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Limited Deposit Insurance Coverage and Bank Competition

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Abstract

Deposit insurance designs in many countries place a limit on the coverage of deposits in each bank. However, no limits are placed on the number of accounts held with different banks. Therefore, under limited deposit insurance, some consumers open accounts with different banks to achieve higher or full deposit insurance coverage. We compare three regimes of deposit insurance: No deposit insurance, unlimited deposit insurance, and limited deposit insurance. We show that limited deposit insurance weakens competition among banks and reduces total welfare relative to no or unlimited deposit insurance.

Keywords: Limited deposit insurance coverage, deposit rates, bank competition.

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1. Introduction

During the Free Banking Era and the Great Depression banks faced deposit runs, where small depositors simultaneously withdrew their deposits triggering illiquidity and default on otherwise healthy financial institutions. The financial crisis of 2008 brought a new type of "bank runs", which involved the non-traditional "shadow" banking system, and where financial institutions ran on other financial institutions.[1] The most significant institutional change since the Great Depression that prevented the traditional type of bank runs was the presence of deposit insurance. This paper focuses on two aspects of the design of the deposit insurance that have not received much attention in the academic literature and the importance of which became evident during the 2008 financial crisis.

The first aspect of the deposit insurance design is that insurance is partial in the sense that it has limited coverage. The second aspect is that the deposit insurance limit applies to one institution per depositor account but is unlimited with respect to the number of accounts with different banks all of which are subject to the same deposit insurance limit. Our paper addresses the question of how limited deposit insurance coverage affects the intensity of competition in the deposit market. We also explore the effects of limited deposit insurance on consumer welfare as well as total welfare compared with systems of unlimited or no deposit insurance.

Our study initially documents a few stylized facts on the demand for multiple deposit accounts across different banks. We demonstrate that wealthier U.S. households hold multiple deposit accounts with multiple deposit institutions. The demand for multiple accounts correlates positively with the financial wealth of U.S. households. Further, the average amount deposited in accounts that exceed the deposit insurance limit is approximately at most three times the deposit insurance limit, thus, making it feasible for depositors with partially insured deposit accounts to achieve full insurance by distributing their deposits among several banks. We further document that smaller banks, which are deemed riskier, attract more insured brokered certificates of deposits as compared to larger banks. During the recent financial crisis, however, both small and large banks experienced an equally large increase in the share of insured brokered deposits.

[1] See Gorton (2010) and Gorton (2012) for analysis of the recent financial crisis in historical perspective.

We next develop a stylized theoretical model of deposit market competition with the feature that some consumers diversify their funds across different banks in order to qualify for complete deposit insurance coverage. We establish that a system with limited deposit insurance coverage softens deposit market competition as compared to systems with unlimited or no deposit insurance. We further show that limited deposit insurance reduces consumer welfare and total welfare not only by inducing depositors to bear costs of opening several accounts, but also by weakening competition in the deposit market.

We build on an extensive literature which has examined the role of deposit insurance for social welfare. Following the seminal contribution by Diamond and Dybvig (1983), the literature has typically analyzed deposit insurance systems within the framework of models focusing on bank runs. Diamond and Dybvig (1983) demonstrated how the interaction between pessimistic depositor expectations may generate bank runs as an inefficient Nash equilibrium, and how deposit insurance systems can eliminate such inefficient equilibria. Subsequently, an important and extensive category of studies, exemplified by Keeley (1990), Matutes and Vives (2000), and Shy and Stenbacka (2004), has explored the consequences of imperfect competition for deposits on the risk-taking incentives by banks. For example, Matutes and Vives (2000) characterize in detail the roles played by limited liability, deposit insurance with complete coverage, and deposit market competition for the determination of risk-taking by banks. Also, Matutes and Vives (1996) characterize how the welfare implications of deposit insurance with complete coverage depend on the market structure of the banking industry.

Furthermore, theoretical studies regarding the effects of deposit insurance have typically focused on complete deposit insurance with unlimited coverage. One exception is Manz (2009), who characterizes the optimal level of deposit insurance coverage as well as its determinants. However, Manz (2009) does not analyze the effect of limited deposit insurance coverage on the demand for multiple deposit accounts and the competition in the deposit market.

Empirical studies have presented cross-country evidence regarding the effects of deposit insurance coverage on deposit rates. Penati and Protopapadakis (1988) analyze moral hazard issues generated by deposit insurance. Demirgüç-Kunt and Huizinga (2004) exploit cross-country differences regarding the country-specific features of deposit insurance to conclude that the existence of an explicit insurance policy lowers deposit rates, while at the same time it also reduces market discipline on bank risk taking. Bartholdy, Boyle, and Stover (2003) present evidence that the risk premium is on average over 40 basis points higher in countries without deposit insurance than in countries with deposit insurance. Bartholdy, Boyle, and Stover (2003) argue that the risk premium is a non-linear function of the deposit insurance coverage, a feature which they interpret to mean that the market recognizes that extended deposit insurance coverage makes the moral hazard problems more severe. Pennacchi (2006) shows that the combination of a deposit insurance design which facilitates complete insurance coverage through multiple deposit accounts and mispriced deposit insurance premia has given banks a competitive advantage over money market funds in providing safe haven asset classes.

Since Merton (1978), who applied option pricing to characterize the arbitrage free pricing of deposit insurance premia under costly supervision, the debate on the deposit insurance design has focused on formulating actuarially fair premia that correctly reflect the credit risk that individual banks face. This debate was in the early 1990s accompanied with the introduction of capital requirements imposed by the Basel regulation, which focused on controlling the individual bank credit risk. Since the financial crisis, the paradigm of both capital requirements and the design of deposit insurance premia shifted to analyze the pricing the systemic risk of financial institutions, see Pennacchi (2009). However, neither of these studies nor the policy debate has focused on the effect of the partial insurance design on bank competition.

It should be emphasized that our study analyzes the effects of deposit insurance with limited coverage on deposit market competition without explicitly modeling banks' risky lending decisions. Abstracting from moral hazard issues, we develop a stylized model in order to highlight in a transparent way how deposit insurance systems with limited coverage induce some consumers to diversify their deposits across several banks.[2] Our normative analysis is restricted to the investigation of how deposit insurance systems with limited coverage affect bank profits, consumer

[2] A number of important studies, for example, Hellwig (1998) and Winton (1997), have analyzed the performance of the banking system from the perspective of diversification of economy-wide risks. These studies have typically focused on banks' lending activities. In our model the diversification is caused by the limited coverage of deposit insurance as some consumers split their funds across several banks.

welfare, and total welfare. We do not attempt to address the more challenging issue of how to characterize the socially optimal design of deposit insurance. Instead, the goal of this study is to point out some distortions that arise from partial insurance and do not arise in systems with no or unlimited deposit insurance.

The paper is organized as follows. Section 2 presents some empirical facts regarding the implementation of deposit insurance in the United States. Section 3 constructs a model of deposit market competition. Section 4 analyzes equilibrium deposit rates and profits as well as consumer and total welfare in the absence of deposit insurance. Section 5 introduces unlimited deposit insurance. Section 6 analyzes equilibrium deposit rates and profits as well as consumer and total welfare with limited deposit insurance. Section 7 presents the main results of our analysis by comparing the performance of the banking industry under the three regimes of deposit insurance. Section 8 extends the model to independent bank failures. Section 9 outlines some further extensions. Finally, Section 10 presents some concluding comments.

2. Deposit Insurance and Demand for Multiple Deposit Accounts: Empirical Facts

Since its establishment with the passing of the Banking Act in 1933, the Federal Deposit Insurance Corporation (FDIC) in the United States was designed to insure bank deposits up to a certain dollar amount, called the deposit insurance limit.[3] The rationale for the limited insurance design is twofold: to guarantee financial stability by preventing bank runs, and to provide incentives to monitor the banks.

The intention behind the partial deposit insurance coverage is to protect small and unsophisticated investors, while at the same time to expose the wealthier and better informed investors to the individual bank's credit risk. Being exposed to a bank's credit risk, the wealthier and more sophisticated investors are expected to impose market discipline on banks by withdrawing deposits from banks with lower asset quality. However, the deposit insurance design gives the option to

[3]Partial deposit insurance is also the norm in most countries with explicit deposit insurance. A survey by the IMF Garcia (2000) documents that out of the 78 countries with explicit deposit insurance in 2000, 68 had implemented limited deposit insurance and only 10 countries had unlimited deposit insurance.

these wealthy investors to extend the insurance coverage or even achieve complete deposit insurance by opening multiple deposit accounts with different banks. To achieve full insurance, the number of accounts can be computed by dividing total deposit amounts by the deposit insurance limit.[4]

The FDIC does not provide any official explanation for how the deposit insurance limit was determined and to what extent the two rationales for its design were met. Table 1 displays the historical values of the deposit insurance limit both in nominal terms at the time they were set and in real values measured in 2010 dollar amounts. Table 1 shows that for the average U.S. household the deposit insurance limit was always sufficient to cover the average financial wealth held in deposits and most part of the total financial wealth. Similarly, Figure 1 shows the time series behavior of the real values of the deposit insurance limit, the average deposit, and total financial wealth during the periods between the insurance limit adjustments.

Table 1: FDIC insurance limits 1934-present

Year	Limit (nominal)	Limit (real)	Fin.wealth (real)	Deposits (real)
1934	2,500	40,218	n/a	n/a
1935	5,000	78,434	n/a	n/a
1950	10,000	89,460	119,581	20,439
1966	15,000	99,497	184,555	37,293
1969	20,000	117,384	194,933	39,321
1974	40,000	174,658	181,028	47,361
1980	100,000	261,263	208,522	49,177
2008	250,000	250,000	370,674	69,176

NOTE:All real values are computed using the consumer price index for all items with base year 2008, the financial wealth and deposits are the average real values per U.S. household.
SOURCE: The FDIC, "A Brief History of Deposit Insurance in the United States", FRED database, Census Bureau and Financial Accounts of the United States.

