports results related to bank risk-taking prior to the Great Depression, while Section 6.2 reports results related to deposit growth prior to the Great Depression. Section 6.3 examines deposit growth during the Great Depression.

6.1 Bank risk-taking Prior to the Great Depression

Table 4 reports coefficient estimates based on specification (7). We include as controls the log of bank age and the log of total bank assets. In every specification, we cluster standard errors by county.[24] For the period December 1925 - June 1929, columns (1) and (3) show that state Fed-member banks (aggregated across New York and New Jersey) held less cash relative to assets than national banks, but this difference becomes statistically insignificant once county and time fixed effects are included. We find no statistically significant relationship between the New Jersey indicator variable and either the cash or capital ratio, and no relationship between the state Fed-

[24] In results available from the authors, we have estimated a number of alternative specifications that treat standard errors differently, including two-way clustering at the county-time level. Our results, including statistical significance, are unchanged by these alternative approaches.

membership indicator and the capital ratio, regardless of the specification.

The coefficient of interest is on the interaction term, which measures the difference in risk-taking between single- and double-liability banks. With the cash ratio as the dependent variable, the coefficient is positive but statistically insignificant across every specification. If double liability led to more prudential behavior during the "boom period," we should see New Jersey state Fed-member banks holding *less* cash relative to assets, but we are unable to reject the null that cash ratios were equal between single- and double-liability banks. Further, the positive coefficient we estimate suggests that single-liability New Jersey state Fed-member banks actually held *more* cash. Thus, while we cannot reject the null that double liability had no effect on the cash ratio, the sign of the point estimate indicates that single-liability banks were in fact safer.[25]

In columns (5)–(8), we repeat this exercise but include the capital ratio as our dependent variable. We find no statistically significant relationship between the capital ratio and either the New Jersey bank indicator or the state Fed-membership indicator. Once again, we also find no statistically significant relationship between liability structure, measured by the coefficient on the interaction term, and bank risk. Similarly to the results with the cash ratio as the dependent variable, we estimate a positive coefficient in three of the four specifications, which indicates that single-liability banks held more capital relative to assets (employed less leverage) than double-liability banks.

The results in Table 4 offer no evidence that double liability had any effect on bank risk-taking in the run-up to the Great Depression. It is important to note that we have not precisely estimated a small effect, but rather have found no evidence that allows us to reject the null that New Jersey and New York state Fed-member banks had identical cash and capital ratios relative to their respective national banks. However, even based on the large standard errors of our estimates, the *economic* effects we estimate are unlikely to be large. For example, the lower bound of the 95 percent confidence interval on the interaction term estimated in column (4) is -0.70, which would imply that single-liability banks had roughly one-fifth of one standard deviation lower cash ratios on average than double-liability banks. Likewise, the lower bound of the confidence interval in column (8) would imply single-liability banks had only one-eighth of one standard deviation lower

[25] If we replace the cash ratio with the ratio of "liquid assets" — cash and securities (bonds) — to total assets in the regression, we estimate a negative coefficient but it remains statistically insignificant across all specifications.

capital ratios. Thus, even at the low end of the estimated confidence intervals, double liability would appear to have little economic effect on bank risk choices.[26]

6.2 Deposit Growth Prior to the Great Depression

Table 5 shows the results of estimating equations (9) and (10), which measures the effect of double liability on deposit growth rates prior to the Great Depression. In each specification, we control for bank risk characteristics by including as controls the lagged cash and capital ratios, as well as the lagged log of bank assets and the log of bank age. Once again, standard errors are clustered by county.

Column (1) estimates our baseline specification, with indicators for New Jersey and state Fed-member banks along with their interaction, but no additional controls. As with the results in Table 4, we find no statistically significant effect of extended liability on deposit growth during the boom period. In columns (2) and (3), we include county- and time-fixed effects and controls for bank risk, separately. In column (4), we include both the fixed effects and controls. In each specification, the coefficient on the interaction term remains statistically insignificant. We note also that the null results on the New Jersey state Fed-member interaction term found in Tables 4 and 5 are not necessarily the result of underpowered tests; in Table 5, the lagged capital ratio is positively related to deposit growth rates and this association is economically large and statistically significant at the 1 percent level. Similarly, bank age is negatively related to log deposit growth, and is significant at the 10 percent level (p-value of 0.074).

In columns (5)–(8), we estimate the linear probability model described in equation (10), and phase in the fixed effects and controls in the same manner as in columns (1)–(4). Across all four specifications, we find no evidence of an association between double liability and the likelihood of a deposit outflow. The coefficients on the New Jersey state Fed-member interaction term are small and statistically insignificant. In total, Table 5 offers no empirical evidence of a relationship

[26]Koudijs, Salisbury, and Sran (2018) recently find that limited skin in the game by bankers led to greater risk-taking. While we compare risks *between* single- and double-liability banks, they compare risks *within* double-liability banks, exploiting the introduction of marital property laws that limited liability for newly wedded bankers. The different findings may come from the scale of the offsetting effect through depositor discipline; while depositors might have easily distinguished national and state chartered banks – national banks needed to have the word “National” in their name by law, and state banks were forbidden to do so — they might not have necessarily known marital status of their bank CEOs. Hence, Koudijs, Salisbury, and Sran (2018) more clearly capture the direct effect of bankers’ skin in the game without the interference of the indirect offsetting effect.

between liability structure and deposit growth during the boom period December 1925 - June 1929.

6.3 Deposit Growth During the Great Depression

Next, we turn our attention to deposit growth during the Great Depression. Columns (1)–(4) of Table 6 report results from estimating equation (9) for the period June 1929 - December 1932. Column (1) finds that, without additional controls or time and county fixed effects or bank controls, the coefficient on single-liability New Jersey state Fed-member banks is negative but not statistically significant. However, once time and county fixed effects are included, the coefficient becomes much more negative and statistically significant at the 10 percent level (p-value of 0.083). When we include controls for bank characteristics, but exclude the fixed effects, the coefficient decreases further and becomes significant at the 5 percent level (p-value of 0.017). Finally, in column (4) we include both bank characteristics and the fixed effects, and estimate a coefficient of -2.748 that is once again significant at the 5 percent level (p-value of 0.012).

The economic significance of the coefficient estimated in column (4) is substantial. It implies that New Jersey state Fed-member banks experienced a 2.75 percentage point per-six-months greater outflow on average than New Jersey national banks, relative to their New York national and state Fed-member counterparts. This finding is economically large compared to a median growth rate of -2.79 percent across all banks during this period. Further, both lagged total assets and the lagged capital ratio are positively related to deposit growth rates, suggesting that measures capturing bank health were indeed relevant factors for depositors. While the coefficient on the lagged cash ratio is negative, because deposit withdrawals are met with cash-on-hand the coefficient is difficult to interpret.

Columns (5)–(8) of Table 6 report results from estimating the linear probability model outlined in equation (10). In each specification, we estimate a positive coefficient on the interaction term, and once we include bank characteristics as controls the coefficient becomes statistically significant at the 5 percent level, with p-values of 0.025 and 0.048, respectively, depending on whether the fixed effects are included as well. The coefficients imply that single-liability banks had a roughly 8 percent greater likelihood of experiencing a net deposit outflow than double-liability banks, conditional on bank risk characteristics. This offers additional evidence that depositors in limited liability banks were quicker to withdraw funds during the economic downturn.

The results in Tables 5 and 6 highlight that extended liability may have heterogeneous effects depending on the state of the financial system. To formally assess whether the relationship between extended liability and deposit growth differs in the pre-crisis and crisis periods, we estimate the model in the full panel by including an indicator for the crisis period. This is shown in Table 7. Column (1) includes county fixed effects and bank controls, column (2) adds interactions between bank controls and the crisis period to allow bank characteristics to have heterogeneous effects prior to and during the Great Depression, and columns (3) and (4) add time and time-by-county fixed effects. Our interest in Table 7 is in the triple-interaction term. In each specification, the coefficient is negative and increases in magnitude with each set of controls. In models with time or time-by-county fixed effects, the coefficient is significant at the 10% level (*p*-values of 0.082 and 0.077, respectively). The marginal statistical significance is unsurprising since the coefficient on the state fed-member New Jersey interaction term in the pre-crisis period has such large standard errors, and therefore inflates the standard errors on the triple-interaction term as well. Nevertheless, we are able to reject the null of no difference in the coefficient between crisis and pre-crisis periods at the 10% level. In appendix Table 12 we repeat this analysis using the deposit outflow indicator. In each specification the coefficient is positive, consistent with the results from Tables 5 and 6. However, due to the large standard errors in the pre-crisis period, the coefficient is not statistically significant.

In Table 11 of Appendix A.2, we conduct a series of robustness checks for the results found in Table 6. We repeat the specification in column (4) of Table 6 for different levels of trimming and winsorization of the deposit growth rate dependent variable. We also repeat the specification in column (8) of Table 6, but calculate the probability of a deposit outflow after trimming the dependent variable at different levels. Across each specification and each test, we continue to find statistically significant coefficients on the interaction term in nearly all cases.[27] This suggests the results in Table 6 are not driven by a small set of observations, or result from a fortunate specification.

Together, the results in Table 6 indicate that double liability had a meaningful effect on stemming deposit outows and reducing the likelihood of bank runs during the Great Depression. This

[27]Further, while the magnitude of the estimated coefficients decrease as we increase the severity of the trimming (winsorizing), their size relative to the resulting standard deviations remains largely stable.

finding is consistent with our model, in which depositors in double-liability banks respond less urgently to arrivals of negative information. These results also suggest that the null results found in Tables 4 and 5 are not solely the result of misspecification or under-powered tests; the same specifications produce statistically significant and economically large coefficients for deposit outflows during the Great Depression.

In summary, our results suggest that double liability had no discernible effect on bank risk-taking or deposit growth during the boom-period immediately prior to the Great Depression. However, double liability appears to have impacted the behavior of depositors during times of bank distress; double-liability banks experienced fewer deposit outflows than their single-liability counterparts. The implication is that double liability was an ineffective tool for restraining excessive risk-taking even if it increased shareholder skin-in-the-game; It also shifted losses away from depositors and thus reduced their monitoring incentives. These findings are consistent with our model's predictions in Section 3.

