

Harming Depositors and Helping Borrowers: The Disparate Impact of Bank Consolidation

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A model of multimarket spatial competition is developed where small, single-market banks compete with large, multimarket banks (LMBs) for retail loans and deposits. Consistent with empirical evidence, LMBs are assumed to set retail interest rates uniformly across markets, have different operating costs, and have access to wholesale funding. If LMBs have significant funding advantages that offset potential loan operating cost disadvantages, then market-extension mergers by LMBs promote loan competition, especially in concentrated markets. However, such mergers reduce retail deposit competition, especially in less concentrated markets. Prior empirical research and our own analysis of retail deposit rates support the model's predictions. (*JEL* G21, G28, G34, L11)

Banks in the United States have experienced rapid consolidation in recent years. Restructurings have been driven by advances in information technology and by deregulation of geographic restrictions on branching and acquisitions. Since the mid-1980s, the number of commercial banks and savings institutions more than halved from 17,900 in 1984 to 8,681 in 2006, and during the same period banks' average asset size (in inflation-adjusted 2006 dollars) more than tripled from \$348 million to \$1.366 billion. Much research has analyzed the competitive effects of this banking consolidation, especially how mergers impact potentially vulnerable customers, such as small businesses and consumers.

While banks have become fewer in number and larger on average, there has not been a systematic increase in the concentration of local banking markets.

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The Herfindahl-Hirschman Index (*HHI*) of deposit shares in Metropolitan Statistical Areas (MSAs) has averaged about the same as before the merger wave.¹ While some horizontal mergers (acquisitions involving two banks in the same market) have occurred, the major impact of consolidation has been to broaden the geographic scope of bank operations through market-extension mergers (acquisitions involving two banks in different markets).

As a result of market-extension mergers, large multimarket banks (LMBs) increasingly compete with smaller community banks in many local markets. While an LMB's entry via acquisition may not directly change a local market's concentration, there is concern that bank-dependent customers, such as small businesses and consumers, may be affected. LMBs tend to use more standardized lending and deposit-taking technologies that may produce cost differences relative to smaller banks and ultimately affect the interest rates faced by retail customers.

The current paper investigates the competitive effects of market-extension mergers that increase the presence of LMBs in local banking markets. It presents a model that accounts for three differences between LMBs and small banks that prior research has documented. First, LMBs' greater size and organizational complexity can give them costs of providing retail loans and deposits that differ from those of smaller banks. Second, LMBs standardize their services by setting retail deposit and loan rates that tend to be uniform across local markets. Third, LMBs have access to wholesale sources of funding while most small banks do not. The model is used to analyze how these three differences affect retail loan and deposit competition in local markets. The paper also examines how the model's predictions square with empirical evidence.

Our model of multimarket, spatial competition assumes that small banks operate in one local market while LMBs operate in multiple markets. A small bank sets retail loan and deposit interest rates based on the competitive conditions in its single market while an LMB chooses retail rates that are uniform across markets and reflect its differential operating and funding costs, as well as the competitive conditions in its multiple markets. The model's Bertrand-Nash equilibrium shows that retail loan and deposit rates set by banks in a particular market depend not only on the market's concentration but also the market's distribution of LMBs and small banks.

The model's most important result is that a greater presence of LMBs tends to promote competition in retail loan markets but also tends to harm competition in retail deposit markets. Depending on the relative magnitudes of these two effects, profits of small banks in a given market can rise or fall with greater penetration by LMBs. We document that several empirical studies are consistent with these implications. Empirical research finds that a greater presence of

¹ See Rhoades (2000) and Pilloff (2004). From 1994 to 2005, the average *HHI* of deposit shares for 369 MSAs rose from 1,543 to 1,601, but the median declined from 1,427 to 1,388.

LMBs in a local market tends to lower small business loan rates but also tends to lower retail deposit rates.

The plan of the paper is as follows. The next section reviews research on large and small bank differences regarding retail loans, retail deposits, and wholesale funding. This evidence justifies the assumptions made by our model presented in Section 2. The model considers large and small bank behavior in a setting of multimarket, spatial competition and solves for banks' equilibrium retail loan and deposit rates. Section 3 examines the model's implications regarding a greater presence of LMBs and evaluates these predictions in light of prior empirical research.

Section 4 presents new empirical evidence using Bankrate, Inc. survey data on retail deposit interest rates. It also analyzes how LMBs' acquisitions of small banks affect Money Market Deposit Account (MMDA) interest rates based on Call Report and Thrift Financial Report data. Section 5 contains concluding remarks.

1. Research on Differences in the Operations of Large and Small Banks

To motivate the modeling assumptions made in the next section, we briefly review three findings of prior research. First, bank size influences the technology used to make retail loans, thereby affecting operating costs. Second, LMBs tend to set retail loan and deposit interest rates that are uniform across markets. And, third, LMBs have access to wholesale sources of funding that are unavailable to smaller banks.

Theories of organization diseconomies, such as Williamson (1967) and Stein (2002), predict that LMBs may face higher costs of servicing small businesses and consumers. An LMB's top management lacks control of branch-level operations because its complex hierarchy makes monitoring lower level employees difficult. As a result, LMB managers may establish explicit decision rules rather than allowing employee discretion, so that loan approval and pricing decisions rely on "hard" information, such as financial statements and credit histories. In contrast, small banks' simpler organization permits employee decisions based on "soft information," such as the borrower's "character" and local market conditions. Empirical research by Berger et al. (2005); Cole, Goldberg, and White (2004); and Haynes, Ou, and Berney (1999) supports such large and small bank operating differences.

While there may be diseconomies of scale in utilizing soft information, other economies of scale are likely to exist. As a bank grows to be an LMB, say via a market-extension merger of smaller banks, it may eliminate some duplicate activities such as personnel and capital assigned to product marketing.² Also, geographic expansion can improve loan portfolio diversification, thereby decreasing the likelihood of incurring costs due to financial distress. Further,

² Jayaratne and Strahan (1997) document an increase in bank efficiency after states removed intrastate branching restrictions, and Hughes et al. (1999) find that performance improves for banks that expand interstate.

greater size may justify the fixed costs of determining standard criteria for loan approvals and for loan and deposit rate setting that reduce the marginal costs of these services.³ Thus, relative to smaller banks, LMBs may not face a net operating cost disadvantage for retail loans and deposits.⁴

Greater standardization by LMBs appears to extend to the setting of interest rates on consumer loans and deposits. Radecki (1998) states that many LMBs have centralized their management and operations along business, rather than geographic, lines. He documents from Bankrate, Inc. survey data that an LMB tends to quote rates for a given type of retail loan or deposit that is the same in different cities throughout a state and often throughout a wider area. Biehl (2002), Heitfield (1999), and Heitfield and Prager (2004) find that small banks set their rates based on the competitive conditions in their local MSA, but LMBs set uniform rates reflecting conditions over a larger region. The growth in Internet advertising may reinforce this uniformity. By quoting uniform rates, rather than local market-specific ones, LMBs avoid offending consumers that would be offered a relatively unattractive rate due to their location.

Prior research highlights another difference between large and small banks. Bassett and Brady (2002) document that small banks' liabilities are mostly Federal Deposit Insurance Corporation (FDIC)-insured retail deposits, while the liabilities of LMBs include large proportions of uninsured wholesale funds.⁵ LMBs, but not small banks, have access to wholesale financing because institutional investors view LMBs to be more transparent, more geographically diversified, and/or "too big to fail."⁶ Thus, small banks may consider the interest rate paid on retail deposits as their marginal cost of financing loans whereas LMBs' marginal funding cost is a wholesale rate, such as LIBOR.⁷ Indirect evidence that small banks face limited financing opportunities stems from empirical tests of a "bank-lending channel" of monetary policy.⁸ During monetary contractions, small banks, but not large ones, have difficulty funding loans, a result consistent with small banks facing retail deposit funding constraints.

³ This is consistent with LMBs' greater adoption of credit scoring for small business loans. A survey by Whiteman (1998) found that more than two-thirds of large banks, but only 12% of small banks, used credit scoring for small business loans. Berger, Frame, and Miller (2005) find similar evidence.

⁴ Berger and Udell (2006) emphasize that because LMBs use a different lending technology, they may not be disadvantaged relative to small banks, even for loans to small, opaque firms.

⁵ Retail deposits (*wholesale funds*) are categorized as "small" deposits (*large liabilities*) that have account balances below (*above*) \$100,000 and that are (*are not*) fully insured by the FDIC. Defining an LMB as a top 100 bank ranked by asset size and a small bank as one below the top 1,000, Bassett and Brady (2002) find that in the year 2000 small banks' average proportion of assets funded by small time deposits was almost three times that of LMBs. In contrast, the category of "other liabilities," which are primarily wholesale sources of funding, financed 33.2% of LMBs' assets but only 3.2% of small banks' assets.

⁶ The model in Diamond (1984) predicts that better-diversified (larger) banks have greater incentives to monitor borrowers and to make payments to uninsured depositors. Stein's (1998) theory shows that less transparent (smaller) banks will have difficulty raising funds from sources other than insured deposits.

⁷ Small banks use retail deposits as a marginal source of funding, which is consistent with Bassett and Brady's (2002) finding that the average difference between small and large banks' rates paid on small time deposits is positively correlated with the average difference between small and large banks' asset growth rates.

⁸ See Campello (2002), Jayaratne and Morgan (2000), Kashyap and Stein (2000), and Kishan and Opiela (2000).

Given these differences between LMBs and small banks, let us now consider a multimarket modeling environment where these two types of banks compete.

2. A Theory of Banking Market Size Structure and Competition

To set the stage for analyzing the rate setting behavior of LMBs and small banks, we begin by analyzing a Salop (1979) circular city model that is similar to Chiappori, Perez-Castrillo, and Verdier (1995). We first consider a situation where all banks in a particular market are small, single-market banks and later analyze markets where some banks have multimarket operations.⁹

2.1 Basic assumptions

A particular banking market has a continuum of two sets of retail customers: depositors and borrowers. These customers are located uniformly around a circle of unit length. Each depositor desires a fixed-sized deposit while each borrower wants a fixed-sized loan. Let D be the total volume of potential deposits in the market, which equals the product of the market's density of depositors and the fixed deposit size. Similarly, let L be the market's total volume of potential loans, equal to the density of borrowers times each borrower's fixed loan size.

Initially, it is assumed that there are n identical banks located equidistantly around this unit circle, so that the distance between each bank is $1/n$.¹⁰ These banks have the same technologies for producing financial services at constant marginal operating costs of c_D per unit of deposits and c_L per unit of loans. c_D includes deposit marketing expenses and the costs of sending monthly statements to depositors, while c_L reflects similar direct costs, as well as the costs of screening a borrower's credit, of monitoring the borrower, and of default losses.

To obtain these services, customers are assumed to incur a cost of traveling to a bank, where $t_D(t_L)$ equals a depositor's (*borrower's*) transportation cost per unit deposit (*loan*).¹¹ We assume that these linear transportation costs do not exceed the gross surplus from consuming each of the banking services. Thus, a given bank has a comparative advantage in serving customers that are

⁹ The novelty of our model is its allowance for multiple markets and bank types. Equilibrium loan and deposit rates can differ among banks, even among the same type of banks located in the same market.

¹⁰ These individual banks are best interpreted as bank offices or branches, with each bank having only a single office or branch in a given market. The focus of this paper is on intermarket linkages rather than the determinants of the market shares of individual banks that might result from intramarket mergers.

¹¹ The assumption of transportation costs is supported by empirical evidence indicating that consumers and small businesses prefer banks that are located near to them. Kwast, Starr-McCluer, and Wolken (1997) report that the Federal Reserve's 1992 Survey of Consumer Finance (SCF) indicates that the median distance between a household and its bank is two miles for checking accounts and three miles for savings accounts and Certificates of Deposit. Replicating their calculations using the 2004 SCF, we find that these median distances have not changed. Using 1993 Survey of Small Business Finances (SSBF) data, Petersen and Rajan (2002) report that the median distance between a small business and its bank lender is five miles. An update of their calculations using the 2003 SSBF finds that for bank loans made in the 1970s, 1980s, 1990s, and 2000–2003, the median distances were 2, 2, 4, and 9 miles, respectively. One might conclude that proximity to a bank is becoming less important for small business borrowers but not for consumer depositors.

closest to it and directly competes for customers with only its two neighboring banks.

Let $r_{L,i}$ be the retail loan rate offered by bank i , and let $r_{L,i-1}$ and $r_{L,i+1}$ be the rates given by its two neighboring banks. A borrower located between bank $i - 1$ and bank i and who is a distance $x_- \in [0, 1/n]$ from bank i is indifferent between obtaining the loan from bank $i - 1$ and bank i if

$$r_{L,i} + t_L x_- = r_{L,i-1} + t_L \left(\frac{1}{n} - x_- \right). \quad (1)$$

Similarly, a borrower located between bank i and bank $i + 1$ and who is a distance $x_+ \in [0, 1/n]$ from bank i would be indifferent between obtaining the loan from bank i and bank $i + 1$ if

$$r_{L,i} + t_L x_+ = r_{L,i+1} + t_L \left(\frac{1}{n} - x_+ \right). \quad (2)$$

Therefore, given these loan rates, bank i 's total demand is $(x_- + x_+)L$. Using Equations (1) and (2), bank i faces the loan demand curve of

$$(x_- + x_+)L = \left(\frac{r_{L,i-1} + r_{L,i+1}}{2} - r_{L,i} \right) \frac{L}{t_L} + \frac{L}{n}. \quad (3)$$

Similarly, if depositors who are a distance of y_- or $y_+ \in [0, 1/n]$ are just indifferent to supplying deposits to bank i , this bank faces a supply curve of deposits given by

$$(y_- + y_+)D = \left(r_{D,i} - \frac{r_{D,i-1} + r_{D,i+1}}{2} \right) \frac{D}{t_D} + \frac{D}{n}. \quad (4)$$

Let r_W be the wholesale borrowing or lending interest rate, such as LIBOR, and let W be bank i 's net amount invested at this wholesale rate. Consistent with the evidence discussed in Section 1, we assume that small single-market banks can invest in wholesale instruments, but cannot borrow at the wholesale rate r_W . Therefore, if bank i is small, it faces the constraint

$$W \geq 0. \quad (5)$$

Later, when LMBs are analyzed, we assume that they have access to wholesale borrowing, in addition to investing, at rate r_W , so that the sign of W is unrestricted for them.