Although the deposit insurance limit once set was continuously eroded by inflation, it was

[4]For example, a depositor with \$1 million could fully insure this amount under the current insurance limit by splitting the amount equally in accounts with four different banks. In August 2013 there were 6,938 FDIC-insured institutions in the U.S. which at the current insurance limit of \$250,000 would allow an individual to be fully insured up to \$1,734,500,000 by splitting the total amount across all 6,938 insured institutions. In addition, the FDIC would insure amounts up to the insurance limit per depositor, per insured bank, for each eligible account ownership category. Eligible account categories include single accounts, certain retirement accounts, joint accounts, revocable trust accounts, irrevocable trust accounts, employee benefit plan accounts, corporation, partnership, unincorporated association accounts and government accounts.

always reset to levels that guaranteed proper coverage of the average deposit balances. In this respect, the deposit insurance design achieved its goal of protecting the small uninformed and unsophisticated investors.[5]

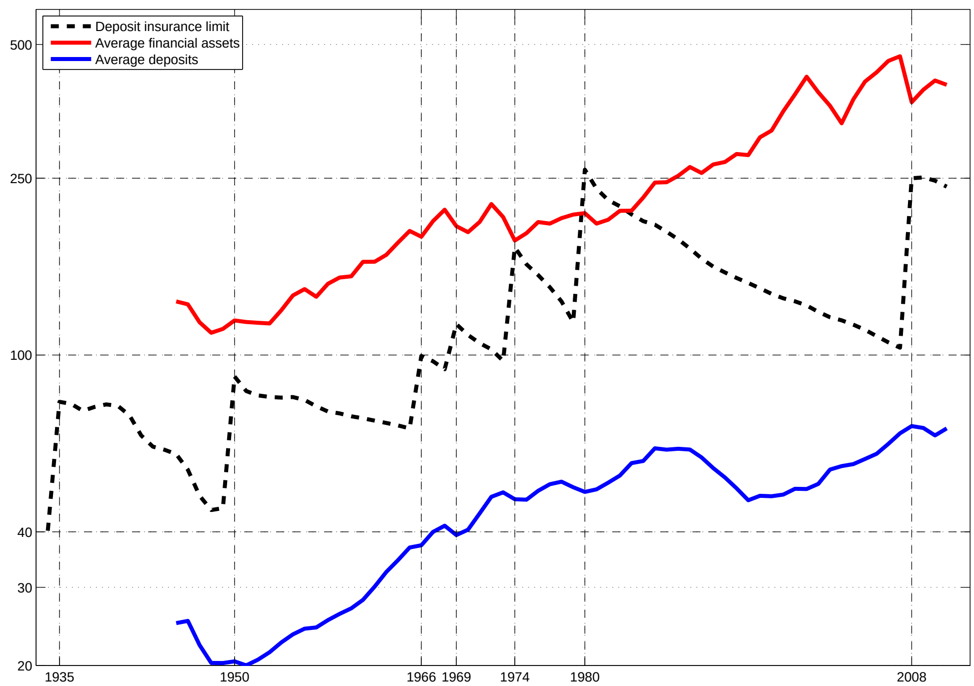
Regarding the second objective that targets wealthy and sophisticated investors to discipline banks, it can be argued that a design with an upper limit on deposit insurance coverage generates a strong demand for multiple deposit accounts. Whereas we do not address the question of how well large and sophisticated investors imposed market discipline on banks, we argue that three factors have contributed to the increasing demand for improved deposit insurance coverage by these investors: First, real economic growth has increased the average incomes and financial wealth of many U.S. households above the levels observed in the 1970s and 1980s. Second, growth in incomes and financial wealth have been disproportionately higher for the wealthiest U.S. households, see Piketty and Saez (2003). Finally, Figure 1 shows that inflation over the period from 1980 until 2008 reduced in half the effective deposit insurance coverage, thereby increasing the fraction of wealthy households not fully insured.[6]

In order to obtain an estimate of the magnitude of the demand for multiple deposit accounts, we use publicly available data on the average deposit balances from the regulatory reports of FDIC insured commercial banks and combine these data with survey data on individual depositor balances from the Survey of Consumer Finances. For data on bank accounts, we use the publicly available data on the total number and the total balance of deposit accounts above the deposit

[5]During the recent financial crisis, the insurance limit was deemed insufficient to guarantee the stability of the payment system and the FDIC implemented the Transaction Account Guarantee (TAG) program that fully insured non-interest bearing transaction deposit accounts. Interest bearing deposit accounts such as interest checking accounts, money market deposit accounts, time deposits and certificates of deposit were kept subject to the limited deposit insurance. As part of the extraordinary measures, the deposit insurance limit which was raised to $250,000 on October 3, 2008 from $100,000 limit which had been in place since 1980. While the TAG program was temporary and expired on December 31, 2012, the new deposit insurance limit was set permanently to $250,000 with the passage of the Dodd-Frank Wall Street Reform and Consumer Protection Act on July 21, 2010.

[6]Further indirect evidence for the rising demand for more extensive deposit insurance through multiple accounts with different banks is the creation of a market that specializes in collecting deposits exceeding the insurance limit and allocating them over the necessary number of different banks to achieve full deposit insurance coverage. For example, the Certificate of Deposit Account Registry Service (CADR) allows individuals, companies, non-profits, and public funds to invest large amounts in one account which CADR splits and places in a network of over 3,000 participating FDIC insured commercial banks. The CDAR is managed by Promontory Interfinancial Network and is protected by U.S. patents US7376606, US7440914, US7596522. For more details see www.cdars.com. CADR acts as a two-sided platform connecting investors seeking complete insurance coverage of their investments with FDIC insured commercial banks seeking funds. Deposits collected and reallocated through the CADR are accounted for as brokered deposits.

Figure 1: The deposit insurance limit, average household financial wealth and deposits (in 2008 USD)



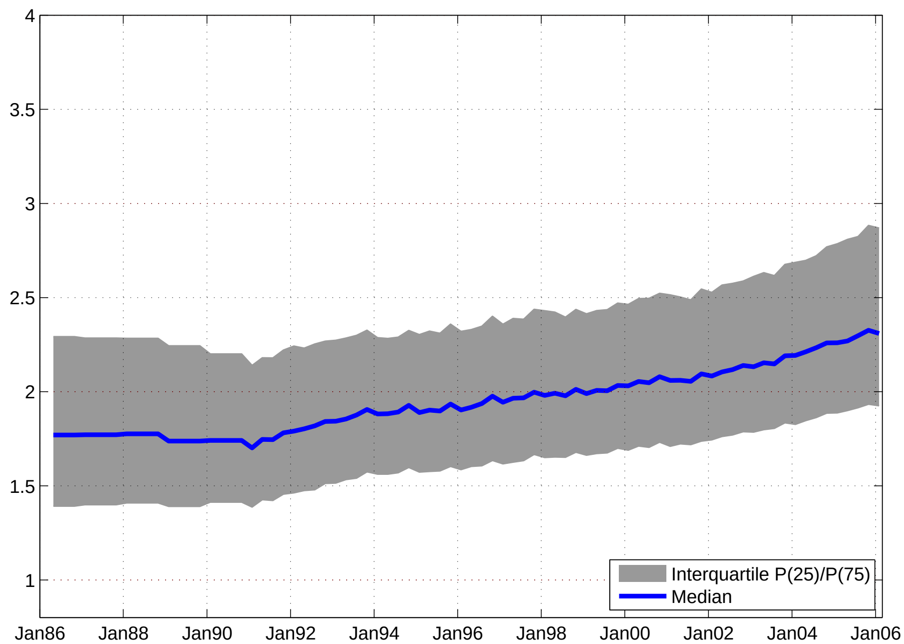
NOTE: All real values are computed using the consumer price index for all items with base year 2008, financial wealth and deposits are the average real values per U.S. household.
SOURCE: FDIC, "A Brief History of Deposit Insurance in the United States", FRED database, Census Bureau and Financial Accounts of the United States

insurance limit to estimate the distribution of average uninsured deposit account balances.[7]

Figure 2 plots the historical variation of the distribution of the average deposit account balances of large denomination accounts at FDIC-insured commercial banks. In addition, Figure 3 plots the empirical cumulative density function of the average account balance held in deposit accounts exceeding the deposit insurance limit of $100,000 in the second quarter of 2008, just a quarter prior to the increase in the deposit insurance limit to $250,000. Approximately, 60 percent of the large denomination deposit accounts were below the new deposit insurance limit and most of the accounts were within two times the new deposit insurance limit. It is evident from these two figures that for most of the time since the deposit insurance limit was set to $100,000 in 1980

[7]The data comes from the regulatory filings of U.S. commercial banks called the Reports on Income and Condition or "Call Reports" which contain quarterly data on banks' balance sheet and income statements. The data are publicly available at Federal Financial Institutions Examination Council https://cdr.ffiec.gov/public.

Figure 2: The inter-quartile range of average partially-insured deposit account balances 1986–2006



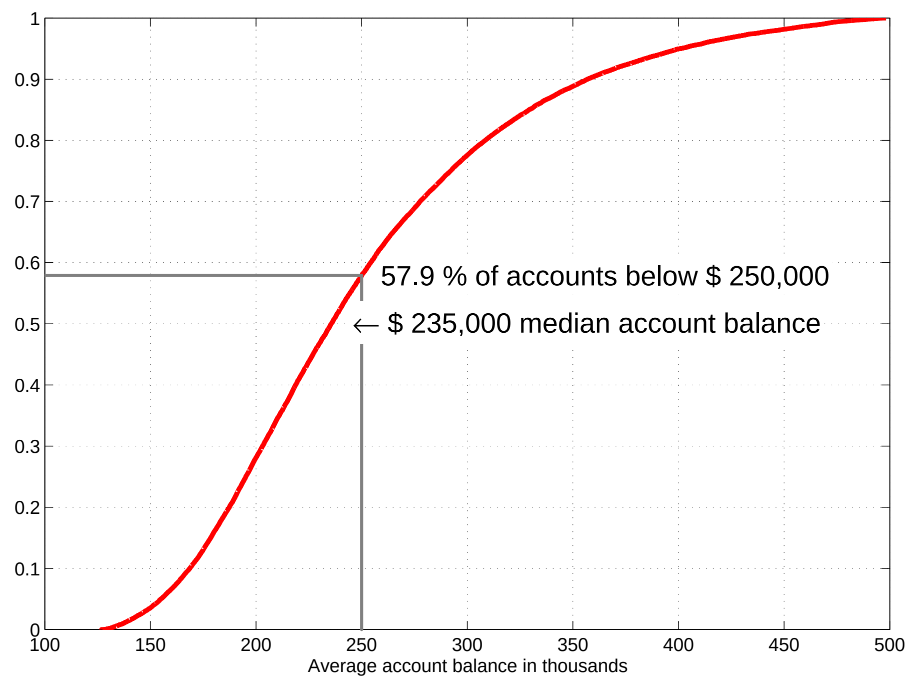
NOTE: The figure plots the inter-quartile range of average balances in large denomination, partially-insured, deposit accounts as a fraction of the insurance limit of $100,000 for the period 1986Q2 to 2006Q1. The average account balance for each bank is computed as the total amount of deposit accounts exceeding $100,000 (item rcon2710) divided by the number of such accounts (item rcon2722).
SOURCE: Reports on Income and Condition (Call Reports)

and until its revision in 2008, large denomination partially insured deposit accounts were within two or three times the deposit insurance limit.