7 Mis-specification and Potential Biases

In this section, we explicitly address two additional factors that may confound our empirical findings. In Section 7.1 we investigate whether selection bias emanating from bank charter choices is a possible driver of the relationship between liability structure and deposit growth, or liability structure and bank risk. In Section 7.2 we empirically examine whether depositors exercised market discipline through price as well as quantity.

7.1 Selection Bias

Banks could choose to become national or state banks. Similarly, state banks could choose to join the Federal Reserve System. Both of these endogenous choices have the potential to bias our coefficient estimates if bank charter choices are correlated with liability rules.

We begin by addressing state versus national charter choices and their relationship with the liability structure. Previous research has found capital and reserve requirements and looser lending restrictions (and branching restrictions where branching was allowed) were important determinants, but not liability structure.[28] Nonetheless, we offer two empirical tests of the possible relationship

[28] See White (2014) and Committee on Branch, Group, and Chain Banking (1932).

between liability structure and bank charter choice. First, we examine the composition of national versus state banks in states where liability rules changed from single liability to double liability: Arizona (in 1912), Arkansas (in 1912), Mississippi (in 1914), Nevada (in 1911), New Hampshire (in 1911), and Oregon (in 1912).[29] Second, we examine the relationship between liability rules and the ratio of state banks to state and national banks across states in 1926.

Table 8 shows the ratio of the number of state banks to state and national banks from 1905 to 1919 for states where liability rules changed from single liability to double liability. If liability structure was an important determinant of banks' charter choices, once state banks became governed by double liability — the same liability structure as national banks — we should see a shift in the composition of state and national charters. However, Table 8 shows virtually no change in the fraction of state-chartered banks around the adoption of double liability. Further, while the proportion of state banks decreased after adoption in Arkansas, it actually increased in Arizona and New Hampshire. While we do not offer a formal analysis of bank charter changes prior to and after the adoption of double liability, Table 8 offers little evidence that changes in liability structure had any effect on charter decisions.

Next, we examine whether the ratio of state to state and national charters is related to liability structure across states in 1926. Column (1) of Table 9 reports results from regressions of the ratio of state banks to state and national banks on an indicator variable for whether the state imposes single liability.[30] The estimated coefficient on the single-liability indicator is zero to the third decimal place, and is statistically insignificant. This provides additional evidence that liability structure is not primarily related to bank choices between state and national charters.

Alternatively, selection bias could result from the choice of Federal Reserve membership conditional on the choice of a state banking charter if membership decisions are correlated with liability structure. However, while the Federal Reserve Board introduced the option of Federal Reserve membership for state banks in hopes of creating a unified banking system, many state banks refrained from joining. The lack of interest by state banks to join the system led policymakers to investigate. The principal objections to membership were: 1) the loss of interest on reserves car-

[29] Recall that all national banks were governed by double liability, so a change to a state's liability rules would only affect state-chartered banks.

[30] For ease of interpretation, we include only states that impose either single or double liability; this excludes Colorado and California.

ried with Federal Reserve member banks, 2) the red tape emanating from compliance with federal regulations, and 3) the high cost of membership when the benefit was not sufficiently remunerative to small banks to be attractive as a business proposition (Krueger (1933)). Liability structure was not an important consideration. While access to the discount window was considered the biggest attraction for joining the system, small banks were indirectly accessing the Federal Reserve discount facilities through their big city correspondents. Thus, state Fed-member banks tended to be larger banks that competed with national banks and engaged in liquidity provision to state non-fed member banks. The discount window reduced liquidity risk and allowed them to expand their small bank correspondent networks (CQ Researcher (1923)).

While joining the Federal Reserve System required state banks to comply with the regulatory requirements of national banks, many state Fed-member banks chose not to become national banks because they did not want to be supervised by the Office of the Comptroller of the Currency (OCC) (White (2011)). When both national and state Fed-members were supervised by the OCC in its early years, state Fed-member banks complained. As a result, the supervision responsibility was transferred to the Federal Reserve Board and regional Federal Reserve banks.

Recall that one of the major reasons for participation in the Federal Reserve system was the availability of the discount window in times of funding distress. Hence, our estimation could be biased if the more severe threat of bank runs in single-liability states led to a greater number of fragile banks joining the system in those states, despite the heavier regulatory burden. We address the concern of a correlation between liability structure and state banks' Federal Reserve participation by examining participation rates across states with different liability structures. Column (2) of Table 9 shows results from regressions of the fraction of state banks comprised by Fed-member (state) banks on an indicator variable for whether the state imposes single liability. Column (2) shows that liability structure is unrelated the fraction of state banks choosing to join the Federal Reserve system. In other words, state bank participation rates in single-liability states were not higher than those in double-liability states.

In summary, while the results in this section are only suggestive, we find no evidence that the selection of bank charter type or Federal Reserve membership are related to liability structure. Importantly, even if selection is present on unobservables, our results will only be biased if those unobservables are correlated with liability structure, or differ systematically between New York and New Jersey. Although our empirical specifications outlined below are not based on exogenous variation, and we can therefore not rule out potential biases that result from omitted variables, our interpretation of these results is that selection based on liability structure is unlikely to be a first-order concern.

7.2 Interest Rates on Deposits

In Section 6.3, we examine the relationship between liability structure and deposit outflows. However, depositors can exercise market discipline not just through withdrawing deposits, but also by demanding an interest rate premium from risky banks. That is, through price as well as quantity. In this section, we analyze the deposit rates offered by New Jersey banks (both national and state fed member banks), collected from national bank examination reports and state bank reports of New Jersey for years 1926, 1928, 1930, and 1932. In particular, we examine (i) whether depositors *ex ante* recognized that double-liability banks provided better protection, and demanded higher deposit rates from single-liability banks as a result; and (ii) whether our previous findings on differential deposit outflows were driven by differential pricing by banks, for example by raising rates to attract deposits during times of deposit outflows, or by reducing rates to incentivize outflows and minimize interest expenses.

We begin by comparing deposit rates of single-liability banks to those of double-liability banks. Figures 4 and 5 plot the distribution of maximum and minimum deposit rates, separately for national and state Fed-member banks, and for years 1926 and 1928, and 1930 and 1932. Figure 4 suggests that depositors demanded an interest rate premium from single-liability banks over our sample period. In 1926 and 1928, the majority of national banks offered maximum rates of 2 percent (per year), with some offering a maximum of 3 percent and very few offering more than 3 percent. Alternatively, state Fed-member banks almost exclusively offered a maximum rate of 4 percent, with little variation between banks. In 1930 and 1932, while single-liability banks continued to pay higher deposit rates, maximum deposit rates fell and became more dispersed. Most national banks paid 2.0 percent maximum rates, but many offered 1.0-1.5 percent, and rates paid above 2 percent were less heaped on 3 percent. For state Fed-member banks, many reduced the maximum rate from 4.0 percent to 3.5 percent, although the plurality continued to offer 4.0 percent. A t-test for differences in means allows us to easily reject the null hypothesis that maximum rates were the same for national and state Fed-member banks during either the pre-crisis or crisis period.

Figure 5 shows that the variation in minimum deposit rates is much smaller between national and state Fed-member banks, both prior to and during the Great Depression. For both, minimum deposit rates were almost exclusively 2 percent in 1926 and 1928. In 1930 and 1932, rates fell for both state Fed-member and national banks (consistent with the findings in Figure 4), with the predominant minimum rates being either 1 or 2 percent. While a t-test allows us to reject the null that average minimum rates were the same between national and state Fed-member banks, the economic differences are tiny, with average minimum rates of 2.02 and 2.14 for the pre-crisis period, and 1.58 and 1.71 for the crisis period.

While Figures 4 and 5 offer preliminary evidence that depositors demanded a risk premium from single-liability banks, this may have originated from differences in bank risk rather than liability structure. Table 10 examines the relationship between deposit rates and liability structure prior to the Great Depression after controlling for our standard measures of bank risk. Because our deposit rate data is for New Jersey banks only, we include an indicator variable for state Fed-member banks which is equivalent to an indicator for single liability. The results in Table 10 confirm that depositors were aware of additional risks associated with limited liability banks, and demanded a risk premium in return. Even after controlling for bank risk, limited liability banks had to offer an additional 1.63 percentage points higher maximum deposit rate than double-liability banks. While the minimum rate was also higher, both the statistical significance and economic magnitude of the single-liability coefficient is substantially smaller. Interestingly, bank risk characteristics appeared to be a second-order concern in 1926 and 1928; only the capital ratio in the case of maximum rates is statistically significant and of the right sign, and the estimated coefficient implies an increase in the maximum rate of just over 0.10 percentage points for a one standard deviation decrease in the capital ratio.

Next, we examine whether differences in deposit outflows between single- and double-liability banks could be driven by changes in deposit rates. Figure 6 plots average maximum and minimum deposit rates over time, along with the 5^{th} and 95^{th} percentile values, separately for national and state Fed-member banks. The top panel of Figure 6 shows that average maximum rates actually decreased by more for double-liability national banks. The change in the average maximum rate from 1930 to 1932 was 1.04 percentage points for national banks (2.54 percent vs. 1.50 percent), and 0.50 percentage points for state Fed-member banks (3.99 percent vs. 3.49 percent). Consistent with Figure 5, the bottom panel of Figure 6 shows that both the levels and changes of minimum rates differed only slightly between national and state Fed-member banks.

The results in Figure 6 suggest that the greater deposit outflows experienced by single-liability banks are unlikely to be the result of double-liability banks offering more generous deposit rates. The fact that single-liability banks reduced their deposit rates by less than double-liability banks also suggests that single-liability banks did not have an endogenously lower demand for deposits. This is particularly true give that deflation was rampant during the Great Depression,[31] and that *real* deposit rates actually rose for both single- and double-liability banks. That single-liability banks simultaneously experienced greater outflows of deposits while raising real deposit rates by more than double-liability banks indicates a heterogeneous response in the *supply* of deposits, not demand.