All banks are assumed to face a regulatory capital constraint of the form

$$E \geq \rho[(y_+ + y_-)D + \max(-W, 0)], \quad (6)$$

where E is the amount of equity capital and ρ is the minimum required equity-to-debt ratio (i.e., $\rho/(1+\rho)$ is the minimum capital-to-asset ratio). The cost of

issuing equity is given by r_E , and we assume $r_E > r_W$ due to debt having a lower agency cost and/or a tax advantage relative to equity.

Given these assumptions, a bank's balance sheet equation takes the form

$$W + (x_- + x_+)L = (y_- + y_+)D + E. \quad (7)$$

2.2 Equilibrium with single-market operations

We now state the profit maximization problem for a small bank in a given market. It is

$$\text{Max}_{r_{L,i}, r_{D,i}, W} W r_W + (x_- + x_+)L(r_{L,i} - c_L) - (y_- + y_+)D(r_{D,i} + c_D) - E r_E, \quad (8)$$

subject to the constraints (5) and (6) and subject to the balance sheet equality (7).

As shown in the Appendix, there are two alternative cases for how this bank would optimally structure its balance sheet. First, if it is optimal for the bank to invest in a positive amount of wholesale funds ($W > 0$), then its equity capital constraint (6) must be binding ($E = \rho(y_- + y_+)D$). This implies that the bank's optimal loan and deposit rates satisfy

$$r_{L,i} = \frac{1}{2} \left(\frac{r_{L,i-1} + r_{L,i+1}}{2} \right) + \frac{1}{2} \left(r_W + c_L + \frac{t_L}{n} \right), \quad (9)$$

$$r_{D,i} = \frac{1}{2} \left(\frac{r_{D,i-1} + r_{D,i+1}}{2} \right) + \frac{1}{2} \left(r_W - \rho(r_E - r_W) - c_D - \frac{t_D}{n} \right). \quad (10)$$

And in a symmetric Bertrand-Nash equilibrium where $r_{L,i} = r_{L,i-1} = r_{L,i+1}$ in Equation (9), and $r_{D,i} = r_{D,i-1} = r_{D,i+1}$ in Equation (10), we have

$$r_{L,i} = r_W + c_L + t_L/n, \quad (11)$$

$$r_{D,i} = r_W - \rho(r_E - r_W) - c_D - t_D/n. \quad (12)$$

This equilibrium holds when the market has total loans less than the total of retail deposits plus required capital; that is, $L < (1 + \rho)D$. Banks' excess deposits are invested at the wholesale rate r_W , which is lower than the cost of raising equity, r_E , and leads banks to conserve capital. In this situation, the optimal loan and deposit rates are anchored by the wholesale rate.

Second, if it is optimal for the bank to issue excess equity capital ($E > \rho(y_- + y_+)D$), then its investment in wholesale funds must be zero ($W = 0$) so that constraint (5) binds. For this second case, a bank's optimal loan and deposit rates satisfy

$$r_{L,i} = \frac{1}{2} \left(\frac{r_{L,i-1} + r_{L,i+1}}{2} \right) + \frac{1}{2} \left(r_E + c_L + \frac{t_L}{n} \right), \quad (13)$$

$$r_{D,i} = \frac{1}{2} \left(\frac{r_{D,i-1} + r_{D,i+1}}{2} \right) + \frac{1}{2} \left(r_E - c_D - \frac{t_D}{n} \right). \quad (14)$$

And in a symmetric Bertrand-Nash equilibrium where $r_{L,i} = r_{L,i-1} = r_{L,i+1}$ in Equation (13), and $r_{D,i} = r_{D,i-1} = r_{D,i+1}$ in Equation (14), we have

$$r_{L,i} = r_E + c_L + t_L/n, \quad (15)$$

$$r_{D,i} = r_E - c_D - t_D/n. \quad (16)$$

This second equilibrium occurs when the market's total loans exceed total deposits plus required equity capital; that is, $L > (1 + \rho)D$. Banks must now use relatively expensive equity capital to fund the excess loans, so that the cost of equity, r_E , becomes the marginal cost of financing in Equations (15) and (16).¹² This case is consistent with Bassett and Brady's (2002) empirical evidence that, relative to large banks, small banks tend to hold more equity capital and have a greater proportion of their assets in the form of loans.

Comparing the size of the equilibrium retail loan rates in (11) and (15), note that $r_{L,i}$ is lower for the case when small banks hold positive amounts of wholesale funds because $r_W < r_E$. Similarly, the equilibrium deposit rate in (12) where $W > 0$ is less than that in (16) where $W = 0$. Thus, both deposit and loan rates are lower when money market instruments are the marginal use of funds compared to when equity capital is the marginal source of funds.

Lastly, to gain intuition for the situation faced by an LMB, suppose that this bank sets possibly different loan and deposit rates for each of the markets in which it operates, so that profits are maximized on a market-by-market basis. As mentioned earlier, a key difference between a small bank and an LMB is that the latter has access to borrowing at the wholesale rate. Hence, this bank's profit maximization problem for a particular market is given by (8) subject to (6) and (7), but not the wholesale borrowing constraint (5).

As with a small bank, there are two cases for how an LMB's balance sheet would be structured. When it has a positive investment in money market instruments, $W > 0$, the LMB acts like a small bank: its optimal loan and deposit rates are the same as (9) and (10). However, for the alternative case of $W < 0$, at the margin the LMB's capital constraint binds and it funds loans with a proportion $1/(1+\rho)$ of less expensive wholesale liabilities. Its optimal loan rate takes the form of the small bank loan rate (13) but with r_E replaced by $(r_W + \rho r_E)/(1 + \rho)$. In addition, since wholesale liabilities, not equity, are the marginal funding source, its optimal retail deposit rate is of the form of the small bank deposit rate (14) but with r_E replaced by r_W .

Hence, an LMB's retail loan and deposit rates are lower than those of similarly situated small banks when wholesale liabilities are its marginal cost of financing. Since empirical evidence supports LMBs' reliance on wholesale

¹² The model could be generalized to permit small banks to issue nonretail debt, such as uninsured jumbo CDs or privately placed notes. Qualitatively, the two types of equilibria would not change as long as the cost of these nonretail debt instruments, say, r_{JCD} , exceeded r_W . This assumption is reasonable if investors view small banks as less transparent and not "too big to fail." If $r_W < r_{JCD} < r_E$, then for the second equilibrium, the small bank's marginal cost of funding would be $(1-\rho)r_{JCD} + \rho r_E$, rather than simply r_E .

funds, our analysis that follows focuses on this case. Also consistent with empirical evidence, we assume that total market loan demand is sufficiently larger than total deposit supply; that is, $L \gg (1 + \rho)D$. This condition will ensure that in equilibrium small banks fund loans with excess shareholders' equity, even in markets where they face competition from LMBs.

2.3 Equilibrium with multimarket operations

We now permit some banks to operate in multiple markets. This new structure can be interpreted as the result of market-extension mergers, which have no effect on individual market concentrations. Thus, it is assumed that the numbers of banks in particular circular cities are unchanged, but merged banks now operate in two markets and are larger. Specifically, assume that small banks in two different markets merge to become an LMB, and the merged banks' cost structures and methods of setting interest rates change in the ways described in Section 1.

To simplify the presentation, we start by assuming that only one bank in each of two markets merges to become an LMB. Thus, if k denotes the number of LMBs in each market, our beginning assumption is $k = 1$. As will be shown, extending our analysis to the $k \geq 1$ case is easy.

Let us assume that local bank $i = 1$ is merged with a bank operating in a different circular city that has $m \leq n$ banks. We refer to the original market with n banks as the less concentrated market N , and this market's total loans and deposits are denoted L^N and D^N , respectively. The other local market having m banks is referred to as the concentrated market M , and this market's total loans and deposits are denoted L^M and D^M , respectively. Without loss of generality, assume that the merged bank (LMB) in market M is also bank $i = 1$.

As discussed earlier, bank 1's operating and funding costs can differ from its smaller rivals due to economies or diseconomies of scale. Specifically, let c_L^* and c_D^* be this LMB's operating costs of making loans and issuing deposits, respectively, while c_L and c_D remain the operating costs of small banks. Bank 1 also has access to wholesale funding at the rate r_W . However, its retail interest rates in markets N and M now must be uniform, and its uniform rates will change the equilibrium interest rates set by the other banks in the two markets.

Assuming, for now, that each of the other banks in the two markets are small single-market banks, we solve for a Nash equilibrium where all banks set profit maximizing loan and deposit rates taking their neighboring banks' rates as given. As will be shown, the equilibrium rates set by the small banks are no longer equal but differ depending on their distance from the LMB (bank 1).¹³

¹³ The model assumes that small banks' postmerger locations around the circle remain the same as before the merger. This implies that a small bank's equilibrium rates and profit depend on its distance from the LMB. We justify this assumption by interpreting the model's results as a short-run equilibrium where a bank faces costs of adjusting its location. In a longer run, small banks might move to asymmetric points around the circle such that their profits are identical. This alternative equilibrium would not change the qualitative nature of the results regarding the impact of mergers on the market's average interest rates. Of course, a longer run equilibrium also would consider market entry and exit decisions.

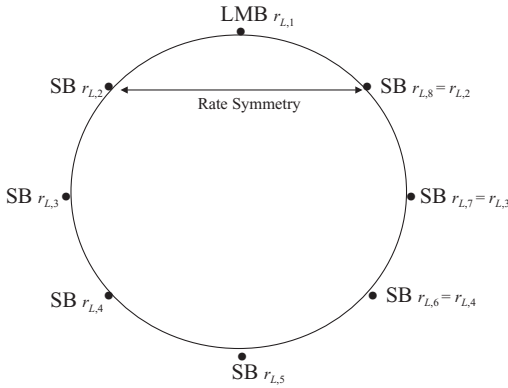


Figure 1
Rate Symmetry with a Single LMB

Note: LMB indicates a large multimarket bank. SB indicates a small bank.

However, the equilibrium is symmetric in the sense that two small banks that are equidistant from the LMB set the same rates. This situation is illustrated in Figure 1 for the case of a market with a total of eight banks.

We first examine the profit maximization problem for the single LMB, then the profit maximization problems for the smaller banks in both markets, and, finally, the equilibrium rates consistent with each bank's optimization. LMB 1 maximizes the joint profit from operating in both markets, taking as given the rates of its neighboring banks. Let $r_{L,2}^N$ and $r_{L,n}^N$ ($r_{D,2}^N$ and $r_{D,n}^N$) be the retail loan (*deposit*) rates of its two neighboring banks in market N , and let $r_{L,2}^M$ and $r_{L,m}^M$ ($r_{D,2}^M$ and $r_{D,m}^M$) be the retail loan (*deposit*) rates of its neighboring banks in market M . Given the aforementioned symmetry in rate setting of small banks that are equidistant from LMB 1, then $r_{L,n}^N = r_{L,2}^N$ ($r_{D,n}^N = r_{D,2}^N$) and $r_{L,m}^M = r_{L,2}^M$ ($r_{D,m}^M = r_{D,2}^M$). Hence, generalizing Equations (3) and (4), the total demand for loans faced by LMB 1 is

$$D_1^L(r_{L,1}, r_{L,2}^N, r_{L,2}^M) \equiv (r_{L,2}^N - r_{L,1}) \frac{L^N}{t_L} + \frac{L^N}{n} + (r_{L,2}^M - r_{L,1}) \frac{L^M}{t_L} + \frac{L^M}{m}, \quad (17)$$

and the total supply of deposits by LMB 1 is

$$S_1^D(r_{D,1}, r_{D,2}^N, r_{D,2}^M) \equiv (r_{D,1} - r_{D,2}^N) \frac{D^N}{t_D} + \frac{D^N}{n} + (r_{D,1} - r_{D,2}^M) \frac{D^M}{t_D} + \frac{D^M}{m}. \quad (18)$$

Then, the LMB 1's profit maximization problem is given by

$$\text{Max}_{r_{L,1}, r_{D,1}} W r_W + D_1^L(r_{L,1}, r_{L,2}^N, r_{L,2}^M) (r_{L,1} - c_L^*)$$

$$-S_1^D(r_{D,1}, r_{D,2}^N, r_{D,2}^M)(r_{D,1} + c_D^*) - Er_E. \quad (19)$$

Since we assume that $L^N \gg (1 + \rho)D^N$ and $L^M \gg (1 + \rho)D^M$, the LMB's capital constraint binds, and it funds loans with both retail deposits and wholesale liabilities ($W < 0$). The first-order conditions lead to the solutions

$$r_{L,1} = \frac{1}{2} \left(\frac{L^N r_{L,2}^N + L^M r_{L,2}^M}{L^N + L^M} \right) + \frac{t_L}{2} \left(\frac{L^N \frac{1}{n} + L^M \frac{1}{m}}{L^N + L^M} \right) + \frac{1}{2} \left(\frac{r_W + \rho r_E}{1 + \rho} + c_L^* \right) \quad (20)$$

and

$$r_{D,1} = \frac{1}{2} \left(\frac{D^N r_{D,2}^N + D^M r_{D,2}^M}{D^N + D^M} \right) - \frac{t_D}{2} \left(\frac{D^N \frac{1}{n} + D^M \frac{1}{m}}{D^N + D^M} \right) + \frac{1}{2} (r_W - c_D^*), \quad (21)$$

which shows that LMB 1's loan and deposit rates depend on market volume-weighted averages of the rates of its neighboring banks and the concentrations of banks in both local markets.