Fact 1. *For the period 1986–2008, the average balance of large denomination, partially-insured, deposit accounts was within two or three times the deposit insurance limit.*

The empirical Fact 1 is a statement about the observed distribution of the average size of large denomination, partially-insured, deposit accounts. Because we do not have information on how many of the existing deposit accounts below the deposit insurance limit are owned by the same individual or firm, we can only make statements regarding the deposit accounts that have not been distributed into multiple institutions. The evidence suggests that, on average, the balance left uninsured in large denomination deposit accounts could be spread over two or three banks to

Figure 3: Empirical cumulative density of average account balances held in deposit accounts exceeding $100,000 in 2008Q2



NOTE: The figure plots the empirical cumulative density function of average deposit account balance for deposit accounts exceeding $100,000 reported by all FDIC insured US commercial banks in 2008Q2. The variable is constructed from the Call Reports as the ratio of the total deposit amount in accounts exceeding $100,000 (item rconf051) to the number of such accounts (item rconf052). As compared to Figure 2, here we use the revised items in the Call reports – item rconf051 replaced item rcon2710 and item rconf052 replaced item rcon2722 in 2006. These new reporting items on the Call reports also reflected the change in the FDIC limit. The FDIC limit was raised to $250,000 on October 3, 2008.
SOURCE: Reports on Income and Condition (Call Reports)

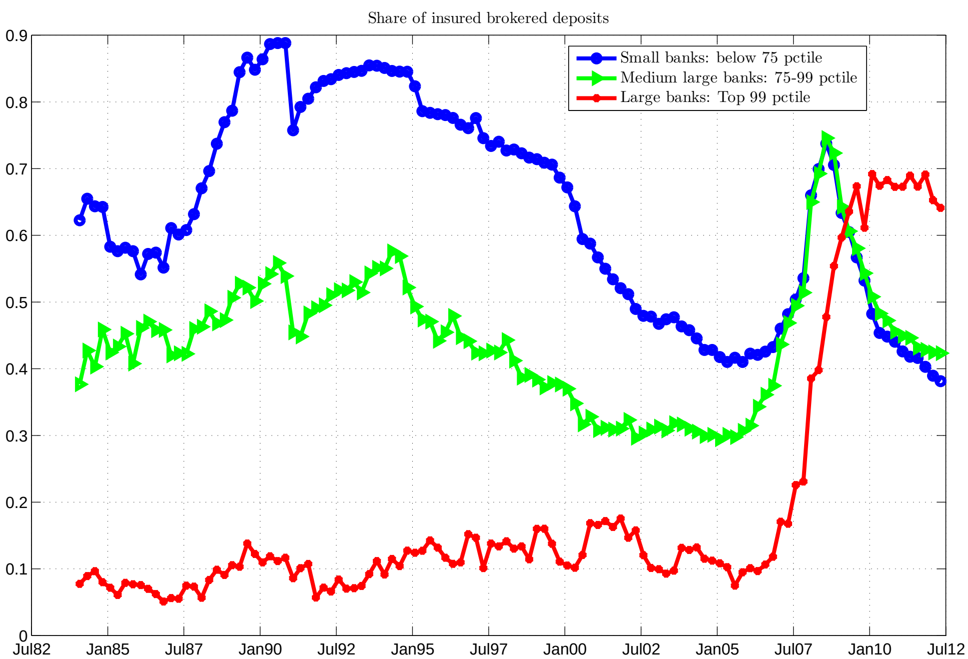
achieve full deposit insurance.

Further evidence regarding the demand for multiple deposit accounts in order to optimize the deposit insurance coverage can be obtained by examining the share of insured brokered deposits.[8] Commercial banks are required to report the total amount of brokered deposits on their balance sheet as well as a breakdown of this amount into insured and uninsured. Figure 4 plots the time series variation of the share of insured brokered deposits on the books of three size classes of banks—small banks with assets below the 75$^{\text{th}}$ percentile, medium large banks with assets

[8]For a legal definition of brokered deposits see FDIC (2011) which was commissioned as a response to regulation introduced by the Dodd-Frank Act.

between the 75th percentile and the 99th percentile, and large banks with assets in the top one percentile of assets. We summarize these observations in the following empirical fact.

Figure 4: Share of insured brokered deposits



NOTE: Computed as the ratio of total insured brokered deposits (item rcon2343) and the total amount of brokered deposits (item rcon2365).
SOURCE: Reports on Income and Condition (Call Reports)

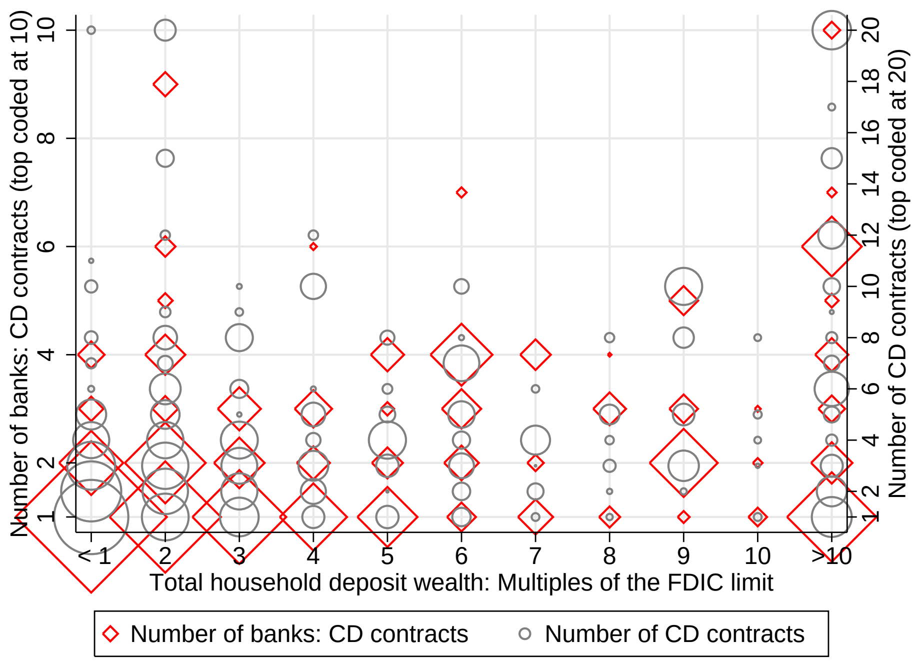
Fact 2. *For most of the period 1982–2008, smaller banks attracted a larger share of brokered insured deposits compared with medium and large size banks. As aggregate default risk increased at the onset of the financial crisis, the demand for deposit insurance increased at banks of all sizes.*

We can think of three reasons that explain the fact that smaller banks carried a higher share of insured deposits. First, on average, smaller banks are more volatile as these banks operate in limited geographic areas and have much less scope for diversification compared with large banks operating in multiple geographical markets. Consequently, these banks rely on retail deposit funding and rarely borrow from the wholesale funding markets. Second, larger banks are implicitly covered by a too-big-to-fail guarantee which is hard to measure, but lowers the perceived likelihood of default. Finally, large banks are more likely to attract larger clients with larger deposit accounts and serve as their primary account custodians. Smaller banks, on the other hand, due to their larger number and the symmetric treatment by the deposit insurance limit, could serve as secondary accounts of depositors who want to achieve higher deposit coverage by distributing their deposits among multiple banks. At the onset of the 2008 financial crisis, the share of insured brokered deposits increased in all types of banks, and the most pronounced increase was recorded in large banks. The evidence suggests that the demand for high deposit insurance coverage increased during that period.

Shifting our attention to the depositors, the Survey of Consumer Finances (SCF) provides evidence regarding the demand for multiple deposit accounts. The survey collects information on the size and allocation of financial assets over different financial institutions from a representative sample of U.S. households. In particular, it surveys households regarding the different bank accounts they have with different financial institutions and their corresponding balances. In Figure 5, we examine the allocation of certificates of deposits over different bank accounts in the 2007 SCF.[9] While a large fraction of households maintain a single account with a single commercial bank, there is also large fraction of wealthy U.S. households maintaining deposit accounts with multiple depository institutions. Households with higher total financial wealth in the form of deposits above the deposit insurance limit are also more likely to hold multiple deposit accounts with different banks. We attribute part of the demand for multiple deposit accounts to the demand for larger insurance coverage.

[9]Households in the 2007 Survey of Consumer Finances are grouped in ten groups according to their total financial wealth deposited with FDIC insured commercial banks. The first group are households with financial wealth within the deposit insurance limit of $100,000. The second group are households with deposits exceeding the deposit insurance limit but no more than two times the deposit insurance limit. The rest of the groups are households with deposits no larger than the corresponding multiple of the deposit insurance limit and greater than the wealth of the preceding group. The tenth group are households with deposits at commercial banks exceeding $1,000,000 (or ten times the deposit insurance limit). The households' deposit wealth as multiples of the FDIC limit is plotted against the allocation of certificates of deposits (CDs). On the left y-axis, we plot the number of commercial banks where CDs are held at (red diamonds). On the right y-axis, we plot the number of CD contracts (grey circles). The size of the marker for both the number of commercial banks and the number of contracts is the relative frequency weighted by aggregate volume of deposits of the observed allocations. In the publicly available version of the SCF, households' deposit allocations into different number of commercial bank accounts and different number of CD contracts accounts are top coded at 10 and 20, respectively.

Figure 5: Deposit insurance limit, financial wealth and deposit allocations



SOURCE: Survey of Consumer Finances, 2007

Fact 3. *According to the Survey of Consumer Finances, a large fraction of wealthy households maintain multiple deposit accounts with multiple depository institutions. There is a strong positive correlation between the average number of CD accounts, the average amount deposited, and the number of banks these accounts are held with.*

3. A Model of Bank Competition

3.1 Banks

There are two financial institutions ("banks" in what follows) that pay interest on deposit accounts. Let r_A and r_B denote the interest rates paid by bank A and bank B, respectively. On each \$1 deposit, a bank earns ρ by lending the money to a risky project or by investing the money in other ways (bonds, stocks, credit default swaps, real estate, and other derivatives).[10] The project

[10]The banks' project return (ρ) and the interest rates paid to individual depositors (r_A and r_B) could also be viewed as real rates. In fact, at the time of completing this article (October 2014), the inflation rate in the United States exceeds 2 percent, whereas interest rates on deposit accounts are below 1 percent. Therefore, our analysis does not rule out

(and hence the investing bank) fails with probability ϕ meaning that the *expected* net return to bank A and B on a \$1 deposit is $(1-\phi)(\rho-r_A)$ and $(1-\phi)(\rho-r_B)$, respectively. Therefore, a bank that fails loses its entire amount of deposits and is not able to pay back the principal and the promised interest to depositors. For reasons of tractability, we will focus on perfectly correlated default risks for banks, but in Section 8 we extend the model to cover independent failure probabilities across banks.

3.2 Depositors

Each consumer is endowed with \$2, and this endowment is initially deposited either in bank A or in bank B. Each consumer has the option to shift the entire deposit (\$2) or part of it to the rival bank. Opening a new account is costly to depositors, but it allows depositors to transfer money to the competing bank.

Depositors are differentiated with respect to two characteristics: their history and the costs associated with opening a new account. We refer to consumers who initially have their entire \$2 deposited with bank A (bank B) as type A (type B) depositors. Type A (similarly, type B) depositors are indexed by their costs of opening a new account with a different bank s, where $0 \le s \le n$. More precisely, the cost of opening a new account to a consumer indexed s is σs, where $\sigma > 0$ is a parameter capturing the magnitude of the cost of switching all or part the deposits. We can also interpret the parameter σ as a measure of the intensity of deposit rate competition between the banks (where lower values of σ imply more intense competition). Further, we assume these switching costs to be uniformly distributed.[11] As shown in Figure 6, depositors with low s have a higher incentive to open a new bank account than depositors with a high s. A type i, $i = A, B$, depositor who is indifferent between opening and not opening a new bank account is denoted in Figure 6 by s_i, $i = A, B$.

negative real interest rates.

