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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.

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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.[3] Deposit insurance, which prevented the traditional type of bank runs, was the most significant institutional change since the Great Depression. This paper focuses on two aspects of the design of 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 this particular design of limited deposit insurance coverage affects the intensity of competition in the deposit market through its effect on demand for multiple deposit accounts. 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 regarding the demand for multiple deposit accounts across different banks. We document that the average amount deposited in accounts that exceed the deposit insurance limit is approximately at most three times the deposit insurance limit. We show that at least half of wealthier U.S. households in the Survey of Consumer Finances indeed held multiple deposit accounts with multiple banks. At the onset of the 2008 financial crisis, the demand for higher deposit insurance increased as measured by the rapid increase in the share of insured brokered deposits.

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

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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 lowers the elasticity of deposit demand and softens deposit market competition as compared to systems with unlimited or no deposit insurance. We further show that limited deposit insurance reduces consumer welfare not only by inducing depositors to bear costs of opening several accounts, but also by weakening competition in the deposit market. Overall, we find that limited deposit insurance induces a social deadweight loss compared with systems of unlimited or no deposit insurance, because the benefits to banks associated with limited deposit insurance fall short of the losses to consumer welfare and total welfare when the bailout costs are taken into account.

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 in the context of models with 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.

These theoretical studies 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) analyzes neither the effect of limited deposit insurance coverage on the demand for multiple deposit accounts, nor deposit market competition. More recent work by Egan et al. (2014) examines the role of competition for insured and uninsured deposits for banks' financial stability. They show that an increase in deposit insurance coverage may increase or decrease the risk to financial stability depending on whether banks or depositors benefit from the increase in insurance. However, their model does not explicitly examine the deposit insurance design or the possibility for uninsured depositors to increase their deposit insurance coverage by maintaining multiple bank accounts.

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 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 et al. (2003) present evidence that the risk premium in deposit rates is on average over 40 basis points higher in countries without deposit insurance than in countries with deposit insurance. They argue that the risk premium is a nonlinear function of deposit insurance coverage, 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 have given banks a competitive advantage over money market funds in providing safe haven asset classes. However, these studies do not examine the effect of limited deposit insurance on deposit rates and profits. Furthermore, they do not provide evidence regarding demand for multiple deposit accounts induced by the deposit insurance design.

Since Merton (1978), who applied option pricing to characterize the pricing of deposit insurance premia under costly supervision, the debate on the deposit insurance design focused on formulating actuarially fair premia. The introduction of capital requirements imposed by the Basel regulation in the early 1990s as a mechanism to control credit risks of individual banks brought these issues strongly into the policy agenda. In the aftermath of the 2007–2008 financial crisis, the paradigm of both capital requirements and the design of deposit insurance premia shifted to incorporating systemic risk of financial institutions, see Pennacchi (2009). However, neither of these academic 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 limited deposit insurance on deposit market competition without explicitly modeling banks' risky lending decisions. Abstracting from political and moral hazard issues, see Calomiris and Jaremski (2016), 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.[4] Our normative analysis is restricted to the investigation of how deposit insurance systems with limited coverage affect deposit rates, bank profits, consumer 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 a set of distortions that arise as unintended consequences of the partial deposit insurance design which do not arise in systems with no or unlimited deposit insurance.

The paper is organized as follows. Section 2 presents a set of empirical facts regarding the implementation of deposit insurance in the United States and the resulting demand for multiple deposit accounts to achieve higher deposit insurance coverage. Section 3 constructs a model of deposit market competition and analyzes equilibrium deposit rates and profits as well as welfare in three regimes of deposit insurance: no deposit insurance, unlimited deposit insurance, and limited deposit insurance. Section 4 presents the main results of our analysis by comparing the performance of the banking industry under the different regimes of deposit insurance. Section 5 outlines extensions of the baseline model. Section 6 presents some concluding comments.

2. Limited deposit insurance and demand for multiple deposit accounts: empirical facts

Since its establishment 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.[5] 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 2008 dollar amounts. In addition, the last two columns of Table 1 show that the deposit insurance limit was

[4] 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.

[5] A limited deposit insurance design is also the norm in most countries with explicit deposit insurance. A survey by the IMF (Garcia, 2000) documented 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.

Table 1
FDIC insurance limits 1934–present.

Year	Limit (nominal)	Limit (real)	Fin. wealth (real)	Deposits (real)
1934	2500	40,218	n/a	n/a
1935	5000	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 inflation-adjusted using the consumer price index with base year 2008. 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.

always raised to levels that were sufficient to cover the average financial wealth held in deposits and a large fraction of the average overall financial wealth of U.S. households.[6] However, over time inflation was eroding the real value of the deposit insurance coverage. To see this, Fig. 1 shows the time series behavior of the inflation-adjusted values of the deposit insurance limit along with the inflation-adjusted values of the average deposit and the average overall financial wealth of U.S. households. The inflation-adjusted values of deposit insurance coverage reached its highest real value in 1980 when the limit was raised to $100,000, which was equivalent to $261,263 in 2008 dollars, and for the first time exceeded the average overall financial wealth of U.S. households.

The commonly cited rationale for limiting insurance coverage is based on three premises. First, deposit insurance coverage should be large enough to guarantee financial stability by preventing bank runs. Second, a limited deposit insurance coverage lowers the cost to the deposit insurance fund by limiting its liability. Third, deposit insurance should limit the coverage of wealthier and sophisticated investors and provide those investors with incentives to impose market discipline on banks by either withdrawing deposits or demanding higher deposit rates from riskier banks. However, the limited deposit insurance design gives the option to expand insurance coverage or even achieve complete insurance by opening multiple deposit accounts with different banks.[7]

Over the period from 1980 until 2008, during which the insurance limit was kept at $100,000, at least two important factors contributed to an increasing demand for improved deposit insurance coverage with multiple bank accounts: First, incomes and financial wealth of many U.S. households increased above levels observed in the 1970s and 1980s, and disproportionately so for the wealthiest U.S. households, see Piketty and Saez (2003). Second, as Fig. 1 shows, inflation over this period reduced in half the effective real deposit insurance coverage, thereby increasing the fraction of depositors not fully insured at one bank. Starting with these observations, we document a few empirical facts which provide evidence for the presence of demand for multiple deposit accounts with different banks.

Our first piece of evidence is the creation of deposit brokers that specialize in collecting deposits exceeding the insurance limit and allocating them over the necessary number of different banks to achieve full deposit insurance coverage. The Certificate of Deposit Account Registry Service (CDARS) is an example of such a deposit broker with a network of over 3000 participating FDIC insured commercial banks.[8] In Fig. 2, we plot the time series variation of the share of insured brokered deposits in total brokered deposits.[9] The share of insured brokered deposits was relatively small prior to the financial crisis. However, at the onset of the 2008 financial crisis and before the deposit insurance limit was raised, this share increased rapidly to reach close to 60 percent of all brokered deposits. We attribute this increase to a rise in the demand for higher deposit insurance coverage through multiple deposit accounts.

Depositors can increase their deposit insurance coverage by directly opening multiple deposit accounts at different banks without a broker. In Fig. 2, we plot the historical distribution of the average balances of deposit accounts above the insurance limit. These balances remained relatively stable around two to three times the deposit insurance limit, growing by about 30 percent from 1986 until 2008. Thus, for most partially insured deposit accounts, depositors needed no more than three additional banks to achieve full insurance. Furthermore, as shown in Fig. 1, inflation reduced by more than half the real deposit insurance coverage between 1980 and 2008, while real deposit balances per household grew by 40 percent over this period. As a result, the relatively stable average nominal balance of uninsured deposits accounts could be rationalized by the active splitting of large uninsured deposits into multiples of the deposit insurance limit and their placement across different banks.

To substantiate this hypothesis, in Table 2, we examine the determinants of the choice of maintaining multiple deposit accounts with different banks using the 2007 panel of households in the Survey of Consumer Finances (SCF, 2007). Two household characteristics influence the likelihood that a household holds multiple deposit accounts with different banks: (1) deposit wealth relative to the insurance limit; and (2) the preference for depositors to shop for better returns on their savings. These two variables remain statistically significant even after conditioning on demographic characteristics such as age, gender, education, and attitudes toward risk.