Turning next to the profit maximization problems of the small banks in each market, note that they face the same market environment as the LMB in that the volume of loans in each market exceeds the available retail deposits plus required capital. Thus, small banks, at the margin, fund loans with equity capital. The small banks in both market N and M choose loan and deposit rates using the conditions in Equations (13) and (14). However, unlike the basic analysis of Section 2.1, $r_{L,i-1} \neq r_{L,i} \neq r_{L,i+1}$ and $r_{D,i-1} \neq r_{D,i} \neq r_{D,i+1}$ since these banks' loan and deposit rates differ depending on their distances from LMB 1. The Appendix shows that if $L^N \gg (1 + \rho)D^N$, then the loan and deposit rates of the small banks in market N can be written as

$$r_{L,i}^N = (1 - \delta_{i,n/k}) \left(r_E + c_L + \frac{t_L}{n} \right) + \delta_{i,n/k} r_{L,1}, \quad i = 2, \dots, n/k, \quad (22)$$

$$r_{D,i}^N = (1 - \delta_{i,n/k}) \left(r_E - c_D - \frac{t_D}{n} \right) + \delta_{i,n/k} r_{D,1}, \quad i = 2, \dots, n/k, \quad (23)$$

where recall that $k = 1$ and for the case that n is an even number,¹⁴

$$\delta_{i,n/k} \equiv \frac{(2 + \sqrt{3})^{\frac{n}{2k} + 1 - i} + (2 - \sqrt{3})^{\frac{n}{2k} + 1 - i}}{(2 + \sqrt{3})^{\frac{n}{2k}} + (2 - \sqrt{3})^{\frac{n}{2k}}}. \quad (24)$$

Small banks' rates in market M are identical to Equations (22) to (24) but with n replaced by m .

Equations (22) to (24) show that small bank i 's interest rates are weighted averages of the standard Salop model rates and the rates set by LMB 1, with weights $(1 - \delta_{i,n/k})$ and $\delta_{i,n/k}$, respectively. The weight $\delta_{i,n/k}$ on LMB 1's

¹⁴ The case of n being an odd number is discussed in the Appendix.

rates is a declining function of i over the range from $i = 2$ to $i = n/2 + 1$, the mid-point of the circle, and it satisfies the symmetry conditions: $\delta_{2,n/k} = \delta_{n,n/k}$, $\delta_{3,n/k} = \delta_{n-1,n/k}$, $\dots$, $\delta_{n/2,n/k} = \delta_{n/2+2,n/k}$. Thus, as expected, a small bank's rates are less affected by LMB 1's rates the farther is its distance from LMB 1. Moreover, the Appendix shows that for a given number of bank intervals i , $i = 1, \dots, n$, away from LMB 1, the less sensitive a small bank's rates to the LMB's rate the greater is the total number of banks in the market; that is, $\partial \delta_{i,n/k} / \partial (n/k) < 0$. Thus, since $n \geq m$, then $0 < \delta_{2,n/k} \leq \delta_{2,m/k} < 1$, so that rates of small banks in the more concentrated market M are relatively more sensitive to LMB 1's rates.

The final step in determining all banks' equilibrium interest rates is to solve for LMB 1's rates given the form of the rates of its neighboring banks in both markets N and M . To find the LMB's equilibrium loan rate, we substitute Equation (22) with $i = 2$ into Equation (20) to obtain

$$r_{L,1} = r_E + c_L + t_L \frac{\beta_{n/k} L^N \frac{1}{n} + \beta_{m/k} L^M \frac{1}{m}}{\beta_{n/k} L^N + \beta_{m/k} L^M} - \frac{\Lambda(L^N + L^M)}{\beta_{n/k} L^N + \beta_{m/k} L^M}, \quad (25)$$

where $\beta_{n/k} \equiv (2 - \delta_{2,n/k}) > 1$, $\beta_{m/k} \equiv (2 - \delta_{2,m/k}) > 1$, and $\Lambda \equiv (r_E - r_W) / (1 + \rho) + c_L - c_L^*$ is the LMB's wholesale funding and loan operating cost advantage relative to a small bank. The first three terms of the right-hand side of Equation (25) are a weighted average of the equilibrium loan rates in markets N and M that would exist in the absence of the LMB, where the weights are $\beta_{n/k} L^N / (\beta_{n/k} L^N + \beta_{m/k} L^M)$ and $\beta_{m/k} L^M / (\beta_{n/k} L^N + \beta_{m/k} L^M)$, respectively. The final term indicates that the LMB's loan rate is lower the greater is its cost advantage, Λ . Lastly, the equilibrium retail loan rate of any small bank in either market is found by substituting (25) into (22):

$$r_{L,i}^M = r_E + c_L + \frac{t_L}{m} - \frac{\delta_{i,m/k}}{\beta_{n/k} L^N + \beta_{m/k} L^M} \times \left[\Lambda(L^N + L^M) + \beta_{n/k} L^N t_L \left(\frac{1}{m} - \frac{1}{n} \right) \right], \quad (26)$$

$$r_{L,i}^N = r_E + c_L + \frac{t_L}{n} - \frac{\delta_{i,n/k}}{\beta_{n/k} L^N + \beta_{m/k} L^M} \left[\Lambda(L^N + L^M) - \beta_{m/k} L^M t_L \left(\frac{1}{m} - \frac{1}{n} \right) \right]. \quad (27)$$

Since the first three terms on the right-hand sides of Equations (26) and (27) are the loan rates that the small banks would set in the absence of the LMB, the presence of an LMB lowers (raises) small banks' loan rates if the terms in brackets are positive (negative).

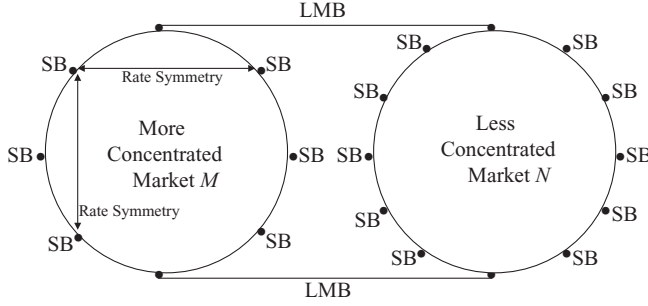


Figure 2
Circular Cities with Two LMBs

Note: LMB indicates a large multimarket bank. SB indicates a small bank.

Based on similar logic, the equilibrium deposit rate set by the LMB is derived to be

$$r_{D,1} = r_E - c_D - t_D \frac{\beta_{n/k} D^N \frac{1}{n} + \beta_{m/k} D^M \frac{1}{m}}{\beta_{n/k} D^N + \beta_{m/k} D^M} - \frac{\Delta(D^N + D^M)}{\beta_{n/k} D^N + \beta_{m/k} D^M}, \quad (28)$$

where $\Delta \equiv r_E - r_W - (c_D - c_D^*)$ is the difference between the LMB's funding and deposit operating cost advantages relative to a small bank. Then, the deposit rate of any small bank can be found by substituting (28) into (23):

$$r_{D,i}^M = r_E - c_D - \frac{t_D}{m} - \frac{\delta_{i,m/k}}{\beta_{n/k} D^N + \beta_{m/k} D^M} \times \left[\Delta(D^N + D^M) - \beta_{n/k} D^N t_D \left(\frac{1}{m} - \frac{1}{n} \right) \right], \quad (29)$$

$$r_{D,i}^N = r_E - c_D - \frac{t_D}{n} - \frac{\delta_{i,n/k}}{\beta_{n/k} D^N + \beta_{m/k} D^M} \times \left[\Delta(D^N + D^M) + \beta_{m/k} D^M t_D \left(\frac{1}{m} - \frac{1}{n} \right) \right]. \quad (30)$$

Thus, an LMB merger lowers (raises) deposit rates if the terms in brackets are positive (negative).

Having now solved for banks' equilibrium interest rates when there is $k = 1$ LMB in each market, we now discuss why Equations (25) to (30) also hold for an extended model where there are $k \geq 1$ LMBs in each of the two markets. Consider an environment where several market-extension mergers between banks in the two markets result in multiple LMBs symmetrically located around markets M and N .¹⁵ Figure 2 illustrates an example of two LMBs and eight

¹⁵ The assumption of symmetry is made for analytical convenience. While a detailed study of LMBs' location choices is beyond the scope of this paper, it is intuitive that if LMBs have a funding cost advantage, they would have a profit incentive to be closer to (compete more intensely with) disadvantaged smaller banks rather than similarly advantaged LMBs. Such incentives may justify locating symmetrically.

total banks in market M and twelve total banks in market N . LMBs are at points equidistant around the two circles, and there are an equivalent number of small banks between each LMB. This symmetry assumption allows us to generalize the previous results because each group of small banks between any two LMBs faces the same rate-setting problems as those of small banks in a market with a single LMB. In turn, each LMB is surrounded by an equal numbers of small banks, making its rate-setting problem analogous to the single merger case.

As in Figure 2 and our earlier analysis, let the number of small banks between each LMB in markets M and N be odd. The Appendix describes how derivations nearly identical to those of the single merger case lead to the LMBs and small banks having loan rates equal to Equations (25), (26), and (27), and deposit rates equal to Equations (28), (29), and (30), but where $k \geq 1$.¹⁶

3. The Model's Predictions and Prior Empirical Evidence

Having derived the equilibrium retail loan and deposit rates for LMBs and small banks in markets of varying concentration, this section analyzes the impact of LMBs on market competition and whether the model's predictions are consistent with prior empirical research. We examine how greater numbers of LMBs affect bank loan rates, deposit rates, and profits.

3.1 The effects of LMBs on loan rates

The effects of LMBs on loan rates in markets N and M depend on Equations (25) to (27). Analysis of these equations leads to the following proposition.

Proposition 1. *Let markets M and N have even numbers of banks equal to m and n , respectively, and let k of each market's banks be LMBs located equidistantly around each circle, where $1 \leq k \leq m/2 \leq n/2$. If $\Lambda > -\frac{L^N}{L^N + L^M}(\frac{1}{m} - \frac{1}{n})t_L\beta_{n/k}$, then the loan rates of all small banks in market M are lower than in the absence of LMBs, and $\Lambda > 0$ is a sufficient condition for rates to decline as k increases. If $\Lambda > \frac{L^M}{L^N + L^M}(\frac{1}{m} - \frac{1}{n})t_L\beta_{m/k}$, then the loan rates of all small banks in market N are lower than in the absence of LMBs, and this is also a sufficient condition for rates to decline as k increases.*

Proof. See the Appendix, which also gives exact conditions for loan rates to decline as k increases. ■

¹⁶ Equations for loan and deposit rates similar to (25)–(30) can be derived for an alternative structure of market extension mergers. One can assume that $k \geq 1$ LMBs operate in market M and each of them operates in a different market with n total banks where it is the only LMB. For this case, rates equal (25)–(30) but with $\delta_{i,n/k}$ and $\beta_{n/k}$ replaced by $\delta_{i,n}$ and β_n in each equation. The qualitative effects of LMBs on market M are the same as our base case where all LMBs operate in the same two markets, M and N . However, in our base case LMBs have “multimarket contact” in that they compete in two markets, rather than one. This strengthens the competitive effects on market M relative to the case of single market contact. Thus, if LMBs have a significant cost advantage, multimarket contact strengthens (weakens) loan (deposit) competition. See Pilloff (1999a) and its references for discussions of multimarket contact and competition.

Proposition 1 says that when LMBs' loan operating and funding cost advantage, Λ , is significant, their presence promotes competition in retail loans, particularly in more concentrated markets. If Λ is close to zero such that $\frac{L^M}{L^N+L^M}(\frac{1}{m} - \frac{1}{n})t_L\beta_{m/k} > \Lambda > -\frac{L^N}{L^N+L^M}(\frac{1}{m} - \frac{1}{n})t_L\beta_{n/k}$, then Equations (25) to (27) indicate that $r_{L,i}^N \leq r_{L,1} \leq r_{L,i}^M$. In this case, LMBs mitigate the difference in the markets' concentrations by setting rates that are intermediate to those of small banks in the two markets (and intermediate to those that would be set in the absence of LMBs). Loan rates in the more concentrated market M (*less concentrated market N*) are lower (*higher*) than they would be in the absence of LMBs. Moreover, Λ being nonnegative is a sufficient condition for further increases in the number of LMBs, k , to lower loan rates in the more concentrated market M .

However, if Λ is sufficiently large, an increase in LMBs can reduce loan rates of small banks in both markets. When $\Lambda > \frac{L^M}{L^N+L^M}(\frac{1}{m} - \frac{1}{n})t_L\beta_{m/k}$, Equations (25) and (27) indicate that $r_{L,1} \leq r_{L,i}^N$ and increases in k lower small bank loan rates even in the less concentrated market N . Note that for the special case of $m = n$ where uniform rate setting does not constrain LMBs because both markets' concentrations are equal, any $\Lambda > 0$ leads to a fall in both markets' loan rates. This result would also hold if concentrations were unequal but LMBs set nonuniform, market-specific rates.

The preponderance of empirical evidence is consistent with LMBs having a funding and operating cost advantage. Studies show that LMBs tend to charge lower retail loan rates compared to smaller banks and market-wide loan rates tend to be lower when LMBs have a greater presence. Berger and Udell (1996) examine small business loans using the Federal Reserve's Survey of Terms of Bank Lending to Business (STBL) during 1986–1994. Controlling for loan terms and market concentration, they find strong evidence that LMBs charge lower small business loan rates and require less collateral compared to small banks. Erel (2006) uses 1987–2004 STBL data to study the effects of mergers on small business loan rates, finding that after a merger, acquiring banks lower their loan rates. She finds that the decline in rates tends to be especially large when the acquirer is an LMB (has assets exceeding \$10 billion).

