Bank Size, Risk Diversification and Money Markets

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Bank Size, Risk Diversification and Money Markets*

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Abstract

This paper presents a theoretical model based on risk diversification to rationalize the observed dichotomy in the federal funds market by which small banks are net providers of funds while large banks become net purchasers. As larger banks are more diversified they can raise a larger proportion of funds as equity and provide more loans. To finance these loans, they will need to obtain funds in the wholesale money market. In contrast, smaller banks will be less diversified and will find it harder to raise equity which means producing a lower amount of loans and supplying the extra funds in the wholesale money market. The model also produces a set of testable predictions about the performance of large and small banks that are in line with data for the US.

Keywords: bank size, diversification, money market, bank solvency
JEL classification codes: E4, E5, G21

1 Introduction

This paper presents a model of the money market dichotomy between large and small banks. The empirical literature has repeatedly found that small banks tend to be net sellers of funds while large banks tend to be net purchasers of funds in the market.[1] Allen et al. [2] review three possible reasons for this dichotomy. First, if small banks are more risk averse than large banks, as in Ho and Saunders [13], they would rely on deposits to finance their assets instead of

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[1] See, among others, Gambs and Kimball [12], Furfine [11], Allen et al. [2], and, more recently, Cocco et al. [7], Craid and von Peter [9] or the anecdotal evidence described in Stigum and Crescenzi [9].

on the federal funds market. Second, small banks may prefer deposit financing if they have lower deposit-taking costs than larger banks. As a third explanation, Allen and Saunders [3] show that adverse selection resulting from information asymmetries can also produce this observed pattern of trade if small banks are perceived as more opaque or riskier than large banks.[2]

The purpose of this paper is to show that the small-large dichotomy in the money market is easily reproduced by a theoretical model based on diversification opportunities associated with size. This model adapts the theoretical framework of Bruche and Suarez [5] to incorporate differences in bank size and risk diversification in a tractable way. In the model, larger banks are more diversified and face lower risks. Because they are less risky, they are also able to raise a larger proportion of funds in the form of equity. The existence of binding capital standards allows them to produce more loans. To finance these loans, they will need to obtain funds in the wholesale money market. In contrast, smaller banks will be less diversified and more risky. Because of higher risks, they will find it harder to raise equity and households will provide funds as insured deposits. Lower capital means producing a lower amount of loans and supplying the extra funds in the wholesale money market. Thus, larger banks will be net buyers of funds in money markets and smaller banks net sellers.

Apart from the position of banks in the money market, the model produces a number of additional predictions. In particular, in the model larger banks are funded with proportionally less insured deposits, provide proportionally more loans and face lower cross section volatility in non performing loan ratios as compared with smaller banks. These predictions of the model are taken to the data. For that, I use the statistics on depository institutions provided by the Federal Deposit Insurance Corporation (FDIC). These statistics include information from Call Reports submitted by all FDIC-insured depository institutions in the US. I show how this data support the predictions of the model. These predictions of the model are still confirmed by the data even after splitting the sample of banks by several institutions' characteristics such as their primary specialization, charter class or Federal Reserve district.

The remaining of the paper is organized as follows. Section 2 describes the theoretical model. Section 3 presents the data. Section 4 shows the descriptive statistics. Finally, Section 5 concludes.

2 The Theoretical Model

2.1 The setup

The model draws heavily on Bruche and Suarez [5]. There are two dates, $t = 1, 2$. The economy consists of a continuum of households, firms and banks. Households and firms are ex ante identical while banks vary in size. Households work

[2] There other theoretical papers analyzing this dichotomy. Chen and Mazumdar [6], in their theoretical model, combine the three explanations described by Allen et al. [2]. Ashcraft et al. impose this dichoyomy by assuming credit constraints and limited participation for small banks.

and provide funds. Firms demand funds to hire labor and capital. Banks intermediate between households and firms. Furthermore, there is a money market where banks can exchange funds. At date $t = 1$ decisions are taken regarding supply and demand for funds and production inputs. At date $t = 2$ uncertainty is resolved and production takes place. One of the novel contributions of this paper is the physical distribution of these agents which allows for a tractable representation of risk diversification and bank size. To describe such a setup, I will construct the model in steps.

2.1.1 Households

There is a continuum of measure 1 of identical risk neutral households. Households are endowed with an amount S of saved funds. These funds are provided to the single bank they have dealings with. Households also supply a unit of labor inelastically. They want to maximize their expected net worth at $t = 2$.

2.1.2 Firms

There is a continuum of firms with measure 1. Firms are exante identical. A firm using capital k and labor n produces according to the technology

$$z\left[Af(k,n) + (1-\delta)k\right], \tag{1}$$

where A is the aggregate TFP level which is constant and equal across firms, $f(k,n)$ is the production function which depends on the inputs of capital and labor, and $0 < \delta \leq 1$ is the depreciation rate. In this expression, z is a random variable taking values

$$z = \begin{cases} 1 & \text{with probability } \pi \\ 0 & \text{with probability } 1-\pi. \end{cases}$$

Thus, the firm stays in business with probability π while it fails with probability $1 - \pi$. Notice that in the event of failure, there are no resources left. This assumption greatly simplifies the solution of the model.

Firms start with no resources. At date $t = 1$ each firm asks for a loan l to the single bank it deals with. The loan pays for capital and labor

$$l = k + wn,$$

where w is the wage rate. In exchange for the loan, the firm promises the bank to pay R if it does not fail, which happens with probability π. However, with probability $1-\pi$ the firm will be unable to repay the loan and will be bankrupt. In such a case, because of limited liability, the firm pays 0. At date $t = 2$ uncertainty over the value of z is resolved and production (together with loan repayment in case of the firm not being bankrupt) takes place.

2.1.3 Sectors

Sectors are composed of a continuum of firms with measure 1. Each sector is characterized by a probability π of firm failure. Because of the law of large numbers, this probability also represents the fraction of firms failing in the sector. At date $t = 1$ the probability π is assumed to follow a continuous distribution $G(\pi)$ with support on the interval $[\pi_{\min}, \pi_{\max}]$. Furthermore, define

$$\pi^e \equiv E(\pi) = \int_{\pi_{\min}}^{\pi_{\max}} \pi g(\pi) d\pi$$

where $g(\pi)$ is the probability density function associated with $G(\pi)$. At date $t = 1$ sectors do not know the realization of its fraction of failing firms which is resolved at time $t = 2$.

2.1.4 Regions and banks

Each region contains a continuum of households with measure 1, a continuum of banks with measure 1, and a continuum of sectors also with measure 1. What characterizes a region is the size of the banks that live in it. All banks in region i are ex ante identical but are able to have business with a contiguous interval of sectors with measure i. In other words, a bank in region i only covers a contiguous section with measure i of the distribution of the fraction of surviving firms $G(\pi)$.

Let $\pi(i)$ be the realized fraction of surviving firms within the pool of firms of a bank in region i. This fraction is a random variable characterized by some truncated distribution $\Gamma[\pi(i), i]$ which will depend upon the value of i as well as on the initial distribution of sectors $G(\pi)$ and its support $[\pi_{\min}, \pi_{\max}]$. The support of this truncated distribution is $[\pi_{\min}(i), \pi_{\max}(i)]$ with

$$\pi_{\min}(i) = \frac{1}{i} \int_{\pi_{\min}}^{\pi_a} \pi g(\pi) d\pi,$$

which is the lowest possible average firm surviving rate across a contiguous section of measure i from the distribution G, where

$$\pi_a = G^{-1}(i),$$

and

$$\pi_{\max}(i) = \frac{1}{i} \int_{\pi_b}^{\pi_{\max}} \pi g(\pi) d\pi$$

which is the largest possible average firm surviving rate across a contiguous section of measure i from the distribution F, where

$$\pi_b = G^{-1}(1 - i).$$

Notice all truncated distributions $\Gamma[\pi(i), i]$ have the same mean π^e independently of the value of i. Furthermore, as i increases, uncertainty associated with the fraction of failing firms within the pool of loans of the bank decreases (see Figure 1). Given that i measures the size of the bank (in terms of the measure of its balance sheet), in this economy larger banks (i.e. banks in regions with larger index i) are also both more diversified and are exposed to lower risk.

As an example, consider the case in which G is uniform within the interval $[\pi_{\min}, \pi_{\max}]$. In this case, the distribution of surviving firms in region i, $\Gamma[\pi(i), i]$, is also uniform with support $[\pi_{\min}(i), \pi_{\max}(i)]$ where

$$\pi_{\min}(i) = \pi_{\min} + \frac{i}{2}(\pi_{\max} - \pi_{\min})$$

and

$$\pi_{\max}(i) = \pi_{\max} - \frac{i}{2}(\pi_{\max} - \pi_{\min}).$$

As $i \to 1$, the distribution collapses to a mass point at

$$\pi^e = \frac{\pi_{\max} + \pi_{\min}}{2}.$$

The degree of diversification is assumed to lay within the range $i \in [i_{\min}, i_{\max}]$, with $i_{\min}$ indexing the region with least diversified banks and $i_{\max}$ indexing the region with most diversified banks. At one extreme, if $i_{\min} = 0$, the least diversified banks face a risk from surviving firms in its pool of loans equal to the one derived from the whole population distribution $G(\pi)$ of surviving firms. At the other extreme, if $i_{\max} = 1$, the most diversified banks face no risk as the fraction of surviving firms within their pool of loans equals a mass point located at π^e. In between these extreme cases, the model can accommodate any distribution of diversification across banks regarding the fraction of surviving firms within its pool of loans. Assume the cross section distribution of regions according to the diversification index follows some function $H(i)$.