8 Conclusion

Considerable evidence has shown that excessive risk-taking by banks was integral to the financial crisis of 2008. Under limited (single) liability, shareholders have incentives to take excessive risks because they receive all upside gains from risky projects, with limited downside exposure. Policymakers have introduced various measures to enhance regulatory and supervisory solutions, but critics have advocated for the implementation of alternative policies that are rooted in incentive alignment.

One such proposal is to increase shareholder liability. By increasing shareholder liability, regulators can institutionally demand shareholders to absorb greater losses in the event of a bank failure and incentivize them to avoid moral hazard. We evaluate this conventional wisdom by examining the effect of double liability imposed prior to the Great Depression. We develop a model that demonstrates two competing effects of double liability: a direct effect that constrains excessive risk-taking due to increased skin in the game, and an indirect effect that promotes risk-taking due to weaker monitoring of better-protected depositors. We then test the model's predictions using a novel identification strategy that compares state Fed-member banks and national banks in New

[31] The consumer price index changed by -27.9 percent during the period 1930-1932 (Cecchetti (1992)).

York and New Jersey. By doing so, we attempt to control for differences regulation, supervision, local economic conditions, and other unobservable biases in order to isolate the effect of liability structure on bank risk-taking and depositor runs.

We find an ambiguous relationship between double liability and bank risk-taking. We find no difference in liquidity and capital buffers between single-liability and double-liability banks prior to the Great Depression. However, we do find that double-liability banks had lower deposit outflows during the Great Depression. These findings suggest that double liability mitigated depositor runs during the downturn, and stickier funding weakened market discipline as well as offsetting the direct effect of more skin in the game in constraining risk-taking.

Our findings also suggest that double liability failed to resolve the agency problem effectively because of the conflict between shareholder incentive alignment and depositor market discipline. Reallocation of losses between shareholders and depositors in times of bank failures changes the incentives of both shareholders and depositors, and such changes may interact in complex or unanticipated ways. If decreased market discipline by depositors offsets the increased prudence gained from greater shareholder liability, the net effect on reducing moral hazard may be weaker than expected.

Our paper has implications for current policy discussions. Various commentators have advocated for a return to extended liability as key pillar of regulation designed to prevent excessive risk-taking by financial institutions. However, the effectiveness of these policies may be undermined by the reduced incentives of certain creditors, including both insured and uninsured depositors, to monitor bank activities. This is particularly relevant given the emerging research on the potential for runs on uninsured deposits. Our results indicate that the magnitude of the offsetting effect of reduced market discipline may be significant, and could materially dampen the effectiveness of regulatory tools centered on incentive alignment and increased shareholder liability.

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9 Tables and Figures

9.1 Tables

Table 1: Asset and Liability Categories

Assets	**Liabilities**
Loans and Discounts	Paid-in Capital
Bonds and Securities	Surplus and Profits
Miscellaneous	Deposits
Cash and Exchanges, Due from Banks	Other Liabilities

Source: *Rand McNally Bankers' Directory*.

Table 2: Summary Statistics (December 1925 - June 1929)

	New Jersey			New York		
	National	State	# of Obs. (*t*-value)	National	State	# of Obs. (*t*-value)
Total Assets ($1,000)	6,620	11,500	509 /392	4,986	7,292	565 /531
	(8,178)	(21,400)	(-4.28)	(3,539)	(12,300)	(-4.16)
Cash Ratio (%)	10.557	10.116	500 /383	10.224	9.299	564 /530
	(6.121)	(3.889)	(1.30)	(4.046)	(4.327)	(3.65)
Loan Ratio (%)	51.746	52.843	499 /383	53.619	51.625	564 /529
	(14.813)	(13.850)	(-1.13)	(15.137)	(15.129)	(2.18)
Securities Ratio (%)	33.066	31.940	499 /383	32.863	35.610	563 /528
	(15.918)	(14.391)	(1.10)	(16.124)	(15.997)	(-2.82)
Capital Ratio (%)	14.192	13.681	498 /381	13.503	12.974	564 /529
	(9.227)	(7.005)	(0.93)	(6.251)	(7.191)	(1.30)
Surplus Ratio (%)	47.873	48.979	506 /389	56.086	55.501	564 /530
	(17.332)	(14.222)	(-1.05)	(16.710)	(13.849)	(0.63)
Cash Growth Rate (%)	2.537	3.147	423 /325	-0.121	0.527	478 /454
	(45.814)	(44.414)	(-0.18)	(36.773)	(35.197)	(-0.27)
Securities Growth Rate (%)	5.880	3.233	421 /325	4.024	4.628	476 /450
	(34.690)	(39.383)	(0.96)	(32.668)	(44.225)	(-0.23)
Loans Growth Rate (%)	9.896	8.856	422 /325	5.329	6.073	478 /453
	(24.883)	(25.897)	(0.55)	(19.338)	(22.757)	(-0.54)
Deposit Growth Rate (%)	6.959	6.411	421 /325	3.925	3.498	478 /452
	(17.351)	(14.802)	(0.52)	(13.144)	(10.446)	(0.55)

Table 2 reports the mean values of various measures of activities for banks in our main sample for the period December 1925 - June 1929. Standard deviations are in parenthesis. "National" refers to national banks, and "State" refers to state Fed-member banks. Columns (3) and (6) report the number of observations for national and state Fed-member banks, respectively, as well as two-sample t-statistics for mean differences between national and state Fed-member banks within the state. Ratios are defined as relative to total assets, except for the Surplus Ratio which is surplus profit divided by total equity. Securities comprise bonds and other securities. Growth rates are calculated as log-changes. Observations are bank-by-time.

Table 3: Summary Statistics (December 1929 - December 1932)

	New Jersey			New York		
	National	State	# of Obs. (t-value)	National	State	# of Obs. (t-value)
Total Assets ($1,000)	7,255	13,000	401 /324	4,997	7,705	518 /484
	(8,954)	(26,100)	(-3.79)	(3,591)	(14,900)	(-3.89)
Cash Ratio (%)	10.890	10.741	398 /322	10.612	9.743	518 /484
	(5.166)	(5.197)	(0.38)	(6.648)	(5.279)	(2.30)
Loan Ratio (%)	47.898	52.821	398 /322	48.840	50.430	516 /484
	(13.635)	(12.545)	(-5.04)	(14.355)	(14.155)	(-1.76)
Securities Ratio (%)	35.358	29.950	398 /321	36.922	34.905	516 /484
	(13.270)	(12.524)	(5.60)	(14.503)	(14.734)	(2.18)
Capital Ratio (%)	14.288	16.314	398 /322	15.291	14.090	518 /484
	(6.872)	(7.721)	(-3.68)	(8.961)	(4.393)	(2.72)
Surplus Ratio (%)	44.514	48.729	400 /322	54.134	56.162	518 /484
	(16.581)	(13.147)	(-3.81)	(16.742)	(14.297)	(-2.07)
Cash Growth Rate (%)	0.457	0.123	396 /320	0.488	0.212	514 /482
	(42.124)	(41.871)	(0.11)	(40.124)	(45.896)	(0.10)
Securities Growth Rate (%)	4.989	-0.943	396 /318	4.455	-0.340	511 /482
	(36.829)	(34.343)	(2.22)	(27.455)	(31.986)	(2.53)
Loans Growth Rate (%)	-6.662	-5.000	396 /320	-4.723	-2.763	512 /481
	(22.942)	(24.922)	(-0.92)	(15.208)	(23.209)	(-1.56)
Deposit Growth Rate (%)	-2.166	-4.199	396 /320	-1.496	-2.577	511 /482
	(17.799)	(14.786)	(1.67)	(12.169)	(13.692)	(1.31)

Table 3 reports the mean values of various measures of activities for banks in our main sample for the period December 1929 - December 1932. Standard deviations are in parenthesis. "National" refers to national banks, and "State" refers to state Fed-member banks. Columns (3) and (6) report the number of observations for national and state Fed-member banks, respectively, as well as two-sample t-statistics for mean differences between national and state Fed-member banks within the state. Ratios are defined as relative to total assets, except for the Surplus Ratio which is surplus profit divided by total equity. Securities comprise bonds and other securities. Growth rates are calculated as log-changes. Observations are bank-by-time.

Table 4: Bank Risk (Dec. 1925 - Jun. 1929)

	(1) Cash Ratio	(2) Cash Ratio	(3) Cash Ratio	(4) Cash Ratio	(5) Capital Ratio	(6) Capital Ratio	(7) Capital Ratio	(8) Capital Ratio
NJ	-0.007		0.059		-0.062		-0.098	
	(0.687)		(0.676)		(1.243)		(1.220)	
State Fed-member	-0.917**	-0.543	-0.866*	-0.336	-0.752	0.177	-1.082	0.230
	(0.429)	(0.406)	(0.453)	(0.419)	(0.986)	(0.848)	(0.895)	(0.675)
State Fed-member x NJ	0.806	0.478	0.825	0.578	0.580	-0.122	1.410	0.935
	(0.656)	(0.695)	(0.623)	(0.632)	(1.304)	(1.349)	(1.056)	(0.838)
Log Bank Age			0.128	0.389*			-0.250	-0.289
			(0.178)	(0.221)			(0.330)	(0.317)
Lag Log Assets			-0.176	-0.565**			-2.072***	-2.874***
			(0.192)	(0.247)			(0.338)	(0.321)
County FE	No	Yes	No	Yes	No	Yes	No	Yes
Time (Semi-annual) FE	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.009	0.101	0.010	0.113	0.001	0.156	0.157	0.378
Observations	1674	1674	1674	1674	1674	1674	1674	1674

Table 4 reports results from regressions of the cash ratio and capital ratio, each as defined in Section 4.2, on a indicator variable for New Jersey banks, an indicator for state Fed-member banks, and their interaction, for the period December 1925 - June 1929. Log(Bank Age) is the natural log of years since the bank was established, and Lag Log Assets is the one-period (6 month) lagged value of the natural log of total bank assets. Standard errors are clustered by county. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5: Deposit Growth Rates (Dec. 1925 - Jun. 1929)