The results from this regression analysis support the hypothesis that wealthy households responded to the option provided by the limited deposit insurance design to achieve more extensive insurance coverage by maintaining multiple deposit accounts with different banks. However, not all households took advantage of this option as households faced idiosyncratic costs of opening accounts with different banks as measured by differences in their preferences for shopping for higher return on savings. In the theoretical model presented in the next section, we will capture this feature by assuming that depositors are differentiated with respects to their costs of opening a new account with a second bank.

[6] 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.

[7] In addition, the FDIC would insure amounts up to the insurance limit per depositor, per insured bank, for certain eligible account ownership categories. 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.

[8] See FDIC (2011) for the legal treatment of brokered deposits by the FDIC and www.cdars.com for information on the services provided by CDAR. Deposits collected and reallocated through CDARS are accounted for as reciprocal brokered deposits. As of 2014Q1, there were 2229 banks reporting non-zero balances of reciprocal brokered deposits in their regulatory filings. The total such deposits were $30 billion, which was a small fraction of overall deposits in the banking system.

[9] We use information from the regulatory filings of U.S. commercial banks called the Reports on Income and Condition or Call Reports. The data are publicly available at Federal Financial Institutions Examination Council https://cdr.ffiec.gov/public.

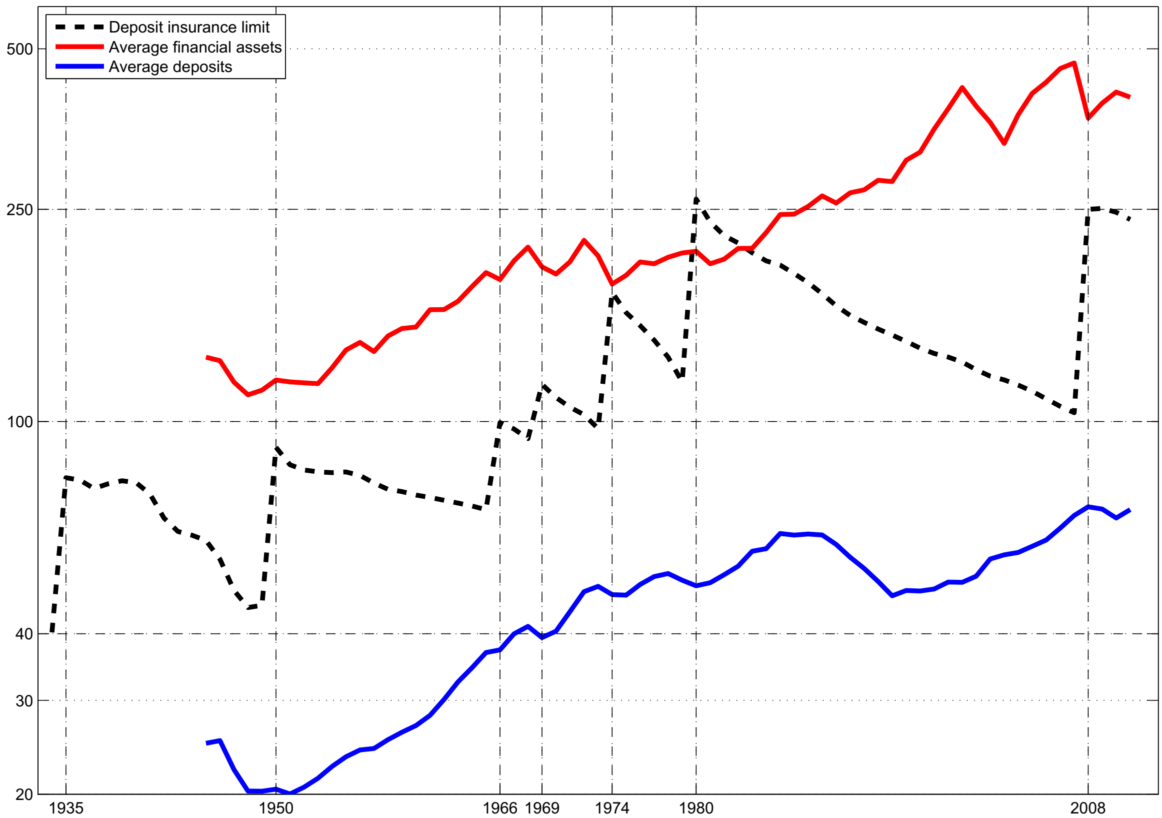

Fig. 1. The deposit insurance limit, average household financial wealth, and deposits (in thousands, 2008 prices). Note: All nominal values are adjusted for inflation using the consumer price index with base year 2008. The average financial wealth and deposits of U.S. households are computed as total financial wealth and deposits divided by the number of U.S. households. Source: FDIC, "A Brief History of Deposit Insurance in the United States", FRED database, Census Bureau and Financial Accounts of the United States.

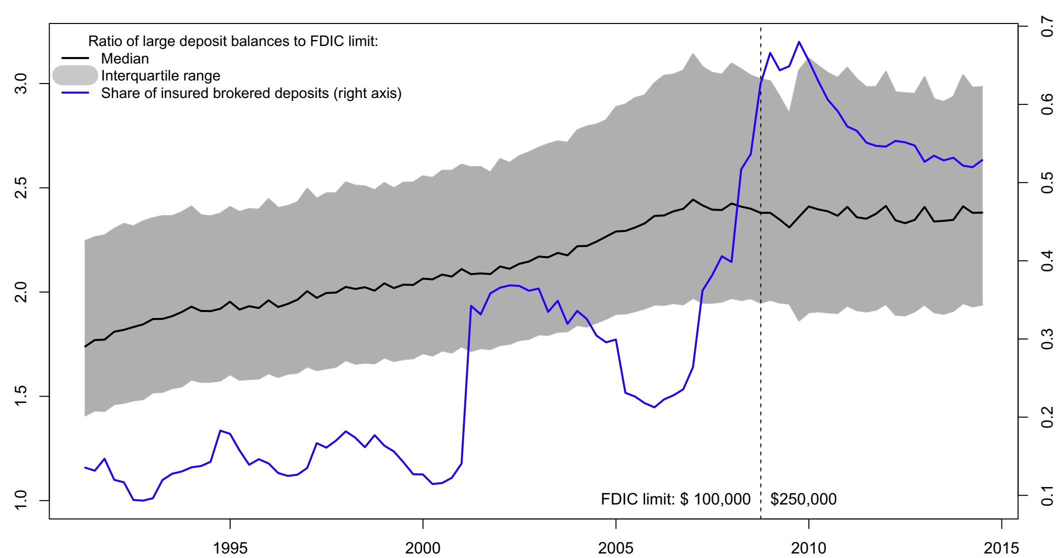

Fig. 2. The inter-quartile range of average partially-insured deposit account balances and the share of insured brokered deposits: quarterly, 1991–2014. Note: The figure plots the median and the inter-quartile range of average balances in large denomination, partially-insured, deposit accounts as a fraction of the insurance limit for the period 1991: Q1 to 2014:Q2. The average account balance for each bank is computed as the total amount of deposit accounts exceeding the deposit insurance limit (item rcon2710 prior to 2008:Q2 and rconf051 afterward) divided by the number of such accounts (correspondingly, items rcon2722 and rconf052). Source: Reports on Income and Condition (Call Reports).

There is strong evidence that switching costs are empirically significant and differentiated in bank deposit and loan markets. As for deposits, a spectrum of studies present empirical evidence regarding the important effects of switching costs for deposit rates in different countries. Examples include Sharpe (1997), Carbo-Valverde et al. (2011) and Hannan and Adams (2011). These studies highlight the existence of heterogeneous switching costs in deposit markets by demonstrating that the tradeoff between attracting new customers who have to overcome switching costs and exploiting old ones leads banks to offer higher deposit rates

Table 2
Depositor characteristics and maintenance of multiple deposit accounts.