Banks in each region obtain funds from households and provide loans to firms living and producing in the same region, respectively. This segmentation of the financial sector at the retail level is the basic friction in the model. Labor is immobile and firms cannot attract funds directly from outside the region. Households decide whether to supply funds to the bank as deposits or as equity. Deposits are insured by the government. This insurance is financed through a lump sum tax raised at $t = 2$. Banks can also supply funds to or obtain them from other banks through a money market. Thus, the balance sheet of a bank in region i is

$$l(i) + a(i) = d(i) + e(i)$$

where $l(i)$ is the amount of loans, $a(i)$ is lending (borrowing if negative) in the money market, $d(i)$ are deposits by households, and $e(i)$ is equity.

For precautionary reasons banks are obliged to hold a fraction γ of the loans as equity to satisfy the capital requirement

$$e(i) \geq \rho l(i).$$

2.1.5 Money market

At date $t = 1$ a perfectly competitive money market opens where banks from different regions can exchange funds in the form of unsecured loans. Because of precautionary reasons assume these loans have to be perfectly diversified across all borrowing regions. However, banks in different regions will face different probabilities of being insolvent. For this motive, money market lenders will charged a region-specific spread $s(i)$, to be determined below.

Let r be the money market interest rate. For a lending bank, the revenue for lending in the money market [i.e. banks for which $a(i) = l(i) - d(i) - e(i) > 0$] is $1 + r$ per unit lent while for a borrowing bank [i.e. banks for which $a(i) = l(i) - d(i) - e(i) < 0$] the borrowing cost is $1 + r + s(i)$ per unit borrowed. These expressions can be written in compact form as

$$1 + r + s(i)\xi(i)$$

where $\xi(i)$ is an indicator function taking value 0 for lending banks and value 1 for borrowing banks.

2.2 Equilibrium

To define the equilibrium we need to construct the loan contract between banks and firms. For that, first we have to look at how households split their bank financing between deposits and equity. Then, we look at how banks provide loans to firms.

2.2.1 Banks payoff

Let $R(i)$ be the repayment by firms to banks in region i. A bank in this region will obtain as revenue $\pi(i)R(i)$ where $\pi(i)$, the fraction of non-failing firms in the bank's portfolio, is a random variable at the time the loan is set. Let $r_d(i)$ be the interest rate on deposits. Because these deposits are insured by the government, depositors do not ask for any spread above this rate. With this notation, the random payoff to bank owners in region i if the bank is solvent would be

$$\pi(i)R(i) + [1 + r + s(i)\xi(i)]\, a(i) - [1 + r_d(i)]\, d(i).$$

The second term is the revenue/cost associated with lending/borrowing in the money market. The third term is the cost paid to depositors. Notice, given choices $[\xi(i), l(i), d(i), e(i)]$ and prices $[R(i), r, s(i), r_d(i)]$, a bank in region i will be solvent, ex post, as long as the realization of the fraction of surviving firms in its pool of firms, $\pi(i)$, is high enough. In particular, a bank in region i will be solvent as long as

$$\pi(i) \geq \frac{[1 + r_d(i)]\, d(i) - [1 + r + s(i)\xi(i)]\, a(i)}{R(i)} \equiv \underline{\pi}(i). \tag{2}$$

Thus, $\underline{\pi}(i)$ is the minimum fraction of surviving firms that guarantees solvency of banks in region i. If the bank is insolvent, shareholders receive 0.

Because households are risk neutral, they will be willing to provide equity to the bank as long as its expected payoff compensates for the opportunity cost of deposits, i.e. if

$$\int_{\pi(i)\geq\underline{\pi}(i)} \{\pi(i)R(i) + [1 + r + s(i)\xi(i)]\, a(i) - [1 + r_d(i)]\, d(i)\}\, d\Gamma\, [\pi(i), i]$$
$$\geq [1 + r_d(i)]\, e(i).$$

Naturally, expected payoffs to shareholders are only computed when the bank is solvent, i.e. when $\pi(i) \geq \underline{\pi}(i)$. Because I will concentrate in equilibria where $d(i) > 0$, this expression can be rewritten as

$$R(i) \int_{\pi(i)\geq\underline{\pi}(i)} \pi(i) d\Gamma\, [\pi(i), i] \geq [1 + r_d(i)]\, e(i) -$$
$$- \{[r + s(i)\xi(i) - r_d(i)]\, a(i) + [1 + r_d(i)]\, [l(i) - e(i)]\}\, [1 - \Gamma\, (\underline{\pi}(i), i)]\,. \qquad (3)$$

From this expression it is easy to show two results equivalent to proposition 4 in Bruche and Suarez [5].[3]

Lemma 1 *In equilibrium with $d(i) > 0$, it must be the case that $r + s(i)\xi(i) = r_d(i)$ for banks with $a(i) \neq 0$.*

Lemma 2 *In equilibrium the capital constraint is binding $e(i) = \rho l(i)$.*

With these two results and using the definition of $\underline{\pi}(i)$, the participation constraint (3) becomes

$$(1 - \rho) \int_{\pi(i)\geq\underline{\pi}(i)} \pi(i) d\Gamma\, [\pi(i), i] = \underline{\pi}(i)\, [1 - (1 - \rho)\Gamma\, [\underline{\pi}(i), i]]\,.$$

This expression endogenously determines the minimum level for the fraction of surviving firms in region i, $\underline{\pi}(i)^*$, above which banks in that region will be solvent. Notice this expression only depends on the distribution $\Gamma\, [\pi(i), i]$ and the minimum capital ratio ρ. To see the conditions under which there exists a solution $\underline{\pi}(i)^*$ to that expression, rewrite it as[4]

$$(1 - \rho) \int_{\pi(i)\geq\underline{\pi}(i)} \pi(i) d\Gamma\, [\pi(i), i] = \rho\underline{\pi}(i) + (1 - \rho)\underline{\pi}(i) \int_{\pi(i)\geq\underline{\pi}(i)} d\Gamma\, [\pi(i), i]$$

or

$$(1 - \rho) \int_{\pi(i)\geq\underline{\pi}(i)} [\pi(i) - \underline{\pi}(i)]\, d\Gamma\, [\pi(i), i] = \rho\underline{\pi}(i). \qquad (4)$$

Define the left-hand side of (4) as

$$\Psi\, [x, i] \equiv (1 - \rho) \int_{\pi(i)\geq x} [\pi(i) - x]\, d\Gamma\, [\pi(i), i]\,.$$

[3] The proof of these two lemmas follow exactly the one for Proposition 4 in Bruche and Suarez [5] and is not included here.

[4] The derivations below resemble the ones in the job market search model of McCall [15]. In contrast with that model here we deal with a general equilibrium economy.

Using the Leibnitz rule, the partial derivative of $\Psi[x,i]$ with respect to its first argument, $\Psi_x[x,i]$, is

$$\begin{aligned}\Psi_x[x,i] &= -(1-\rho)[x-x]\gamma[x,i]-(1-\rho)\int_{\pi(i)\geq x} d\Gamma[\pi(i),i] \\ &= -(1-\rho)[1-\Gamma(x,i)]<0,\end{aligned}$$

where $\gamma[\pi(i),i]$ is the density function associated with the distribution $\Gamma[\pi(i),i]$. Thus, the left-hand side of expression (4) is decreasing in $\underline{\pi}(i)$. Because the right-hand side is increasing in $\underline{\pi}(i)$, it can be shown that a necessary and sufficient condition for the existence of a level for $\underline{\pi}(i)$ such that expression (4) is satisfied in region i is:

$$\pi_{\min}(i) < (1-\rho)\pi^e.$$

Notice that because $\pi_{\min}(i) \longrightarrow \pi^e$ as i increases, there may be regions with high diversification whose banks will never be insolvent.

To analyze how the bank solvency threshold $\underline{\pi}(i)$ changes with the degree of diversification i, rewrite (4) as

$$(1-\rho)\int_{\underline{\pi}(i)}^{\pi_{\max}(i)}[\pi(i)-\underline{\pi}(i)]\,d\Gamma[\pi(i),i]+(1-\rho)\int_{\pi_{\min}(i)}^{\underline{\pi}(i)}[\pi(i)-\underline{\pi}(i)]\,d\Gamma[\pi(i),i]$$
$$-(1-\rho)\int_{\pi_{\min}(i)}^{\underline{\pi}(i)}[\pi(i)-\underline{\pi}(i)]\,d\Gamma[\pi(i),i]=\rho\underline{\pi}(i).$$

or

$$(1-\rho)\pi^e-(1-\rho)\underline{\pi}(i)-(1-\rho)\int_{\pi_{\min}(i)}^{\underline{\pi}(i)}[\pi(i)-\underline{\pi}(i)]\,d\Gamma[\pi(i),i]=\rho\underline{\pi}(i)$$

and integrating by parts the integral in this expression obtain

$$(1-\rho)\pi^e+(1-\rho)\int_{\pi_{\min}(i)}^{\underline{\pi}(i)}\Gamma[\pi(i),i]\,d\pi(i)=\underline{\pi}(i). \tag{5}$$

A decrease in the diversification index i works as a mean preserving spread. Thus, for a given value of $\underline{\pi}(i)$ the second term in the left-hand side increases and, therefore, the bank solvency threshold $\underline{\pi}(i)$ should increase too. Therefore, less diversified banks (lower values of i) are associated with higher solvency thresholds $[\underline{\pi}(i)]$ and higher probabilities of default $[\Gamma(\underline{\pi}(i),i)]$. In other words

$$\frac{d\underline{\pi}(i)}{di}<0;\qquad \frac{d\Gamma[\underline{\pi}(i),i]}{di}<0.$$

Continuing with the example of the uniform distribution, expression (5) becomes

$$(1-\rho)\pi^e+(1-\rho)\frac{\left[\underline{\pi}(i)-\pi_{\min}-\frac{1}{2}(\pi_{\max}-\pi_{\min})\right]^2}{2(\pi_{\max}-\pi_{\min})(1-i)}=\underline{\pi}(i).$$

It can be shown that the left hand side is decreasing in i. Therefore, as i increases, the corresponding solution to this equation, $\underline{\pi}(i)$, is reduced.