	(1) $\Delta\log$ Dep_t	(2) $\Delta\log$ Dep_t	(3) $\Delta\log$ Dep_t	(4) $\Delta\log$ Dep_t	(5) $\Delta\log$ $Dep_t < 0$	(6) $\Delta\log$ $Dep_t < 0$	(7) $\Delta\log$ $Dep_t < 0$	(8) $\Delta\log$ $Dep_t < 0$
NJ	3.135***		1.920		-0.081***		-0.070***	
	(1.007)		(1.179)		(0.024)		(0.024)	
State Fed-member	-0.419	-0.552	-0.926	-1.130	0.013	0.012	0.033	0.023
	(0.569)	(0.519)	(0.892)	(0.856)	(0.025)	(0.030)	(0.027)	(0.031)
State Fed-member x NJ	-0.199	-0.024	0.275	0.559	0.044	0.045	0.019	0.019
	(1.224)	(1.347)	(1.141)	(1.207)	(0.053)	(0.060)	(0.055)	(0.062)
Log Bank Age			-2.234***	-1.539***			0.024*	0.016
			(0.500)	(0.538)			(0.013)	(0.016)
Lag Cash Ratio			0.021	-0.093			0.011***	0.013***
			(0.138)	(0.145)			(0.003)	(0.003)
Lag Cap. Ratio			0.684***	0.865***			-0.006***	-0.007***
			(0.144)	(0.166)			(0.002)	(0.002)
Lag Log Assets			-0.641*	-0.682*			0.032**	0.045***
			(0.325)	(0.371)			(0.014)	(0.015)
County FE	No	Yes	No	Yes	No	Yes	No	Yes
Time (Semi-annual) FE	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.010	0.030	0.179	0.220	0.005	0.036	0.032	0.069
Observations	1671	1671	1671	1671	1671	1671	1671	1671

Table 5 reports results from regressions of the change in the natural log of deposits, or an indicator for a net deposit outflow, on an indicator variable for New Jersey banks, an indicator for state Fed-member banks, and their interaction, for the period December 1925 - June 1929. The lag of the cash ratio is the one-period (6-month) lagged value of the ratio of cash holdings to total assets, and the lag capital ratio is the one-period lag of the ratio of bank equity to total assets, each as defined in Section 4.2. Log(Bank Age) is the natural log of years since the bank was established, and Lag Log Assets is the one-period lagged value of the natural log of total bank assets. Standard errors are clustered by county. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 6: Deposit Growth Rates (Dec. 1929 - Dec. 1932)

	(1) $\Delta\log$ Dep_t	(2) $\Delta\log$ Dep_t	(3) $\Delta\log$ Dep_t	(4) $\Delta\log$ Dep_t	(5) $\Delta\log$ $Dep_t < 0$	(6) $\Delta\log$ $Dep_t < 0$	(7) $\Delta\log$ $Dep_t < 0$	(8) $\Delta\log$ $Dep_t < 0$
NJ	-0.670		-0.493		0.042*		0.039	
	(0.754)		(0.959)		(0.024)		(0.025)	
State Fed-member	-1.081	-0.512	-1.139	-0.613	0.008	-0.002	0.016	-0.000
	(0.776)	(0.794)	(0.699)	(0.687)	(0.027)	(0.030)	(0.028)	(0.030)
State Fed-member x NJ	-0.952	-1.624*	-2.364**	-2.748**	0.057	0.063	0.083**	0.079**
	(0.851)	(0.909)	(0.943)	(1.039)	(0.039)	(0.039)	(0.037)	(0.039)
Log Bank Age			-0.874*	-0.117			0.029*	0.003
			(0.499)	(0.490)			(0.016)	(0.018)
Lag Cash Ratio			-0.362***	-0.279**			0.010***	0.007**
			(0.110)	(0.121)			(0.003)	(0.003)
Lag Cap. Ratio			0.584***	0.627***			-0.012***	-0.011***
			(0.190)	(0.197)			(0.003)	(0.003)
Lag Log Assets			0.791***	0.534*			-0.018**	0.002
			(0.264)	(0.270)			(0.008)	(0.011)
County FE	No	Yes	No	Yes	No	Yes	No	Yes
Time (Semi-annual) FE	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2	0.002	0.115	0.072	0.179	0.005	0.104	0.034	0.123
Observations	1709	1709	1709	1709	1709	1709	1709	1709

Table 6 reports results from regressions of the change in the natural log of deposits, or an indicator for a net deposit outflow, on an indicator variable for New Jersey banks, an indicator for state Fed-member banks, and their interaction, for the period December 1929 - December 1932. The lag of the cash ratio is the one-period (6-month) lagged value of the ratio of cash holdings to total assets, and the lag capital ratio is the one-period lag of the ratio of bank equity to total assets, each as defined in Section 4.2. Log(Bank Age) is the natural log of years since the bank was established, and Lag Log Assets is the one-period lagged value of the natural log of total bank assets. Standard errors are clustered by county. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 7: Panel Regressions

	(1) Δlog (Dep_t)	(2) Δlog (Dep_t)	(3) Δlog (Dep_t)	(4) Δlog (Dep_t)
Crisis	-6.478***	-25.792***		
	(1.157)	(6.751)		
State Fed-member	-0.690	-0.834	-1.096	-1.156
	(0.723)	(0.832)	(0.860)	(0.921)
State Fed-member x NJ	0.030	0.218	0.646	0.754
	(0.947)	(1.138)	(1.252)	(1.385)
State Fed x Crisis	-0.588	-0.188	0.488	0.474
	(0.917)	(1.147)	(1.198)	(1.292)
NJ x Crisis	-2.809*	-2.312	0.305	-30.472***
	(1.521)	(1.423)	(1.181)	(7.105)
NJ x State Fed x Crisis	-2.401*	-2.714	-3.397*	-3.740*
	(1.416)	(1.700)	(1.898)	(2.059)
County FE	Yes	Yes	Yes	No
Bank Controls	Yes	Yes	Yes	Yes
Crisis x Bank Controls	No	Yes	Yes	Yes
Time (Semi-Annual) FE	No	No	Yes	No
County x Time FE	No	No	No	Yes
Adjusted R^2	0.172	0.185	0.249	0.247
Observations	3382	3382	3382	3382

Table 7 reports results from regressions of the change in the natural log of deposits on an indicator variable for New Jersey banks, an indicator for state Fed-member banks, an indicator for the crisis period, and their interactions. The lag of the cash ratio is the one-period (6-month) lagged value of the ratio of cash holdings to total assets, and the lag capital ratio is the one-period lag of the ratio of bank equity to total assets, each as defined in Section 4.2. Log(Bank Age) is the natural log of years since the bank was established, and Lag Log Assets is the one-period lagged value of the natural log of total bank assets. Standard errors are clustered by county. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 8: Bank Charter Composition Before and After Adoption of Double Liability

Year	Arizona	Arkansas	Mississippi	Nevada	New Hampshire	Oregon
1905	0.62	0.91	0.90	0.81	0.23	0.69
1906	0.65	0.90	0.90	0.85	0.24	0.73
1907	0.67	0.90	0.90	0.77	0.24	0.66
1908	0.69	0.89	0.89	0.78	0.24	0.69
1909	0.73	0.89	0.89	0.73	0.24	0.65
1910	0.74	0.89	0.90	0.69	0.25	0.67
1911	0.75	0.89	0.90	0.68	0.25	0.69
1912	0.75	0.89	0.90	0.68	0.25	0.68
1913	0.77	0.89	0.91	0.67	0.26	0.67
1914	0.78	0.88	0.91	0.68	0.29	0.67
1915	0.78	0.87	0.91	0.68	0.30	0.67
1916	0.80	0.85	0.91	0.68	0.30	0.68
1917	0.80	0.85	0.91	0.68	0.32	0.69
1918	0.77	0.84	0.91	0.70	0.32	0.68
1919	0.78	0.83	0.91	0.70	0.32	0.67
Adoption Year	1912	1912	1914	1911	1911	1912

Table 8 reports the ratio of state chartered banks to state and nationally chartered banks from 1905 through 1914, for states that changed the liability rules governing state banks from single to double liability between the years 1911 and 1914. The final row reports the year in which the state adopted double liability for state chartered banks.

Table 9: Bank Charter Composition and Liability Structure in 1926

	(1) # State / # State + National	(2) # Fed-member / # State
Single Liability	0.000	0.042
	(0.054)	(0.030)
Constant	0.677***	0.078***
	(0.025)	(0.014)
Adjusted R^2	-0.022	0.019
Observations	47	47

Table 9 reports results from regressions of the fraction of state and national banks that are state banks, and the fraction of state Fed-member and non-member banks that are Fed-members, on an indicator variable for whether the state is single (and not double) liability. The independent variable is based on liability rules as of 1926, and the regression includes only one observation per state. Only states where state banks were governed by single or double liability are included, which excludes California (unlimited) and Colorado (triple). * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 10: Deposit Rates (1925 and 1927)

	(1) Max Rate	(2) Max Rate	(3) Max Rate	(4) Min Rate	(5) Min Rate	(6) Min Rate
State Fed-member	1.629***	1.626***	1.626***	0.105*	0.105*	0.105*
	(0.086)	(0.099)	(0.100)	(0.046)	(0.047)	(0.045)
Cash Ratio	-0.000		0.007	-0.003		-0.004*
	(0.006)		(0.007)	(0.002)		(0.002)
Capital Ratio		-0.009**	-0.011***		0.000	0.001
		(0.003)	(0.002)		(0.001)	(0.001)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.783	0.791	0.791	0.097	0.095	0.091
Observations	160	160	160	160	160	160

Table 10 reports results from regressions of the maximum and minimum deposit interest rates paid by banks on an indicator variable for state Fed-membership, for the years 1926 and 1928. Only national banks and state Fed-member banks in New Jersey are included in the regression. The the cash ratio is the value of the ratio of cash holdings to total assets, and the capital ratio is the ratio of bank equity to total assets, each as defined in Section 4.2. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