[11]Throughout this paper, we use "switching cost" and "cost of opening a new account" interchangeably because initially each consumer has one account with one bank only. Also, there is ample evidence that switching costs are empirically significant in banking markets and that the switching costs are differentiated across consumers; see, for example, Shy (2002), Kim, Kliger, and Vale (2003), and Yankov (2014).

Figure 6: Division of type i depositors between those who open and do not open a new bank account.

3.3 Assumptions

We analyze three regimes of deposit insurance and compute the equilibrium deposit rates under each regime. In order to facilitate the formal analysis of the effects of partial deposit insurance on competition, we have to impose some technical conditions on the relationship between the return on the banks' outside investment project ρ and the bankruptcy probability ϕ. The following conditions are sufficient for ensuring interior equilibrium market shares:

ASSUMPTION 1. *The return on a \$1 investment by a bank is bounded. Formally,*

$$\frac{2n\sigma}{\phi(2-\phi)} - 1 < \rho < \frac{n\sigma(2+\phi)}{\phi(2-\phi)} - 1.$$

Assumption 1 is needed in Section 6 (limited deposit insurance). The lower bound on ρ ensures existence of equilibrium when some depositors split their savings between two banks. The upper bound ensures that some consumers choose not to do so due to sufficiently high switching costs, as reflected by the parameter σ. Note that the interval where ρ is bounded is nonempty as its length equals $n\sigma/(2-\phi) > 0$.

4. No Deposit Insurance

With no deposit insurance, consumers lose their entire deposit(s) with probability ϕ.

The expected utility of a type A depositor $s \in [0, n]$ (initially invested in bank A only) is given by[12]

$$u_A(s) = \begin{cases} (1-\phi)\,2\,r_A - \phi\,2 & \text{if does not open a second bank account} \\ (1-\phi)\,2\,r_B - \phi\,2 - \sigma s & \text{if opens a second account and transfers \$2 to bank } B. \end{cases} \tag{1}$$

Note that (1) ignores a potential third option where a type A depositor opens a second account with bank B but transfers less than \$2 (thereby keeping a positive balance with both banks). In the absence of deposit insurance (and also under unlimited insurance), this option is not beneficial because a depositor that maintains two accounts should transfer the entire amount to the bank that pays the highest interest.

The first term in the first row in (1) , $(1-\phi)2r_A$, is the expected interest payment on the \$2 deposit kept in bank A. The second term, $\phi 2$, reflects the expected loss of a deposit resulting from a failure of bank A. The second row is very similar to the first one, except that the depositor holds the entire \$2 with bank B instead of bank A. The additional term, σs, measures the cost of opening an account with bank B borne by a type A depositor indexed by s. The parameter $\sigma > 0$ captures the magnitude of this cost, and, like switching costs, it can be viewed as a measure of the intensity of deposit market competition (where low values of σ are associated with more intense competition). The case $\sigma = 0$ implies that all depositors can open a second account at no cost. In contrast, higher levels of σ makes this operation more costly and also widens the variation of this cost across depositors (thereby enhancing differentiation across depositors with different values of s).

Similar to (1), the expected utility of a type B depositor $s \in [0, n]$ (initially invested in bank B only) is given by

$$u_B(s) = \begin{cases} (1-\phi)\,2\,r_B - \phi\,2 & \text{if does not open a second bank account} \\ (1-\phi)\,2\,r_A - \phi\,2 - \sigma s & \text{if opens a second account and transfers \$2 to bank } A. \end{cases} \tag{2}$$

The utility function (1) implies that a type A depositor s opens an account with bank B and transfers the entire \$2 deposit if $(1-\phi)\,2\,r_B - \phi\,2 - \sigma s > (1-\phi)\,2\,r_A - \phi\,2$. Similarly, the utility

[12]We do not assume any reservation utility to allow for possible real losses from checking and savings accounts. For example, the deposit rates in the United States are presently below 1-percent whereas the inflation rate exceeds 1.5-percents in 2014. The underlying assumption in this paper is that the expected loss from storing large sums of money "under the mattress" exceeded the loss from bank accounts at times where deposit rates are below the inflation rate. Of course, an alternative approach would be to impose a participation constraint for the depositors.

function (2) implies that a type B depositor s opens an account with bank A and transfers the entire \$2 deposit if $(1-\phi)\,2\,r_A - \phi\,2 - \sigma s > (1-\phi)\,2\,r_B - \phi\,2$. Therefore, type A depositors who open a second bank account (with bank B) and transfer their deposits are characterized by an idiosyncratic switching cost s smaller than a threshold s_A:

$$s < s_A \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_A \geq r_B \\ \dfrac{2(1-\phi)(r_B - r_A)}{\sigma} & \text{if } r_B - \dfrac{\sigma n}{2(1-\phi)} < r_A < r_B \\ n & \text{if } r_A \leq r_B - \dfrac{\sigma n}{2(1-\phi)}. \end{cases} \tag{3}$$

According to (3), type A depositors who face high cost of opening a new account ($s > s_A$) decide not to open a new account. Similarly, type B depositors who open a new bank account with bank A and transfer their deposits are characterized by an idiosyncratic switching cost s smaller than a threshold s_B:

$$s < s_B \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_B \geq r_A \\ \dfrac{2(1-\phi)(r_A - r_B)}{\sigma} & \text{if } r_A - \dfrac{\sigma n}{2(1-\phi)} < r_B < r_A \\ n & \text{if } r_B \leq r_A - \dfrac{\sigma n}{2(1-\phi)}. \end{cases} \tag{4}$$

The nature of the thresholds defined in (3) and (4) implies that if $s_A > 0$ then $s_B = 0$ and if $s_B > 0$ then $s_A = 0$. Intuitively, type B depositors will open a new bank account (with bank A) only if bank A pays a higher deposit rate than bank B, $r_A > r_B$, while type A depositors, in this case, would lose from opening an account with bank B.

With no loss of generality, we derive the equilibrium deposit rates by examining the case where $r_A \geq r_B$ so that $s_A = 0$. In this case, the total volumes of deposits maintained by bank A and bank B are $2(n + s_B)$ and $2(n - s_B)$, respectively. Therefore, the optimization problem facing bank A is to take the interest rate set by bank B as given and decide on its interest rate r_A in order to maximize $\pi_A = (1-\phi)(n + s_B)\,2(\rho - r_A)$, where $\rho - r_A$ is the profit per dollar deposited and $1 - \phi$ is the probability that this bank does not fail. Similarly, bank B determines its interest rate r_B in order to maximize $\pi_B = (1-\phi)(n - s_B)\,2(\rho - r_B)$.

Maximizing profits subject to the thresholds s_A and s_B given in (3) and (4), the equilibrium interest rates and the resulting profit levels are found to be

$$r_A^N = r_B^N = \rho - \frac{\sigma n}{2(1-\phi)} \quad \text{and} \quad \pi_A^N = \pi_B^N = \sigma n^2, \tag{5}$$

where the superscript "N" refers to equilibrium values with *no* deposit insurance. It should be pointed out that, with no deposit insurance, depositors do not benefit from opening a second bank account ($s_A^N = s_B^N = 0$) because, in a symmetric equilibrium, banks pay the same deposit rate.

Next, consumer welfare with no deposit insurance is defined by $cw^N = nu_A + nu_B$, where n is the number (measure) of consumers of each type. Substituting (5) into (1) and (2) yields

$$cw^N = 4n \left[(1-\phi) \left(\rho - \frac{\sigma n}{2(1-\phi)} \right) - \phi \right]. \tag{6}$$

Finally, we define total welfare as the sum of consumer welfare and profits of the banks and we subtract the expected bailout costs associated with the prevailing system of deposit insurance (di). Of course, with no deposit insurance $di = 0$. Hence, from (5) and (6), with no deposit insurance, total welfare (w^N) is given by

$$w^N = cw^N + \pi_A^N + \pi_B^N = 4n \left[(1-\phi)\rho - \phi \right]. \tag{7}$$

From the deposit rate equilibrium (5), as well as welfare expressions (6) and (7), we can apply straightforward differentiation to draw the following conclusions:

Result 1. *Suppose that banks operate without any deposit insurance.*

(a) The equilibrium interest rates (r_A^N and r_B^N), consumer welfare (cw^N), and total welfare (w^N) increase in response to an increase in banks' investment return (ρ), whereas banks' equilibrium profits (π_A^N and π_B^N) are invariant.

(b) An increase in consumers' cost of opening a new bank account (σ) reduces the equilibrium deposit rates (r_A^N and r_B^N) and consumer welfare (cw^N), it increases banks' profits (π_A^N and π_B^N), whereas total welfare (w^N) is invariant.

(c) The equilibrium deposit rates (r_A^N and r_B^N), consumer welfare (cw^N), and total welfare (w^N) decrease in response to an increase in banks' failure probability (ϕ), whereas banks' equilibrium profits (π_A^N and

π_B^N) are invariant.

Result 1(a) reveals that competition between banks guarantees that the gains from higher investment returns for banks that do not fail flow to the depositors in the form of higher deposit rates.

The intuition behind Result 1(b) can be formulated as follows. An increase in the switching cost parameter σ implies that banks have stronger market power that leads to lower equilibrium deposit rates and higher profits. Such an increase in σ induces a redistribution of surplus from consumers to banks. However, because all individuals deposit all their funds with the two banks, this redistribution is neutral from the perspective of total welfare.

Result 1(c) characterizes the equilibrium response to a more fragile banking industry. The qualitative findings reported in Result 1(c) are the mirror image of those reported in Result 1(a). This feature reflects the fact that banks' expected returns $(1-\phi)\rho$ are multiplicative with $(1-\phi)$ and ρ as factors and therefore decline with the default probability ϕ. Furthermore, it should be emphasized that the assumed Bernoulli distribution of asset returns does not allow us to distinguish an increase in default risk from a decrease in expected asset returns. This feature is important for the conclusion that equilibrium deposit rates fall with an increase in the default probability ϕ. Subsection 9.1 demonstrates that this feature need not hold true if we focus on a mean-preserving distribution of asset returns.

5. Unlimited Deposit Insurance

We shift our attention to an environment with unlimited deposit insurance, that is, a system such that all bank accounts are insured to their full amount. In this case, consumers do not face any risk associated with their deposits. In an event of a bank failing to meet its obligation, depositors receive their principal and the promised interest from the insuring agency.

The deposit insurance system can be viewed as a redistributive taxation system. Following an established tradition, we assume that it is funded by a lump sum tax so that we can disregard potential distortions created by this form of taxation. Of course, such distortions could easily be incorporated into the analysis by multiplying the raised tax with a multiplier (larger than one) that represents the social costs associated with those distortions.