	Dependent variable: Multiple deposit accounts with different banks		
	(1)	(2)	(3)
[Deposit wealth/FDIC limit]	0.036*	0.042**	0.048**
	(0.019)	(0.020)	(0.020)
ln(Risky assets)		−0.013	−0.015
		(0.012)	(0.013)
Risk-taking (1 (low)...5 (high))	0.046	0.022	−0.058
	(0.091)	(0.094)	(0.101)
Shopping for return (1 (low)...5 (high))	0.148***	0.149***	0.166***
On savings	(0.050)	(0.051)	(0.051)
Age			0.014**
			(0.006)
Gender (0 (M), 1 (F))			0.305
			(0.234)
Education			0.017
			(0.034)
Constant	−1.205***	−1.027***	−2.294***
	(0.341)	(0.380)	(0.829)
Observations	396	396	396
Log Likelihood	−249.430	−248.861	−244.325
Akaike Inf. Crit.	506.860	507.723	504.649

Note: The probit regression is run on the sample of households in the SCF (2007) with deposit account balances exceeding the deposit insurance limit. The dependent variable takes the value of one if the household maintains multiple accounts. The ratio [Deposit wealth/FDIC limit] measures deposit wealth as multiples of the deposit insurance limit and takes discrete values. Risky assets measure financial wealth of households in stocks and corporate bonds. Attitude towards risk and shopping for higher return on savings are measured on a discrete scale 1 (low) to 5 (high) scale.

Source: All variables are contained or derived from data in the Survey of Consumer Finances, 2007.

* $p < 0.1$.

** $p < 0.05$.

*** $p < 0.01$.

in areas with more in-migration. Other studies applying different approaches establish the empirical significance of switching costs in deposit markets include Shy (2002), Brown et al. (2014) and Yankov (2014). As for bank loans, for example, Kim et al. (2003) present evidence for significant and differentiated switching costs using Norwegian data.

Fig. 3. Division of depositors between those who open and those who do not open a second bank account.

3. A model of bank competition

3.1. Banks

There are two financial institutions ("banks") that pay interest on deposits. Let r_A and r_B denote the rates paid by bank A and bank B, respectively. On each \$1 deposit, a bank earns ρ from lending, investment, or trading activities. The portfolio of activities of bank $i \in \{A, B\}$ (and hence the investing bank) fails with probability ϕ resulting in an *expected* net return $(1-\phi)(\rho - r_i)$ on a \$1 deposit. 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 focus on perfectly correlated defaults, but in Section 5.1, we extend the model to independent bank failures.

3.2. Depositors

Depositors are differentiated according to their bank account history, wealth, and switching costs. In terms of history, an equal mass of n depositors starts with one deposit account with a main bank—either bank A or bank B. In terms of wealth, a fraction λ of depositors have *large* deposit accounts of \$2. We refer to such depositors as large depositors. A fraction $1-\lambda$ of depositors have *small* deposit accounts of \$1 and are referred to as small depositors. The aggregate deposit volume is the sum of deposits in the two banks held by the large and small depositors, $2[2 \times \lambda n + 1 \times (1-\lambda)n] = 2(1+\lambda)n$.

Next, depositors are indexed by $0 \leqslant s \leqslant 1$ according to their cost of opening a new account with the competing bank. We refer to this cost as "switching costs", although such depositors do not completely switch as they maintain two accounts with two different banks. These costs are distributed uniformly and independently from the initial wealth or account history. In addition, they are scaled by a parameter $\sigma > 0$ which controls the relative cost heterogeneity among depositors, so that the maximum switching cost is σ and the mean (also median) switching cost is $\frac{\sigma}{2}$.

As illustrated in Fig. 3, a fraction of depositors $0 \leqslant s_i \leqslant 1$ from bank i opens a second account with bank j if their switching costs do not exceed a threshold s_i. We characterize the demand for multiple bank accounts in terms of the resulting equilibrium thresholds in three regimes of deposit insurance: no deposit insurance, unlimited deposit insurance, and limited deposit insurance. In each of these regimes, the costs of maintaining multiple deposit accounts have to be weighed against the benefit of having multiple deposit accounts. As we show, this benefit depends on the deposit insurance design. We solve for the Bertrand–Nash equilibrium in which banks compete in deposit rates taking into account the resulting demand for deposits under each of the three deposit insurance regimes.

To guarantee the existence of an interior equilibrium with $0 < s_i < 1$ under limited deposit insurance in Section 3.5, Assumption 1 imposes lower and upper bounds on the maximum cost of opening a second deposit account σ.

Assumption 1. The maximum cost of opening a second bank account σ is bounded according to

$$(1+\rho)\frac{\phi[1+(1-\phi)\lambda]}{1+\lambda+\phi} \leqslant \sigma \leqslant (1+\rho)\frac{1+(1-\phi)\lambda}{1+\lambda}. \quad (1)$$

Within these bounds, we show that under limited deposit insurance some large depositors have incentives to open a second account, whereas others do not open a second account as their idiosyncratic costs exceed the benefit of having more than one deposit account.

3.3. No deposit insurance

With no deposit insurance, consumers lose their entire deposit(s) with probability ϕ. If bank i offers a deposit rate r_i, depositors earn this interest rate only in non-default states. The utility of a small depositor in bank $i \in \{A, B\}$ and with an idiosyncratic switching cost $s \in [0, 1]$ is given by

$$u_{i,1}(s) = \begin{cases} (1-\phi)r_i - \phi & \text{if does not open a second bank account} \\ (1-\phi)r_j - \phi - \sigma s & \text{if opens a second account and transfers} \\ & \text{\$1 to bank } j. \end{cases} \quad (2)$$

The first row in (2) displays that the expected return of staying with the initial bank i is $(1-\phi)r_i - \phi$. The second row in (2) describes the utility of switching to the alternative bank j, in which case the consumer earns the expected return offered by j net of the switching costs σs.

The utility of large depositors initially invested in bank $i \in \{A, B\}$ is similarly defined as

$$u_{i,2}(s) = \begin{cases} 2[(1-\phi)r_i - \phi] & \text{if does not open a second bank account} \\ 2[(1-\phi)r_j - \phi] - \sigma s & \text{if opens a second account and transfers} \\ & \text{\$2 to bank } j. \end{cases} \quad (3)$$

Note that (2) and (3) ignore a potential third option where depositors open a second account and transfer a fraction of their initial deposit to the alternative bank. In the absence of deposit insurance, this option is not beneficial because a depositor who opens a second account should optimally transfer the entire amount to the bank that pays the highest expected return.

A small depositor in bank i with a switching cost s opens a second bank account with j and transfers the entire initial deposit amount if $(1-\phi)r_j - \phi - \sigma s > (1-\phi)r_i - \phi$. Analogously, a large depositor with switching cost s transfers the entire deposit from bank i to j if $(1-\phi)2r_j - \phi 2 - \sigma s > (1-\phi)2r_i - \phi 2$. As illustrated in Fig. 3, we can express these conditions as switching cost thresholds. If d stands for the initial deposit amount, these thresholds are

$$s_{i,d} \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_i \geq r_j \\ \frac{(1-\phi)d(r_j - r_i)}{\sigma} & \text{if } 0 \leq r_j - r_i \leq \frac{\sigma}{d(1-\phi)}, \quad \text{for } i,j = A,B \text{ and } d = 1,2 \\ 1 & \text{if } r_j - r_i \geq \frac{\sigma}{d(1-\phi)}. \end{cases} \quad (4)$$

A depositor will open a new bank account only if the competing bank pays a higher deposit rate, and if the rate differential is larger than the switching cost. With no loss of generality, we derive the symmetric equilibrium starting from a case where bank A pays a higher deposit rate. In this case, some depositors of bank B switch to bank A ($s_{B,d} > 0$) and no bank A depositors switch to bank B ($s_{A,d} = 0$). The expected profits of the two banks are

$$\pi_A^N(r_A, r_B) = (1-\phi)(\rho - r_A)[(1-\lambda)n(1+s_{B,1}) + 2\lambda n(1+s_{B,2})] \quad (5)$$

$$\pi_B^N(r_B, r_A) = (1-\phi)(\rho - r_B)[(1-\lambda)n(1-s_{B,1}) + s_{A,1} + 2\lambda n(1-s_{B,2})]. \quad (6)$$

We solve for the symmetric Bertrand–Nash equilibrium in pure strategies. Each bank maximizes its profit function taking as given the competitor's deposit rate. Solving the system of equations defined by the banks' best-response functions gives the equilibrium deposit rates and profits

$$r^N = r_A^N = r_B^N = \rho - \frac{(1+\lambda)\sigma}{(1-\phi)(1+3\lambda)} \quad \text{and} \quad \pi^N = \pi_A^N = \pi_B^N = \frac{(1+\lambda)^2 n\sigma}{1+3\lambda}, \quad (7)$$

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, because, in the symmetric equilibrium, banks pay the same deposit rate and, therefore, $s_{A,d} = s_{B,d} = 0$ for $d = 1, 2$.