9.2 Figures

Figure 1: Liability Structure by State

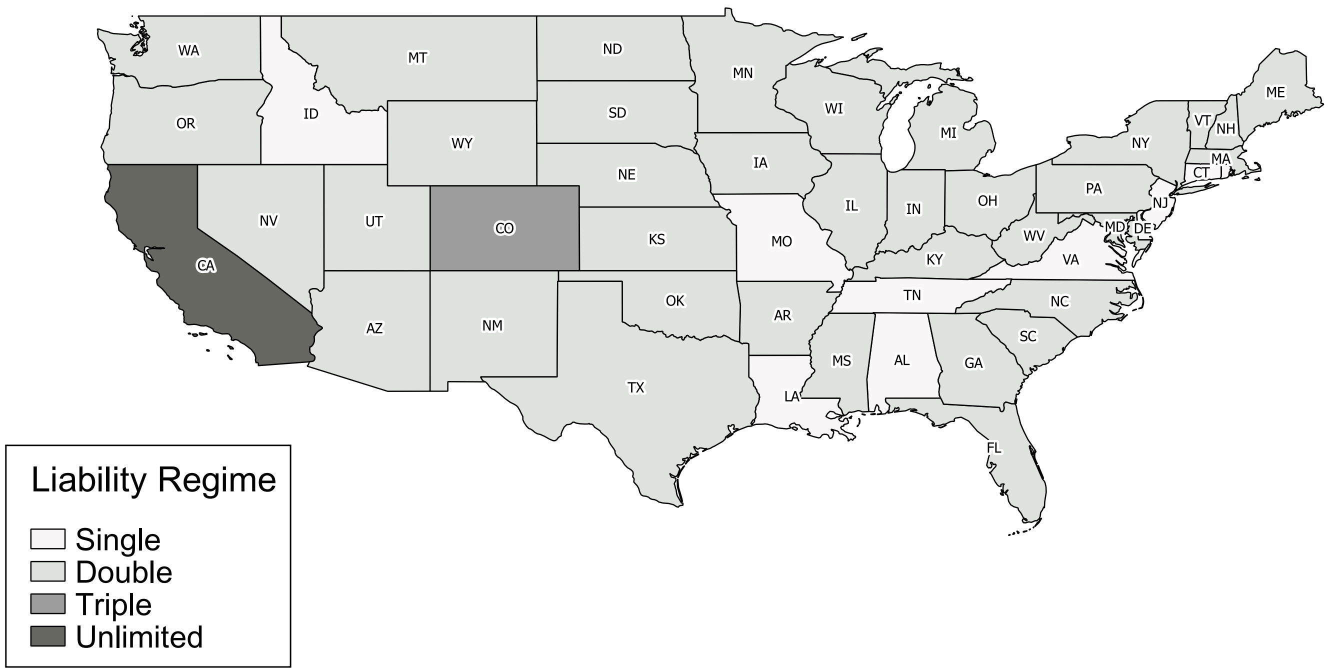


Figure 1 shows bank shareholder liability structure by state in 1930, based on Marquis and Smith (1937).

Figure 2: Time-Series of Cash and Capital Ratios

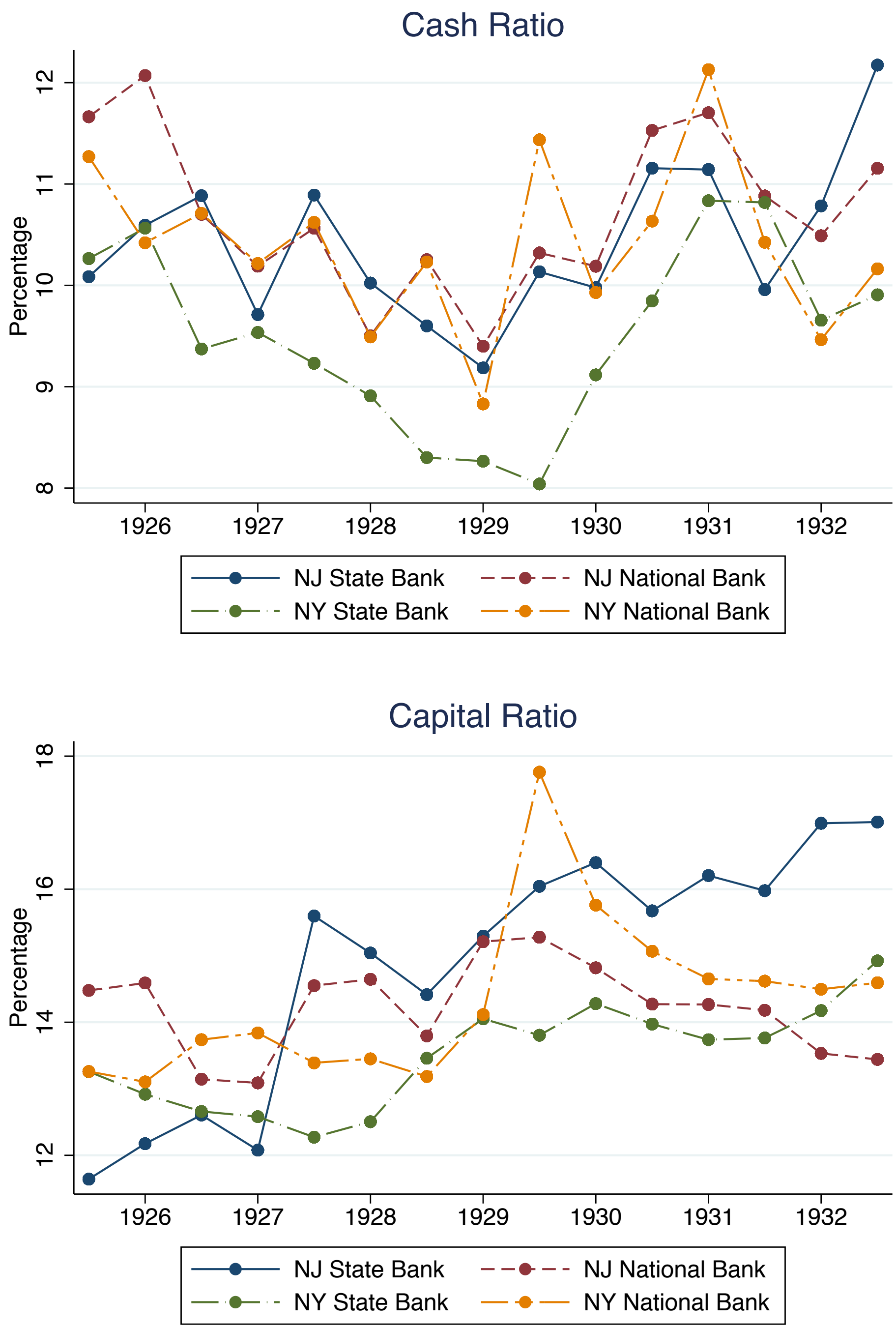


Figure 2 plots the mean value of the ratios of cash holdings to total assets (the cash ratio) and bank equity to total assets (the capital ratio) over time for New York and New Jersey national and state Fed-member banks. Means are computed separately for New York national, New York state Fed-member, New Jersey national, and New Jersey state Fed-member banks.

Figure 3: Change in Log Deposits

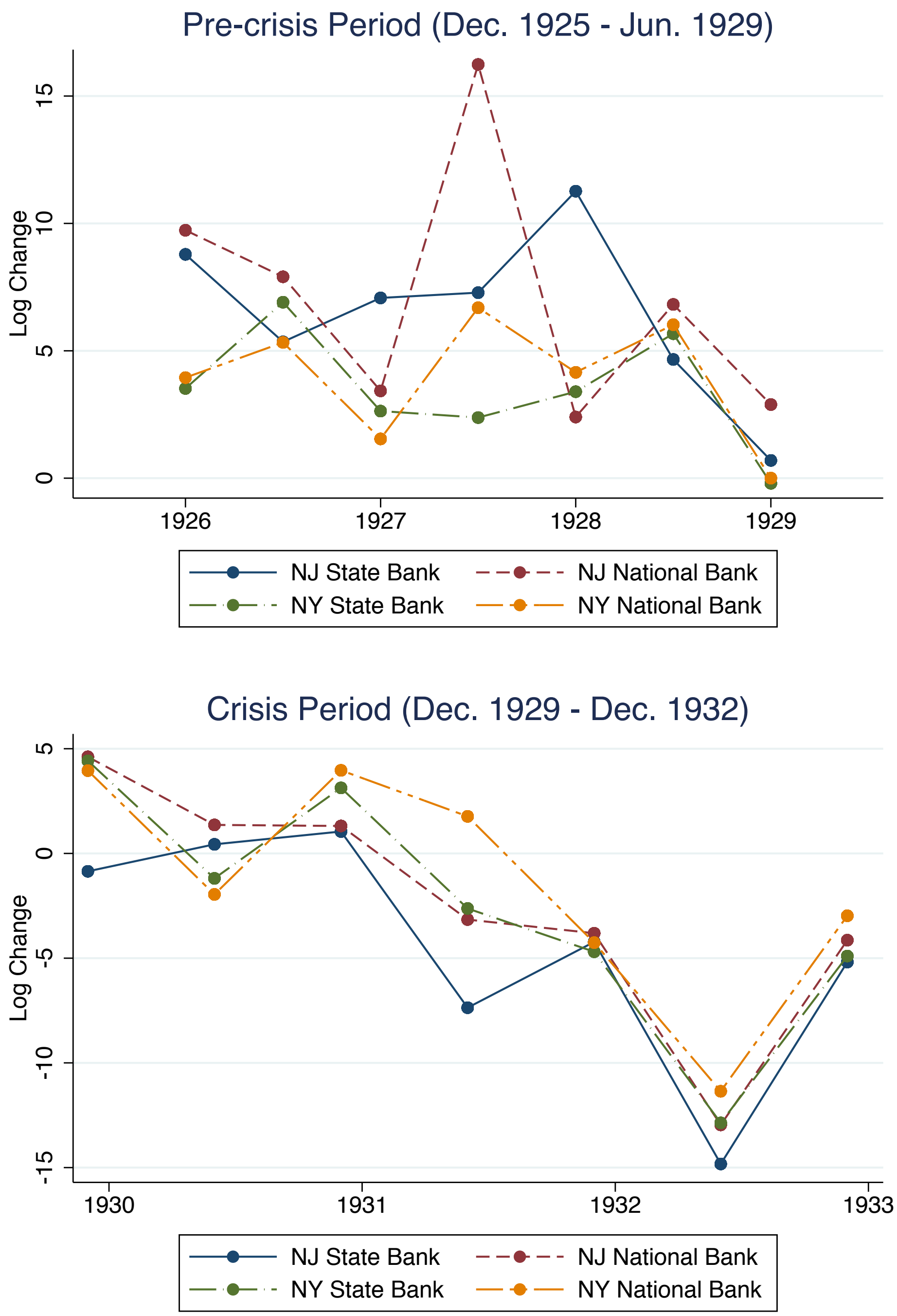


Figure 3 plots the mean change in the natural log of bank deposits for the period prior to the Great Depression (pre-crisis) and during the Great Depression (crisis). The pre-crisis period is December 1925 - June 1929, and the crisis period is December 1929 - December 1932. Means are computed separately for New York national, New York state Fed-member, New Jersey national, and New Jersey state Fed-member banks.