Berger, Rosen, and Udell (2007) examine lines of credit made to small businesses using the 1993 Survey of Small Business Finance (SSBF). Controlling for borrower risk and market concentration, they find that when LMBs have a greater local market share, rates on small business loans by both LMBs and small banks are lower. They conclude that there is more aggressive competition for small business credit in markets where LMBs have a greater presence.

3.2 The effects of LMBs on deposit rates

Let us now consider the impact of LMBs on retail deposit rates. Proposition 2 derives from the LMB and small bank deposit rates given in Equations (28) to (30).

Proposition 2. *Let markets M and N have even numbers of banks equal to m and n , respectively, and let k of each market's banks be LMBs located equidistantly around each circle, where $1 \leq k \leq m/2 < n/2$. If $\Delta > -\frac{D^M}{D^N+D^M}(\frac{1}{m} - \frac{1}{n})t_D\beta_{m/k}$, then the deposit rates of all small banks in market N are lower than in the absence of LMBs. If $\Delta > \frac{D^N}{D^N+D^M}(\frac{1}{m} - \frac{1}{n})t_D\beta_{n/k}$, then the deposit rates of all small banks in market M are lower than in the absence of LMBs, and this is also a sufficient condition for small banks' deposit rates in both markets N and M to decline as k increases.*

Proof. See the Appendix, which also gives exact conditions for loan rates to decline as k increases. ■

Proposition 2 implies that if the difference between an LMB's funding and deposit operating cost advantages relative to a small bank, Δ , is significant, then the presence of LMBs lowers small banks' retail deposit rates, particularly in less concentrated markets. Note that if Δ is close to zero such that $\frac{D^N}{D^N+D^M}(\frac{1}{m} - \frac{1}{n})t_D\beta_{n/k} > \Delta > -\frac{D^M}{D^N+D^M}(\frac{1}{m} - \frac{1}{n})t_D\beta_{m/k}$, then Equations (28) to (30) indicate that $r_{D,i}^M \leq r_{D,1} \leq r_{D,i}^N$. In this case, LMBs lessen the impact of differences in concentrations across markets such that all small banks' deposit rates in the less concentrated market N (*more concentrated market M*) are lower (*higher*) than in the absence of LMBs.

However, if LMBs have a sufficiently large wholesale funding advantage such that $\Delta > \frac{D^N}{D^N+D^M}(\frac{1}{m} - \frac{1}{n})t_D\beta_{n/k}$, then an increased presence of LMBs can reduce retail deposit rates even in the more concentrated market M as well. Moreover, for the special case of $m = n$, so that the markets have equal concentrations, deposit rates are lower in both markets whenever Δ is positive.

Thus, if LMBs have a significant funding advantage, as they expand into a market their anticompetitive effect on retail deposits is exactly opposite to their procompetitive effect on retail loans. Consequently, our model predicts that market-extension mergers may benefit retail borrowers but harm retail depositors. The intuition for the decline in deposit market competition stems from an LMB's unwillingness to compete aggressively for retail deposits if it has a cheaper source of wholesale funding. If, at the margin, an LMB finances loans with wholesale funds, it would never set a retail deposit rate greater than $r_W - c_D^*$, and this constraint is more likely to bind in less concentrated markets where small banks' deposit rates would tend to be higher.

Empirical studies on retail deposit market competition are generally supportive of our model's predictions. Empirical work in Hannan and Prager (2004) is motivated by a model similar to Barros (1999), which assumes that LMBs' deposit rates are exogenous but uniform across local markets. It, like our Proposition 2, predicts that the deposit rates paid by small banks become more like those of LMBs the greater is LMBs' share of the local market. This implication is tested using quarterly interest expense and deposit balance data from 1996 and 1999 Call Reports to impute the NOW and MMDA rates paid by small,

single-market banks. They find that these deposit rates diminish as LMBs' share of the local market rises, primarily because LMBs' rates are lower, consistent with a wholesale funding advantage.¹⁷

Hannan and Prager (2006a) focus on NOW and MMDA rates paid by multimarket banks during 2000–2002 and find that the rates are lower the larger is the bank's size.¹⁸ They also find that a multimarket bank's deposit rate is negatively related to a weighted average of the *HHIs* of the markets in which it operates and, even more strongly, to the state-level *HHIs* where it has a presence. These findings support the notion that LMBs enjoy a funding advantage and, as in Equation (28), an LMB's deposit rate is a deposit-weighted average of the concentrations of its markets. Hannan (2006) provides related evidence on deposit account fees, which might be viewed as “negative” deposit interest rates. He finds that LMBs charge higher fees than small banks and that a greater presence of LMBs raises the fee levels of the local single-market banks.

Our model's prediction that LMBs compete less aggressively for retail deposits is also consistent with Pilloff and Rhoades (2000) who examine the 1990–1996 change in LMBs' deposit market shares. They find that LMBs retained their market shares in more urban MSAs but lost them in relatively rural MSAs. Since LMBs obtain wholesale deposits in urban markets while only retail deposits are obtained in rural markets, these findings are consistent with LMBs' reliance on wholesale funding and their reluctance to compete for retail deposits.

3.3 The effects of LMBs on bank profitability

This section analyzes how the presence of LMBs affects the overall profitability of banks. To isolate the effect of an LMB's wholesale funding advantage from the effect of its uniform rate setting, consider the case where the concentrations of markets *N* and *M* are equal. In this case, LMBs would charge uniform rates even when permitted to charge different ones. Setting $m = n$ in the equilibrium loan and deposit rate in Equations (25) to (30) and then calculating banks' profits based on these rates, it is straightforward to show that the profits of LMBs equal

$$\begin{aligned} & (L^N + L^M)t_L \left[\frac{1}{n} + \frac{\Delta}{t_L} \left(\frac{1 - \delta_{2,n/k}}{\beta_{n/k}} \right) \right]^2 + (D^N + D^M)t_D \\ & \times \left[\frac{1}{n} - \frac{\Delta}{t_D} \left(\frac{1 - \delta_{2,n/k}}{\beta_{n/k}} \right) \right]^2, \end{aligned} \quad (31)$$

¹⁷ Rosen (2007) also finds that from 1988 to 2004, small banks paid lower NOW rates when large banks (those with more than \$20 billion in assets) had a greater share of the local market.

¹⁸ Their results are consistent with Kiser (2004), who uses banks' retail deposit rates from the single Bankrate survey taken in the first week of June 1998. She regresses deposit rates on a large number of control variables and finds that retail rates are negatively related to the log of bank assets.

while the profits of small bank i , $i = 2, \dots, n/k$, equal¹⁹

$$L^N t_L \left[\frac{1}{n} - \frac{\Lambda}{t_L} \left(\frac{\delta_{i,n/k}}{\beta_{n/k}} \right) \right]^2 + D^N t_D \left[\frac{1}{n} + \frac{\Delta}{t_D} \left(\frac{\delta_{i,n/k}}{\beta_{n/k}} \right) \right]^2. \quad (32)$$

The quantities in brackets in (31) and (32) are the individual banks' equilibrium market shares of total loans and deposits.²⁰ Thus, a bank's profit in a loan or a deposit market is proportional to its squared share of that market. Since $1/n$ is the average of the n banks' market shares, when LMBs have a significant wholesale funding advantage such that Λ and Δ are both positive, LMBs (*small banks*) have loan market shares that are greater (*smaller*) than average. In contrast, LMBs (*small banks*) have deposit market shares that are smaller (*greater*) than average.

Moreover, when $\Lambda > 0$ the first term in (32) indicates that small banks' loan market shares and profits fall as the number of LMBs, k , rises because the factor $\delta_{i,n/k}/\beta_{n/k} = \delta_{i,n/k}/(2 - \delta_{2,n/k})$ rises with k . Furthermore, small banks located closest to an LMB experience the lowest loan market profits. In contrast, if $\Delta > 0$, the second term in (32) shows that small banks' deposit market shares and profits rise with an increase in the number of LMBs, and small banks that are closest to LMBs have the highest deposit market profits.²¹ The impact of LMBs on a given small bank's total profits can be positive or negative depending on the relative sizes of total market loans to deposits and differences in loan and deposit transportation and operating costs. Thus, a greater presence of LMBs may increase small bank profits in some markets but decrease them in others.

For the general case of $m \leq n$, expressions for LMB and small bank profitability are more complex than (31) and (32). However, note from Propositions 1 and 2 that the competitive impact of LMBs on loan and deposit markets is relatively greater for the concentrated market M compared to the less concentrated market N . Hence, all else equal, LMBs are more likely to reduce small banks' profits in relatively concentrated markets.²² Intuitively, this is because LMBs' uniform rates are averages across markets, so that their loan rates tend to be lower, and their deposit rates tend to be higher, than those of small banks in concentrated markets.

¹⁹ Equation (32) is for a small bank in market N . The equation is the same for a small bank in market M except that L^M replaces L^N and D^M replaces D^N .

²⁰ In deriving the profits in (31) and (32), it is assumed that the market shares in the brackets are all positive. This restriction constrains the parameters in our model to cases where the impact of LMBs is moderate enough to leave all banks with positive loan and deposit market shares and, hence, positive profits.

²¹ Similarly, note from (31) that if Λ and Δ are positive, LMBs' loan (*deposit*) market profits fall (*rise*) as the number of LMBs, k , increase. Also, recall that since customers' demands for loans and supplies of deposits are inelastic, and that loan and deposit rates fall for all banks, the consumer surplus of borrowers (*depositors*) rises (*falls*) with an increase in the number of LMBs.

²² This result suggests that in a dynamic model with entry and exit decisions, LMBs will find entry into more concentrated markets to be most attractive. For the case where both markets have the same concentration and have no initial LMB, note that the incentive for two small banks to merge to form an LMB equals the difference between profits given in (31) with $k = 1$ and $(L^N + L^M)t_L/n^2 + (D^N + D^M)t_D/n^2$.

Since the model predicts that LMBs' impact on small bank profits are case specific, it is unsurprising that empirical research on this issue is mixed. Whalen (2001) finds that during 1995–1999 small bank profits were lower when LMBs had greater shares of their MSAs, while Pilloff (1999b) reports that small bank profits for 1995–1996 in non-MSA rural counties increased with the presence of LMBs. Using 1985 data for MSAs and rural counties of eight unit-banking states, Wolken and Rose (1991) find that small bank profits declined with LMB market share.

Berger et al. (2007) show that a greater LMB market share increased small bank profitability during the 1980s but decreased it during the 1990s. They surmise that technological progress in lending allowed LMBs to more effectively compete with small banks in recent years.²³ Finally, Hannan and Prager (2006b) report that during 1996–2003 an increased presence of LMBs reduced small bank profits in non-MSA counties but not in the less concentrated MSAs. Consistent with our model, they find that impact of LMBs in reducing small bank profits is the greatest in the most concentrated non-MSA counties.

4. New Evidence on Retail Deposit Competition

This section presents new empirical tests of our model's predictions regarding retail deposit market competition. We first examine equilibrium in a static setting using Bankrate, Inc. survey data. Second, we use Call Report and Thrift Financial Report data to investigate the dynamics of MMDA rates before and after LMBs' acquisitions of small banks.

4.1 Evidence using Bankrate survey data

This section analyzes individual LMB and small bank retail deposit rates observed in different local markets. We begin by describing the data used in our tests.

4.1.1 Data and sample selection. Our data include retail deposit interest rates from annual Bankrate, Inc. surveys of individual commercial banks and thrift institutions over the seven-year period from 1998 to 2004. The deposit rates are for MMDAs, six-month maturity retail Certificates of Deposits (CDs), and one-year maturity retail CDs paid by banks in up to 145 different MSAs. The date of each year's survey is chosen to be the last week of June so as to match annual FDIC Summary of Deposits (SOD) data. The SOD data record the amount of deposits issued by individual banks in each MSA and are used to calculate the total deposits (market size) and the *HHI* of each MSA, as well as each of our sample bank's deposits issued both within and outside of the

²³ In terms of our model, a technological change may have increased $c_L - c_L^*$, so that Λ has grown and intensified retail loan competition. Ergungor (2005) finds that during 1996–2002 when bank mergers were prevalent, community banks that specialized in small business loans underperformed other small banks.

Table 1
MMDA and CD rates and spreads for small banks and LMBs, 1998–2004

Deposit type Year (No. of MSAs)	Small bank rates		LMB rates				Small bank-LMB rate spreads			
	Mean	Obs	Mean	Obs	Rate diversity [†]	LIBOR	Mean	Obs	% > 0	Test of > 0 (<i>p</i> -values)
MMDA										
1998 (113)	2.83	175	2.22	425	0.33	5.66	0.61	174	82.8	0.00***
1999 (115)	2.57	191	1.73	435	0.26	5.23	0.83	186	90.3	0.00***
2000 (114)	2.75	91	1.86	447	0.33	6.64	0.87	91	83.5	0.00***
2001 (145)	2.36	72	1.42	544	0.20	3.86	0.99	72	88.9	0.00***
2002 (139)	1.26	75	0.81	443	0.23	1.83	0.44	75	80.0	0.00***
2003 (143)	0.78	62	0.42	510	0.16	1.12	0.38	62	80.6	0.00***
2004 (142)	0.79	59	0.50	532	0.17	1.36	0.37	59	83.1	0.00***
Six-month CD										
1998 (113)	4.93	193	4.55	444	0.40	5.78	0.40	192	84.9	0.00***
1999 (115)	4.29	199	3.96	441	0.33	5.65	0.33	199	84.4	0.00***
2000 (114)	5.32	100	5.06	466	0.30	7.00	0.30	100	61.0	0.00***
2001 (145)	3.84	77	3.27	565	0.25	3.90	0.66	79	96.2	0.00***
2002 (139)	2.06	74	1.57	478	0.22	1.95	0.45	74	90.5	0.00***
2003 (143)	1.22	66	0.82	519	0.14	1.11	0.40	65	90.8	0.00***
2004 (142)	1.22	69	0.99	546	0.16	1.94	0.27	69	75.4	0.00***
One-year CD										
1998 (113)	5.22	193	4.81	444	0.40	5.84	0.41	192	89.6	0.00***
1999 (115)	4.61	199	4.30	441	0.33	5.84	0.32	199	79.4	0.00***
2000 (114)	5.87	100	5.43	466	0.26	7.18	0.44	100	73.0	0.00***
2001 (145)	4.08	77	3.47	565	0.24	4.18	0.68	79	93.7	0.00***
2002 (139)	2.46	74	1.92	478	0.18	2.28	0.47	74	94.6	0.00***
2003 (143)	1.47	67	0.88	519	0.17	1.19	0.53	63	95.2	0.00***
2004 (142)	1.58	70	1.45	546	0.13	2.46	0.20	70	68.6	0.00***

[†]Rate diversity is the proportion of markets in which a given LMB is surveyed for which it sets different interest rates. Specifically, the statistic reported is the median for all LMBs of the ratio (Number of different survey rates quoted by the LMB–1)/(Number of markets in which the LMB was surveyed–1).