Consumer welfare with no deposit insurance (cw^N) is defined as the sum of the utilities of small and large depositors at each bank weighed by their relative population sizes according to $cw^N = \lambda n(u_{A,1} + u_{B,1}) + (1-\lambda)n(u_{A,2} + u_{B,2})$. Consumer welfare evaluated at the equilibrium is

$$cw^N = 2n(1+\lambda)\left[(1-\phi)\rho - \phi - \frac{(1+\lambda)\sigma}{1+3\lambda}\right]. \quad (8)$$

Finally, we define total welfare (w^N) as the sum of consumer welfare and bank profits, from which we subtract the expected bailout costs (di^N). Of course, with no deposit insurance $di^N = 0$. Evaluated at the equilibrium, total welfare (w^N) with no deposit insurance is

$$w^N = cw^N + \pi_A^N + \pi_B^N = 2n(1+\lambda)[(1-\phi)\rho - \phi]. \quad (9)$$

Equilibrium total welfare (w^N) turns out to be simply the aggregate deposits $2n(1+\lambda)$ times the expected return on banks' risky assets $(1-\phi)\rho - \phi$ which, in our model, is the socially optimal level of total welfare.

To understand the equilibrium, we examine how deposit rates and profits (7), as well as welfare (8) and (9) respond to changes in the model parameters.

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

(a) *The equilibrium interest rates (r^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^N) are invariant.*
(b) *An increase in consumers' cost of opening a new bank account (σ) reduces the equilibrium deposit rates (r^N) and consumer welfare (cw^N), and it increases banks' profits (π^N), whereas total welfare (w^N) is invariant.*
(c) *The equilibrium deposit rates (r^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^N) are invariant.*
(d) *A higher share of large depositors (λ) leads to higher deposit rates (r^N). Furthermore, profits (π^N) decrease in λ, if $\lambda < \frac{1}{3}$, and increase in λ, if $\lambda > \frac{1}{3}$. In addition, higher λ leads to higher consumer (cw^N) and total welfare (w^N).*

Result 1(a) reveals that competition between banks guarantees that the gains from higher investment returns for solvent banks flow to the depositors in the form of higher deposit rates. Next, Result 1(b) shows that an increase in the switching cost parameter σ increases banks' market power and leads to lower equilibrium deposit rates and higher profits. An increase in σ redistributes surplus from depositors to banks, leaving total welfare unchanged.

Result 1(c) characterizes the equilibrium response to a more fragile banking industry. The qualitative findings are the mirror image of those reported in Result 1(a). This feature reflects the fact that banks' expected returns $(1-\phi)\rho$ 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 between an increase in default risk and 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. Section 5.2 demonstrates that this feature need not hold true if we examine a mean-preserving spread of asset returns.

Finally, Result 1(d) shows that a higher share of large depositors (higher λ) increases equilibrium deposit rates. This is due to the fact that large depositors have higher interest rate elasticity of demand relative to that of small depositors. This can be easily seen from the expressions for the switching cost thresholds (4) and is a result of the higher wealth of large depositors. A higher share of large depositors by leading to higher equilibrium deposit rates should also reduce profits. However, a higher share of large depositors also implies larger aggregate deposits $2n(1+\lambda)$ which increases profits. The two opposing effects of higher λ on profits balance at $\lambda = \frac{1}{3}$. For $\lambda < \frac{1}{3}$, the effect of higher λ on equilibrium deposit rates dominates the increase in aggregate deposits and profits decrease. The opposite is true for $\lambda > \frac{1}{3}$. Equilibrium profits are equal to $\pi^N = \sigma n$ at the two extremes of this share ($\lambda = 0$ and $\lambda = 1$). A higher share of large depositors increases aggregate wealth of consumers and leads to higher consumer and total welfare.

3.4. Unlimited deposit insurance

With unlimited deposit insurance, consumers do not face any risk associated with their deposits. In an event of bank default, depositors receive their principal and the promised interest from the deposit insurance fund.

We assume that the deposit insurance fund is funded by a lump sum tax so that we can disregard distortions created by this form of taxation. Of course, such distortions could be incorporated into the analysis by multiplying the raised tax with a multiplier (larger than one) that represents the social costs associated with taxation distortions.

Given that the default risk of the banks is completely insured, depositors do not gain from diversification through maintaining deposit balances in different banks. The expected utility of small ($d = \$1$) and large ($d = \$2$) depositors with bank $i = A, B$ is

$$u_{i,d}(s) = \begin{cases} dr_i & \text{if does not open a second bank account} \\ dr_j - \sigma s & \text{if opens a second account and transfers} \\ & \qquad\qquad d \text{ to bank } j. \end{cases} \tag{10}$$

The utility functions (10) imply the following thresholds for switching from a main bank i to an alternative bank j

$$s_{i,d} \stackrel{\text{def}}{=} \begin{cases} 0 & \text{if } r_i \ge r_j \\ \frac{d(r_j - r_i)}{\sigma} & \text{if } 0 \le r_j - r_i \le \frac{\sigma}{d}, \text{for } i,j = A,B \text{ and } d = 1,2 \\ 1 & \text{if } r_j - r_i \ge \frac{\sigma}{d}. \end{cases} \tag{11}$$

The profit functions of the two banks are identical to the case of no deposit insurance, except for the differences in the switching cost thresholds (4) and (11). Applying a profit maximization procedure analogous to the previous section, we now find that the equilibrium deposit rates and the associated equilibrium profits under unlimited deposit insurance are

$$r^U = r_A^U = r_B^U = \rho - \frac{(1+\lambda)\sigma}{1+3\lambda} \quad \text{and}$$
$$\pi^U = \pi_A^U = \pi_B^U = \frac{(1-\phi)(1+\lambda)^2 n\sigma}{1+3\lambda}, \tag{12}$$

where the superscript "U" denotes equilibrium values under *unlimited* deposit insurance. Note that 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. Therefore, no depositor opens a second bank account ($s_{i,d}^U = 0$ for $i = A, B$ and $d = 1, 2$).

Evaluating depositors' utility (10) with the equilibrium deposit rates (12) and weighing by the mass of small and large depositors yields the equilibrium consumer welfare

$$cw^U = 2n(1+\lambda)\left[\rho - \frac{(1+\lambda)\sigma}{1+3\lambda}\right]. \tag{13}$$

Next, unlike the case of no deposit insurance, the presence of deposit insurance introduces an economy-wide cost of funding such an insurance system. The expected cost of deposit insurance is

$$\begin{aligned} di^U &= \phi\left[4\lambda n(1+r^U) + 2(1-\lambda)n(1+r^U)\right] \\ &= \phi 2n(1+\lambda)\left[1+\rho - \frac{(1+\lambda)\sigma}{1+3\lambda}\right]. \end{aligned} \tag{14}$$

The expected cost of bailing out two failing banks is the product of the failure probability ϕ, the total amount deposited in the two banks $2n(1+\lambda)$, and the promised interest payment.

Finally, the expected total welfare is the sum of consumer welfare and bank profits net of the expected costs of the deposit insurance fund

$$w^U = cw^U + \pi_A^U + \pi_B^U - di^U = 2n(1+\lambda)[(1-\phi)\rho - \phi]. \tag{15}$$

We summarize the comparative statics properties of the equilibrium under unlimited deposit insurance in the following result.