Figure 4: Maximum Deposit Rates

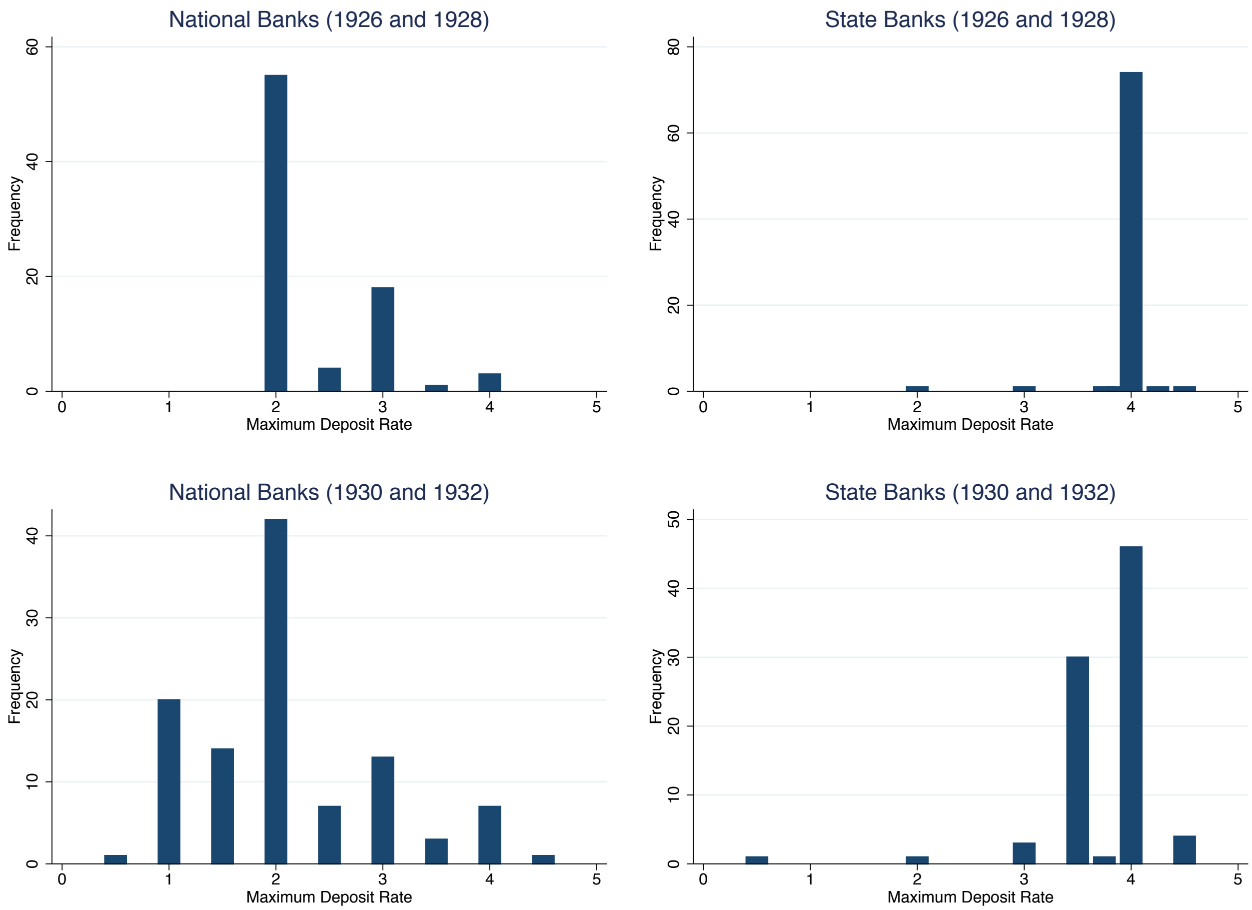


Figure 4 shows histograms of the maximum deposit rates paid by national and state banks in New Jersey, separately, for the years 1926 and 1928, and 1930 and 1932.

Figure 5: Minimum Deposit Rates

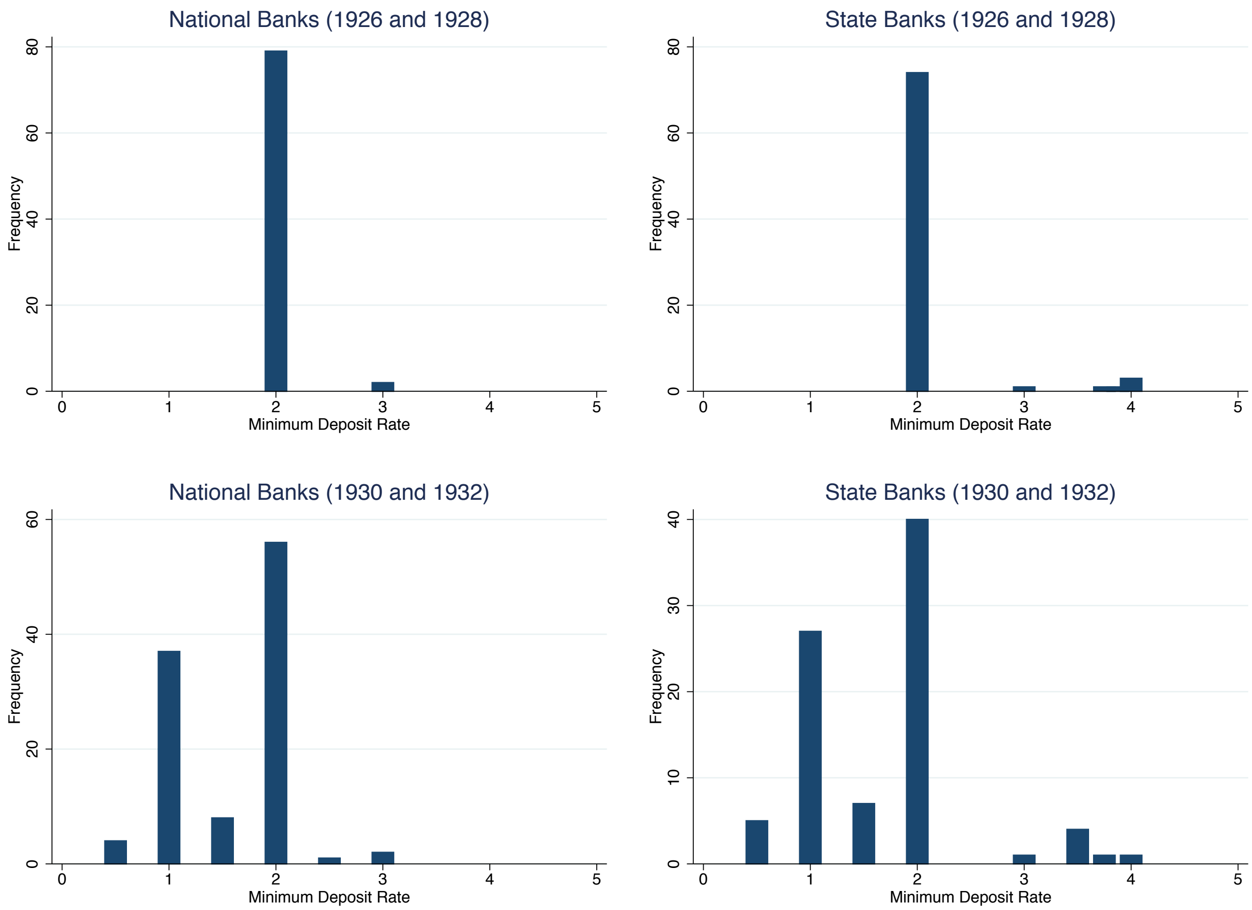
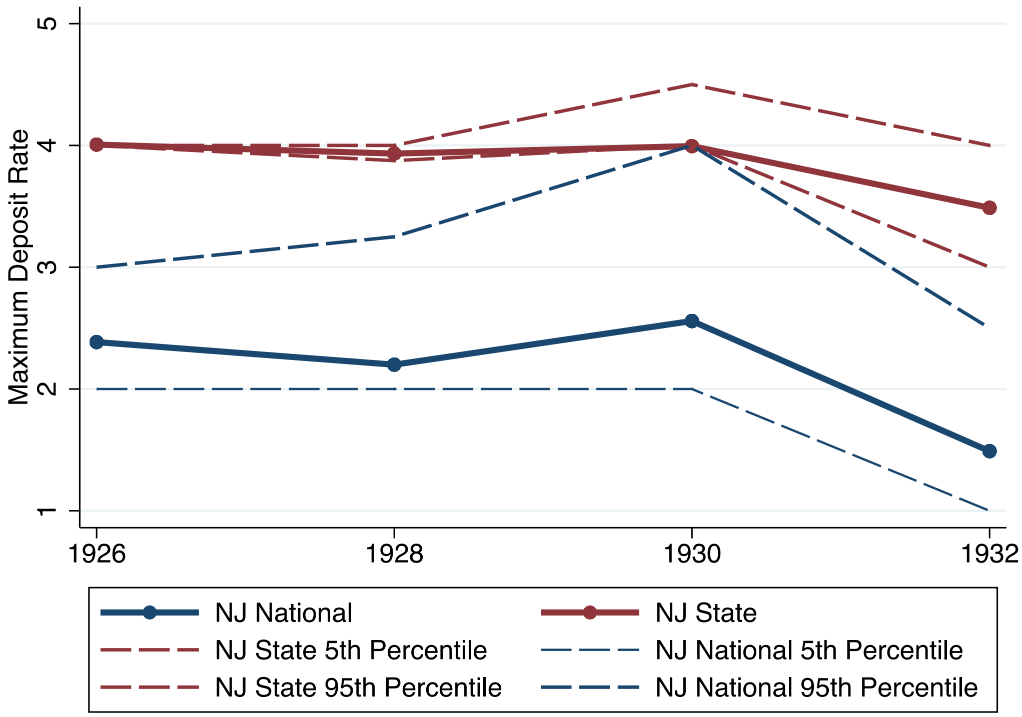


Figure 5 shows histograms of the minimum deposit rates paid by national and state banks in New Jersey, separately, for the years 1926 and 1928, and 1930 and 1932.