***Significance at the 1% level.

This table reports summary statistics on individual banks' Money Market Deposit Account (MMDA) and Certificate of Deposit (CD) interest rates surveyed by *Bank Rate Monitor* for the fourth week in June during the years 1998–2004. To make MMDA and CD rates comparable to the equivalent maturity London Inter-Bank Offered Rates (LIBOR), we convert all MMDAs to monthly compounding, six-month CDs to semiannual compounding, and one-year CDs to annual compounding. Small banks are defined as having total deposits less than \$1 billion while large multimarket banks (LMBs) are defined as having total deposits greater than \$10 billion. LIBOR data are from the British Bankers' Association. MMDA and CD rate spreads between small banks and LMBs are computed as the rate paid by each small bank less the average of the rates paid by the LMBs in the small bank's local market. Tests of whether the small bank-average LMB spread are positive are carried out using both a *t*-test and a Wilcoxon *z*-test. As reported below, both of these tests indicate a significantly positive spread at better than the 1% level for all deposits and all years.

surveyed MSAs. In addition, as a proxy for an LMB's wholesale funding cost, we obtained one-, six-, and twelve-month LIBOR corresponding to the survey dates from the British Bankers' Association.

The Bankrate data are attractive because they contain the actual MMDA and retail CD rates paid by an individual bank at a given date in a particular local market. However, not all MSAs and not all banks in a given MSA are surveyed by Bankrate. The first column in Table 1 lists the number of MSAs surveyed in each of the seven years, with 130 MSAs per year being the average.

Bankrate tends to select large- and medium-sized MSAs.²⁴ It surveys ten banks in each of the largest MSAs, but fewer in the others, with 5.6 being the average. Because Bankrate surveys relatively large MSAs, and within those MSAs it selects banks with the highest market shares, large banks are more likely to be surveyed than smaller ones. In our tests, we define an LMB as any bank having greater than \$10 billion in total deposits while a small bank is one with less than \$1 billion in total deposits. Columns 3 and 5 in Table 1 gives the total number of small bank and LMB observations per deposit type and year. In only a handful of cases was a given small bank surveyed in more than one MSA. However, there were approximately fifty-one different LMBs surveyed per year, and, on average, an LMB was surveyed in 9.7 different MSAs.

4.1.2 Deposit rates: small banks versus LMBs. Our model assumes that LMBs set uniform rates across markets and have access to wholesale funding. We now show that the data are consistent with these assumptions. LMB rates tend to be uniform across the surveyed markets. Also, LMBs appear to have access to lower cost wholesale funding because they do not compete aggressively for retail deposits. Large bank MMDA and retail CD rates tend to be lower than those of small banks.

In Table 1, columns 2 and 4 give the mean MMDA and CD rates offered by small banks and LMBs for the years 1998–2004.²⁵ It also reports in column 6 a measure of LMB “rate diversity,” defined as the proportion of markets in which a given LMB is surveyed for which it sets different rates. Specifically, the statistic reported is the median for all LMBs of

$$\text{Rate Diversity} = \frac{\text{Number of Different Survey Rates Quoted by an LMB} - 1}{\text{Number of Markets in which the LMB Was Surveyed} - 1} \quad (33)$$

Note that if an LMB sets a uniform rate across all markets, its rate diversity equals 0, while if it sets different rates in each market, its rate diversity equals 1. Column 6 of Table 1 shows that the tendency for LMBs to set uniform rates increased over the sample period. We also found that if an LMB’s rate diversity is calculated at the state, rather than national, level, the median value was 0.0 for all deposit types for each of the years, indicating strong state-wide uniformity. This is consistent with the findings of Radecki (1998).

Table 1 reports that during each of the seven years, and for both MMDAs and CDs, the average deposit rates offered by small banks exceeded the corresponding average rates offered by LMBs. Moreover, the mean LMB retail rates were always lower than their equivalent maturity LIBOR, but this was not always the case for the mean small bank rates.

²⁴ There are approximately 330 MSAs in the United States, and those surveyed by Bankrate tend to be larger and less concentrated than the U.S. average. MSAs in the Bankrate sample have an average and median HHI of 1,460 and 1,300, respectively.

²⁵ The median values for deposit rates were close to their reported mean values.

A simple comparison of mean deposit rates fails to control for possible differences in the structure of markets in which small banks and LMBs operate. To control for differences, for each small bank surveyed by Bankrate, we computed the spread between the small bank's deposit rate and the average of the rates paid by the LMBs in that small bank's local market. Columns 8–11 of Table 1 show that the average spreads based on this market-by-market calculation are significantly positive at better than a 99% confidence level for each type of deposit and each year. These results provide clear evidence that LMBs do not compete for retail deposits as aggressively as small banks, and they match the empirical research discussed previously.

4.1.3 The effect of LMB market share on retail deposit rates. Recall that Proposition 2 predicts that LMBs' uniform rate setting lessens the impact of market concentration on smaller banks' deposit rates and, if LMBs have a significant funding advantage, their greater presence reduces small bank deposit rates primarily in less concentrated markets. We test this proposition by regressing individual banks' retail deposit rates on market structure and bank size variables. The dependent variables in these regressions are MMDA, six-month CD, or one-year CD rates. The explanatory market variables are the MSA's concentration level (*HHI*), the natural log of total MSA deposits as a proxy for market size ($\ln(\text{MSADep})$), and the share of the MSA's total deposits issued by LMBs (*LMB Share*). Another explanatory variable is a bank size dummy variable that equals 1 if the bank is an LMB, and zero otherwise (*LMB Dummy*). Also, as explained below, an interaction variable, the product of *HHI* and *LMB Share*, is included.²⁶

If, as Table 1 suggests, LMBs have a wholesale funding advantage that reduces the rate they are willing to pay on retail deposits, then the regression's *LMB dummy* variable will have a negative coefficient. The coefficient on *HHI* also is expected to be negative since, all else equal, deposit rates are lower in more concentrated markets. Furthermore, Proposition 2 predicts that the coefficients on *LMB Share* and *LMB Share*HHI* should be negative and positive, respectively. The rationale is that a greater presence of LMBs lowers other banks' deposit rates in less concentrated markets, but the reduction is less (and may even become an increase) in more concentrated markets. Hence, *LMB Share*'s impact on lowering deposit rates should be greatest when *HHI* is low but mitigated as *HHI* rises. Finally, since less concentrated MSAs with high LMB market shares are often large MSAs, we include the log of total MSA deposits to reduce the possibility that market size-related factors might bias the other variables' coefficient estimates.

Panel A of Table 2 presents results for MMDA interest rates based on cross-sectional regressions for each year from 1998 to 2004. As expected,

²⁶ In addition, because LMBs tend to set deposit rates that are uniform across different MSAs, especially those in the same state, the regressions control for bank fixed effects across same-state MSAs.

Table 2
Regressions of MMDA rates on market structure and bank size variables, 1998–2004

Independent variable	Dependent variable: MMDA rate							
	1998	1999	2000	2001	2002	2003	2004	FM (98–04)
Panel A								
Market structure variables								
<i>HHI</i>	−0.160 (−1.42)	−0.100 (−1.24)	−0.093 (−0.65)	−0.332*** (−2.84)	−0.160* (−1.90)	−0.227*** (−3.68)	−0.032 (−0.41)	−0.158*** (−4.23)
<i>Ln(MSADep)</i>	−0.018 (−0.86)	0.030 (1.28)	−0.021 (−0.82)	−0.010 (−0.51)	0.011 (0.74)	0.008 (0.84)	0.073*** (2.62)	0.010 (0.84)
<i>LMB Share</i>	−0.273 (−1.05)	0.034 (0.12)	0.625* (1.80)	−0.273 (−0.99)	−0.128 (−0.66)	−0.222 (−1.52)	0.147 (0.88)	−0.013 (−0.10)
Bank size variable								
<i>LMB Dummy</i>	−0.440*** (−7.61)	−0.676*** (−10.53)	−0.552*** (−7.29)	−0.748*** (−11.61)	−0.360*** (−8.64)	−0.305*** (−9.97)	−0.299*** (−7.28)	−0.483*** (−7.10)
Interaction variable								
<i>HHI* LMB Share</i>	0.150 (1.05)	0.010 (0.07)	−0.095 (−0.49)	0.362** (2.29)	0.139 (1.20)	0.241*** (2.91)	−0.006 (−0.07)	0.114* (1.92)
Adjusted <i>R</i> – square	0.39	0.42	0.36	0.58	0.48	0.40	0.35	
DF	127	130	135	159	113	142	146	6
Observations	743	791	709	778	601	687	710	7

Table 2
(Continued)

Independent variable	Dependent variable: MMDA rate							
	1998	1999	2000	2001	2002	2003	2004	FM (98–04)
Panel B								
Market structure variables								
<i>HHI</i>	−0.209*** (−2.72)	−0.137* (−1.85)	−0.138 (−1.14)	−0.182* (−1.68)	−0.119** (−2.23)	−0.106* (−1.80)	−0.077 (−1.09)	−0.138*** (−8.15)
<i>Ln(MSADep)</i>	−0.001 (−0.06)	0.026 (1.12)	−0.017 (−0.68)	−0.000 (−0.02)	0.012 (0.82)	0.015 (1.51)	0.064** (2.30)	0.014 (1.44)
<i>LMB Share*(1−RD)</i>	−1.116*** (−2.96)	−0.057 (−0.16)	0.561 (1.03)	−0.141 (−0.40)	−0.099 (−0.45)	−0.076 (−0.42)	0.106 (0.57)	−0.117 (−0.62)
Bank size variable								
<i>LMB Dummy</i>	−0.436*** (−7.61)	−0.673*** (−10.50)	−0.524*** (−6.93)	−0.731*** (−11.37)	−0.362*** (−8.71)	−0.297*** (−9.64)	−0.294*** (−7.16)	−0.474*** (−7.12)
Interaction variable								
<i>HHI* LMB Share*(1−RD)</i>	0.479** (2.43)	0.106 (0.61)	−0.003 (−0.01)	0.225 (1.12)	0.128 (1.18)	0.102 (1.02)	0.058 (0.58)	0.156** (2.62)
Adjusted <i>R</i> -square	0.40	0.42	0.36	0.58	0.49	0.39	0.35	
DF	127	130	135	159	113	142	146	6
Observations	743	791	709	778	601	687	710	7

*, **, and *** indicates significance at the 10%, 5%, and 1% levels, respectively.

MMDA rates are from *Bank Rate Monitor* surveys conducted in the fourth week of June of each year. Deposit quantity data are from each year's FDIC Summary of Deposits. The independent variables are *HHI*: Herfindahl-Hirschman index of the MSA's deposits divided by 1,000; *Ln(MSADep)*: Log of the MSA's total deposits; *LMB Share*: share of MSA deposits issued by banks having total deposits exceeding \$10 billion. *LMB Dummy* equals 1 if the bank has total deposits exceeding \$10 billion (0 otherwise); *RD* is rate diversity as defined in the text. *t*-statistics are in parentheses. The estimation accounts for fixed effects of multiple observations of the same bank operating in the same state. The column FM reports the average of time-series coefficients with Fama-MacBeth *t*-statistics in parentheses.

the coefficient on *HHI* is always negative and is statistically significant for three of the seven years. The coefficient on *LMB Dummy* is negative and highly significant in all cases, a result consistent with the evidence in Table 1. The coefficients on *LMB Share* and *HHI*LMB Share* are of the predicted signs (negative and positive, respectively) for four of the seven years, but they are often not statistically significant. An indication of the explanatory variables' effects for the entire sample period is given in the last column of the table, which reports the time-series averages of the year-by-year regression coefficients along with their Fama-MacBeth standard errors. It shows that *HHI*, *LMB Dummy*, *LMB Share*, and *HHI*LMB Share* all have their expected signs and are statistically significant except for the variable *LMB Share*.

Panel B of Table 2 repeats the regressions in panel A but accounts for the fact that some LMBs do not set perfectly uniform rates and, instead, may vary rates based on local market conditions. If this were the case, then one would expect *LMB Share* to have a smaller effect since LMBs would set rates similar to small local banks. Hence, we replace *LMB Share* with $LMB\ Share*(1-RD)$, where *RD* is the average of the rate diversities for the LMBs surveyed in the MSA. The results with this modification are qualitatively similar to those in panel A; perhaps because *RD* is relatively small in most markets. In particular, the Fama-MacBeth coefficient for $HHI*LMB\ Share*(1-RD)$ remains positive and statistically significant.

Tables 3 and 4 report similar year-by-year regressions for six-month CD rates and one-year CD rates, respectively. The results in these two tables are similar to each other, and are even more aligned with the model's predictions. The coefficient on *LMB Dummy* is always significantly negative, and the coefficient on *HHI* is always negative and is statistically significant in over 85% of the cases. Also, the coefficients on *LMB Share* and *HHI*LMB Share* [or $LMB\ Share*(1-RD)$ and $HHI*LMB\ Share*(1-RD)$] have their expected negative-positive signs over 82% of the time and are statistically significant almost 40% of the time. Based on the Fama-MacBeth coefficient averages, these variables always have their expected signs and are statistically significant in all but one instance.