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

(a) *The equilibrium interest rates (r^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^U) are invariant.*
(b) *An increase in consumers' cost of opening a new bank account (σ) reduces the equilibrium interest rates (r^U), bailout costs (di^U), and consumer welfare (cw^U), and increases banks' profits (π^U), whereas total welfare (w^U) is invariant.*
(c) *An increase in banks' failure probability (ϕ) reduces the equilibrium profits (π^U) and total welfare (w^U); it increases bailout costs (di^U), whereas equilibrium interest rates (r^U) and consumer welfare (cw^U) are invariant.*
(d) *A higher share of large depositors (λ) leads to higher deposit rates (r^U). Furthermore, profits (π^U) decrease in λ, if $\lambda < \frac{1}{3}$, and increase in λ, if $\lambda > \frac{1}{3}$. In addition, a higher share of large depositors (λ) increases the expected costs to the deposit insurance fund (di^U), and leads to higher consumer (cw^U) and total welfare (w^U).*

Result 2(a) is identical to Result 1(a) with the exception that a higher return also implies higher bailout costs as banks offer higher deposit rates. Similarly, Result 2(b) is identical to Result 1 (b). The new element is that higher switching costs reduce equilibrium deposit rates and, therefore, they also reduce the expected bailout costs. Next, Result 2(c) formalizes the very intuitive idea that, with unlimited deposit insurance, depositors are perfectly secured against increases in banks' failure rate. Finally, Result 2(d) is identical to Result 1(d). In addition, since a higher share of large depositors (λ) leads to higher aggregate deposits, all of which are fully insured, the expected costs to the deposit insurance fund increase.

Before we proceed to the next section, it is important to note that total welfare under no deposit insurance (9) is identical to that under unlimited deposit insurance (15). This highlights the nature of our model of competition. In particular, we do not consider bank runs in the case of no deposit insurance or distortions related to the provision of unlimited deposit insurance such as moral hazard. This allows us to highlight in a transparent way the redistribution of surplus between depositors and banks under the different deposit insurance designs.

3.5. Limited deposit insurance

We introduce a particularly simple form of limited deposit insurance. Each account with a different bank is insured up to \$1 of the initial balance plus the accrued interest. Initial deposit balances of \$1 or less are fully insured, whereas initial deposit balances exceeding \$1 are only partially insured up to the limit of \$1.

Under limited deposit insurance, small depositors are fully insured. Their utility and switching cost threshold functions are identical to Eqs. (10) and (11), respectively. As in the unlimited deposit insurance regime, small depositors would switch to a rival bank only if the interest differential exceeds their switching costs. Suppose that $r_A > r_B$, then no small depositor at bank A would open an account with B, but some small depositors at bank B would switch to bank A. Bank A's expected demand from small depositors is $(1-\lambda)n(1+s_{B,1})$ and bank B's expected demand from small depositors is $(1-\lambda)n(1-s_{B,1})$.

Large depositors' initial deposit balances are partially insured. However, the insurance design gives the option to achieve full insurance by opening a second account with a different bank and keeping \$1 in each account, so that each deposit account falls within the insurance limit.[10] A large depositor faces the following trade-off: To accept exposure to the risk of a bank failure while avoiding the cost σs of opening a new account or to diversify away this risk by bearing the cost associated with opening a second account. The expected utility of large depositors is

$$u_{i,2}(s) = \begin{cases} 1\,r_i + (1-\phi)1\,r_i - \phi\,1 & \text{does not open a second bank account} \\ 1\,r_i + 1\,r_j - \sigma s & \text{opens a second account and transfers \$1} \\ 1\,r_j + (1-\phi)1\,r_j - \phi\,1 - \sigma s & \text{opens a second account and transfers \$2.} \end{cases} \tag{16}$$

The expected utility (16) demonstrates the consequences of limited deposit insurance for large depositors. If the entire initial deposit balance is kept in the main bank i, a large depositor is guaranteed a riskless return of r_i only up to the deposit insurance limit as described in the first row of (16). The excess deposit of \$1 will provide a positive return only with probably $1-\phi$, whereas the depositor will lose the \$1 principal with probability ϕ. The second row in (16) shows that a large depositor can eliminate default risk by opening a second account with the rival bank j and splitting the initial deposit amount into two separate bank accounts each within the insurance limit. Lastly, the third row in (16) describes 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 because the transfer still leaves \$1 uninsured, but with a bank different from the consumer's main bank.[11]

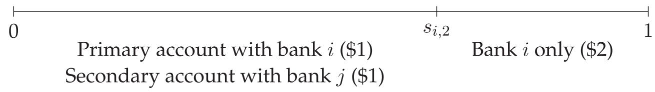

Fig. 4. Division of large depositors of bank $i \in \{A, B\}$ between those who open and do not open a new bank account.

The utility function (16) implies that a large depositor with an initial account in bank i and idiosyncratic switching cost σs opens an account with bank j (and transfers \$1) if $r_i + r_j - \sigma s > r_i + (1-\phi)r_i - \phi$. The switching cost threshold for a large depositor with bank $i \in \{A, B\}$ is

$$s_{i,2} \overset{\text{def}}{=} \begin{cases} 0 & \text{if } r_i \geq \frac{r_j+\phi}{1-\phi} \\ \frac{r_j-(1-\phi)r_i+\phi}{\sigma} & \text{if } \frac{r_j+\phi-\sigma n}{1-\phi} < r_i < \frac{r_j+\phi}{1-\phi} \\ 1 & \text{if } r_i \leq \frac{r_j+\phi-\sigma n}{1-\phi}. \end{cases} \tag{17}$$

Fig. 4 illustrates how large depositors allocate their deposits between one or two deposit accounts depending on the magnitude of their switching costs. Large depositors with switching costs higher than $s_{i,2}$ keep their full amount with bank i, while those with lower switching costs open a second account with bank j and keep only \$1 with i. Simultaneously, a fraction of large depositors from j with switching costs below $s_{j,2}$ opens a second account with i. Therefore, the expected demand from large depositors for bank i is $\lambda n[2 - s_{i,2} + s_{j,2}]$.

The resulting bank profit functions are

$$\begin{aligned} \pi_A^L(r_A, r_B) &= (1-\phi)(\rho - r_A)n[(1-\lambda)(1+s_{B,1}) + \lambda(2 - s_{A,2} + s_{B,2})] \\ \pi_B^L(r_A, r_B) &= (1-\phi)(\rho - r_B)n[(1-\lambda)(1-s_{B,1}) + \lambda(2 + s_{A,2} - s_{B,2})]. \end{aligned} \tag{18}$$

Next, following the same equilibrium solution procedure as before, the equilibrium deposit rates and profits are

$$r^L = r_A^L = r_B^L = \rho - \frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda} \quad \text{and}$$

$$\pi^L = \pi_A^L = \pi_B^L = \frac{(1-\phi)(1+\lambda)^2 n\sigma}{1+(1-\phi)\lambda}. \tag{19}$$

Just as in the previous two regimes, in the symmetric equilibrium, small depositors do not switch between banks ($s_{A,1}^L = s_{B,1}^L = 0$). In contrast, large depositors with switching costs lower than

$$s_2^L = s_{A,2}^L = s_{B,2}^L = \frac{\phi}{\sigma}\left[1 + \rho - \frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right]. \tag{20}$$

open a new bank account and transfer half of their initial deposit balance in the new account, thus achieving complete deposit insurance. Summing the costs incurred by all large depositors who open second bank accounts, we calculate the aggregate switching costs to be

$$SW_2^L = 2\lambda n \int_0^{s_2^L} \sigma s\, ds = \lambda n \frac{\phi^2}{\sigma}\left[1 + \rho - \frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right]^2. \tag{21}$$

[10] The assumption that the insurance limit equals to half of large depositors' wealth makes it possible for large depositors to achieve full deposit insurance with only two banks. Keeping the number of banks fixed at two, partial deposit insurance systems with limits different from half of depositor's wealth would generate oscillations in deposit pricing with the feature that each bank attempts to attract consumers to transfer deposit amounts exceeding the insurance coverage. Similar types of price oscillations have been analyzed in Maskin and Tirole (1988).