2.2.2 The contract problem

Each bank in region i has to decide on the variables defining the loan contract with the firms in the region, given the participation constraint of the households providing funds and prices in the region. The contract is defined through the variables $\{R(i),\ l(i),\ k(i),\ n(i)\}$. Banks make these decisions to maximize the output of firms conditional on the bank being solvent, that is they maximize

$$\int_{\pi(i)\geq\underline{\pi}(i)} \{\pi(i)\left[Af(k(i),n(i))+(1-\delta)k(i)-R(i)\right]\} d\Gamma\left[\pi(i),i\right]$$

subject to the participation constraint (3)

$$\begin{aligned} R(i)\int_{\pi(i)\geq\underline{\pi}(i)} \pi(i)d\Gamma\left[\pi(i),i\right] &= \left[1+r+s(i)\xi(i)\right]\left[1-(1-\rho)\Gamma\left(\underline{\pi}(i),i\right)\right] \\ &\quad \times\left[k(i)+w(i)n(i)\right], \end{aligned}$$

where in this expression I have used lemmas 1 and 2. Substituting the participation constraint in the objective function and taking first order conditions we get

$$Af_k\left[k(i),n(i)\right]+1-\delta=\frac{\left[1-(1-\rho)\Gamma\left(\underline{\pi}(i),i\right)\right]}{\left[1-\Gamma\left(\underline{\pi}(i),i\right)\right]}\left[1+r+s(i)\xi(i)\right]$$

and

$$Af_n\left[k(i),n(i)\right]=\frac{\left[1-(1-\rho)\Gamma\left(\underline{\pi}(i),i\right)\right]}{\left[1-\Gamma\left(\underline{\pi}(i),i\right)\right]}\left[1+r+s(i)\xi(i)\right]w(i),$$

where f_x denotes the partial derivative of the production function with respect to input $x=k,n$.

From the point of view of money market lenders, a borrowing bank in region i has a default probability of $\Gamma\left(\underline{\pi}(i),i\right)$. By the law of large numbers, only a fraction $1-\Gamma\left(\underline{\pi}(i),i\right)$ of money market loans to region i will be recovered. This means that the spread borrowing banks have to pay in region i should satisfy

$$1+r=\left[1-\Gamma\left(\underline{\pi}(i),i\right)\right]\left[1+r+s(i)\right]. \tag{6}$$

Substituting this expression and including the choice of being a lender $[\xi(i)=0]$ or a borrower $[\xi(i)=1]$, the first order necessary and sufficient conditions for an interior optimal decision by bank in region i are

$$Af_k\left[k(i),n(i)\right]+1-\delta=c(r,i)$$

and

$$Af_n\left[k(i),n(i)\right]=c(r,i)w(i)$$

where $c(r,i)$ represents the cost of funds which equals

$$c(r,i)=\frac{\left[1-(1-\rho)\Gamma\left(\underline{\pi}(i),i\right)\right]}{\left[1-\Gamma\left(\underline{\pi}(i),i\right)\right]^{1+\xi(i)}}(1+r).$$

It is easy to show that the cost of funds $c(r,i)$ is decreasing with i

$$\frac{dc(r,i)}{di} < 0,$$

and, for a given i, it is lower if the bank decides to lend $[\xi(i) = 0]$ than to borrow $[\xi(i) = 1]$.

2.2.3 Characterization of equilibrium in the money market

Because of segmentation, equilibrium in labor markets implies that $n(i) = 1$ for all $i \in [i_{\min}, i_{\max}]$. Furthermore, let i^b be the value of the diversification index for which

$$Af_k(S,1) + 1 - \delta = \frac{\left[1 - (1-\rho)\Gamma\left(\underline{\pi}(i^b), i^b\right)\right]}{\left[1 - \Gamma\left(\underline{\pi}(i^b), i^b\right)\right]^2}(1+r).$$

Thus, i^b is the diversification index for which banks in that region are just indifferent between using the whole amount of funds in the region or borrowing a marginal unit of funds in the money market. Notice in each region there is the same measure of households as of firms so in autarky S is the funds that are channeled to each firm from households. Because the cost of funds is decreasing in i more diversified regions (regions with values of $i \geq i^b$) will find it profitable to borrow in the money market.

On the other hand, let i^l be the value of the diversification index for which

$$Af_k(S,1) + 1 - \delta = \frac{\left[1 - (1-\rho)\Gamma\left(\underline{\pi}(i^l), i^l\right)\right]}{\left[1 - \Gamma\left(\underline{\pi}(i^l), i^l\right)\right]}(1+r).$$

Thus, i^l is the diversification index for which banks in that region are just indifferent between using the whole amount of funds in the region or lending a marginal unit of funds in the money market. Again, because the cost of funds is decreasing in i, less diversified regions (regions with values of $i \leq i^b$) will find it profitable to lend in the money market.

Notice it must be the case that

$$i^l < i^b.$$

Then, the demand for capital should be

$$k(r,i)\begin{cases} \geq S & \text{for } i^b \leq i \leq i_{\max} \\ = S & \text{for } i^l \leq i \leq i^b \\ \leq S & \text{for } i_{\min} \leq i \leq i^l. \end{cases} \tag{7}$$

Furthermore, the clearing in the deposit and equity markets in each region implies

$$d(r,i) + e(r,i) = S + w(i).$$

On the other hand, using the equilibrium value for labor, $n(i) = 1$, loans are equal to

$$l(r, i) = k(r, i) + w(i).$$

Substituting these expressions in the balance sheet of the representative bank of region i, its money market position is

$$a(r, i) = S - k(r, i), \tag{8}$$

which is negative for regions $i^b \leq i \leq i_{\max}$, zero for regions $i^l < i < i^b$, and positive for regions $i_{\min} \leq i \leq i^l$. In other words, small, less diversified banks (those in regions $i_{\min} \leq i \leq i^l$) will be net lenders in the money market ($a(r,i) < 0$) while large, more diversified banks (those in regions $i^b \leq i \leq i_{\max}$) will be net borrowers in the money market ($a(r, i) > 0$). Medium-sized banks (those in regions $i^l \leq i \leq i^b$) will be autarkic with respect to the money market ($a(r, i) = 0$).

With these considerations in mind, equilibrium in the money market exists if there exists an interest rate r^* such that

$$\int_{i^b}^{i_{\max}} a(r^*, i) dH(i) + \int_{i_{\min}}^{i^l} a(r^*, i) dH(i) = 0,$$

or, using (8),

$$\int_{i^b}^{i_{\max}} k(r^*, i) dH(i) + \int_{i_{\min}}^{i^l} k(r^*, i) dH(i) = S \times [H(i_{\max}) - H\left(i^b\right) + H\left(i^l\right) - H(i_{\min})],$$

where $k(r^*, i)$ is defined by

$$Af_k[k(r^*, i), 1] + 1 - \delta = c(r^*, i)$$

with

$$c(r^*, i) = \frac{[1 - (1 - \rho)\Gamma\left(\underline{\pi}(i), i\right)]}{[1 - \Gamma\left(\underline{\pi}(i), i\right)]^{1+\xi(i)}}(1 + r^*),$$

where

$$\xi(i) \begin{cases} = 0 & \text{for } i^b \leq i \leq i_{\max} \\ = 1 & \text{for } i_{\min} \leq i \leq i^l \end{cases}$$

and $\underline{\pi}(i)$ is given by

$$(1 - \rho)\pi^e + (1 - \rho) \int_{\pi_{\min}(i)}^{\underline{\pi}(i)} \Gamma\left[\pi(i), i\right] d\pi(i) = \underline{\pi}(i).$$

3 The Data

The data used in this paper is taken from the database *Statistics on Depository Institutions* provided by the FDIC and available at www.fdic.gov. According to the FDIC, this data "(...) *is obtained primarily from the Federal Financial*

Institution Examination Council (FFIEC) Call Reports and the Office of Thrift Supervision (OTS) Thrift Financial Reports submitted by all FDIC-insured depository institutions." The data set spans from the last quarter of 1992 until the first quarter of 2014 which represent 86 periods of data. The number of depository institutions included in the sample has been decreasing over time, due to mergers and exits, a trend well documented in the literature.[5] At the end of 1992 there were 13973 institutions reporting while at the beginning of 2014 this number has been reduced to 6739, less than half of the original size of the sample.[6]

According to the model, larger banks purchase funds from money markets, provide proportionally more loans, and are funded with less insured deposits as compared with smaller banks. Also, as larger banks are more diversified than smaller banks, they encounter a lower volatility in their fraction of non-performing loans. To empirically check these predictions, I concentrate in the following variables of interest taken from data: Total assets/liabilities (asset), Total loans (idlnls), Federal funds sold and reverse repurchase (frepo), Federal funds purchased and repurchase agreements (frepp), Noncurrent loans to total loans (nclnlsr), and Insured deposits (depins).[7]

In the data, banks specialize in different sectors and in different products, namely loan and nonloan activity. In the model, banks can only issue loans. So, to be consistent with the model, *size* will be measured by Total loans. Despite that, Total assets/liabilities will be used to control for the actual size of the institutions and to normalize other variables like insured deposits. In any case, Total assets and Total loans are highly correlated variables. Depending on the quarter, the cross section correlation between Total assets and Total loans ranges from 0.9461 to 0.9797.

Below, I will use size, as measured by Total loans, as the explanatory variable in regressions for a number of variables. First, I will relate size with the Federal Funds Market activity of each bank. For that I compute the variable Net federal funds sold (frepn) as the difference between Federal funds sold and reverse repurchase (frepo) and Federal funds purchased and repurchase agreements (frepp). A positive value of this variable indicates the bank is a net seller of funds while a negative value means the bank is a net purchaser. Second, I will look at Noncurrent loans to total loans. Third, I will analyze Insured deposits. Because larger banks will have larger insured deposits just due to pure size, I will divide Insured deposits by Total liabilities to eliminate this effect. Finally, I include a fourth variable, namely, Total loans over Total assets to see how important loans are for large and small banks.