Under unlimited deposit insurance, consumers' expected utilities (1) and (2) are simplified to

$$u_A(s) = \begin{cases} 2\,r_A & \text{if does not open a second bank account} \\ 2\,r_B - \sigma s & \text{if opens a second account and transfers \$2 to bank } B. \end{cases} \tag{8}$$

$$u_B(s) = \begin{cases} 2\,r_B & \text{if does not open a second bank account} \\ 2\,r_A - \sigma s & \text{if opens a second account and transfers \$2 to bank } A. \end{cases} \tag{9}$$

The utility function (8) implies that a type A depositor s opens a new account with bank B (and transfers the entire \$2 deposit) if $2\,r_B - \sigma s > 2\,r_A$. Similarly, the utility function (9) implies that a type B depositor s opens an account with bank A (and transfers the entire \$2 deposit) if $2\,r_A - \sigma s > 2\,r_B$. Therefore, with unlimited deposit insurance, the thresholds (3) and (4) are transformed to be

$$s_A \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_A \geq r_B \\ \dfrac{2(r_B - r_A)}{\sigma} & \text{if } r_B - \dfrac{\sigma n}{2} < r_A < r_B \\ n & \text{if } r_A \leq r_B - \dfrac{\sigma n}{2} \end{cases} \quad \text{and} \quad s_B \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_B \geq r_A \\ \dfrac{2(r_A - r_B)}{\sigma} & \text{if } r_A - \dfrac{\sigma n}{2} < r_B < r_A \\ n & \text{if } r_B \leq r_A - \dfrac{\sigma n}{2}. \end{cases} \tag{10}$$

Applying an optimization procedure analogous to the previous section, we now find that the equilibrium deposit rates and the resulting equilibrium profits under unlimited deposit insurance are given by

$$r_A^U = r_B^U = \rho - \frac{\sigma n}{2} \quad \text{and} \quad \pi_A^U = \pi_B^U = (1-\phi)\sigma n^2, \tag{11}$$

where the superscript "U" denotes equilibrium values under *unlimited* deposit insurance. Note that $s_A^U = s_B^U = 0$, because depositors cannot benefit from opening a second account if all banks offer the same interest rate and if all banks are insured to the full amount. Substituting the equilibrium deposit rates (11) into (8) and (9) yields the consumer welfare

$$cw^U = nu_A + nu_B = 4n\left(\rho - \frac{\sigma n}{2}\right). \tag{12}$$

Next, unlike the configuration with no deposit insurance analyzed in the previous section, the presence of deposit insurance introduces an economy-wide cost of funding such an insurance system. Thus, the expected cost of the deposit insurance system should be subtracted from consumer welfare or banks' profit in order to obtain the relevant expected total welfare. The expected bailout cost of deposit insurance is

$$di^U = \phi n\, 2(1 + r_A^U) + \phi n\, 2(1 + r_B^U) = \phi 4n \left(1 + \rho - \frac{\sigma n}{2}\right). \tag{13}$$

Equation (13) captures formally the expected cost of bailing out two failing banks. This expected bailout cost is the product of the failure probability (ϕ), total amount deposited in the two banks ($\$4n$), and the promised interest payment.

Finally, the expected total welfare is obtained by subtracting the expected bailout costs (di^U) from the sum of expected consumer welfare and industry profits. Hence,

$$w^U = cw^U + \pi_A^U + \pi_B^U - di^U = 4n\left[(1-\phi)\rho - \phi\right]. \tag{14}$$

From the deposit rate equilibrium (11), the welfare expressions (12) and (14), as well as the bailout cost (13), we can conduct ordinary comparative statics to draw the following conclusions:

Result 2. *Suppose all bank accounts are covered by unlimited deposit insurance.*

(a) The equilibrium interest rates (r_A^U and r_B^U), consumer welfare (cw^U), bailout costs (di^U), and total welfare (w^U) all increase in response to an increase in banks' investment return (ρ), whereas banks' equilibrium profits (π_A^U and π_B^U) are invariant.

(b) An increase in consumers' cost of opening a new bank account (σ) reduces the equilibrium interest rates (r_A^U and r_B^U), bailout costs (di^U), and consumer welfare (cw^U); it increases banks' profits (π_A^U and π_B^U), whereas total welfare (w^U) is invariant.

(c) An increase in banks' failure probability (ϕ) reduces the equilibrium profits (π_A^U and π_B^U) and total welfare (w^U); it increases bailout costs (di^U), whereas equilibrium interest rates (r_A^U and r_B^U) and consumer welfare (cw^U) are invariant.

Result 2(a) verifies that competition between banks ensures that the gains from higher banks' investment returns flow to depositors in the form of higher deposit rates also with unlimited deposit insurance. In this respect, it is qualitatively identical to Result 1(a) with the exception that a higher return also implies higher bailout costs.

The intuitive explanation for Result 2(b) is identical to that for Result 1(b). The new element included in Result 2(b) is that the induced reduction in deposit rates also reduce the expected bailout costs.

Finally, Result 2(c) formalizes the very intuitive idea that, with unlimited deposit insurance, depositors are perfectly secured against increases in banks' failure rate.

6. Limited Deposit Insurance

In order to exhibit the economic mechanisms in a very transparent way, we introduce a particularly simple form of limited deposit insurance: Each account is insured up to \$1 worth of deposits.[13]

By opening a second account, and bearing the cost σs, a consumer can benefit from complete deposit insurance. More precisely, through diversification by allocating \$1 to each bank, a depositor's entire wealth would be fully insured. In contrast, maintaining a single bank account would save a depositor the cost σs, but would leave \$1 (out of \$2) uninsured. Thus, with limited deposit insurance a depositor faces the following tradeoff: To accept exposure to the risk of a bank failure while avoiding the cost σs of opening a new account or to diversify away the risk caused by a potential bank failure by bearing the cost associated with opening a second account.

Under limited deposit insurance, consumers' expected utilities (1) and (2) are modified to[14]

$$u_A(s) = \begin{cases} 1\,r_A + (1-\phi)1\,r_A - \phi\,1 & \text{does not open a second bank account} \\ 1\,r_A + 1\,r_B - \sigma s & \text{opens a second account and transfers \$1 to bank } B \\ 1\,r_B + (1-\phi)1\,r_B - \phi\,1 - \sigma s & \text{opens a second account and transfers \$2 to bank } B. \end{cases} \tag{15}$$

[13] The assumption that the insurance limit equals exactly half of the initial deposit amount saves us a *tremendous* amount of algebra, because under the computed equilibrium deposit rates, low-cost consumers who open a second account will transfer exactly half their initial deposit to the second account thereby maintaining full insurance coverage. Assuming otherwise would generate oscillations with the feature that each bank attempts to attract consumers to transfer deposit amounts exceeding the insurance coverage. Price oscillations are commonly referred to as "Edgeworth Price Cycles," and occur in oligopolies selling homogeneous products or services. Maskin and Tirole (1988) tackle this problem by using a Markov Perfect Equilibrium, which is beyond the scope of our paper.

[14] For the sake of simplicity, the specification of the utility functions (15) and (16) is incomplete as they omit other possible transfers of lower than \$1 and amounts strictly between \$1 and \$2. Appendix A indeed shows that, in equilibrium with a limited deposit insurance, consumers who open a second account will transfer exactly the amount of the deposit insurance limit, which is \$1.

$$u_B(s) = \begin{cases} 1\,r_B + (1-\phi)1\,r_B - \phi\,1 & \text{does not open a second bank account} \\ 1\,r_B + 1\,r_A - \sigma s & \text{opens a second account and transfers \$1 to bank } A \\ 1\,r_A + (1-\phi)1\,r_A - \phi\,1 - \sigma s & \text{opens a second account and transfers \$2 to bank } A. \end{cases} \tag{16}$$

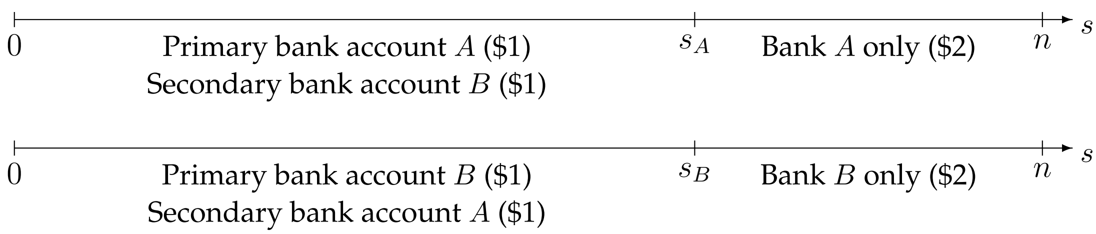
The expected utility (15) demonstrates the consequences of limited deposit insurance. Without diversification, a type A depositor is guaranteed a riskless return of r_A on a \$1 deposit only. The excess deposit of \$1 will provide a return only with probably $1-\phi$, whereas the depositor will lose the \$1 principal with probability ϕ. These features are captured by the first row in (15). The second row in (15) shows that this depositor can eliminate all risks by opening a second account and splitting the initial deposit amount into two separate bank accounts that do not exceed the insurance limit. Lastly, the third row in (15) captures a depositor who opens a second account and completely transfers the entire initial deposit to the new account. In this case, opening a second account would not result in any risk reduction for this consumer because the transfer still leaves \$1 uninsured (with a different bank).

The utility function (15) implies that a type A depositor s opens an account with bank B (and transfers \$1) if $r_A + r_B - \sigma s > r_A + (1-\phi)r_A - \phi$. Therefore, with limited deposit insurance, (3) and (4) become

$$s_A \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_A \geq \frac{r_B+\phi}{1-\phi} \\ \dfrac{r_B - (1-\phi)r_A + \phi}{\sigma} & \text{if } \frac{r_B+\phi-\sigma n}{1-\phi} < r_A < \frac{r_B+\phi}{1-\phi} \\ n & \text{if } r_A \leq \frac{r_B+\phi-\sigma n}{1-\phi} \end{cases}$$
$$\text{and} \quad s_B \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_B \geq \frac{r_A+\phi}{1-\phi} \\ \dfrac{r_A - (1-\phi)r_B + \phi}{\sigma} & \text{if } \frac{r_A+\phi-\sigma n}{1-\phi} < r_B < \frac{r_A+\phi}{1-\phi} \\ n & \text{if } r_B \leq \frac{r_A+\phi-\sigma n}{1-\phi}. \end{cases} \tag{17}$$

Figure 7 illustrates how the two types of consumers allocate their deposits between one or two accounts.

Figure 7: Division of type A (top) and type B (bottom) depositors between those who open and do not open a second bank account.