Table 5 gives regression results that pool the seven years of data for each deposit type. In addition to the previously described explanatory variables, these regressions include dummy variables to account for time fixed effects. In all cases, coefficients on *HHI* and *LMB Dummy* are significantly negative. In five of six cases, the coefficients on *LMB Share* or $LMB\ Share*(1-RD)$ have their expected negative signs, but are statistically significant only once. However, the coefficients on *HHI*LMB Share* or $HHI*LMB\ Share*(1-RD)$ are always significantly positive.²⁷

²⁷ As discussed by Bassett and Zakrajšek (2003), during the slow growth years of 2001–2003, as well as 1998, which endured the effects of the Asian financial crisis, larger banks were disproportionately affected by macroeconomic events compared to smaller banks. Loan demand at large banks fell while a flight to quality allowed them to

Table 3
Regressions of 6-M CD Rates on market structure and bank size variables, 1998–2004

Independent variable	Dependent variable: six-month CD Rate							
	1998	1999	2000	2001	2002	2003	2004	FM (98–04)
Panel A								
Market structure variable								
<i>HHI</i>	−0.214*** (−2.83)	−0.075* (−1.69)	−0.234* (−1.82)	−0.295*** (−4.13)	−0.248*** (−3.95)	−0.182*** (−3.74)	−0.115** (−2.41)	−0.195*** (−6.71)
<i>Ln(MSADep)</i>	−0.060*** (−4.39)	−0.015 (−1.16)	−0.016 (−0.72)	−0.011 (−0.88)	−0.006 (−0.56)	−0.011 (−1.26)	0.057*** (3.23)	−0.009 (−0.67)
<i>LMB Share</i>	−0.315* (−1.82)	−0.153 (−1.00)	0.065 (0.21)	−0.122 (−0.72)	−0.294** (−2.04)	−0.080 (−0.67)	−0.063 (−0.59)	−0.137** (−2.73)
Bank size variable								
<i>LMB Dummy</i>	−0.198*** (−5.27)	−0.266*** (−7.77)	−0.165** (−2.47)	−0.468*** (−12.15)	−0.432*** (−13.92)	−0.297*** (−12.01)	−0.121*** (−4.49)	−0.278*** (−5.58)
Interaction variable								
<i>HHI* LMB Share</i>	0.254*** (2.65)	0.054 (0.76)	0.131 (0.76)	0.250** (2.56)	0.278*** (3.20)	0.158** (2.39)	0.099* (1.79)	0.175*** (5.35)
Adjusted <i>R</i> -square	0.50	0.38	0.45	0.65	0.56	0.52	0.47	
DF	128	133	138	160	119	132	154	6
Observations	764	804	725	778	638	669	745	7

Panel B								
Market structure variables								
<i>HHI</i>	-0.133*** (-2.62)	-0.061 (-1.51)	-0.280*** (-2.58)	-0.261*** (-3.96)	-0.075** (-2.01)	-0.163*** (-3.52)	-0.136*** (-3.12)	-0.158*** (-4.96)
<i>Ln(MSADep)</i>	-0.054*** (-4.08)	-0.014 (-1.17)	-0.011 (-0.48)	-0.009 (-0.71)	0.001 (0.10)	-0.007 (-0.86)	0.051*** (2.85)	-0.006 (-0.53)
<i>LMB Share*(1-RD)</i>	-0.450* (-1.80)	-0.179 (-0.94)	-0.441 (-0.91)	-0.162 (-0.76)	0.018 (0.11)	-0.149 (-1.01)	-0.103 (-0.89)	-0.209** (-3.19)
Bank size variable								
<i>LMB Dummy</i>	-0.190*** (-5.08)	-0.268** (-7.85)	-0.149** (-2.24)	-0.457*** (-11.95)	-0.426*** (-13.59)	-0.291*** (-11.83)	-0.117*** (-4.35)	-0.271*** (-5.44)
Interaction variable								
<i>HHI* LMB Share*(1-RD)</i>	0.321** (2.47)	0.044 (0.47)	0.404 (1.52)	0.289** (2.33)	0.057 (0.73)	0.174** (2.20)	0.151** (2.45)	0.206*** (3.99)
Adjusted <i>R</i> -square	0.50	0.38	0.45	0.65	0.55	0.52	0.47	
DF	128	133	138	160	119	132	154	6
Observations	764	804	725	778	638	669	745	7

*, **, and *** indicates significance at the 10%, 5%, and 1% levels, respectively.

Six-month CD rates are from *Bank Rate Monitor* surveys conducted in the fourth week of June of each year. Deposit quantity data are from each year's FDIC *Summary of Deposits*. The independent variables are *HHI*: Herfindahl-Hirschman index of the MSA's deposits divided by 1,000; *Ln(MSADep)*: Log of the MSA's total deposits; *LMB Share*: share of MSA deposits issued by banks having total deposits exceeding \$10 billion. *LMB Dummy*: equals 1 if the bank has total deposits exceeding \$10 billion (0 otherwise); *RD* is rate diversity as defined in the text. *t*-statistics are in parentheses. The estimation accounts for fixed effects of multiple observations of the same bank operating in the same state. The column FM reports the average of time-series coefficients with Fama-MacBeth *t*-statistics in parentheses.

Table 4
Regressions of 1-Y CD rates on market structure and bank size variables, 1998–2004

Independent variable	Dependent variable: one-year CD rate							
	1998	1999	2000	2001	2002	2003	2004	FM (98–04)
Panel A								
Market structure variables								
<i>HHI</i>	−0.134** (−2.06)	−0.062 (−1.30)	−0.141 (−1.05)	−0.279*** (−3.59)	−0.244*** (−3.59)	−0.260*** (−4.21)	−0.143** (−2.21)	−0.180*** (−5.91)
<i>Ln(MSADep)</i>	−0.032*** (−2.72)	−0.008 (−0.59)	−0.018 (−0.76)	−0.015 (−1.11)	−0.007 (−0.58)	−0.006 (−0.57)	0.100*** (4.23)	0.002 (0.12)
<i>LMB Share</i>	−0.028 (−0.19)	0.056 (0.34)	0.308 (0.96)	−0.117 (−0.64)	−0.186 (−1.20)	−0.302** (−1.97)	−0.106 (−0.75)	−0.054 (−0.73)
Bank size variable								
<i>LMB Dummy</i>	−0.266*** (−8.16)	−0.326*** (−8.60)	−0.270*** (−3.87)	−0.480*** (−11.27)	−0.451*** (−13.51)	−0.406*** (−12.99)	−0.098*** (−2.72)	−0.328*** (−6.58)
Interaction variable								
<i>HHI* LMB Share</i>	0.136* (1.66)	−0.010 (−0.13)	0.039 (0.21)	0.231** (2.17)	0.248*** (2.66)	0.266*** (3.18)	0.118 (1.57)	0.147** (3.62)
Adjusted <i>R</i> -square	0.55	0.37	0.42	0.61	0.59	0.55	0.44	
DF	129	133	137	161	119	136	153	6
Observations	764	799	724	777	639	674	743	7

Panel B								
Market structure variables								
<i>HHI</i>	−0.094** (−2.14)	−0.067 (−1.52)	−0.226** (−2.00)	−0.262*** (−3.65)	−0.093** (−2.32)	−0.245*** (−4.16)	−0.188*** (−3.18)	−0.168*** (−5.45)
<i>Ln(MSADep)</i>	−0.026** (−2.33)	−0.008 (−0.65)	−0.016 (−0.70)	−0.015 (−1.13)	0.004 (0.31)	−0.004 (−0.34)	0.085*** (3.61)	0.003 (0.20)
<i>LMB Share*(1−RD)</i>	−0.152 (−0.71)	0.074 (0.36)	−0.064 (−0.13)	−0.150 (−0.64)	−0.002 (−0.01)	−0.414** (−2.20)	−0.156 (−1.00)	−0.123* (−2.11)
Bank size variable								
<i>LMB Dummy</i>	−0.258*** (−7.93)	−0.323*** (−8.56)	−0.245*** (−3.53)	−0.471*** (−11.15)	−0.445*** (−13.24)	−0.396*** (−12.76)	−0.093*** (−2.58)	−0.319*** (−6.37)
Interaction variable								
<i>HHI* LMB Share*(1−RD)</i>	0.206* (1.85)	−0.004 (−0.05)	0.331 (1.20)	0.289** (2.15)	0.073 (0.88)	0.315*** (3.13)	0.206** (2.47)	0.202*** (4.23)
Adjusted <i>R</i> -square	0.55	0.37	0.42	0.61	0.59	0.54	0.45	
DF	129	133	137	161	119	136	153	6
Observations	764	799	724	777	639	674	743	7

*, **, and *** indicates significance at the 10%, 5%, and 1% levels, respectively.

One-year CD rates are from *Bank Rate Monitor* surveys conducted in the fourth week of June of each year. Deposit quantity data are from each year's *FDIC Summary of Deposits*. The independent variables are *HHI*: Herfindahl-Hirschman index of the MSA's deposits divided by 1,000; *Ln(MSADep)*: Log of the MSA's total deposits; *LMB Share*: share of MSA deposits issued by banks having total deposits exceeding \$10 billion. *LMB Dummy*: equals 1 if the bank has total deposits exceeding \$10 billion (0 otherwise); *RD* is rate diversity as defined in the text. *t*-statistics are in parentheses. The estimation accounts for fixed effects of multiple observations of the same bank operating in the same state. The column FM reports the average of time-series coefficients with Fama-MacBeth *t*-statistics in parentheses.

Table 5
Pooled regressions of MMDA and CD rates on market structure and bank size variable, 1998–2004

Independent variable	Dependent variable: deposit rate					
	MMDA	Six-month MMDA	Six-month CD	One-year CD	One-year CD	CD
Market structure variables						
<i>HHI</i>	−0.156*** (−4.25)	−0.144*** (−5.20)	−0.170*** (−6.61)	−0.113*** (−5.85)	−0.160*** (−5.88)	−0.116*** (−5.64)
<i>Ln(MSADep)</i>	0.005 (0.76)	0.006 (0.89)	−0.015*** (−2.80)	−0.012** (−2.33)	−0.008 (−1.48)	−0.007 (−1.27)
<i>LMB Share</i>	−0.040 (−0.44)		−0.121* (−1.89)		−0.021 (−0.32)	
<i>LMB Share*(1−RD)</i>		−0.117 (1.14)		−0.082 (−1.13)		0.030 (0.40)
Bank size variable						
<i>LMB Dummy</i>	−0.489*** (−0.489***)	−0.483*** (−0.483***)	−0.273*** (−0.273***)	−0.269*** (−0.269***)	−0.322*** (−0.322***)	−0.317*** (−0.317***)
Interaction variable						
<i>HHI* LMB Share</i>	0.115** (2.40)		0.147*** (4.35)		0.122*** (3.41)	
<i>HHI* LMB Share*(1−RD)</i>		0.155*** (3.02)		0.109*** (3.02)		0.098** (2.57)
Adjusted <i>R</i> -square	0.75	0.75	0.96	0.95	0.95	0.95
DF	928	928	940	940	944	944
Observations	5,019	5,019	5,123	5,123	5,120	5,120

*, **, and *** indicates significance at the 10%, 5%, and 1% levels, respectively.

MMDA, six-month CD, and one-year CD rates are from *Bank Rate Monitor* surveys conducted in the fourth week of June of each year. Deposit quantity data are from each year's FDIC *Summary of Deposits*. The independent variables are *HHI*: Herfindahl-Hirschman index of the MSA's deposits divided by 1,000; *Ln(MSADep)*: Log of the MSA's total deposits; *LMB Share*: share of MSA deposits issued by banks having total deposits exceeding \$10 billion. *LMB Dummy*: equals 1 if the bank has total deposits exceeding \$10 billion (0 otherwise); *RD* is rate diversity as defined in the text. *t*-statistics are in parentheses. The estimation accounts for fixed effects of multiple observations of the same bank operating in the same state. It also includes dummy variables for each year.

As an example of the economic significance of these estimates, consider the six-month CD regression results in column 3 of Table 5. They imply that the rates paid by LMBs are 27.3 basis points lower than other banks. They also imply that if the MSA was less concentrated such that the *HHI* was lower by 1,000, then six-month CD rates would be higher by 17.0 basis points if there were no LMBs in the market but they would be only 9.65 basis points (0.170−0.50*0.147) higher if LMBs had a 50% share of the market.

4.2 Evidence from LMB acquisitions of small banks

The previous section's results are consistent with our theory's prediction that LMBs pay lower retail deposit rates and that their greater presence in an MSA tends to reduce deposit rates. However, there is the possibility that the association between lower deposit rates and a greater LMB presence has an alternative explanation if our previous tests omitted a variable that affects both

aggressively cut deposit rates. As a robustness test to see whether our results are driven by these events, we repeated the pooled regressions in Table 5 but excluded the years 1998 and 2001–2003. The results, while weaker in some cases, were qualitatively similar.

LMB presence and deposit rates. This section attempts to provide additional support for a causal relationship between LMB market share and lower deposit rates by analyzing the dynamics of deposit rates around the time of an LMB's acquisition of a small bank.

Similar to Focarelli and Panetta (2003), we examine the dynamics of deposit rates paid by banks involved in a merger. A finding that the small bank's deposit rate prior to a merger is higher than that of the acquiring LMB after the merger would be consistent with a causal relationship between LMB presence and lower deposit rates. An alternative finding of no decline in the pre- and post-merger rates would lend credence to another explanation for the link between LMB presence and lower deposit rates.