Figure 2 shows five different cross section distributions of size corresponding to five different quarters, namely, 1992(IV), the first observation available, 2001(II), a recession quarter, 2007(I) the end of the housing bubble, 2009(I),

[5] See, among others, Ennis [10], Janicki and Prescott [14] or Corbae and D'Erasmo [8].

[6] The number of banks used in the computations below is further reduced each quarter due to data limitation problems, see below.

[7] Acronyms from the original data set are in parenthesis. A detailed description of the variables used in this paper can be found in the Appendix.

right in the middle of the Great Recession, and 2014(I), the last observation available. The data is normalized by the average loan size of the corresponding quarter, so that all of them are comparable, and then plotted on a log scale. With these transformations the value 0 in the graph corresponds to the average size of the banks in that quarter. We can see how all distributions behave similarly, although they have been moving to the left, a fact already documented in Janicki and Prescott [14]. They are also highly skewed, with a large number of small banks and a few large banks. Because of this skewness, some characteristics of the data may not show using simple regressions. To control for this, I also show results for the top and bottom 5 percent of banks in the size distribution. This serves several purposes. First, there seems not to be different clusters of banks regarding size. Thus, any classification along this dimension in groups is purely arbitrary. By looking at two populations to the right and to the left of the mode of the distribution there is a larger chance their behavior will be significantly different in a statistical sense. Furthermore, the two populations will have the same number of banks so that any disparity between the two cannot be attributed to different sample sizes. Below I include the same computations using different thresholds and the results remain valid in general. Furthermore, when looking at the bottom and top groups of the distribution, for each quarter, I normalize each variable by the corresponding average of the quarter. This way, all data is comparable across time.

Finally, I drop banks with ratios of loans to assets or insured deposits to assets larger than 1 or smaller than 0 as I attribute these values to measurement errors. These corrections reduce the sample size only by 100 or less banks per quarter which only represents below 2 percent of the actual sample size.

4 Empirical results

4.1 Whole sample

Figures 3, 4, 6 and 7 show regression results for the variables of interest. All figures show the estimated coefficient of the regression of the variable of interest on size (the black line) together with 95 percent confidence intervals, plotted as grey lines. Each of these coefficients is computed for each quarter in the database, starting at the fourth quarter of 1992 and ending at the first quarter of 2014. Figures 5 and 8 show results for small and large banks in the sample. In all Figures, grey areas represent recessions as published by the NBER.

Figure 3 presents the result of the regressions relating size with the net position in the federal funds market. Up to the Great Recession, regression coefficients are negative and statistically significant. That is, there was a negative relation between size and the net position of banks in the federal funds market, a result widely found in the literature. This result, however, has changed after the second half of 2007 with coefficients significantly positive. This could be due to the severe disruptions in money markets observed during the recent financial crisis of 2007-2009 that induced financial institutions to hold precautionary reserves and to be reluctant to lend.[8]

Figure 4 includes the regression coefficients of Nonperforming loans to size. With the exception of two brief periods at the beginning of the sample and after the Great Recession, the coefficient linking these two variables are not statistically different than zero. Thus, on average, larger and smaller banks have similar loan performing ratios as it is assumed in the model. However, the model assumes that smaller banks face loan distributions representing mean preserving spreads compared to the distributions faced by larger banks. Thus, it is the *volatility* of loan performing ratios what should be larger for smaller banks than for large banks. To check this prediction Figure 5 shows the standard deviation of the cross section of the Nonperforming loan ratio for each quarter of the sample for large and small banks. In the figure large means the top 5 percent of banks in terms of loans while small means the bottom 5 percent. With very few exceptions, the cross section dispersion of the ratio of nonperforming loans is larger for small banks than for large banks. To check whether this result is due to the particular split between large and small banks, Figure 6 includes computations where small and large banks represent, respectively, the bottom and top 1 percent, 10 percent, 25 percent and 50 percent of the size distribution. We see that in general large banks face less dispersion in the fraction of Nonperforming loans as compared with large banks. Of course, these differences are smaller the closer the two groups get to each other in the distribution.

Figure 7 shows the coefficients of the corresponding regression where now the dependent variable is Insured deposits over total liabilities. We can see that large banks have, proportionally, less insured deposits than smaller banks. Although these coefficients have increased over time, they have remained negative and statistically significant.

Finally, Figure 8 presents the results of regressing the ratio of total loans over total assets on size. For most of the quarters in the sample these coefficients are not significantly different from 0. However, the result changes when we look at the average ratio of loans over assets for the top and bottom banks in the size distribution. As Figure 9 shows, large banks proportionally provide more loans than smaller banks. Again, to check whether this result is due to the particular split between large and small banks, Figure 10 present the same computations for different size groups. The conclusions remain the same.

4.2 Robustness analysis

The empirical findings described above could be due to a particular distribution of banks across different bank characteristics such as charter classes, product specializations or geographical location. To check whether similar results hold for these bank characteristics, the same computations are done for a variety of subsamples. To save on space, I will reproduce, for these categories, the main computations shown above, that is, the equivalent ones for Figures 3, 4, 6 and

[8] See Afonso et al. [1] or Ashcraft et al. [4].

8. Also, because the number of banks decreases rapidly as the sample is divided in categories, quarterly data is pooled annually and I will show the main results for the largest four categories in each dimension.

The dimensions in which I split the sample are:

- *Specialization*: the FDIC classifies depository institutions in 8 categories according to their primary specialization in terms of asset concentration. These categories, ordered by number of banks in each category, are:

  1. Commercial Lending Specialization – Institutions with commercial and industrial loans, plus real estate construction and development loans, plus loans secured by commercial real estate properties in excess of 25 percent of total assets.
  2. Agricultural Specialization – Banks with agricultural production loans plus real estate loans secured by farmland in excess of 25 percent of total loans and leases.
  3. All Other < \$1 Billion – Institutions with assets less than \$1 billion that do not meet any of the definitions in other groups, they have significant lending activity with no identified asset concentrations.
  4. Mortgage Lending Specialization – Institutions with residential mortgage loans, plus mortgage-backed securities, in excess of 50 percent of total assets.
  5. Other Specialized < \$1 Billion – Institutions with assets less than \$1 billion and with loans and leases are less than 40 percent of total assets.
  6. Consumer Lending Specialization – Institutions with residential mortgage loans, plus credit-card loans, plus other loans to individuals, in excess of 50 percent of total assets.
  7. All Other > \$1 Billion – Institutions with assets greater than \$1 billion that do not meet any of the definitions in other groups, they have significant lending activity with no identified asset concentrations.
  8. Credit-card Specialization – Institutions with credit-card loans plus securitized receivables in excess of 50 percent of total assets plus securitized receivables.
  9. International Specialization – Institutions with assets greater than \$10 billion and more than 25 percent of total assets in foreign offices.

- *Charter class*: this is a classification code assigned by the FDIC based on the institution's charter type (commercial bank or savings institution), charter agent (state or federal), Federal Reserve membership status (Fed member, Fed nonmember) and its primary federal regulator (state chartered institutions are subject to both federal and state supervision). With this information, banks are classified in 6 categories, ordered by number of banks in each

1. NM = commercial bank, state charter and Fed nonmember, supervised by the FDIC or OCC
2. N = commercial bank, national (federal) charter and Fed member, supervised by the Office of the Comptroller of the Currency (OCC)
3. SA = FDIC supervised state chartered thrifts and OCC supervised federally chartered thrifts. Prior to that date, state or federally chartered savings associations supervised by the Office of Thrift Supervision (OTS).
4. SM = commercial or savings bank, state charter and Fed member, supervised by the Federal Reserve (FRB)
5. SB = savings banks, state charter, supervised by the FDIC
6. OI = insured U.S. branch of a foreign chartered institution (IBA)

- *Federal Reserve district*: The Federal Reserve District in which the institution is physically located. These regions, from largest to smallest, are:

1. Chicago: Iowa and most of Illinois, Indiana, Michigan and Wisconsin.
2. Kansas City: Colorado, Kansas, Nebraska, Oklahoma, Wyoming, and portions of western Missouri and northern New Mexico.
3. Atlanta: Alabama, Florida, and Georgia, and portions of Louisiana, Mississippi, and Tennessee.
4. Saint Louis: Arkansas and portions of Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee.
5. Minneapolis: Minnesota, Montana, North and South Dakota, parts of Wisconsin and the Upper Peninsula of Michigan
6. Dallas: Texas, northern Louisiana and southern New Mexico.
7. San Francisco: Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington, plus American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands
8. Richmond: District of Columbia, Maryland, Virginia, North Carolina, South Carolina and most of West Virginia.
9. Cleveland: Ohio, western Pennsylvania, eastern Kentucky, and the northern panhandle of West Virginia.
10. Boston: Connecticut (except Fairfield County), Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.
11. New York: New York state, the 12 northern counties of New Jersey, Fairfield County in Connecticut, Puerto Rico and the U.S. Virgin Islands. .
12. Philadelphia: eastern Pennsylvania, southern New Jersey, and Delaware.

Figures 11 through 13 present results for the estimation of the coefficient of regressing the net federal funds market position on size for different bank characteristics. We can see how the same pattern found for the whole sample also repeats itself for the different classes considered here. Only with few exceptions these coefficients are negative and statistically significant. Figures 14 through 16, 17 through 19 and 20 through 22 include, respectively, the results for the cross section dispersion of nonperforming loans for large and small banks, the regression coefficient of the share of insured deposits with respect to total liabilities on size and the average total loans over total assets for large and small banks. In general, all these results are in line with the corresponding computation for the whole sample.