In view of Figure 7, the banks' profit functions are given by

$$\begin{aligned} \pi_A &= (1-\phi)(\rho - r_A)\left[2(n-s_A) + s_A + s_B\right] \\ \pi_B &= (1-\phi)(\rho - r_B)\left[2(n-s_B) + s_B + s_A\right]. \end{aligned} \tag{18}$$

The term in the brackets in the first row in (18) is the demand facing bank A, which consists of three components: First, bank A maintains the volume $\$2(n - s_A)$ of deposits from type A depositors who remain loyal and do not open a second account. Second, the bank keeps the volume $\$s_A$ of deposits from type A depositors, who decide to split their resources between the two banks. And, third, bank A attracts the volume $\$s_B$ of type B depositors, who each decide to diversify $1 to bank A. Substituting (17) into (18), we find the equilibrium profit-maximizing deposit rates and the associated equilibrium profits under limited deposit insurance to be

$$r_A^L = r_B^L = \rho - \frac{2\sigma n}{2-\phi} \quad \text{and} \quad \pi_A^L = \pi_B^L = \frac{4(1-\phi)\sigma n^2}{2-\phi}, \tag{19}$$

where the superscript "L" denotes equilibrium values with *limited* deposit insurance.

Next, substituting (19) into (17) shows that the equilibrium thresholds determining market segmentation are given by

$$s_A^L = s_B^L = \frac{\phi}{\sigma}\left(1 + \rho - \frac{2\sigma n}{2-\phi}\right) \tag{20}$$

The thresholds (20) are proportional to the cost of opening a new account at which the depositor is indifferent between diversifying $1 to the rival bank in order to qualify of complete deposit insurance or remaining loyal to its present banking relationship. For depositors with a cost of opening a new bank account exceeding this threshold, the benefit from a complete deposit insurance are insufficient to justify the cost of diversification across two banks, whereas the opposite holds true for costs below this threshold. Technically, Assumption 1 guarantees that $0 < s_A^L = s_B^L < n$. In particular, Assumption 1 implies that in equilibrium with limited deposit insurance, the benefits of full deposit insurance exceed the cost of opening a second account for some depositors, more precisely for those with relatively low switching costs.

Formally, by combination of consumers' utility functions (15) and (16), the equilibrium deposit rates (19), and the associated equilibrium segmentation thresholds (20), we find aggregate consumer welfare under limited deposit insurance to be

$$
\begin{aligned}
cw^L = cw_A^L + cw_B^L = & \underbrace{\int_0^{s_A^L} (r_A^L + r_B^L - \sigma s)\, ds + \int_0^{s_B^L} (r_A^L + r_B^L - \sigma s)\, ds +}_{\text{Utility of depositors with two accounts}} \\
& + \underbrace{(n - s_A^L)\left[r_A^L + (1-\phi) r_A^L - \phi\right] + (n - s_B^L)\left[r_B^L + (1-\phi) r_B^L - \phi\right]}_{\text{Utility of depositors with one account}} = \\
& = \frac{\phi^2}{\sigma}\Big(1 + \rho - \frac{2n\sigma}{2-\phi}\Big)^2 + 2n(2-\phi)\Big(1 + \rho - \frac{2n\sigma}{2-\phi}\Big) - 4n
\end{aligned}
\tag{21}
$$

The first component in the first row of (21) is the sum of utilities of depositors with idiosyncratic switching costs below the thresholds (s_A^L, s_B^L) who open two accounts. The component in the second row is the sum of utilities for those depositors who do not open a second account, and therefore do not bear costs of opening a new account.

Next, considering the market segmentation of depositors into depositors with a single account and depositors with two accounts (Figure 7), we compute the expected cost to the deposit insurance fund of bailing out failing banks by summing the effective deposit insurance coverage for each of these segments. Hence,

$$
\begin{aligned}
di^L = & \phi \underbrace{(s_A^L + s_B^L)(2 + r_A^L + r_B^L)}_{\text{Depositors with two accounts}} + \phi \underbrace{\Big((n - s_A^L)(1 + r_A^L) + (n - s_B^L)(1 + r_B^L)\Big)}_{\text{Depositors with one account}} \\
= & 2\frac{\phi^2}{\sigma}\Big(1 + \rho - \frac{2\sigma n}{2-\phi}\Big)^2 + 2\phi n\Big(1 + \rho - \frac{2\sigma n}{2-\phi}\Big).
\end{aligned}
\tag{22}
$$

The first term in the first row in (22) is the expected cost of bailing out type A and type B depositors who split their \$2 evenly between the two banks. For these accounts, the deposit insurance fund covers the full amount and promised interest rates. The second term applies to type A and type B depositors who do not open a second account, in which case only \$1 is insured (out of a total of \$2 deposit). Using (19), (21), and (22), total welfare under limited deposit insurance is given by

$$\begin{aligned} w^L =& cw^L + \pi_A^L + \pi_B^L - di^L = \\ =& 4n((1-\phi)\rho - \phi) - \underbrace{\frac{\phi^2}{\sigma}\Big(1+\rho-\frac{2\sigma n}{2-\phi}\Big)^2}_{s^L}. \end{aligned} \tag{23}$$

The total welfare can be decomposed into two terms. The first term measures the total expected value of investing the aggregate amount of deposits $4n$ in the risky portfolio of banks assets. The expected return per dollar of investment is $(1-\phi)\rho - \phi$.

The second term in (23) takes into account the deadweight losses of the aggregate switching costs incurred by the mass of depositors who open two deposit accounts with the two banks to achieve full deposit insurance. To see this observe that, under limited deposit insurance, s_A^L depositors of type A and s_B^L depositors of type B bear the costs of opening a second account. In view of Figure 7, the aggregate costs of opening a second account are therefore computed to be

$$S^L = \int_0^{s_1} \sigma s \; ds + \int_0^{s_2} \sigma s \; ds = \frac{\phi^2}{\sigma}\Big(1+\rho-\frac{2\sigma n}{2-\phi}\Big)^2. \tag{24}$$

This cost is a component of consumer welfare (21) which also appears in the aggregate welfare (23). As the next section shows, this aggregate switching cost plays a key role when distinguishing the regime with limited deposit insurance from those associated with either no or unlimited deposit insurance.

7. A Comparison of Three Regimes of Deposit Insurance

We are now ready to characterize the effects of limited deposit insurance coverage on equilibrium deposit rates, associated industry profits, consumer welfare, bailout costs and total welfare based on a comparison among the investigated three deposit insurance regimes (no insurance, unlimited, and limited insurance). We start by focusing on total welfare. Comparing (7), (14), and (23), yields the following result:

Result 3. *A regime with limited deposit insurance coverage yields lower total welfare than either no or unlimited deposit insurance. Formally,* $w^L < w^U = w^N$*. Moreover, the reduction in total welfare caused by limited deposit insurance coverage equals the depositors' aggregate costs of opening a second account.*

The second part of Result 3 can formally be verified by adding depositors' aggregate cost (24) to (23), which yields $w^L + S^L = w^U = w^N$.

In our model, the regimes with no deposit insurance and unlimited insurance are efficient from the perspective of total welfare. Under the regime with limited deposit insurance, consumers with sufficiently low switching costs have an incentive to open a second bank account in order to obtain complete deposit insurance. But, the switching costs associated with opening new accounts generate a social deadweight loss.

By comparing the equilibrium deposit rates (5), (11), and (19), we obtain the relationship that $r_k^U - r_k^N = n\sigma\phi/[2(1-\phi)] > 0$, for each bank $k = A, B$. Furthermore $r_k^N - r_k^L = n\sigma(2-3\phi)/[2(1-\phi)(2-\phi)] > 0$, if $\phi < 2/3$. A comparison of (5), (11), and (19) also implies, for each bank $k = A, B$, that $\pi_k^U - \pi_k^N = -n^2\sigma\phi < 0$ and $\pi_k^N - \pi_k^L = -n^2\sigma[3 - 4/(2-\phi)] < 0$, if $\phi < 2/3$. These inequalities prove the following results:

Result 4. *(a) A system with limited deposit insurance coverage softens competition in the deposit market compared with no deposit insurance if the probability of bank default is not too high. Furthermore, competition is always more intense with unlimited than with no deposit insurance. Formally,* $r_k^U > r_k^N > r_k^L$*, for each bank* $k = A, B$*, if* $\phi < 2/3$*.*

(b) The nature of the deposit insurance system determines the banks' equilibrium profits according to the following relationship: $\pi_k^L > \pi_k^N > \pi_k^U$*, for each bank* $k = A, B$*, if* $\phi < 2/3$*.*

According to Result 4(a), limited deposit insurance coverage softens deposit rate competition between banks as long as the probability of bank default is not too high. This feature can be explained according to the following mechanism. Limited deposit insurance relaxes competition for consumers with low switching costs. For these consumers, the benefits associated with deposit insurance outweigh the loss from lower deposit rates. In fact, our formal model endows each bank with some monopoly power over the rival bank's depositors with low switching costs. In equilibrium, each bank's receives a reciprocal mass of switching depositors over which both banks gain some monopoly power.

Result 4(a) could also be explained by reference to the fact that the different deposit insurance systems induce different demand elasticities. To see this, we compare the nature of the demand functions with no deposit insurance and with limited deposit insurance coverage. For the purpose of this argument we focus on bank A. For the case of no deposit insurance the demand function for bank A is given by $2(n + s_B) = 2n + \frac{4(1-\phi)(r_A - r_B)}{\sigma}$ (see Section 4), whereas the demand with limited deposit insurance is given by $2(n - s_A) + s_A + s_B = 2n + \frac{(2-\phi)(r_A - r_B)}{\sigma}$ (see Section 6). By comparing these two demand functions we can conclude that the demand function is less sensitive to a change in the deposit rate difference $r_A - r_B$ in the regime with limited deposit insurance precisely if $\phi < 2/3$. Banks exploit the feature with lower elasticity of demand under limited deposit insurance by paying lower deposit rates. Furthermore, the probability of bank default affect the elasticity of demand in each of the considered systems of deposit insurance in such a way that the deposit rate ranking reported in Result 4(a) hold true as long as $\phi < 2/3$. [15]

Limited deposit insurance coverage essentially relaxes deposit market competition by inducing some depositors to transfer money between banks in order to improve their insurance coverage. From a theoretical perspective, this mechanism resembles how information exchange between lenders (who have established customer relationship) softens lending rate competition by improving banks' ability to target their poaching activities towards specific borrowers from the rival bank.[16]

In addition, Result 4(a) captures the idea that consumers can benefit more from deposit rate competition in a system with unlimited deposit insurance compared with a system offering no deposit insurance. This can be explained as follows. In these two regimes banks compete for deposits in a symmetric way with the only difference that bank competition is supported by a

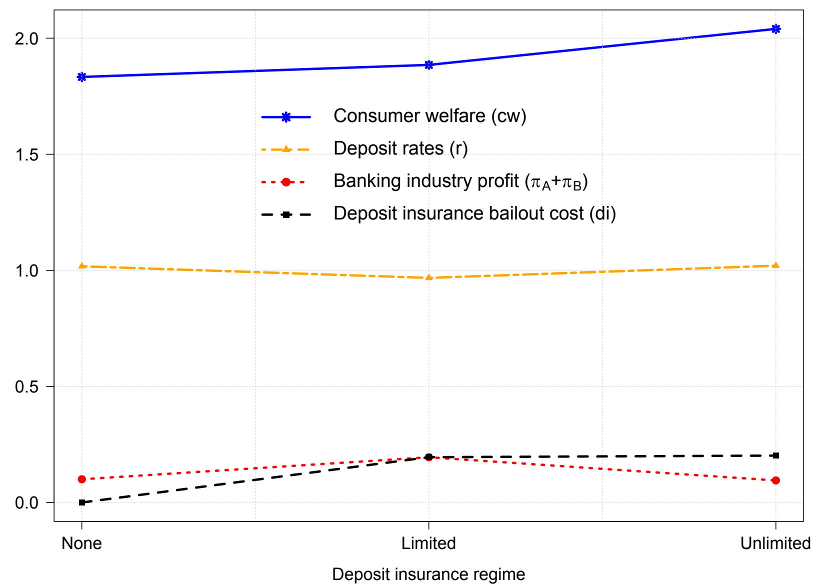
[15] Placed within the framework of a horizon where bank bankruptcies are not too frequent the restriction that $\phi < 2/3$ seems empirically plausible.