4.2.1 Data and sample selection. We searched annual SOD data on all MSAs for 1994–2005 to identify instances where a small, single-market bank was acquired by an LMB. Our tests use both narrow and broad definitions of small banks and LMBs. Small, single-market banks are defined as having total deposits below \$1 billion with at least 75% (narrow definition) or 50% (broad definition) of their deposits in a single MSA. LMBs are defined as having total deposits exceeding \$10 billion (narrow definition) or \$5 billion (broad definition).²⁸ Similar to prior studies on deposit competition, we calculated implicit MMDA rates for commercial banks using the bank's quarterly Call Report data on MMDA interest expense and deposit balances. For thrift institutions, MMDA rates were based on their weighted average cost of MMDAs as reported on their Thrift Financial Reports. MMDA rates for the acquired small bank and the acquiring LMB were estimated as of mid-year for the year prior to the acquisition. Also, mid-year MMDA rates for the LMB were estimated for each of the three years after the acquisition. MMDA rates were also estimated for each of the other banks in the small bank's MSA over this four-year period.²⁹

For an acquisition to be included in our analysis, we required that an MMDA rate be available for the acquired small bank and the acquiring LMB for the year prior to the merger. Because data needed for calculating MMDA rates are often missing, this requirement led us to drop many potential merger observations. Under the narrow definitions of small banks and LMBs, there were forty-eight acquisitions that met our sample selection criteria. For the broader definitions, seventy-four acquisitions met our criteria.

4.2.2 Pre- and postacquisition MMDA rates. As a benchmark for comparing MMDA rates for the small bank and the LMB involved in the merger, we

²⁸ The median deposit sizes for small banks (LMBs) in our samples are \$191 million (\$18.5 billion) under the narrow definition and \$183 million (\$11.4 billion) under the broad definition.

²⁹ Note that our calculation of an MMDA rate for each multimarket bank assumes that the bank pays a uniform rate across the markets in which it operates. This is due to the fact that Call Report and Thrift Financial Report data are not broken down by market but are aggregated across all of the bank's markets.

calculated the spreads between their MMDA rates and the average of MMDA rates for the other banks in the small bank's MSA. We then compared the acquired small bank's premerger spread to the acquiring LMB's pre- and postmerger spreads to see if there were statistically significant differences. The results are given in Table 6.

Panel A of Table 6 reports tests using the sample of forty-eight acquisitions meeting the narrow definitions of small banks and LMBs. The first two rows show that the mean and median MMDA spreads for the acquiring LMBs were somewhat lower than those for the acquired small bank in the year prior to the merger, though the difference is not statistically significant. In rows three and four we then examine the thirty-four of forty-eight mergers for which MMDA spreads could be computed one year after the merger. Here we see that for this sample the LMB's postmerger spread was significantly lower than the small bank's premerger spread. Specifically, the mean premerger small bank spread was + 6.5 basis points while the mean postmerger LMB spread was -39.1 basis points. Rows five and six show that of the twenty-five mergers for which MMDA spreads could be computed two years after the merger, the LMBs' postmerger spread was, again, significantly lower than their acquired small banks' premerger spread. For three years after the merger, there is an average premerger small bank spread of 15 basis points and a postmerger average LMB spread of -15 basis points, but the difference is not significant.

Panel B of Table 6 reports results for the broader definitions of small banks and LMBs. Here, the number of merger observations is larger and the statistical significance of the pre- and postmerger spread differences is greater. The mean and median spreads of the acquiring LMBs for one, two, and three years following the merger are always significantly lower than those of the acquired small bank in the year prior to the merger. The decline in the average spread from the year before to one, two, and three years after the merger is 37, 48, and 37 basis points, respectively. In summary, these results are consistent with a causal relationship between LMB presence and lower deposit rates and present a challenge to alternative explanations.

5. Concluding Remarks

Prior empirical research finds that, relative to small banks, LMBs have more standardized operations and set retail interest rates that are uniform across many local markets. LMBs also differ from their smaller rivals in their ability to access wholesale financing. Our model of multimarket competition accounts for these findings and analyzes competition for retail loans and deposits when LMBs command a greater presence in local markets.

Our model predicts that if LMBs have a significant funding advantage that is not offset by a loan operating cost disadvantage, their rates on retail loans will be lower than their smaller bank competitors, especially in more concentrated markets. A greater presence of LMBs intensifies competition for retail loans

Table 6
Tests of differences in premerger versus postmerger MMDA spreads

Year-to-merger	-1		1	2	3
Bank type	SB	LMB	LMB	LMB	LMB
Panel A: LMBs have deposits exceeding \$10 billion, SBs have at least 75% of deposits in one market					
Premerger small bank LMB comparison (forty-eight observations)					
Mean	-0.028	-0.080			
<i>t</i> -test (<i>p</i> -value) with SB		(0.677)			
Median	-0.026	-0.110			
Wilcoxon test (<i>p</i> -value) with SB		(0.543)			
Premerger small bank versus postmerger year 1 LMB comparison (thirty-four observations)					
Mean	0.065	-0.154	-0.391		
<i>t</i> -test (<i>p</i> -value) with SB		(0.128)	(0.009)***		
Median	0.089	-0.293	-0.343		
Wilcoxon test (<i>p</i> -value) with SB		(0.136)	(0.008)***		
Premerger small bank versus postmerger year 2 LMB comparison (twenty-five observations)					
Mean	0.150	-0.195		-0.363	
<i>t</i> -test (<i>p</i> -value) with SB		(0.061)*		(0.010)**	
Median	0.201	-0.308		-0.358	
Wilcoxon test (<i>p</i> -value) with SB		(0.072)*		(0.010)**	
Premerger small bank versus postmerger year 3 LMB comparison (twenty-five observations)					
Mean	0.150	-0.195			-0.149
<i>t</i> -test (<i>p</i> -value) with SB		(0.061)*			(0.109)
Median	0.201	-0.308			-0.236
Wilcoxon test (<i>p</i> -value) with SB		(0.072)*			(0.170)
Panel B: LMBs have deposits exceeding \$5 billion, SBs have at least 50% of deposits in one market					
Premerger small bank LMB comparison (seventy-four observations)					
Mean	-0.000	-0.056			
<i>t</i> -test (<i>p</i> -value) with SB		(0.572)			
Median	-0.017	-0.051			
Wilcoxon test (<i>p</i> -value) with SB		(0.424)			
Premerger small bank versus postmerger year 1 LMB comparison (fifty-eight observations)					
Mean	0.057	-0.092	-0.314		
<i>t</i> -test (<i>p</i> -value) with SB		(0.174)	(0.002)***		
Median	0.089	-0.078	-0.201		
Wilcoxon test (<i>p</i> -value) with SB		(0.181)	(0.002)***		
Premerger small bank versus postmerger year 2 LMB comparison (forty-seven observations)					
Mean	0.126	-0.147		-0.351	
<i>t</i> -test (<i>p</i> -value) with SB		(0.025)**		(0.000)***	
Median	0.188	-0.109		-0.214	
Wilcoxon test (<i>p</i> -value) with SB		(0.033)**		(0.001)***	
Premerger small bank versus postmerger year 3 LMB comparison (forty-three observations)					
Mean	0.085	-0.149			-0.282
<i>t</i> -test (<i>p</i> -value) with SB		(0.099)*			(0.006)***
Median	0.175	-0.111			-0.236
Wilcoxon test (<i>p</i> -value) with SB		(0.117)			(0.009)***

*, **, and *** indicates significance at the 10%, 5%, and 1% levels, respectively.

This table tests for differences in MMDA spreads prior to, and following, large multimarket banks' (LMBs') acquisitions of small banks (SBs) during the years 1994–2005. Implicit MMDA rates are calculated from Call Report or Thrift Financial Report data. A SB's or LMB's spread is its MMDA rate minus the average MMDA rate of all other banks in the SB's local MSA. In panel A (panel B), LMBs are defined as having total deposits exceeding \$10 (\$5) billion, while SBs are defined as having total deposits below \$1 billion where at least 75% (50%) of the total deposits are in a single MSA in the year prior to the merger.

and reduces small banks' loan rates. Interestingly, in such a situation, LMBs' effect on retail deposit market competition is the opposite. When LMBs have a significant wholesale funding advantage, they will not compete aggressively for higher cost retail deposits. As a result, their smaller rivals can pay lower rates on retail deposits than otherwise, especially in less concentrated markets.

Our theory's predictions are consistent with prior empirical studies, as well as the new empirical findings presented in this paper. Greater market share by LMBs is associated with increased competition in small business lending but reduced competition in retail deposit taking. The impact of LMBs on overall small bank profits depends on the relative magnitudes of these two opposing effects. Our analysis underscores the likelihood that market-extension mergers, which increase the scope of LMBs, have disparate welfare consequences for different types of bank customers.

While our analysis has been in the context of banking, our theory is applicable to other industries where some competitors operate in multiple markets and set prices uniformly. For example, our model could be applied to a chain store retailer whose centralized management sets uniform prices for a wide geographic area that covers multiple local markets of varying concentrations. Such firms would enhance competition primarily in concentrated markets, forcing a lowering of prices by single-market retailers. A general effect from the spread of multimarket competitors is to reduce the variation in prices across local markets.

Appendix

A. Profit maximization in a market with only small banks

Using (7) to substitute for E in (8) and (6) and using (3) and (4), the problem becomes

$$\begin{aligned} \max_{r_{L,i}, r_{D,i}, W} & W(r_W - r_E) + \left[\frac{r_{L,i-1} + r_{L,i+1}}{2} - r_{L,i} + \frac{t_L}{n} \right] \frac{L}{t_L} (r_{L,i} - c_L - r_E) \\ & - \left[r_{D,i} - \frac{r_{D,i-1} + r_{D,i+1}}{2} + \frac{t_D}{n} \right] \frac{D}{t_D} (r_{D,i} + c_D - r_E), \end{aligned} \quad (\text{A.1})$$

subject to

$$W + \left[\frac{r_{L,i-1} + r_{L,i+1}}{2} - r_{L,i} + \frac{t_L}{n} \right] \frac{L}{t_L} \geq (1 + \rho) \left[r_{D,i} - \frac{r_{D,i-1} + r_{D,i+1}}{2} + \frac{t_D}{n} \right] \frac{D}{t_D} \quad (\text{A.2})$$

and to the constraint (5). Letting λ_1 be the Lagrange multiplier for constraint (A.2) and λ_2 be the Lagrange multiplier for the constraint (5), the first-order Kuhn-Tucker conditions are³⁰

$$\frac{r_{L,i-1} + r_{L,i+1}}{2} - 2r_{L,i} + \frac{t_L}{n} + c_L + r_E - \lambda_1 = 0, \quad (\text{A.3})$$

$$2r_{D,i} - \frac{r_{D,i-1} + r_{D,i+1}}{2} + \frac{t_D}{n} + c_D - r_E + (1 + \rho)\lambda_1 = 0, \quad (\text{A.4})$$

$$(r_W - r_E + \lambda_1 + \lambda_2)W = 0. \quad (\text{A.5})$$

³⁰ We consider only realistic cases where $r_{L,i}$, $r_{D,i}$, and loan and deposit quantities are positive.

From (A.5) we see that if $W > 0$, then $r_W - r_E + \lambda_1 + \lambda_2 = 0$. Also when $W > 0$, the constraint (5) is not binding, so that $\lambda_2 = 0$. Hence, $\lambda_1 = r_E - r_W > 0$. With λ_1 strictly positive, the capital constraint is binding. For this case (A.3) and (A.4) become Equations (9) and (10) in the text, and the symmetric equilibrium is Equations (11) and (12).

From (A.5) we see that if instead of $W > 0$, we have $W = 0$, then $\lambda_2 > 0$. For this case there are two possibilities: either the capital constraint is binding, so that $\lambda_1 > 0$; or it is not binding, so that $\lambda_1 = 0$. If the capital constraint is binding, then using $W = 0$ it becomes

$$\left[\frac{r_{L,i-1} + r_{L,i+1}}{2} - r_{L,i} + \frac{t_L}{n} \right] \frac{L}{t_L} - (1 + \rho) \left[r_{D,i} - \frac{r_{D,i-1} + r_{D,i+1}}{2} + \frac{t_D}{n} \right] \frac{D}{t_D} = 0, \quad (\text{A.6})$$

or solving for the deposit rate,

$$r_{D,i} = \frac{r_{D,i-1} + r_{D,i+1}}{2} - \frac{t_D}{n} + \frac{Lt_D}{Dt_L(1 + \rho)} \left[\frac{r_{L,i-1} + r_{L,i+1}}{2} - r_{L,i} + \frac{t_L}{n} \right]. \quad (\text{A.7})$$

But using the first-order conditions (A.3) and (A.4) and substituting out for λ_1 implies

$$\begin{aligned} r_{D,i} = & \frac{1}{2} \left[\frac{r_{D,i-1} + r_{D,i+1}}{2} - \frac{t_D}{n} - c_D + r_E \right] + \frac{1}{1 + \rho} \\ & \times \left[r_{L,i} - \frac{r_{L,i-1} + r_{L,i+1}}{4} - \frac{1}{2} \left(\frac{t_L}{n} + c_L + r_E \right) \right]. \end{aligned} \quad (\text{A.8})$$

Since condition (A.8) cannot be satisfied by (A.7) for arbitrary L and D , it must be suboptimal for capital to be constrained. Hence, $\lambda_1 = 0$. Thus, when $W = 0$ and $\lambda_1 = 0$, (A.3) and (A.4) imply Equations (13) and (14) in the text and the symmetric equilibrium is Equations (15) and (16).

From Equations (3) and (4) in the text, we see that for each of these symmetric equilibria, the individual banks' loans and deposits are L/n and D/n . For the first equilibrium (11) and (12), where $W > 0$ and the capital constraint is binding, we have from an individual bank's balance sheet constraint that $W = (1 + \rho)D/n - L/n > 0$. For the second equilibrium (15) and (16), where $W = 0$ and the capital constraint does not bind, the individual bank's balance sheet implies that $E = L/n - D/n > \rho D/n$. Hence, the first equilibrium of (11) and (12) occurs when $L > (1 + \rho)D$ while the second equilibrium of (15) and (16) obtains when $L > (1 + \rho)D$.