5 Conclusions

This paper presents a theoretical model to rationalize the observed dichotomy in the federal funds market by which small banks are net providers of funds while large banks become net purchasers. This model adapts the theoretical framework of Bruche and Suarez [5] to incorporate differences in bank size and risk diversification in a tractable way. Because larger banks are more diversified and face lower risks they are also able to raise a larger proportion of funds in the form of equity which allows them to produce more loans. To finance these loans, they will need to obtain funds in the wholesale money market. In contrast, smaller banks will be less diversified and more risky. Because of higher risks, they will find a harder time raising equity and households will provide funds as insured deposits. Lower capital means producing a lower amount of loans and supplying the extra funds in the wholesale money market.

Apart from their position in the money market, the model also produces a set of testable predictions about the performance of large and small banks: large banks should face a lower volatility of nonperforming loans, should be financed with proportionally less insured deposits and produce proportionally more loans as a fraction of total assets. These predictions seem to accord with the data for the US.

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A Description of the Data

As described in the main text, the data is taken from the database *Statistics on Depository Institutions* provided by the FDIC and available at www.fdic.gov. The data set spans from the last quarter of 1992 until the first quarter of 2014 which represent 86 periods of data. At the end of 1992 there were 13973 institutions reporting while at the beginning of 2014 this number has been reduced to 6739.

The variables of interest are as follows (acronyms in parenthesis):

- Total assets/liabilities (asset): The sum of all assets owned by the institution including cash, loans, securities, bank premises and other assets. This total does not include off-balance-sheet accounts.
- Total loans (idlnls): Loans and lease financing receivables of the institution, including unearned income.
- Federal funds sold and reverse repurchase (frepo): Total federal funds sold and securities purchased under agreements to resell in domestic offices.
- Federal funds purchased and repurchase agreements (frepp): Total federal funds purchased and securities sold under agreements to repurchase in domestic offices. Thrift Financial Reports include only federal funds purchased.
- Noncurrent loans to total loans (nclnlsr): Total noncurrent loans and leases, Loans and leases 90 days or more past due plus loans in nonaccrual status, as a percent of gross loans and leases.
- Insured deposits (depins): The estimated amount of FDIC insured deposits in domestic offices and in insured branches of Puerto Rico and US territories and possessions.

Figure 1:

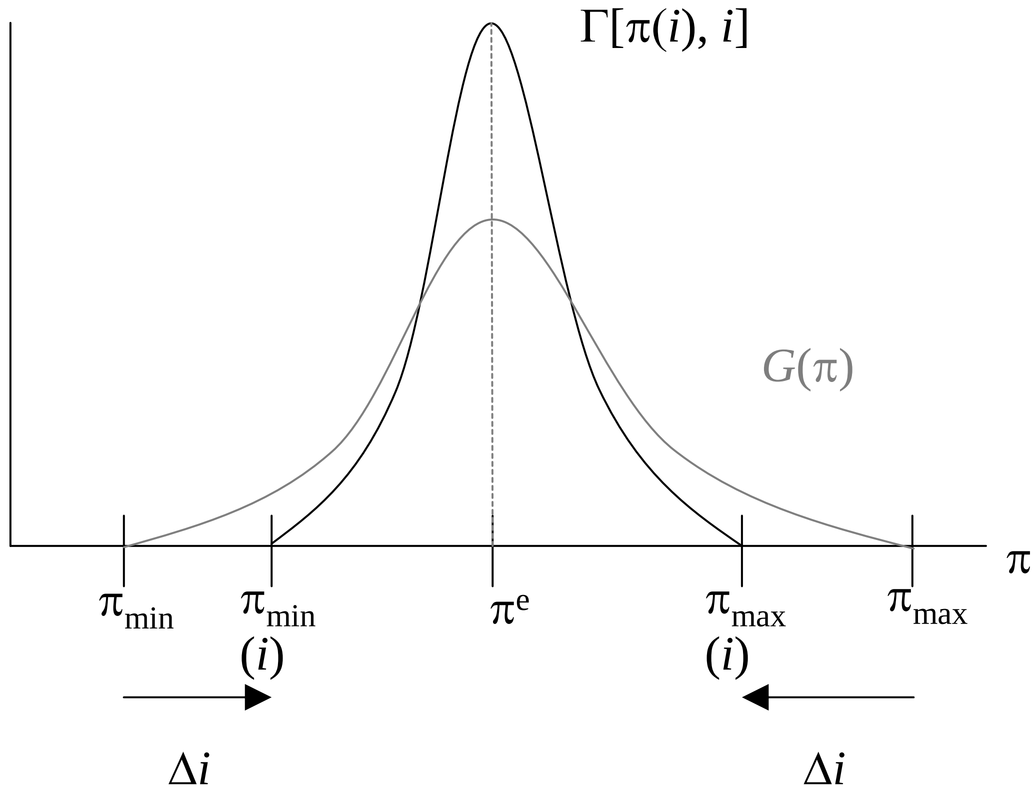

Figure 2: Distributions of total loans for different quarters

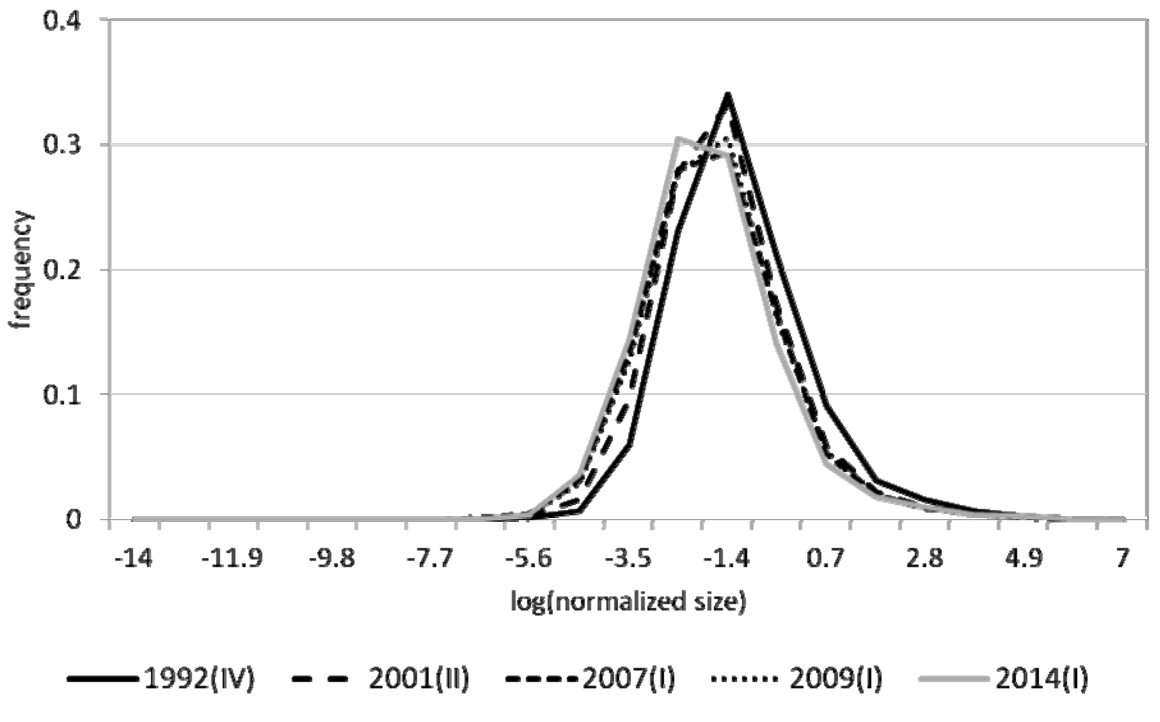

Figure 3: Net federal funds sold

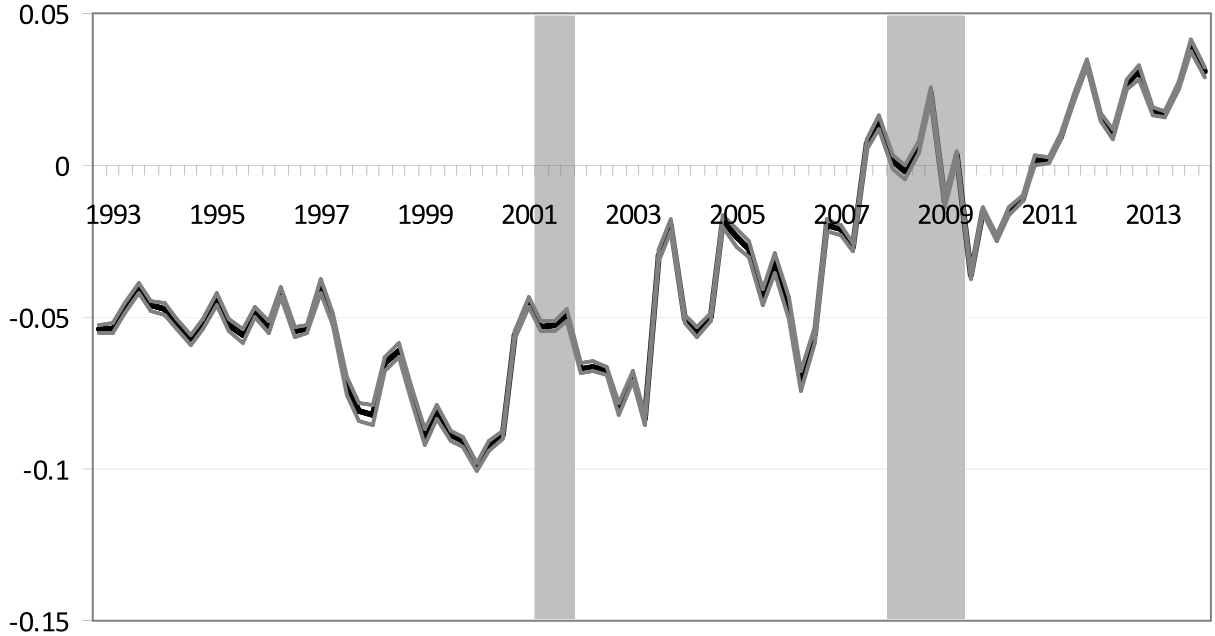

Figure 4: Nonperforming loans

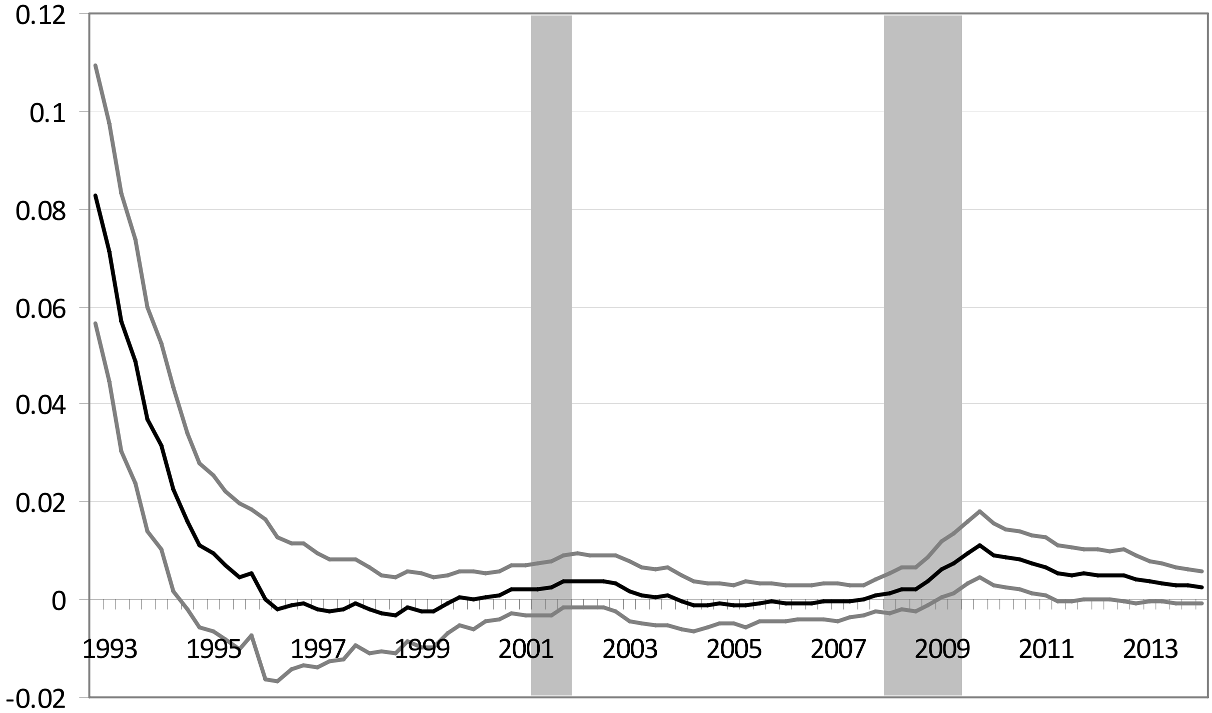

Figure 5: Cross section dispersion of nonperforming loan ratio for large and small banks

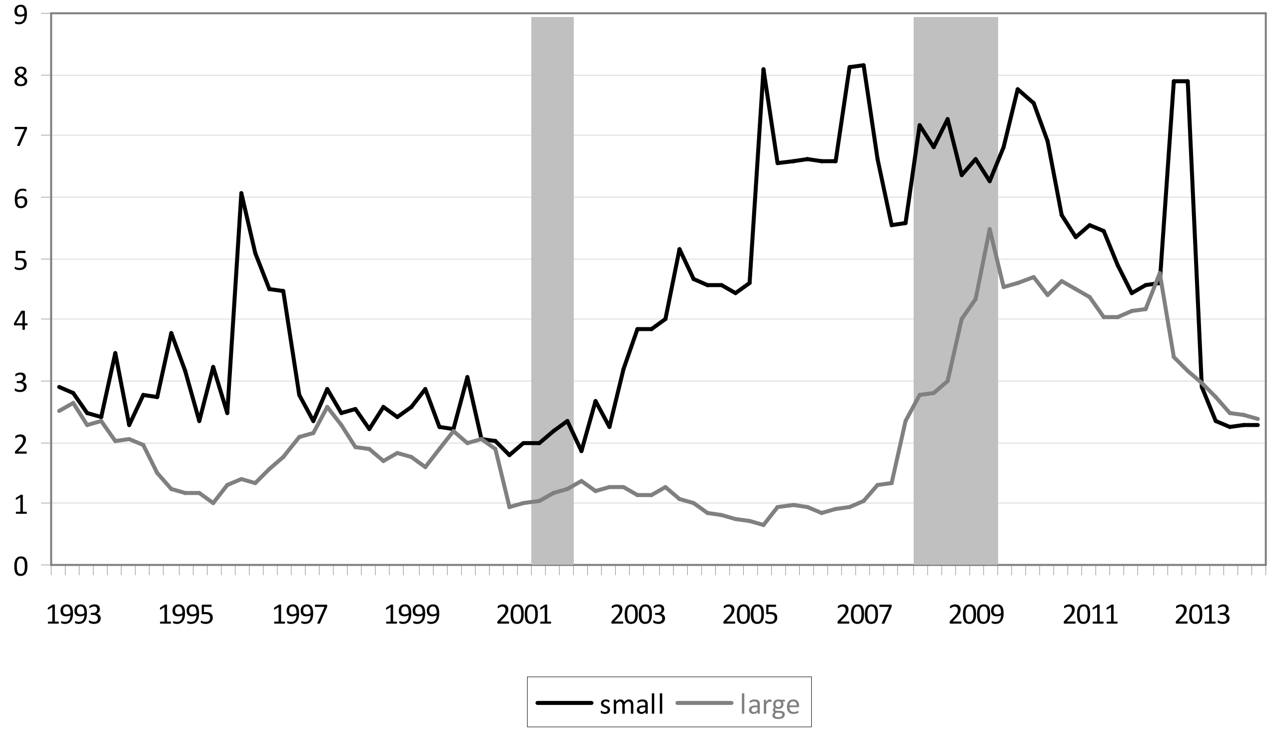

Figure 6: Cross section dispersion of nonperforming loan ratio for large and small banks (different size thresholds)