Figure 6: Deposit Rates, 1926-1932



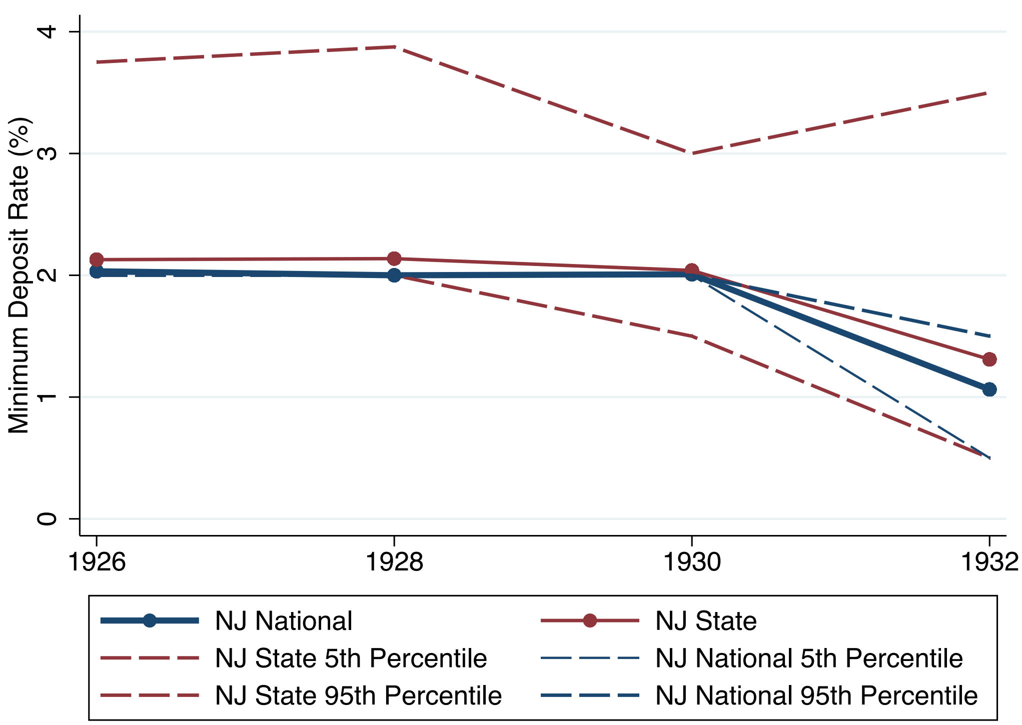


Figure 6 plots the time series of the average maximum and minimum deposit rates, along with the 95% confidence bands, for New Jersey national and state Fed-member banks.

Figure 7: Regulatory Requirements in New York and New Jersey

	National and Fed Members	***New York Nonmembers***	***New Jersey Nonmembers***
Capital Requirements	Population of town less than 3,000 : $25,000 Population of town greater than 3,000 but less than 6,000 : $50,000 Population of town greater than 6,000 but less than 50,000 : $100,000 Population of town more than 50,000 : $200,000 In an outlying district of a town with a population more than 50,000 : $100,000	Population of town less than 2,000 : $25,000 Population of town greater than 2,000 and less than 30,000 : $50,000 Population of town over 30,000 : $100,000	$ 50,000
Reserves Requirements	If not in a reserve or central reserve city: 7% demand deposits and 3 percent time deposits If in a reserve city: 10 % demand deposits and 3 % time deposits If in a central reserve city: 13 % demand deposits and 3 % time deposits	Population of town less than 1,000,000 : 12% of demand deposits with 4 % on hand Population of town over 1,000,000 but less than 1,500,000 : 15 % of demand deposits with 10 % on hand Population of town over 1,500,000 : 18% of demand deposits with 12 % on hand	15% demand deposits
Branching	Yes, as long as it is in the same town as the main office.	Yes, as long as it is in the same town as the main office.	Yes, as long as it is in the same town as the main office.

Sources: *Federal Reserve Bulletins*, *Annual Report of the New York State Banking Department* (1930), *Laws of New Jersey Relating to Banks and Banking Trust Companies and Safe Deposit Corporation* (1932).

Figure 7 shows the regulatory requirements for banks in New York and New Jersey.

Figure 8: Information on Deposit Rates in the National Bank examination reports

INDIVIDUAL DEPOSITS

1. State minimum and maximum rate of interest paid on open accounts. Certificates of deposit.
   2% on public funds 4%
2. Whether a proper record of all certificates of deposit, cashier's checks, and certified checks issued is regularly kept in a book for that purpose.
   Yes
3. Does bank retain all canceled certified checks or take receipts for any delivered?
   Yes
4. If bank conducts "savings department," give method of verifying pass books and rate of interest, and state whether interest is paid quarterly, semiannually, or annually, and date last credited.
   By comparison; 4%; S. A. 6-30-26
5. State whether previous notice of savings deposit withdrawals are provided for and number of days' notice provided for.
   Yes; 30 days
6. Give total of dormant ledger. How are withdrawals safeguarded?
   None
7. State whether surrendered certificates are properly canceled and filed in numerical order for auditing.
   Yes
8. State whether certificates, cashier's checks, certified checks, individual, savings, and dormant ledgers were audited at this examination, and were certificates of deposit checked against list taken at previous examination.
   Yes
9. State whether a numerical list of outstanding certificates of deposit was made for use at next examination.
   Yes

Figure 8 shows deposit rate information in the national bank examination reports.

Figure 9: Information on Deposit Rates in the New Jersey State Bank reports

Interest to Depositors	Dividends to Stockholders	Number of Depositors December 31	Number of Deposits Bearing Interest	Total Amount of Deposits Bearing Interest	Rate Per Cent of Interest on Deposits
$173,849.48	$30,000.00	9,044	8,895	$4,781,325.74	2 —4
5,887.70	....	1,413	814	139,787.00	2, 4
149,283.31	....	11,913	9,262	2,879,317.56	2, 4
159,098.17	60,000.00	7,577	6,206	4,658,858.04	2, 4
....	....	....	....	....	....
1,063,139.60	265,000.00	29,931	25,584	28,870,279.69	2 —4
23,626.66	5,500.00	1,663	1,142	600,003.36	4
64,832.66	12,000.00	10,193	5,095	1,409,879.34	2, 4
34,495.91	....	7,776	4,375	991,846.72	2 —4
269,371.04	68,000.00	12,242	9,504	5,525,556.00	2 —4

Figure 9 shows deposit rate information in the New Jersey state bank reports.

A Appendix

A.1 Model Appendix

In this section, we presents an example where introduction of double liability *promotes* banks' risk shifting incentives using our model in Section 3. Concretely, we derive and compare risk shifting thresholds under single liability (denoted by $\overline{Lev}_1$) and double liability (denoted by $\overline{Lev}_2$) as derived in equations (1) and (2) in Section 3. This is the maximum amount of leverage for which the bank will choose asset G. Note that risk shifting incentives are stronger if this risk shifting threshold is lower. Hence, our focus is the case with $\overline{Lev}_1 > \overline{Lev}_2$.

Denote the *ex ante* likelihood of a bank run under single and double liability as β^* and β^*_{double}. We then have:

$$\beta^* = \int_{\alpha^*}^{1} \alpha dF_{\tilde{\alpha}}(\alpha),$$

and

$$\beta^*_{double} = \int_{\alpha^*_{double}}^{1} \alpha dF_{\tilde{\alpha}}(\alpha),$$

where α^* and α^*_{double} are from (3) and (6), with $\alpha^* < \alpha^*_{double}$ as discussed in Section 3.4.

We argue that the loss of market discipline under double liability could exacerbate the risk shifting problem. As an extreme example, we consider a case with $F_{\tilde{\alpha}}$ leading to $\beta^*_{double} = 0$ such that depositors never withdraw under double liability.[32] Hence, market discipline disappears entirely under double liability.

We begin with deriving the risk shifting threshold under single liability ($\overline{Lev}_1$), allowing depositor withdrawals at $t = 1$. Under single liability with a possible run, the banker's expected payoff with asset G, denoted by $\pi^E_{G,1}$ is

$$\pi^E_{G,1} = p_G R(D+E) - r p_G D,$$

and the payoff with asset B, denoted by $\pi^E_{B,1}$, is

$$\pi^E_{B,1} = (1-\beta^*) \times \Big(p_B R'(D+E) - r p_B D\Big) + \beta^*(\ell A - D)$$

[32] This is possible if $\int_{\alpha^*_{double}}^{1} dF_{\tilde{\alpha}}(\alpha) = 0$.

as with probability β^*, the depositors withdraw at $t = 1$ leading to asset liquidation, which leaves the banker $\ell A - D$ after paying to the depositors.