[11] For the sake of simplicity, the specification of the indirect utility function (16) is incomplete as it omits possible transfers lower than \$1, and amounts strictly between \$1 and \$2. However, Appendix A 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.

Next, the consumer welfare under limited deposit insurance is

$$cw^L = \underbrace{2(1-\lambda)nr^L}_{\text{Small depositors}} + \underbrace{2\lambda n(1-s_2^L)\left[(2-\phi)r^L-\phi\right]}_{\text{Large depositors with a single account}} + \underbrace{2\lambda n\int_0^{s_2^L}(2r^L-\sigma s)ds}_{\text{Large depositors with two accounts}}$$
$$= \lambda n\frac{\phi^2}{\sigma}\left[1+\rho-\frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right]^2 + 2n[1+(1-\phi)\lambda]\left[1+\rho-\frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right] - 2n(1+\lambda). \quad (22)$$

The expected cost of bailing out failing banks includes the principal amount and interest of all insured accounts. In equilibrium, fully insured deposit accounts are all small deposit accounts and all accounts of large depositors that are held in two bank accounts. Partially insured accounts are the accounts of large depositors that are held in a single bank. The expected cost to the deposit insurance is

$$di^L = \underbrace{\phi 2(1-\lambda)n(1+r^L)+\phi 4s_2^L\lambda n(1+r^L)}_{\text{Fully insured accounts}} + \underbrace{\phi 2\lambda n(1-s_2^L)(1+r^L)}_{\text{Partially insured accounts}}$$
$$= 2\lambda n\frac{\phi^2}{\sigma}\left[1+\rho-\frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right]^2 + 2\phi n\left[1+\rho-\frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right]. \quad (23)$$

The sum of consumer welfare and bank profits net of the expected costs to the deposit insurance fund defines total welfare which equals to

$$w^L = cw^L + 2\pi^L - di^L = 2n(1+\lambda)[(1-\phi)\rho-\phi] \underbrace{-\lambda n\frac{\phi^2}{\sigma}\left[1+\rho-\frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}\right]^2}_{SW_2^L}. \quad (24)$$

The equilibrium total welfare can be decomposed into two terms. The first term is the aggregate amount of deposits $2n(1+\lambda)$ multiplied by the expected return $(1-\phi)\rho-\phi$. It equals the socially optimal welfare achieved under no and limited deposit insurance in Eqs. (9) and (15), respectively. The second term in (24) subtracts the deadweight losses of the aggregate switching costs born by the mass of large depositors who open and maintain two deposit accounts.

4. 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 by comparing the three deposit insurance regimes.

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 resulting from limited deposit insurance coverage equals the depositors' aggregate costs of opening a second account.*

Result 3 can be formally verified by adding depositors' aggregate cost (21)–(24), which yields $w^L + SW^L = w^U = w^N$. 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, large depositors with sufficiently low switching costs have an incentive to open a second bank account in order to obtain complete deposit insurance. The switching costs associated with opening and maintaining new accounts generate a social deadweight loss.

Apart from differences in realized switching costs, the three deposit insurance regimes have different implications for how the generated surplus is distributed between banks and depositors. First, we show that banks pay lower deposit rates under no deposit insurance as compared to unlimited deposit insurance $r^U - r^N = \frac{\phi(1+\lambda)\sigma}{(1-\phi)(1+3\lambda)} > 0$, and, therefore, earn higher profits under no deposit insurance $\pi^N - \pi^U = \phi\frac{(1+\lambda)^2\sigma n}{1+3\lambda} > 0$. If the probability of default is not too high $\phi < \frac{2\lambda}{1+2\lambda}$, the equilibrium deposit rates are lower under limited deposit insurance than under no deposit insurance $r^N - r^L = \frac{(1+\lambda)\sigma[2\lambda(1-\phi)-\phi]}{(1-\phi)(1+3\lambda)[1+(1-\phi)\lambda]} > 0$, which also results in higher profits under limited deposit insurance $\pi^L - \pi^N = \frac{(1+\lambda)^2\sigma n[2\lambda(1-\phi)-\phi]}{(1+3\lambda)[1+(1-\phi)\lambda]} > 0$.

Result 4. *If the probability of bank default is not too high $\phi < \frac{2\lambda}{1+2\lambda}$, the equilibrium deposit rates and profits in the three deposit insurance regimes are related as follows:*

(a) *A system with limited deposit insurance coverage softens competition in the deposit market compared with no deposit insurance. Furthermore, competition is always more intense with unlimited than with no deposit insurance. Formally, $r^U > r^N > r^L$.*
(b) *In addition, profits under the three insurance regimes can be ranked as follows $\pi^L > \pi^N > \pi^U$.*

Note that if all depositors are small (or $\lambda = 0$), then there is no distinction between the unlimited deposit insurance regime and the limited deposit insurance regime as all deposit accounts would be effectively insured. With some large depositors ($\lambda > 0$), limited deposit insurance coverage softens deposit rate competition between banks. This feature can be explained with the following mechanism. Limited deposit insurance offers gains from diversification that relax competition for large depositors with low switching costs. In fact, our model endows each bank with market power to successfully compete for the rival bank's large depositors with low switching costs. Furthermore, under limited deposit insurance, the demand for diversification by large depositors implies that banks compete not for the full amount of the large deposit accounts of the rival, but rather, banks compete for attracting the amount left uninsured. Furthermore, in the symmetric equilibrium, even though some depositors transfer their uninsured deposits to the second bank, these transfers are reciprocal, and neither bank loses deposits as $s_{A,2}^L = s_{B,2}^L$.[12]

Result 4(a) could also be explained by the fact that the different deposit insurance systems induce different interest rate elasticities of the demand from large depositors. To see this, we compare the demand functions of large depositors with unlimited deposit insurance and with limited deposit insurance coverage. For the purpose of this argument and without loss of generality, we focus on bank A and assume that we start from a situation with $r_A > r_B$. For the case of unlimited deposit insurance, the demand from large depositors is given by $2(1+s_{B,2}) = 2+\frac{4}{\sigma}(r_A-r_B)$, which compared with the demand under limited deposit insurance $2-s_{A,2}+s_{2,B} = 2+\frac{2-\phi}{\sigma}(r_A-r_B)$, is less sensitive to a change in the deposit rate differ-

[12] Note that this outcome of the model matches observed market behavior. In particular, deposit placement services such as CDARS are characterized by a reciprocal mechanism of allocation of large deposits among member banks, implying that participating banks do not experience outflow of deposits.

ence $r_A - r_B$ as $\frac{2-\phi}{\sigma} < \frac{4}{\sigma}$. With no deposit insurance, the demand of large depositors is determined by $2(1+s_{B,2}) = 2 + \frac{4(1-\phi)}{\sigma}(r_A - r_B)$ which has a strictly lower elasticity compared with the unlimited deposit insurance case since $\frac{4(1-\phi)}{\sigma} < \frac{4}{\sigma}$. Comparing the demand elasticities between limited deposit insurance and no deposit insurance, we can see that the former is lower than the latter (i.e. $\frac{2-\phi}{\sigma} < \frac{4(1-\phi)}{\sigma}$) as long as the probability of default is not too large, $\phi < \frac{2}{3}$. This condition on the probability of default is less restrictive than what is required for Result 4 as $\frac{2\lambda}{1+2\lambda} < \frac{2}{3}$. It captures the fact that Result 4 is based on the total demand for deposits which includes the demand of both small and large depositors.

Limited deposit insurance coverage essentially relaxes deposit market competition for large depositors. By inducing some large depositors to transfer money between banks in order to enhance their insurance coverage, it reduces the effective interest rate elasticity of demand. From a theoretical perspective, this mechanism resembles how information exchange between lenders, who have established customer relationship, softens lending rate competition by strengthening banks' ability to target their poaching activities towards specific borrowers from the rival bank.[13]

In addition, Result 4(a) captures the idea that consumers 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 transfer from the insurance agency to depositors under unlimited deposit insurance.