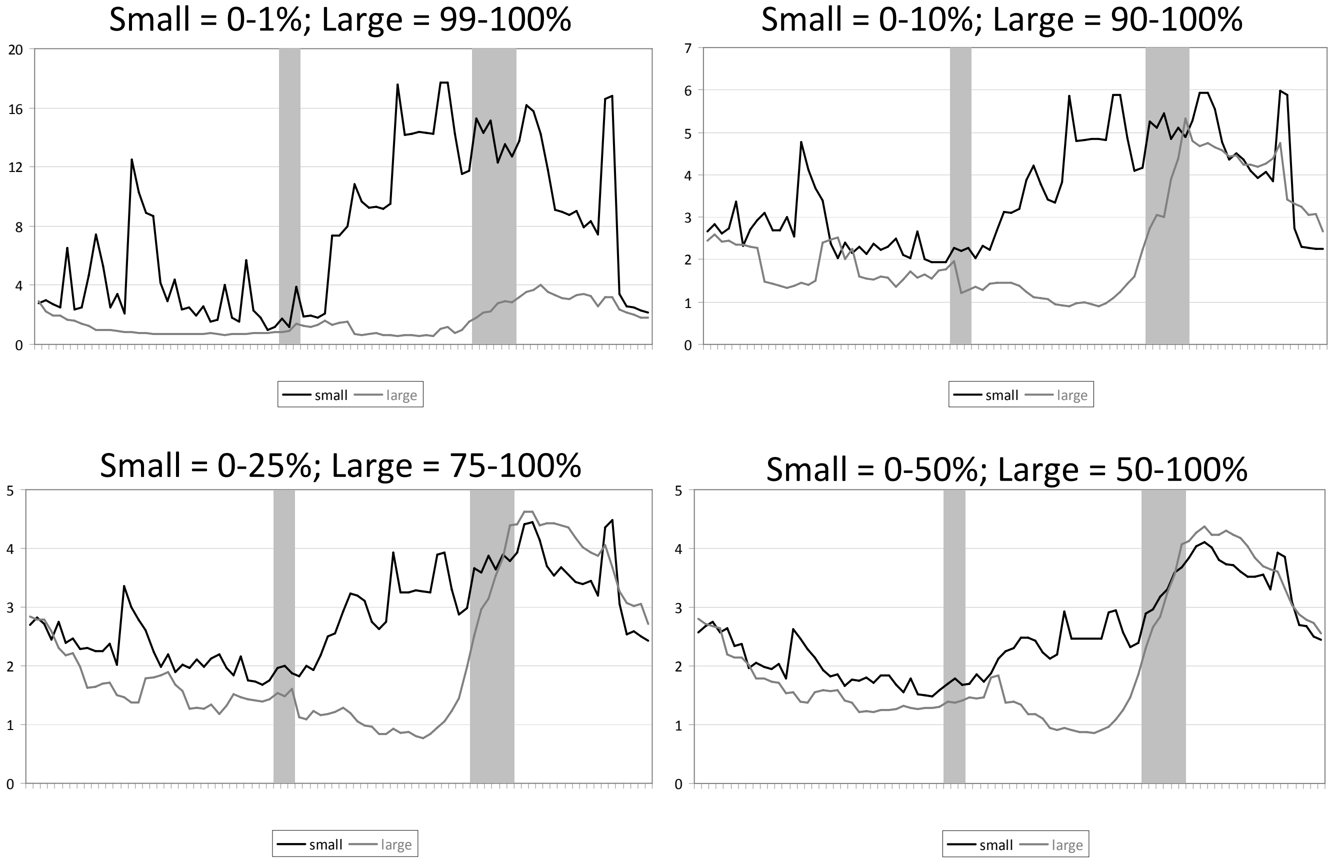

Figure 7: Insured deposits over total liabilities

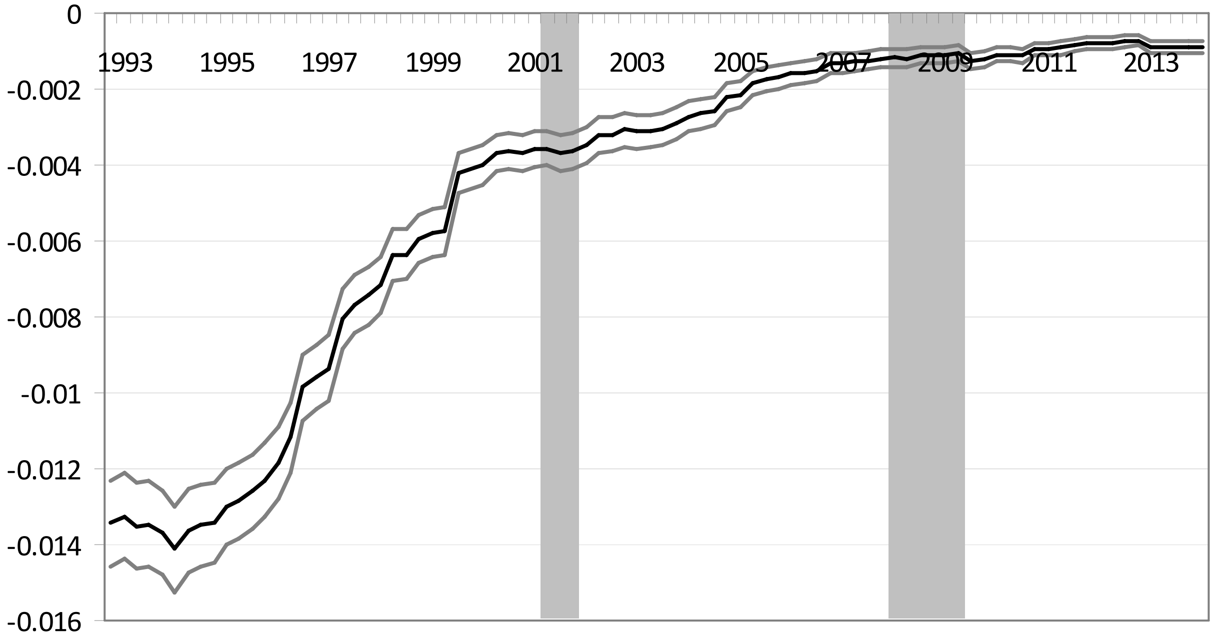

Figure 8: Total loans over total assets

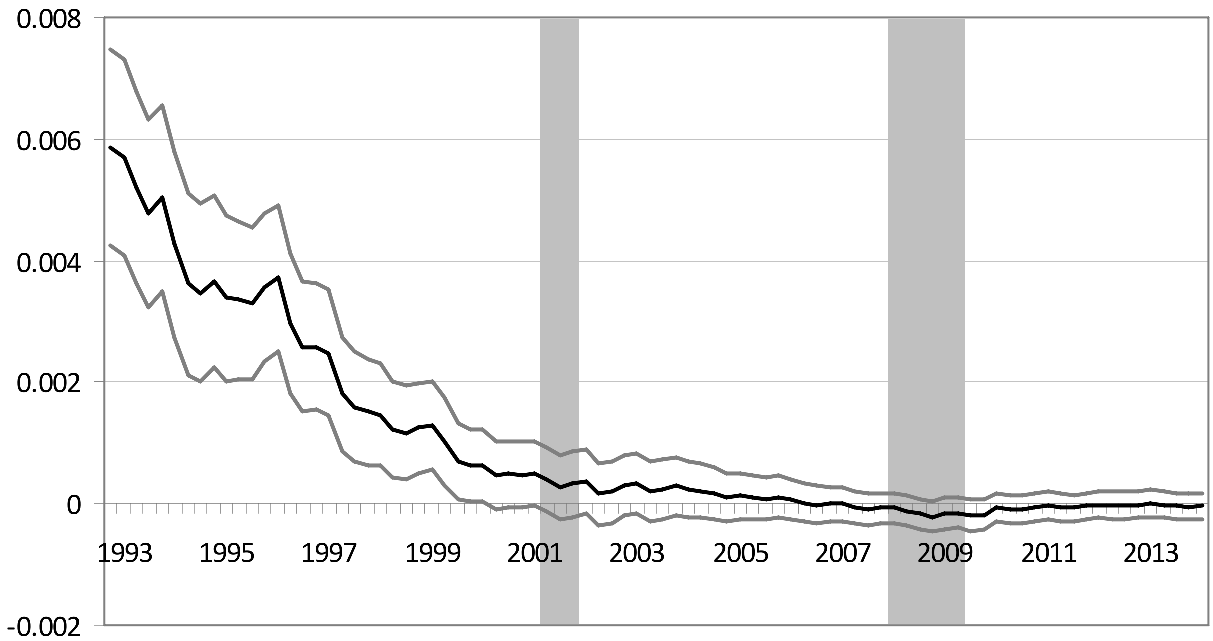

Figure 9: Average total loans over total assets for large and small banks

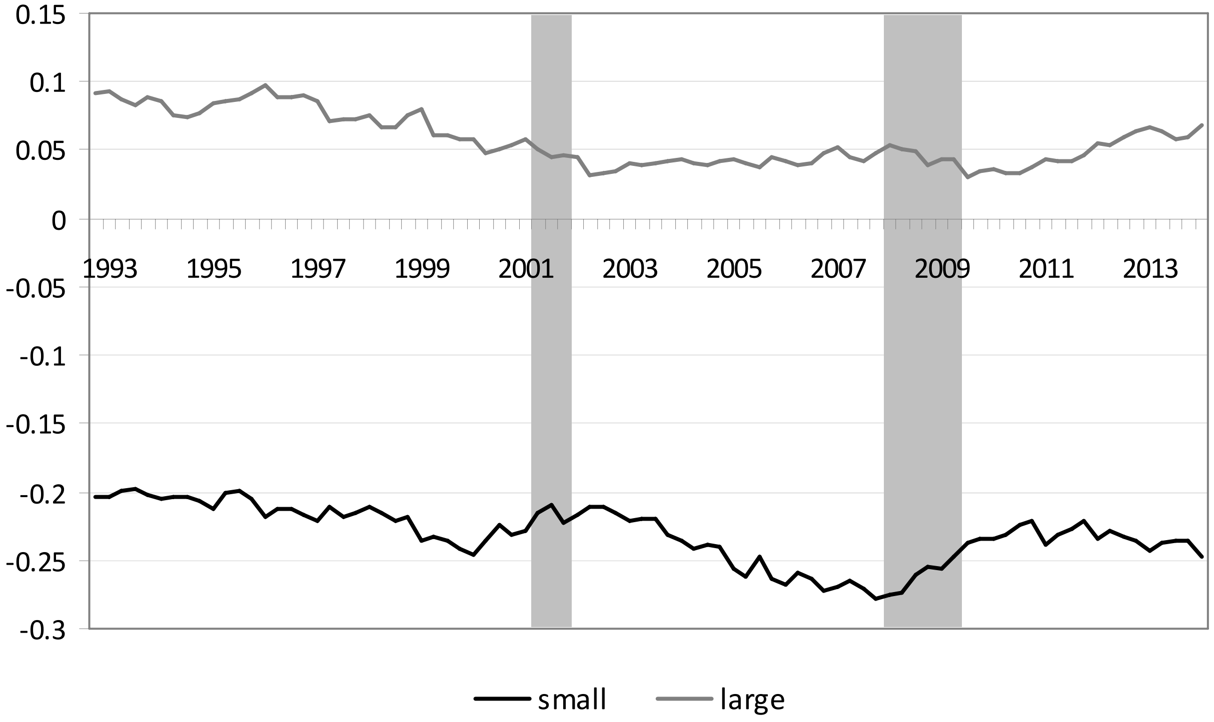

Figure 10: Average total loans over total assets for large and small banks (different size thresholds)