B. Equilibrium with multimarket operations

Let there be a total n banks competing in a local market with one LMB located at $i = 1$. Thus, banks $i = 2, \dots, n$ are small banks. When $L \gg (1 + \rho)D$, their optimal retail loan rates satisfy Equation (13), which can be written in the form of a second-order difference equation:³¹

$$r_{L,i+1} - 4r_{L,i} + r_{L,i-1} + 2(r_E + c_L + t_L/n) = 0. \quad (\text{A.9})$$

This can be rewritten using the backward operator as

$$(1 - 4B + B^2)r_{L,i} + 2(r_E + c_L + t_L/n) = 0, \quad (\text{A.10})$$

for $i = 3, \dots, n$. The roots to the quadratic equation for the backward operator are $B = 2 \pm \sqrt{3}$. Also, note that a particular solution to Equation (A.10) is $r_{L,i} = r_E + c_L + t_L/n$. Therefore, the general solution to (A.10) takes the form

$$r_{L,i} = \alpha_1(2 + \sqrt{3})^i + \alpha_2(2 - \sqrt{3})^i + r_E + c_L + t_L/n, \quad (\text{A.11})$$

³¹ The difference equation for deposit rates is similar but with $r_E + c_L + t_L/n$ is replaced with $r_E - c_D - t_D/n$.

where the constants α_1 and α_2 are determined subject to two boundary conditions. One boundary condition results from the rate set by the LMB bank $i = 1$, which, initially, we take as exogenous:

$$r_{L,1} = \alpha_1(2 + \sqrt{3}) + \alpha_2(2 - \sqrt{3}) + r_E + c_L + t_L/n. \quad (\text{A.12})$$

The second boundary condition is the symmetry property for the one or two banks that are most distant from LMB 1. When n is even, the one farthest bank is $i = n/2 + 1$, and symmetry implies that the loan rates of its two neighbors, $r_{L,i-1}$ and $r_{L,i+1}$, are the same. Hence, Equation (13) is

$$r_{L,\frac{n}{2}+1} = \frac{1}{2}r_{L,\frac{n}{2}} + \frac{1}{2}(r_E + c_L + t_L/n), \quad n \text{ even}. \quad (\text{A.13})$$

When n is an odd number, there are two banks farthest away from LMB 1, banks $i = (n+1)/2$ and $i = (n+1)/2 + 1$. If Equation (13) is written down for each of these two banks, and the symmetry condition $r_{L,\frac{n+1}{2}+2} = r_{L,\frac{n+1}{2}-1}$ is imposed, then solving these two equations for $r_{L,\frac{n+1}{2}}$ results in

$$r_{L,\frac{n+1}{2}} = \frac{1}{3}r_{L,\frac{n+1}{2}-1} + \frac{2}{3}(r_E + c_L + t_L/n), \quad n \text{ odd}. \quad (\text{A.14})$$

It what follows, we derive the solution assuming that n is even.³² Therefore, in addition to (A.12), the second boundary condition is based on (A.13). Substituting (A.11) into (A.13), simplifying, and noting that $(2 - \sqrt{3}) = (2 + \sqrt{3})^{-1}$, leads to a proportional relationship between α_1 and α_2 :

$$\alpha_2 = \alpha_1(2 + \sqrt{3})^{n+2}. \quad (\text{A.15})$$

Using (A.15) to substitute for α_2 in boundary condition (A.12), one finds the solution for α_1 to be

$$\alpha_1 = \frac{r_{L,1} - (r_E + c_L + t_L/n)}{(2 + \sqrt{3})[1 + (2 + \sqrt{3})^n]}. \quad (\text{A.16})$$

Using (A.15) and (A.16) to substitute for α_1 and α_2 in (A.12), we obtain the solution

$$r_{L,i} = (1 - \delta_{i,n})(r_E + c_L + t_L/n) + \delta_{i,n}r_{L,1}, \quad i = 1, \dots, n, \quad (\text{A.17})$$

which shows that $r_{L,i}$ is a weighted average of rates with the weight on LMB 1's rate being

$$\delta_{i,n} \equiv \frac{(2 + \sqrt{3})^{\frac{n}{2}+1-i} + (2 - \sqrt{3})^{\frac{n}{2}+1-i}}{(2 + \sqrt{3})^{\frac{n}{2}} + (2 - \sqrt{3})^{\frac{n}{2}}}. \quad (\text{A.18})$$

Note that (A.18) satisfies the symmetry conditions: $\delta_{2,n} = \delta_{n,n}$, $\delta_{3,n} = \delta_{n-1,n}$, $\dots$, $\delta_{n/2,n} = \delta_{n/2+2,n}$. Its derivative with respect to i is

$$\frac{\partial \delta_{i,n}}{\partial i} = \frac{\ln(2 + \sqrt{3})}{(2 + \sqrt{3})^{\frac{n}{2}} + (2 - \sqrt{3})^{\frac{n}{2}}} \left[(2 - \sqrt{3})^{\frac{n}{2}+1-i} - (2 + \sqrt{3})^{\frac{n}{2}+1-i} \right]. \quad (\text{A.19})$$

Since $0 < (2 - \sqrt{3}) < 1 < (2 + \sqrt{3})$, $\partial \delta_{i,n} / \partial i < 0$ over the range from $i = 2$ to $i = n/2 + 1$, the mid-point of the circle. This implies that a small bank rate's weight on LMB 1's rate declines the further is its distance from LMB 1. The derivative of (A.18) with respect to n is

$$\frac{\partial \delta_{i,n}}{\partial n} = \frac{\ln(2 + \sqrt{3})}{[(2 + \sqrt{3})^{\frac{n}{2}} + (2 - \sqrt{3})^{\frac{n}{2}}]^2} [(2 - \sqrt{3})^{i-1} - (2 + \sqrt{3})^{i-1}]. \quad (\text{A.20})$$

³² The case of n being odd is similar but uses condition (A.14) rather than (A.13).

Since $i = 2, \dots, n$ for the small banks, $\partial \delta_{i,n} / \partial n < 0$. This means that the rate charged by a small bank of a given distance $i - 1$ from LMB 1 will have a smaller weight on LMB 1's rate the less concentrated is the market. In other words, keeping distance constant, the less LMB 1's rate affects a small bank's rate the greater is the number of small banks in the market.

For the general case of a market with n total banks having $k \geq 1$ LMBs located symmetrically around the circle, let the number of small banks between any two LMBs, $(n/k) - 1$, be an odd integer. Then the same derivation as above applies to each $(n/k) - 1$ group of small banks bordered by two LMBs.³³ A small bank's rate is given by Equation (A.17) except that $\delta_{i,n}$ is replaced with $\delta_{i,n/k}$, where $\delta_{i,n/k}$ is given by Equation (A.18) but with (n/k) replacing n . This is exactly Equations (22) and (24). Since $\partial \delta_{i,n/k} / \partial (n/k) = \partial \delta_{i,n} / \partial n < 0$, we have $\partial \delta_{i,n/k} / \partial k = -(n/k^2) [\partial \delta_{i,n/k} / \partial (n/k)] > 0$. This implies that given n , the greater weight small banks' rates place on the rate of the LMBs the greater is the number of LMBs in the market. Each LMB's rate setting problem is the same as in the $k = 1$ case, such that its equilibrium loan rate equals (25) and, inserting this back into its neighboring small bank's loan rate, one obtains Equation (27). The same derivation is used to find small bank loan rates in market M and deposit rates in markets N and M .

C. Proofs of Propositions 1 and 2

To prove Proposition 1, note from the last terms in Equations (26) and (27) that the presence of LMBs lowers all small banks' loan rates in markets M and N when $\Lambda(L^N + L^M) > -\beta_{n/k} L^N t_L (\frac{1}{m} - \frac{1}{n})$ and $\Lambda(L^N + L^M) > \beta_{m/k} L^M t_L (\frac{1}{m} - \frac{1}{n})$, respectively. To find the conditions on Λ for which small bank loan rates in market M decline as k , the number of LMBs, increases, we differentiate (26) and find that $\partial r_{L,i}^M / \partial k < 0$ when

$$\Lambda > -\frac{L^N (\frac{1}{m} - \frac{1}{n}) t_L \beta_{n/k}}{L^N + L^M} \frac{\Psi_{i,m}^L + \delta_{i,m/k} L^M \frac{\partial \beta_{n/k}}{\partial k} (\frac{\beta_{m/k}}{\beta_{n/k}} + \frac{L^N}{L^M})}{\Psi_{i,m}^L}, \quad (\text{A.21})$$

where $\Psi_{i,m}^L \equiv \frac{\partial \delta_{i,m/k}}{\partial k} (\beta_{n/k} L^N + \beta_{m/k} L^M) - \delta_{i,m/k} (L^N \frac{\partial \beta_{n/k}}{\partial k} + L^M \frac{\partial \beta_{m/k}}{\partial k}) > 0$. In (A.21), since $\beta_{n/k} = (2 - \delta_{2,n/k}) > 0$ and $\partial \beta_{n/k} / \partial k = -\partial \delta_{2,n/k} / \partial k < 0$, then $\delta_{i,m/k} L^M \frac{\partial \beta_{n/k}}{\partial k} (\frac{\beta_{m/k}}{\beta_{n/k}} + \frac{L^N}{L^M}) < 0$, which permits us to show that $1 \geq [\Psi_{i,m}^L + \delta_{i,m/k} L^M \frac{\partial \beta_{n/k}}{\partial k} (\frac{\beta_{m/k}}{\beta_{n/k}} + \frac{L^N}{L^M})] / \Psi_{i,m}^L > 0$. Thus, a sufficient condition for $\partial r_{L,i}^M / \partial k < 0$ is $\Lambda > 0$. Similarly, differentiating (27), one finds that $\partial r_{L,i}^N / \partial k < 0$ when

$$\Lambda > \frac{L^M (\frac{1}{m} - \frac{1}{n}) t_L \beta_{m/k}}{L^N + L^M} \frac{\Psi_{i,n}^L + \delta_{i,n/k} L^N \frac{\partial \beta_{m/k}}{\partial k} (\frac{\beta_{n/k}}{\beta_{m/k}} + \frac{L^M}{L^N})}{\Psi_{i,n}^L}. \quad (\text{A.22})$$

In (A.22), $\delta_{i,n/k} L^N \frac{\partial \beta_{m/k}}{\partial k} (\frac{\beta_{n/k}}{\beta_{m/k}} + \frac{L^M}{L^N}) < 0$, and therefore $1 \geq [\Psi_{i,n}^L + \delta_{i,n/k} L^N \frac{\partial \beta_{m/k}}{\partial k} (\frac{\beta_{n/k}}{\beta_{m/k}} + \frac{L^M}{L^N})] / \Psi_{i,n}^L$. Thus, a sufficient condition for $\partial r_{L,i}^N / \partial k < 0$ is $\Lambda > \frac{L^M}{L^N + L^M} (\frac{1}{m} - \frac{1}{n}) t_L \beta_{m/k}$.

The proof of Proposition 2 follows that of Proposition 1. Note from the last terms in Equations (29) and (30) that the presence of LMBs lowers all small banks' deposit rates in markets M and N when $\Delta(D^N + D^M) > \beta_{n/k} D^N t_D (\frac{1}{m} - \frac{1}{n})$ and $\Delta(D^N + D^M) > -\beta_{m/k} D^M t_D (\frac{1}{m} - \frac{1}{n})$, respectively. Differentiating (29), one finds that $\partial r_{D,i}^M / \partial k < 0$ when

$$\Delta > \frac{D^N (\frac{1}{m} - \frac{1}{n}) t_D \beta_{n/k}}{D^N + D^M} \frac{\Psi_{i,m}^D + \delta_{i,m/k} D^M \frac{\partial \beta_{n/k}}{\partial k} (\frac{\beta_{m/k}}{\beta_{n/k}} + \frac{D^N}{D^M})}{\Psi_{i,m}^D}. \quad (\text{A.23})$$

³³ Note that since LMBs are identical and are assumed to set rates symmetrically, (A.12) continues to be a boundary condition because the two LMBs bordering a group of small banks that set the same rates.

Because $1 \geq [\Psi_{i,m}^D + \delta_{i,m/k} D^M \frac{\partial \beta_{n/k}}{\partial k} (\frac{\beta_{m/k}}{\beta_{n/k}} + \frac{D^N}{D^M})] / \Psi_{i,m}^D > 0$, $\Delta > \frac{D^N}{D^N + D^M} (\frac{1}{m} - \frac{1}{n}) t_D \beta_{n/k}$ is a sufficient condition for $\partial r_{D,i}^M / \partial k < 0$. Similarly, differentiating (30), one finds that $\partial r_{D,i}^N / \partial k < 0$ when

$$\Delta > - \frac{D^M (\frac{1}{m} - \frac{1}{n}) t_D \beta_{m/k}}{D^N + D^M} \frac{\Psi_{i,n}^D + \delta_{i,n/k} D^N \frac{\partial \beta_{m/k}}{\partial k} (\frac{\beta_{n/k}}{\beta_{m/k}} + \frac{D^M}{D^N})}{\Psi_{i,n}^D}. \quad (\text{A.24})$$

While $[\Psi_{i,n}^D + \delta_{i,n/k} D^N \frac{\partial \beta_{m/k}}{\partial k} (\frac{\beta_{n/k}}{\beta_{m/k}} + \frac{D^M}{D^N})] / \Psi_{i,n}^D \leq 1$, it can be negative so that $\partial r_{D,i}^N / \partial k$ can be positive for positive values of Δ . However, inspection of $\partial r_{D,i}^N / \partial k$ shows that $\Delta > \frac{D^N}{D^N + D^M} (\frac{1}{m} - \frac{1}{n}) t_D \beta_{n/k}$ is a sufficient condition for $\partial r_{D,i}^N / \partial k < 0$.³⁴

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³⁴ More detailed proofs of Propositions 1 and 2 are available upon request.

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