Hence, $\pi^E_{G,1} < \pi^E_{B,1}$ if

$$\frac{A}{E} > \frac{p_G R - (1-\beta^*) p_B R' - \beta^* \ell}{\{p_G - (1-\beta^*) p_B\} r - \beta^*} \equiv \overline{Lev}_1. \tag{11}$$

Again, $\overline{Lev}_1$ is the maximum amount of leverage under single liability for which the bank would still choose asset G, with a possible bank run when choosing asset B. For simplicity, we choose ℓ such that $\ell D = A$ under this leverage level. That is, the banker gets nothing after paying to the depositors at $t = 1$, which makes

$$\overline{Lev}_1 = \frac{p_G R - (1-\beta^*) p_B R'}{\{p_G - (1-\beta^*) p_B\} r}.$$

We next derive the risk-shifting threshold under double liability ($\overline{Lev}_2$). Under our assumption of no depositor withdrawal with double liability ($\beta^*_{double} = 0$), this is the same case as in Section 3.2. Hence, as shown previously, risk shifting arises if A/E is greater than $\overline{Lev}_{double} = \frac{p_G(R+1) - p_B(R'+1)}{(p_G - p_B)(r+1)}$, thus we have

$$\overline{Lev}_2 = \frac{p_G(R+1) - p_B(R'+1)}{(p_G - p_B)(r+1)}.$$

Hence, $\overline{Lev}_1 > \overline{Lev}_2$ here can be written as

$$\frac{p_G R - (1-\beta^*) p_B R'}{\{p_G - (1-\beta^*) p_B\} r} > \frac{p_G(R+1) - p_B(R'+1)}{(p_G - p_B)(r+1)},$$

which becomes

$$\beta^* p_B R' (p_G - p_B)(r+1) + (p_G R - p_B R')(p_G - p_B) > (p_G - p_B)^2 r + \beta^* p_B r (p_G R - p_B R' + p_G - p_B).$$

Since $R' > R$, a sufficient condition of the above is

$$\beta^* p_B R' (p_G - p_B)(r+1) + (p_G R - p_B R')(p_G - p_B) > (p_G - p_B)^2 r + \beta^* p_B r (p_G R' - p_B R' + p_G - p_B),$$

which becomes

$$\beta^* p_B R'(r+1) + p_G R - p_B R' > (p_G - p_B)r + \beta^* p_B r(R'+1),$$

and thus

$$(1-\beta^*)p_B(R'-r) < p_G(R-r).$$

Hence, greater risk-shifting will occur under double-liability when either (i) β^* is large enough, and/or $p_B(R'-r) - p_G(R-r)$, which is positive by A3, is not too large. The first factor captures a decrease in market discipline under double liability compared to single liability; and the second factor captures the benefit of risk-shifting. In sum, if double liability significantly weakens market discipline imposed by depositors under single liability, it could adversely promote risk-shifting by banks.

A.2 Robustness

Table A.2 shows results from three sets of robustness checks for our main specifications in Table 6. Panel A reports results for the same specification as in column (4) of Table 6, but with the dependent variable (log deposit growth) trimmed at various levels. Panel B reports results from a similar analysis, but with the dependent variable winsorized rather than trimmed. Finally, Panel C reports results from the linear probability model in column (8) of Table 6, but with the dependent variable trimmed in the same manner as in Panel A.

As in Table 6, the focus is on the State Fed Member x NJ interaction term, which under our identification assumption measures the effect of single liability compared to double liability. The coefficients generally decrease in magnitude as the trimming and winsorizing become more severe, but this is unsurprising given effect of large outflows (and inflows) on the average treatment effect. Further, the coefficients remain statistically significant in almost all specifications, which suggests our results are robust to excluding a small set of high-value observations.

Table 11: Deposit Growth Robustness (Jun. 1929 - Dec. 1932)

PANEL A: TRIMMING

Dep. Variable: $\Delta\log(Dep_t)$	(No Trim)	(1 & 99)	(2 & 98)	(5 & 95)	(10 & 90)	(25 & 75)
State Fed Member	-0.613	-0.925*	-0.940*	-0.917**	-0.873**	-0.752***
	(0.687)	(0.500)	(0.492)	(0.432)	(0.378)	(0.252)
State Fed Member x NJ	-2.748**	-1.652**	-1.420**	-1.319**	-1.136**	-0.792**
	(1.039)	(0.742)	(0.611)	(0.556)	(0.553)	(0.329)
Lag Cash Ratio	-0.279**	-0.270**	-0.187**	-0.126	-0.150***	-0.115***
	(0.121)	(0.102)	(0.075)	(0.081)	(0.036)	(0.028)
Lag Cap. Ratio	0.627***	0.358***	0.248**	0.135*	0.077	0.078**
	(0.197)	(0.110)	(0.101)	(0.069)	(0.063)	(0.033)
Lag Log Assets	0.534*	0.490*	0.390	0.531*	0.404*	0.266*
	(0.270)	(0.269)	(0.263)	(0.272)	(0.207)	(0.147)
Observations	1709	1679	1645	1541	1369	857

PANEL B: WINSORIZING

Dep. Variable: $\Delta\log(Dep_t)$	(No Winz.)	(1 & 99)	(2 & 98)	(5 & 95)	(10 & 90)	(25 & 75)
State Fed Member	-0.613	-0.633	-0.978*	-0.858*	-0.796*	-0.829***
	(0.687)	(0.627)	(0.532)	(0.464)	(0.410)	(0.271)
State Fed Member x NJ	-2.748**	-2.043**	-1.489*	-1.614***	-1.410***	-0.856***
	(1.039)	(0.946)	(0.755)	(0.585)	(0.456)	(0.270)
Lag Cash Ratio	-0.279**	-0.274**	-0.250**	-0.207**	-0.182**	-0.117***
	(0.121)	(0.113)	(0.102)	(0.091)	(0.073)	(0.036)
Lag Cap. Ratio	0.627***	0.460***	0.384***	0.265***	0.184***	0.099***
	(0.197)	(0.124)	(0.098)	(0.072)	(0.058)	(0.034)
Lag Log Assets	0.534*	0.387	0.346	0.355	0.388*	0.226*
	(0.270)	(0.245)	(0.252)	(0.230)	(0.207)	(0.117)
Observations	1709	1709	1709	1709	1709	1709

PANEL C: PROBABILITY OF DEPOSIT OUTFLOW

Dep. Variable: $Pr(\Delta\log(Dep_t)) < 0$	(No Trim)	(1 & 99)	(2 & 98)	(5 & 95)	(10 & 90)	(25 & 75)
State Fed Member	-0.000	0.004	0.004	0.009	0.015	0.024
	(0.030)	(0.029)	(0.030)	(0.032)	(0.034)	(0.037)
State Fed Member x NJ	0.079**	0.080**	0.082*	0.084*	0.084	0.116**
	(0.039)	(0.039)	(0.042)	(0.044)	(0.052)	(0.046)
Lag Cash Ratio	0.007**	0.007**	0.006**	0.006*	0.008***	0.009**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.004)
Lag Cap. Ratio	-0.011***	-0.011***	-0.010**	-0.009**	-0.008*	-0.009*
	(0.003)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
Lag Log Assets	0.002	-0.001	0.000	-0.007	-0.007	-0.004
	(0.011)	(0.012)	(0.012)	(0.014)	(0.015)	(0.021)
Observations	1709	1679	1645	1541	1369	857

Table 11 reports results from various robustness tests. Panel A repeats specifications from column (4) of Table 6, but trims the dependent variable (deposit growth rates) at the specified values. Panel B repeats Panel A but winsorizes instead of trims. Panel C repeats the specifications in column (8) of Table 6, but with the dependent variable trimmed as in Panel A. Bank age is included as a control but not displayed and is insignificant in all specifications. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 12: Panel Regressions

	(1) $\Delta\log$ $Dep_t < 0$	(2) $\Delta\log$ $Dep_t < 0$	(3) $\Delta\log$ $Dep_t < 0$	(4) $\Delta\log$ $Dep_t < 0$	(5) $\Delta\log$ $Dep_t < 0$
Crisis	0.294***	0.309***	1.168***		
	(0.024)	(0.024)	(0.244)		
State Fed-member	0.006	0.020	0.023	0.021	0.023
	(0.026)	(0.025)	(0.028)	(0.030)	(0.032)
State Fed-member x NJ	0.046	0.029	0.018	0.018	0.014
	(0.056)	(0.054)	(0.057)	(0.063)	(0.067)
State Fed x Crisis	-0.005	-0.009	-0.016	-0.019	-0.018
	(0.038)	(0.039)	(0.043)	(0.048)	(0.051)
NJ x Crisis	0.116***	0.096***	0.102***	0.002	-0.150***
	(0.032)	(0.033)	(0.027)	(0.035)	(0.041)
NJ x State Fed x Crisis	0.015	0.043	0.066	0.060	0.060
	(0.059)	(0.058)	(0.065)	(0.072)	(0.076)
County FE	Yes	Yes	Yes	Yes	Yes
Bank Controls	No	Yes	Yes	Yes	Yes
Crisis x Bank Controls	No	No	Yes	Yes	Yes
Time (Semi-Annual) FE	No	No	No	Yes	Yes
County x Time FE	No	No	No	No	Yes
Adjusted R^2	0.120	0.145	0.147	0.203	0.242
Observations	3383	3382	3382	3382	3382

Table 12 reports results from regressions of an indicator for a net deposit outflow on an indicator variable for New Jersey banks, an indicator for state Fed-member banks, an indicator for the crisis period, and their interactions. The lag of the cash ratio is the one-period (6-month) lagged value of the ratio of cash holdings to total assets, and the lag capital ratio is the one-period lag of the ratio of bank equity to total assets, each as defined in Section 4.2. Log(Bank Age) is the natural log of years since the bank was established, and Lag Log Assets is the one-period lagged value of the natural log of total bank assets. Standard errors are clustered by county. Standard errors in parenthesis. * denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.