The comparison of the three regimes of deposit insurance with respect to consumer welfare and the expected cost of the insurance fund can be summarized as follows with a formal proof in Appendix B.

Result 5.

(a) *Consumer welfare is always higher under unlimited than under limited or no deposit insurance. In addition, consumer welfare is lower under limited than no deposit insurance if the probability of default is sufficiently low and the switching costs are sufficiently high.*
(b) *Expected cost of bailing out banks increases with the limit on deposit insurance.*
Formally, $di^N < di^L < di^U$.

When comparing limited (L) deposit insurance coverage with no (N) deposit insurance, we can first make use of Results 3 and 4 to conclude that the introduction of limited deposit insurance imposes social costs in the form of expected bank bailouts or costs on consumers in the form of switching costs or lower deposit rates. From the perspective of consumers the regime of limited deposit insurance presents the following trade off when compared with that of no deposit insurance. On one hand, large depositors are given the option to open a second account and achieve full deposit insurance at a cost or stay with one bank and have half of their deposits uninsured. On the other hand, under limited deposit insurance banks offer lower deposit rates to consumers. Depending on whether the diversification effect or the competition effect dominates the introduction of limited deposit insurance may improve or diminish consumer welfare. For low default risk of banks, consumers are better off without limited deposit insurance and the competition effect dominates. For high default risk and relatively low switching costs, consumers benefit from the limited deposit insurance.

Overall, taking into account Results 3–5, 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 large depositors with low switching costs, because the limit in the deposit insurance coverage magnifies the incentives of these depositors to open a second account. 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 compared with systems of unlimited or no deposit insurance.

5. Extensions

5.1. Independent bank failures

Our analysis so far has focused on perfectly correlated default risks of 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 failure 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 summarize this section in the following result.

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.*

To show this result, we proceed by examining each of the three deposit insurance regimes separately.

5.1.1. Independent bank failures: no deposit insurance

We examine the possible case in which some consumers open a second account and transfer half of the amount, so they maintain a diversified portfolio bearing *independent* risks. In this case, the utility function for a bank i depositor with deposit amount $d = 1, 2$ is given by:

$$u_{i,d}(s) = \begin{cases} d[(1-\phi)r_i - \phi] & \text{if does not open a second bank account;} \\ (1-\phi)^2(r_i + r_j)\frac{d}{2} + (1-\phi)\phi\frac{d}{2}(r_i - 1) & \text{if opens a second account and} \\ +\phi(1-\phi)\frac{d}{2}(r_j - 1) + \phi^2(-d) - \sigma s & \text{transfers } \frac{d}{2} \text{ to bank } j; \\ d[(1-\phi)r_j - \phi] - \sigma s & \text{if transfers } d \text{ to bank } j. \end{cases} \tag{25}$$

The first row of (25) characterizes the utility of depositors, who keep their entire deposit with their main bank i. The second alternative captures the expected return associated with opening a second bank account and transferring half of the initial deposit amount d. The consumer earns $r_i + r_j$ interest if neither bank fails, which happens with probability $(1-\phi)^2$. If only one bank fails (with probability $(1-\phi)\phi$), the consumer earns interest from the non-failing bank, but loses the deposit with the failing bank. The consumer loses all deposits if both banks fail (with probability ϕ^2). The third row describes the alternative of transferring the full deposit amount to the second bank.

The switching cost threshold for the choice between the first two alternatives in (25) is $s_{i,d} = \frac{(1-\phi)d(r_i - r_j)}{2\sigma}$. This implies that the consumer opens a second account only if there is positive interest rate differential $r_j > r_i$. However, once the switching costs are paid, the risk-neutral consumer is better off transferring the entire deposit

[13] 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).

amount (d) to the higher paying bank j, which rules out the diversification option. With the only viable options one and three in (25), the analysis replicates the results in Section 3.3.

5.1.2. Independent bank failures: unlimited deposit insurance

Under unlimited deposit insurance, consumers do not bear risk and therefore will not open a second account unless the rival bank offers a higher interest. Hence, the analysis of Section 3.4 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 (14). The expected total bailout cost under unlimited deposit insurance with independent failures is given by

$$\begin{aligned} di^U &= \phi^2[2(1+\lambda)n(1+r^U)] + 2(1-\phi)\phi(1+\lambda)n(1+r^U) \\ &= \phi 2(1+\lambda)n(1+r^U). \end{aligned} \tag{26}$$

Comparing (26) with (14) reveals that the expected bailout cost is the same regardless of whether we focus on independent or perfectly correlated bank failures.

5.1.3. Independent bank failures: limited deposit insurance

Following arguments similar to the previous two sections, the equilibrium deposit rates, profits, and segmentation thresholds derived in Section 3.5 hold true also under independent failures. We are left to verify that the expected bailout cost to support the limited deposit insurance under independent failures is unchanged.

$$\begin{aligned} di^L = {} & \phi^2\left[2(1-\lambda)n(1+r^L) + 4s_2^L\lambda n(1+r^L) + 2\lambda n(1-s_2^L)(1+r^L)\right] \\ & + 2(1-\phi)\phi\left[(1-\lambda)n(1+r^L) + 2s_2^L\lambda n(1+r^L)\right. \\ & \left. +\lambda n(1-s_2^L)(1+r^L)\right] = \phi\left[2(1-\lambda)n(1+r^L) + 4s_2^L\lambda n(1+r^L)\right. \\ & \left. +2\lambda n(1-s_2^L)(1+r^L)\right]. \end{aligned} \tag{27}$$

The first row in (27) is the expected insurance cost of bailing out two failing banks taking into account that a fraction of large accounts $s_2^L > 0$ are held in two banks and are fully insured. The second row is the expected cost of bailing out only one bank. The third row shows that the expected cost under independent failures is the same as under perfectly correlated failures (23).

5.2. Mean-preserving asset returns

We examine a mean-preserving spread of the asset returns modeled as a process $(\tilde{\rho}, \tilde{\phi})$ such that $\tilde{\phi} > \phi$ and $(1-\tilde{\phi})\tilde{\rho} = (1-\phi)\rho$. A mean-preserving spread increases the probability of default but leaves the expected return unchanged by simultaneously increasing the return conditional on no default $\tilde{\rho} > \rho$. We can characterize the effects of a mean-preserving spread as follows.

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 proof of Result 7 is given in Appendix C. The importance of this result is that in our model banks do not have incentives to increase the risk of their portfolios even in the presence of deposit insurance.

5.3. Multiple bank accounts

Solving the general problem where large depositors hold higher levels of wealth that would require opening more than two bank accounts to achieve full deposit insurance 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 $\theta(1+r)$ denote the deposit insurance limit. If $d \leqslant \theta$, the depositor is fully insured and, therefore, does not have to open a second account. However, if $d > \theta$, the depositor may benefit from opening additional accounts.

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

$$s^\theta \stackrel{\text{def}}{=} \frac{\phi\theta(2+r)}{\sigma} \quad \text{and} \quad s^M \stackrel{\text{def}}{=} \frac{2\phi M(1+r)}{\sigma}. \tag{28}$$

Then we can characterize the demand for multiple deposit accounts as follows.

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 $s \geqslant \max\{s^\theta, s^M\}$;*
(b) *open I additional accounts if $s^M \leqslant s < s^\theta$;*
(c) *open $I+1$ additional accounts if $s < \min\{s^\theta, s^M\}$.*

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

6. 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 large depositors to diversify their deposits across several banks. Within such a framework, we demonstrated that limited deposit insurance coverage softens competition among banks, thereby introducing a redistribution of surplus from depositors to banks. Furthermore, we established 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' risky lending or 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.[14] 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.

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.

We have restricted our attention to an evaluation of limited deposit insurance coverage by comparing it with systems with unlimited or no deposit insurance. In light of Results 3 and 5 we know that the limited deposit insurance system is not socially optimal. However, our model does not include all the elements which are important from the perspective of a characterization of a socially optimal deposit insurance system. In particular, our model incorporates neither the possibility of bank run equilibria associated with a system of no deposit insurance nor potential moral hazard issues associated with extensive deposit insurance systems. Recent work by Dávila and Goldstein (2016) provides such a general framework but it omits the possibility of multiple bank accounts allowed under the current deposit insurance design and examined in this paper.