[16] Formal two-period models capturing how information exchange softens competition in lending markets have been developed in Bouckaert and Degryse (2004) and Gehrig and Stenbacka (2007).

transfer from the insurance agency to depositors under unlimited deposit insurance, and this transfer intensifies the competition between banks which results in higher deposit rates.

Result 4 is illustrated in Figure 8, which shows a simulation of how equilibrium deposit rates and profits depend on the system of deposit insurance.[17] In particular, Figure 8 demonstrates that limited deposit insurance leads to higher industry profits than unlimited or no deposit insurance simply because both banks pay lower interest on deposit accounts.

Figure 8: Consumer welfare, banks' profit, and deposit insurance bailout cost as functions of three regimes of deposit insurance.



The following result summarizes our comparison of the three regimes of deposit insurance with respect to consumer welfare and the cost of bailing out banks:

Result 5. *(a) Consumer welfare increases with the limit on deposit insurance.*

Formally, $cw^N < cw^L < cw^U$.

(b) Expected cost of bailing out banks increases with the limit on deposit insurance.

Formally, $di^N < di^L < di^U$.

[17]Simulations are based on the following parameter values: Return on bank's investment $\rho = 1.07$, banks' failure probability $\phi = 0.05$, cost parameter $\sigma = 0.2$, and initial measure of depositors with each bank $n = 0.5$.

From Result 3 and Result 4, we can directly conclude that consumers are better off with unlimited (U) compared with limited (L) deposit insurance coverage. That is, because $di^U > di^L$ and $\pi_k^U < \pi_k^L$, it cannot hold true that $w^U > w^L$ unless it also holds true that $cw^U > cw^L$. In other words, consumers unambiguously benefit from unlimited compared with limited deposit insurance coverage.

When comparing limited (L) deposit insurance coverage with no (N) deposit insurance, we can first make use of Result 3 and Result 4 to conclude that the introduction of limited deposit insurance imposes losses on society in the form of expected bailouts or on consumers in the form of switching costs or lower deposit rates. In particular, we know from Result 3 that the sum of these losses exceeds the benefits to banks associated with limited deposit insurance. This explains why consumer welfare is higher under limited deposit insurance compared with no insurance as illustrated in Figure 8.

Result 5(b) does not require a formal proof. It captures the intuitive idea that the expected bailout costs increase as a function of the insurance coverage.

Overall, in light of Result 3, Result 4, and Result 5 we can draw the conclusion that limited deposit insurance introduces a redistribution of surplus between banks and depositors. Limited deposit insurance coverage promotes market power of banks over consumers with small switching costs and this mechanism is the source of the redistribution. Furthermore, we have established that the benefit to banks falls short of the costs to consumers and society when the bailout costs are taken into account. Thus, limited deposit insurance generates a social deadweight loss (costs of opening second bank accounts) compared with systems of unlimited or no deposit insurance.

8. Independent Bank Failures

Our analysis so far has focused on perfectly correlated default risks for banks. This section explores the robustness of our results regarding this assumption by analyzing the configuration where banks face independent default risks. For simplicity, we restrict ourselves to symmetric banks facing identical default risks, measured by the bankruptcy probability ϕ. Under such circumstances, both banks fail with probability ϕ^2, only one bank fails with probabilities $\phi(1 - \phi)$

and $(1-\phi)\phi$, respectively, and none fails with probability $(1-\phi)^2$.

We proceed by examining each of the three deposit insurance regimes separately, and show that the equilibria derived under correlated default risks are identical to the equilibria under independent default risks.

8.1 Independent Bank Failures: No Deposit Insurance

Section 4 established that, in equilibrium, depositors do not open a second account. Furthermore, according to Section 4, if a consumer opens a second account, this consumer transfers the full volume of deposits, i.e. \$2, to the bank that pays the higher interest.

Under independent bank failures, we now examine the possible case (not covered in Section 4) in which some consumers open a second account and transfer half of the amount, so they maintain \$1 with each bank as a diversified portfolio bearing *independent* risks. In this case, the utility function (1) becomes

$$u_A(s) = \begin{cases} (1-\phi)\,2\,r_A - 2\phi & \text{if does not open a second bank account;} \\ (1-\phi)^2(r_A + r_B) + (1-\phi)\phi(r_A - 1) & \text{if opens a second account and} \\ +\phi(1-\phi)(r_B - 1) + \phi^2(-2) - \sigma s & \text{transfers \$1 to bank } B. \end{cases} \tag{25}$$

The first row in (25) is the same as in (1). It characterizes the utility of type A depositors, who keep their entire deposit with bank A. The second alternative in (25) (the second and third rows) captures the expected return associated with opening up a second bank account. The consumer earns $r_A + r_B$ interest if neither bank A nor bank B fails, which happens with probability $(1-\phi)^2$. If only bank B fails (with probability $(1-\phi)\phi$), the consumer earns interest r_A from bank A, but loses the \$1 deposit with bank B. If only bank A fails (probability $\phi(1-\phi)$) the consumer earns interest r_B from bank B, but loses \$1 deposit with bank A. Finally, the consumer loses all his \$2 deposits if both banks fail (with probability ϕ^2).

Comparing the two utilities in (25) reveals that type A depositors who open a second account and transfer \$1 to bank B are characterized by a switching cost lower than a threshold s_A:

$$s < s_A \stackrel{\text{def}}{=} \frac{(1-\phi)(r_B - r_A)}{\sigma}, \tag{26}$$

where we do not display the corner solutions for the sake of brevity. The value of s_A in (26) is proportional to that in (3). This implies a type A consumer opens a second account only if $r_B > r_A$. However, in this case, the consumer is better off transferring the whole deposit ($2) from A to B, which replicates the analysis in Section 4 under correlated bank failures.

8.2 Independent Bank Failures: Unlimited Deposit Insurance

Under unlimited deposit insurance, consumers do not bear any risk and therefore will not open a second account unless the rival bank offers a higher interest. Hence, the analysis of Section 5 applies also to the case of independent bank failures. Still, it is worthwhile to check whether the expected cost of bailing out banks under independent failures is the same as with correlated bank failures, computed in (13).

The expected total bailout cost under unlimited deposit insurance with independent failures is given by

$$\begin{aligned} di^U &= \phi^2\left[2n(1+r_A)+2n(1+r_B)\right]+\phi(1-\phi)\left[2n(1+r_A)\right]+(1-\phi)\phi\left[2n(1+r_B)\right]+(1-\phi)^2 0 \\ &= 2n\phi\left[2(1+\rho)-\sigma n\right], \end{aligned} \tag{27}$$

where the second row is obtained by substituting the equilibrium interest rates from (11) into the first row. The first row in (27) sums up four terms: The expected cost of bailing out two failing banks, expected cost of bailing out bank A only, expected cost of bailing out bank B only, and zero cost of not bailing out any bank (if banks do not fail).

Comparing (27) with (13) reveals that the expected bailout cost is the same independently of whether we focus on independent bank failures or perfectly correlated failures.

8.3 Independent Bank Failures: Limited Deposit Insurance

In view of Figure 7, with limited deposit insurance, s_A and s_B low-cost depositors open a second account and deposit $1 with each bank. Therefore, the equilibrium derived in Section 6 holds also under independent failures.

The expected bailout cost to support limited deposit insurance with independent failures is given by

$$
\begin{aligned}
di^L = \phi^2 & \left[s_A(1 + r_A + 1 + r_B) + (n - s_A)(1 + r_A) + s_B(1 + r_B + 1 + r_A) + (n - s_B)(1 + r_B)\right] \\
& + \phi(1 - \phi)\left[s_A(1 + r_A) + (n - s_A)(1 + r_A) + s_B(1 + r_A)\right] \\
& + (1 - \phi)\phi\left[s_B(1 + r_B) + (n - s_B)(1 + r_B) + s_A(1 + r_B)\right].
\end{aligned} \tag{28}
$$

The first row in (28) is the expected insurance cost of bailing out two failing banks, where in view of Figure 7, s_A type A and s_B type B consumers split their deposits between two banks, whereas $n - s_A$ and $n - s_B$ consumers leave their entire deposit \$2 in a single bank account with only half of this amount being insured under limited deposit insurance. The second row is the expected cost of bailing out bank A only, where s_B type B depositors also keep \$1 of their deposits. Similarly, the third row is the expected cost of bailing out bank B only.

Substituting the equilibrium interest rate (19) and the segmentation thresholds (20) into (28) reveals that the expected insurance cost under independent failures (28) is the same as under perfectly correlated failures (22).

The analysis in subsections 8.1, 8.2 and 8.3 yields the following conclusion.

Result 6. *All the results derived under the assumption that the bank failures are perfectly correlated also apply to a model where the bank failures are realized as independent events. In particular, the expected deposit insurance bailout costs are also the same.*

9. Extensions

9.1 Mean-Preserving Asset Returns

For reasons of a tractability we have focused on a simple return structure which does not make it possible to distinguish between an increase in default risk (increasing ϕ) and a decrease in the expected return on banks' assets. This section conducts a comparative statics analysis to explore how an increase in the probability of default ϕ (without changing the expected return on assets) affects the equilibrium deposit rates and profits.

We focus on a mean-preserving spread of the asset returns modeled as a process $(\tilde{\rho}, \tilde{\phi})$ such that $\phi > \tilde{\phi}$ and $(1 - \tilde{\phi})\tilde{\rho} = (1 - \phi)\rho$. A mean-preserving spread increases the probability of default, but it keeps the expected return unchanged. We can characterize the effects of an increase in the probability of default on the equilibrium deposit rates across the three deposit insurance regimes according to the following result (proof is provided in Appendix B).

Result 7. *Consider a mean-preserving spread of the asset returns of banks. An increase in riskiness leads to (a) higher deposit rates and unchanged profits in equilibrium with no deposit insurance; (b) unchanged deposit rates and lower profits in equilibrium with unlimited deposit insurance; (c) higher deposit rates and lower profits in equilibrium with limited deposit insurance.*

The importance of this result is that, in our model, banks do not have incentives to increase risk even in the presence of deposit insurance. Since we abstract from issues related to moral hazard, this feature of the model allows us to focus on comparing the degree of competition for deposits under the three deposit insurance regimes.