Finally, to motivate our analysis, we have presented evidence using publicly available data on bank's average balances of partially insured deposit accounts and households' holdings of multiple accounts. The evidence suggests that the limited deposit insurance design has led to a strong demand for multiple deposit accounts. To the best of our knowledge, this evidence is novel. However, the available data do not allow us to link individual household deposit accounts with the banks where those accounts are held at, nor with the geographic location of those households. This limits the scope of the feasible empirical tests of our model. A formal test of the model would require a detailed micro-level data and exogenous variation in the level of deposit insurance coverage either in a cross-section of countries at a given point in time or over time for a single country. Interestingly, a recent study by Iyer et al. (2015), which uses a unique account-level data from Denmark, provides such a detailed micro-level empirical analysis. They find that an exogenous change in the deposit insurance coverage in Denmark triggered a sizable reallocation of partially-insured deposits across banks in order to increase insurance. Thus, the study provides evidence that the demand for multiple deposit accounts is not unique to the U.S. It still remains an open issue to empirically evaluate the effect of a partial deposit insurance coverage on deposit market competition.

[14] 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 (2015) 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 large depositors who open a second account may benefit from transferring more than $1 (deposit insurance limit). Such an allocation was considered in the third row of (16) in which large 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 large depositors from bank A to transfer $2 to bank B instead of just $1. We show 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 large depositors from bank A that 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 (16) exceeds that captured by the second row. Substituting (19) for r_A^L yields

$$r'_B > \hat{r}_B \overset{\text{def}}{=} \frac{r_A + \phi}{1-\phi} = \frac{[1+(1-\phi)\lambda](\rho+\phi) - (1+\lambda)\sigma}{(1-\phi)[1+(1-\phi)\lambda]}. \tag{A.1}$$

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

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

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

Finally, 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 5

From Results 3 and 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 $\pi^U < \pi^L$, 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. To show Result 5(a), it remains for us to compare cw^N and cw^L. Let us define the gross equilibrium deposit rate under limited deposit insurance as $y \equiv 1 + \rho - \frac{(1+\lambda)\sigma}{1+(1-\phi)\lambda}$. Then we can express the consumer surplus under the two regimes as a function of y

$$\begin{aligned} cw^N &= 2n(1+\lambda)(1-\phi)y - 2n(1+\lambda) \\ &\quad + \frac{2n(1+\lambda)^2\sigma[2\lambda - (1+2\lambda)\phi]}{(1+3\lambda)[1+(1-\phi)\lambda]} \end{aligned} \tag{B.1}$$

$$cw^L = \lambda n \frac{\phi^2}{\sigma} y^2 + 2n[1+(1-\phi)\lambda]y - 2n(1+\lambda). \tag{B.2}$$

If we form the difference between the two expressions above, we arrive at a quadratic expression in y

$$cw^L - cw^N = \lambda n \frac{\phi^2}{\sigma} y^2 + 2n\phi y - \frac{2n(1+\lambda)^2\sigma[2\lambda - (1+2\lambda)\phi]}{(1+3\lambda)[1+(1-\phi)\lambda]}. \tag{B.3}$$

The quadratic expression has a discriminant $\Delta = 4n^2\phi^2 \left[1 + \frac{2\lambda(1+\lambda)^2[2\lambda-(1+2\lambda)\phi]}{(1+3\lambda)[1+(1-\phi)\lambda]}\right]$ which is strictly positive as long as $\phi < \frac{2\lambda}{1+2\lambda}$. With a nonnegative discriminant, there exist two real roots to the quadratic equation—one positive and one negative. Since the gross deposit rate y can only be positive, we examine the positive root

$$y^* = \frac{\sigma}{\lambda\phi}\left[\sqrt{1 + \frac{2\lambda(1+\lambda)^2[2\lambda - (1+2\lambda)\phi]}{(1+3\lambda)[1+(1-\phi)\lambda]}} - 1\right]. \tag{B.4}$$

For values of y such that $0 < y < y*$, consumer welfare is such that $cw^L < cw^N$. If $y > y*$, then $cw^L > cw^N$. We can translate the condition $y < y*$ into a restriction on the magnitude of the switching costs

$$\sigma > (1+\rho)\frac{\lambda\phi[1+(1-\phi)\lambda]}{\lambda\phi(1+\lambda) + (1+(1-\phi)\lambda)\left[\sqrt{1+\frac{2\lambda(1+\lambda)^2(2\lambda-(1+2\lambda)\phi)}{(1+3\lambda)(1+(1-\phi)\lambda)}} - 1\right]}. \tag{B.5}$$

It is straightforward to verify that for $\phi < \frac{2\lambda}{1+2\lambda}$, the lower bound on σ in (B.5) is lower than the upper bound imposed by Assumption 1.

Finally, 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.

Appendix C. Proof of Result 7

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: with no deposit insurance, banks compensate depositors for the higher default risk by offering higher deposit rates. To see this, we can express the equilibrium deposit rate (5) under a mean preserving spread as $\tilde{r}^N = \frac{(1-\tilde{\phi})\tilde{\rho}(1+3\lambda)-(1+\lambda)\sigma}{(1-\tilde{\phi})(1+3\lambda)} = \frac{1-\phi}{1-\tilde{\phi}} r^N > r^N$. Even though the offered deposit rates are higher under a mean-preserving spread, in expectation, the two deposit rates pay the same spread over the return on assets $(1-\tilde{\phi})(\tilde{\rho} - \tilde{r}^N) = (1-\phi)(\rho - r^N) = \frac{(1+\lambda)\sigma}{1+3\lambda}$. As a result, expected profits are invariant to a mean-preserving spread.
   - Profits: expected profits (12) are invariant to a mean-preserving spread.
2. Unlimited deposit insurance:
   - Deposit rates: deposit rates are higher $\tilde{r}^U - r^U = \tilde{\rho} - \rho > 0$.
   - Profits: profits are lower $\frac{\tilde{\pi}^U}{\pi^U} = \frac{1-\tilde{\phi}}{1-\phi} < 1$.
3. Limited deposit insurance:
   - Deposit rates: deposit rates are higher $\frac{\tilde{r}^L - \tilde{\rho}}{r^L - \rho} = \frac{1+(1-\phi)\lambda}{1+(1-\tilde{\phi})\lambda} > 1$.
   - Profits: profits are lower under a mean-preserving spread because they do not depend on the asset return ρ and are a strictly decreasing function of ϕ as can be seen by $\frac{\partial \pi^L}{\partial \phi} = -\frac{(1+\lambda)^2 n\sigma}{(1+(1-\phi)\lambda)^2} < 0$.

Appendix D. 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

$$\begin{aligned}&(1-\phi)(d-\theta)(1+r) - \phi(d-\theta) + \theta(1+r)\\ &\quad < (1-\phi)(d-2\theta)(1+r) - \phi(d-2\theta) + 2\theta(1+r) - \sigma s,\end{aligned} \tag{D.1}$$

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

$$\begin{aligned}&(1-\phi)(d-2\theta)(1+r) - \phi(d-2\theta) + 2\theta(1+r) - \sigma s\\ &\quad < (1-\phi)(d-3\theta)(1+r) - \phi(d-3\theta) + 3\theta(1+r) - 2\sigma s,\end{aligned} \tag{D.2}$$

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

$$\begin{aligned}&(1-\phi)[d-(N-1)\theta](1+r) - \phi[d-(N-1)\theta] + (N-1)\theta(1+r)\\ &\quad - (N-2)\sigma s < (1-\phi)(d-N\theta)(1+r) - \phi(d-N\theta)\\ &\quad + N\theta(1+r) - (N-1)\sigma s,\end{aligned} \tag{D.3}$$

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

$$(1-\phi)M(1+r) - \phi M < M(1+r) - \sigma s, \tag{D.4}$$

yielding $s < s^M$.

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