9.2 Multiple Bank Accounts

Solving the general problem where depositors may hold different levels of wealth that would require opening multiple bank accounts is beyond the scope of this paper. In fact, such a model should probably be designed for the purpose of using numerical simulations of a nationwide wealth distribution among depositors, rather than for obtaining closed-form solutions as we offer in our simplified model. Therefore, this section sketches only one way in which the demand side could be formulated when a consumer has a large sum of money that must be deposited in more than two bank accounts in order to secure 100-percent deposit insurance.

Suppose that there is a large number of banks and that all banks pay the same interest rate, r. Consider a depositor with d dollars. Let $\lambda(1 + r)$ denote the deposit insurance limit. If $d \leq \lambda$, the depositor is fully insured and therefore does not have to open a second account. However, if $d > \lambda$, the depositor may benefit from opening additional accounts.

Let $I \stackrel{\text{def}}{=} \text{int}[(d-\lambda)/\lambda]$ and $M \stackrel{\text{def}}{=} (d-\lambda) \bmod \lambda$ be the integer and the remainder parts of the ratio of a depositor's total wealth less than the deposit limit to the deposit limit, respectively. Define two thresholds of the cost of opening an additional bank account by

$$s^{\lambda} \stackrel{\text{def}}{=} \frac{\phi\lambda(2+r)}{\sigma} \quad \text{and} \quad s^{M} \stackrel{\text{def}}{=} \frac{2\phi M(1+r)}{\sigma}. \tag{29}$$

Appendix C proves the following result:

Result 8. *A depositor with a wealth level of d and cost of opening each additional account given by σs will*

(a) not open any additional account if $s \geq \max\{s^{\lambda}, s^{M}\}$;

(b) open I additional accounts if $s^{M} \leq s < s^{\lambda}$;

(c) open $I+1$ additional accounts if $s < \min\{s^{\lambda}, s^{M}\}$.

As expected, the number of additional accounts increases when the cost of opening each account declines (lower values of σ). Higher deposit limit (higher λ) and higher interest (higher r) would induce more consumers to open additional accounts.

10. Conclusion

This study compared the performance of a system with limited deposit insurance coverage to the performance of systems with unlimited or no deposit insurance. In order to achieve this goal, we have developed a stylized model to highlight in a transparent way how a deposit insurance system with limited coverage induces some consumers to diversify their deposits across several banks. Within such a framework, we demonstrate that limited deposit insurance coverage softens competition among banks, thereby introducing a redistribution of surplus from depositors to banks. Furthermore, we establish that the benefits to banks of limited deposit insurance fall short of the costs to consumers and society when bailout costs are taken into account. Thus, limited deposit insurance leads to a loss in total welfare compared with unlimited or no deposit insurance.

The simple model we have designed abstracts from many important issues, and could be extended in different directions. Most importantly, we abstract from moral hazard issues associated with the lending or investment decisions of banks. Models incorporating moral hazard associated with banks' lending/investment activities typically emphasize that deposit insurance offers an option value for banks and that this option value is monotonically increasing as a function of the insurance coverage. In our model, the value to the banks of the deposit insurance is very different in nature, because limited deposit insurance coverage is more profitable to banks than unlimited deposit insurance due to the softening of deposit competition.

Further, we do not formally address the following question: Are depositors always guaranteed to receive the insured amount in the case of bank failure? This need not always be the case because the FDIC does not have sufficient reserves to bail out all banks. However, recent experience shows that governments tend to use taxpayer money to bail out banks when the insurance agency (such as the FDIC) does not have sufficient funds to cover bank losses.[18] But, of course, the funding of such bailout programs would cause distortions which would affect welfare evaluations. The welfare analysis could be extended to incorporate the social costs of such distortions.

For reasons of tractability, we have focused on depositors differentiated by the costs associated with opening a new account, but homogeneous with respect to the volume of their deposit ($2). A natural extension would be to analyze a deposit market where consumers are differentiated also with respect to their available funds. This would make the welfare analysis more complicated as some consumers would not be affected by the deposit limit at all, whereas others would benefit from opening multiple accounts in order to qualify for complete deposit insurance.

It should be emphasized that we have focused on an economy with the feature that the consumers have to deposit their money in a bank, and that they have access to no outside option like a shadow banking system. This restriction is increasingly severe in light of the increase of the institutional cash pools. Actually, as Pozsar (2013) argues, the institutional cash pools have expanded to such an extent in the U.S. that dividing the average institutional cash pool into fully FDIC-insured slices would require more banks than there is in the U.S.

Finally, we have restricted our attention to an evaluation of limited deposit insurance coverage by comparing it with systems with unlimited or no deposit insurance. Clearly, a promising direction for extending our approach would be to characterize the socially optimal deposit insurance coverage. With such an approach it would be possible to more fundamentally characterize which particular factors determine optimal deposit insurance policy.

[18] See a May 28, 2013 *Wall Street Journal* article by Alex Pollock entitled "Deposits Guaranteed Up to $250,000–Maybe," which discusses the legal question whether FDIC insured accounts are backed by the "full faith and credit of the United States Government. Further, Cooper and Kempf (2013) explore the effects of orderly liquidation of failing banks on the emergence of bank runs under circumstances where deposit insurance policies have no commitment power.

Appendix A Existence and Uniqueness of an Equilibrium with Limited Deposit Insurance

The derivation of the equilibrium interest rates (19) under limited deposit insurance ignored the possibility that depositors who open a second account may benefit from transferring more than \$1 (deposit insurance limit). Such an allocation was considered in the third rows of (15) and (16) in which depositors transfer their full \$2 initial endowment to the rival bank and maintain zero balance with their initial bank account.

Our first observation is that in any symmetric equilibrium where banks pay the same interest on deposits (so that $r_A = r_B$), depositors who open a second account transfer exactly \$1. This is because any other way of distributing the \$2 total amount between the two banks does not result in higher expected interest payment but increases the risk by leaving some amount uninsured. Therefore, to prove that the derived deposit rates (19) constitute a Nash equilibrium, we only need to rule out a deviation where, say, bank B raises the deposit rate above the equilibrium level (19) in order to attract type A depositors to transfer \$2 to bank B instead of just \$1. This appendix shows that such an deviation is not profitable for bank B.

Let bank A's deposit rate (r_A^L) be given by (19). Then, in order to attract type A depositors who open an account with bank B to transfer \$2 instead of \$1, bank B has to raise its deposit rate to r'_B satisfying $1\,r_A^L + 1\,r'_B - \sigma s < 1\,r'_B + (1-\phi)1\,r'_B - \phi\,1 - \sigma s$. This basically says that the expected utility captured by the third row in A's utility function (15) exceeds that captured by the second row. Substituting (19) for r_A^L yields

$$r'_B > \widehat{r}_B \stackrel{\text{def}}{=} \frac{r_A + \phi}{1-\phi} = \frac{(2-\phi)(\rho+\phi) - 2n\sigma}{(1-\phi)(2-\phi)}. \tag{A.1}$$

For this deviation to be profitable for bank B, the interest $\widehat{r}_B$ paid to depositors cannot exceed the return ρ that bank B earns on a \$1 investment, so that $\widehat{r}_B < \rho$. However, it can be shown that

$$\widehat{r}_B < \rho \quad \text{if and only if} \quad \rho < \frac{2n\sigma}{\phi(2-\phi)} - 1, \tag{A.2}$$

which contradicts Assumption 1. This completes the proof showing that bank B will not deviate from the equilibrium interest rate (19).

Finally, note that this result also shows that banks cannot profit from price discrimination between depositors who maintain balances within the deposit insurance limit and those that maintain balances above the deposit insurance limit (by offering them two different deposit rates).

Appendix B Proof of Result 7

Proof. We focus on a mean-preserving spread and explore the effect of an increase in banks' probability of default on equilibrium deposit rates and profits across the three regimes of deposit insurance:

1. No deposit insurance:
   - deposit rates: By taking the ratio of the equilibrium deposit rates under the mean-preserving spread and the benchmark, we obtain that $\frac{\tilde{r}^N}{r^N} = \frac{1-\phi}{1-\tilde{\phi}} > 1$ or $\tilde{r}^N > r^N$. With no deposit insurance, banks compensate depositors for the higher default risk by offering higher deposit rates.
   - profits: profits are invariant to a mean-preserving spread $\pi^N = \sigma n^2$
2. Unlimited deposit insurance
   - deposit rates: Deposit rates are higher under a mean-preserving spread as $\tilde{\rho} = \frac{1-\phi}{1-\tilde{\phi}}\rho > \rho$ and the equilibrium deposit rate $r^U = \rho - \frac{\sigma n}{2}$ does not depend on the probability of bank default.
   - profits: Profits are lower under a mean-preserving spread $\pi^U = (1-\phi)\sigma n^2$.
3. Limited deposit insurance
   - deposit rates: Deposit rates are higher under a mean-preserving spread as $\tilde{r}^L - r^L = \frac{\tilde{\phi}-\phi}{1-\phi}\left[\rho - \frac{2\sigma n}{2-\phi}\frac{1-\tilde{\phi}}{2-\tilde{\phi}}\right] > 0$.
   - profits: Profits are lower under a mean-preserving spread as the profit function $\pi^L = \frac{1-\phi}{2-\phi}4\sigma n^2$ is a strictly decreasing function in ϕ and $\tilde{\phi} > \phi$ □

Appendix C Proof of Result 8

To prove Result 8, note that a consumer s will open one additional new account (call it a second account) if

$$(1-\phi)(d-\lambda)(1+r)-\phi(d-\lambda)+\lambda(1+r) < (1-\phi)(d-2\lambda)(1+r)-\phi(d-2\lambda)+2\lambda(1+r)-\sigma s, \quad \text{(C.1)}$$

yielding $s < s^\lambda$. The first two terms on the left side of (C.1) are the expected gross benefit from the above-the-limit deposit $d-\lambda$, which is uninsured. The third term is the safe gross return on the insured amount, λ. Next, a consumer s opens 2 additional accounts (third account) if

$$\begin{aligned}(1-\phi)(d-2\lambda)(1+r) - \phi(d-2\lambda) + 2\lambda(1+r) - \sigma s \\ < (1-\phi)(d-3\lambda)(1+r) - \phi(d-3\lambda) + 3\lambda(1+r) - 2\sigma s,\end{aligned} \quad \text{(C.2)}$$

yielding again $s < s^\lambda$. Next, a consumer s with $N-1$ accounts opens an Nth account if

$$\begin{aligned}(1-\phi)[d-(N-1)\lambda](1+r) - \phi[d-(N-1)\lambda] + (N-1)\lambda(1+r) - (N-2)\sigma s \\ < (1-\phi)(d-N\lambda)(1+r) - \phi(d-N\lambda) + N\lambda(1+r) - (N-1)\sigma s,\end{aligned} \quad \text{(C.3)}$$

yielding again $s < s^\lambda$. Finally, a consumer s opens an additional account just to deposit the remainder, M, if

$$(1-\phi)M(1+r) - \phi M < M(1+r) - \sigma s, \quad \text{(C.4)}$$

yielding $s < s^M$.

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