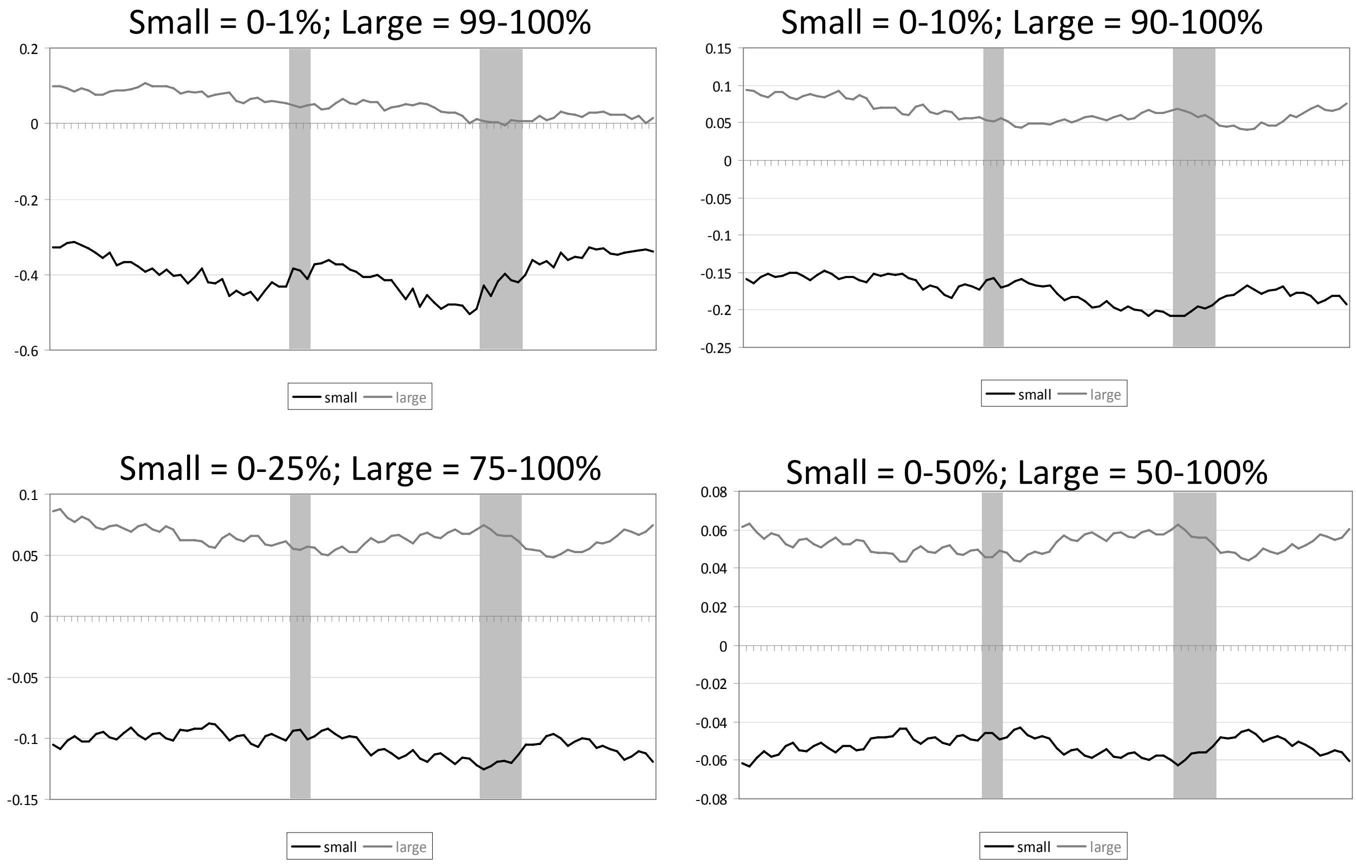

Figure 11: Average net federal funds sold (different specializations)

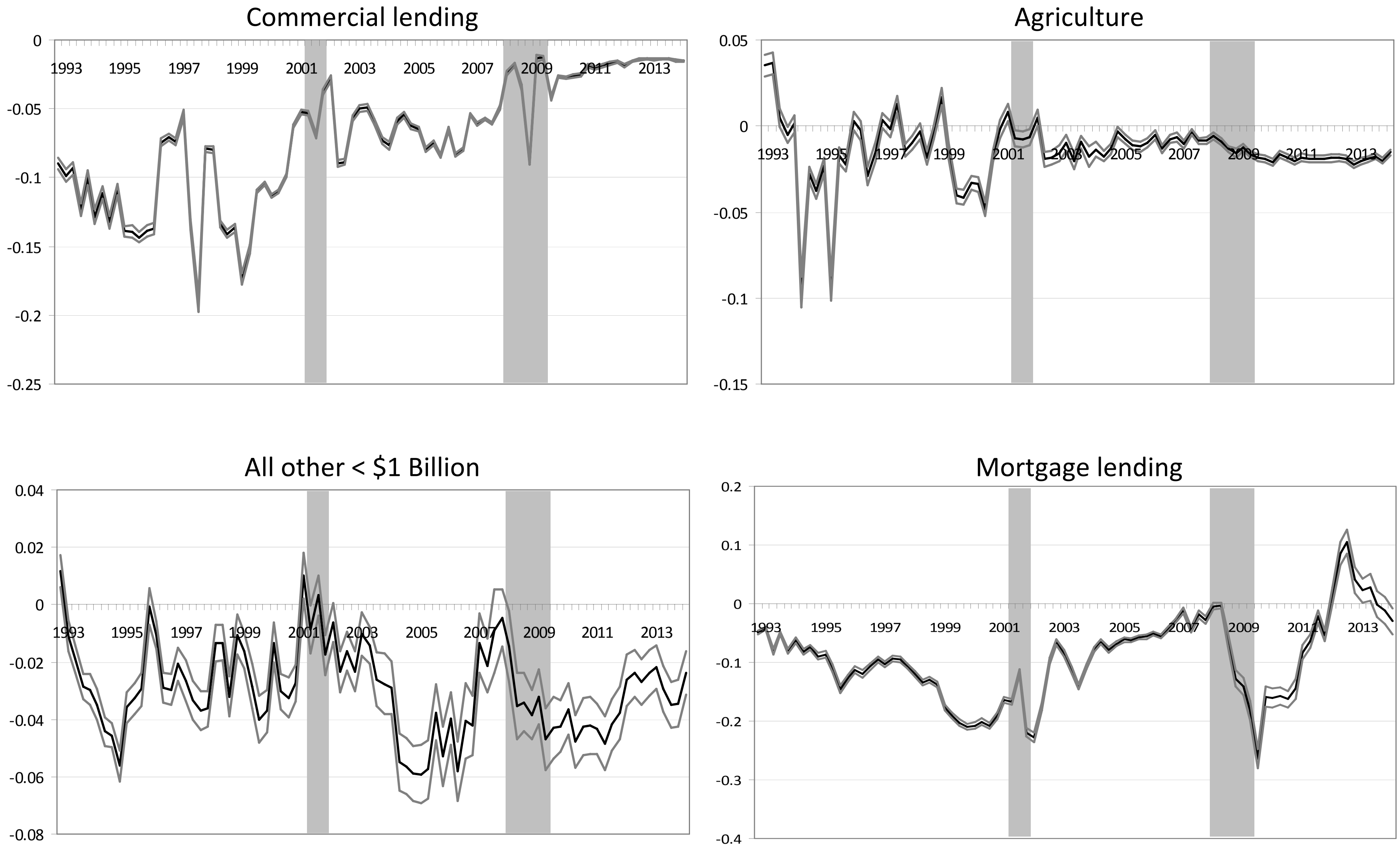

Figure 12: Average net federal funds sold (different charter classes)

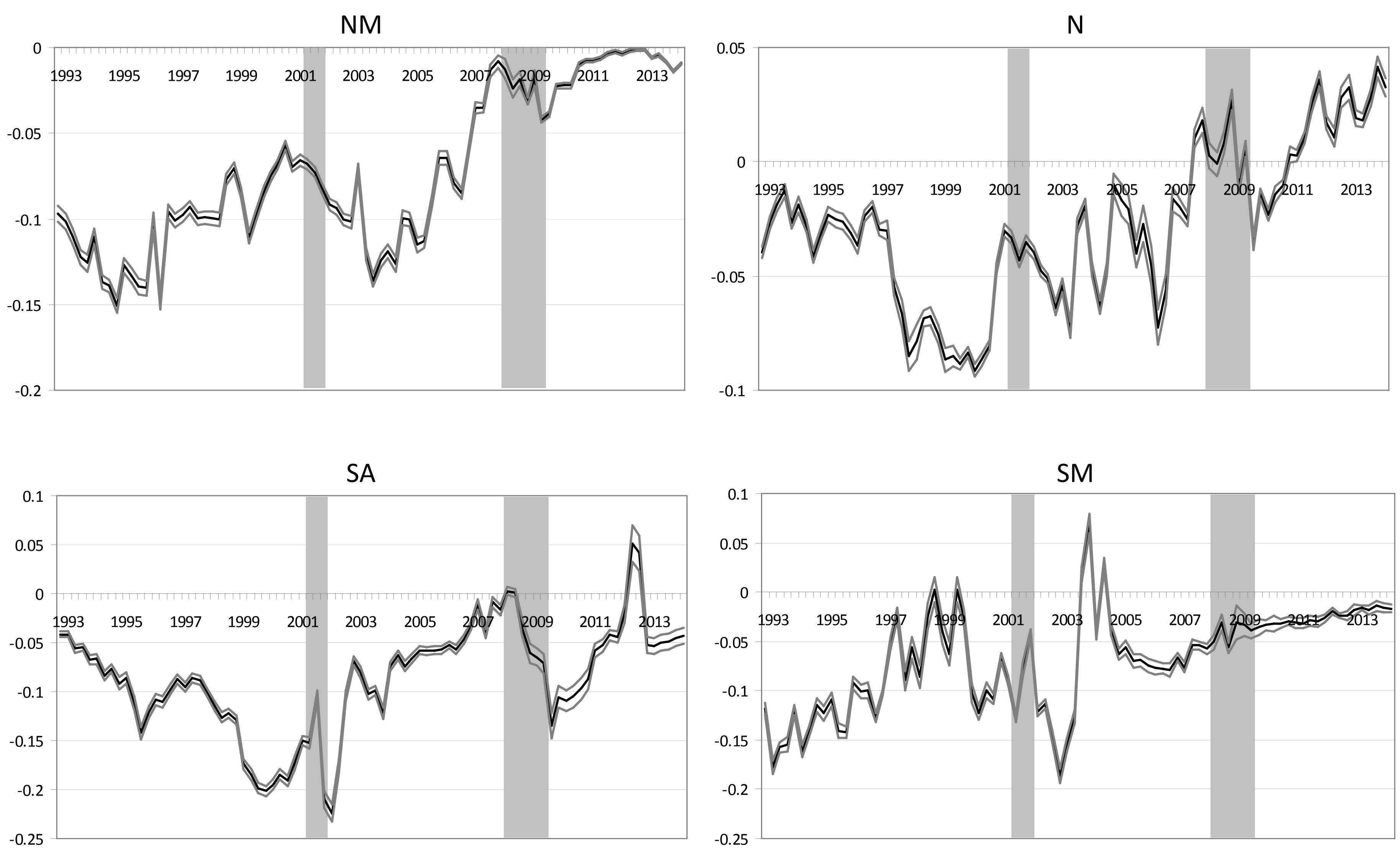

Figure 13: Average net federal funds sold (different FED districts)

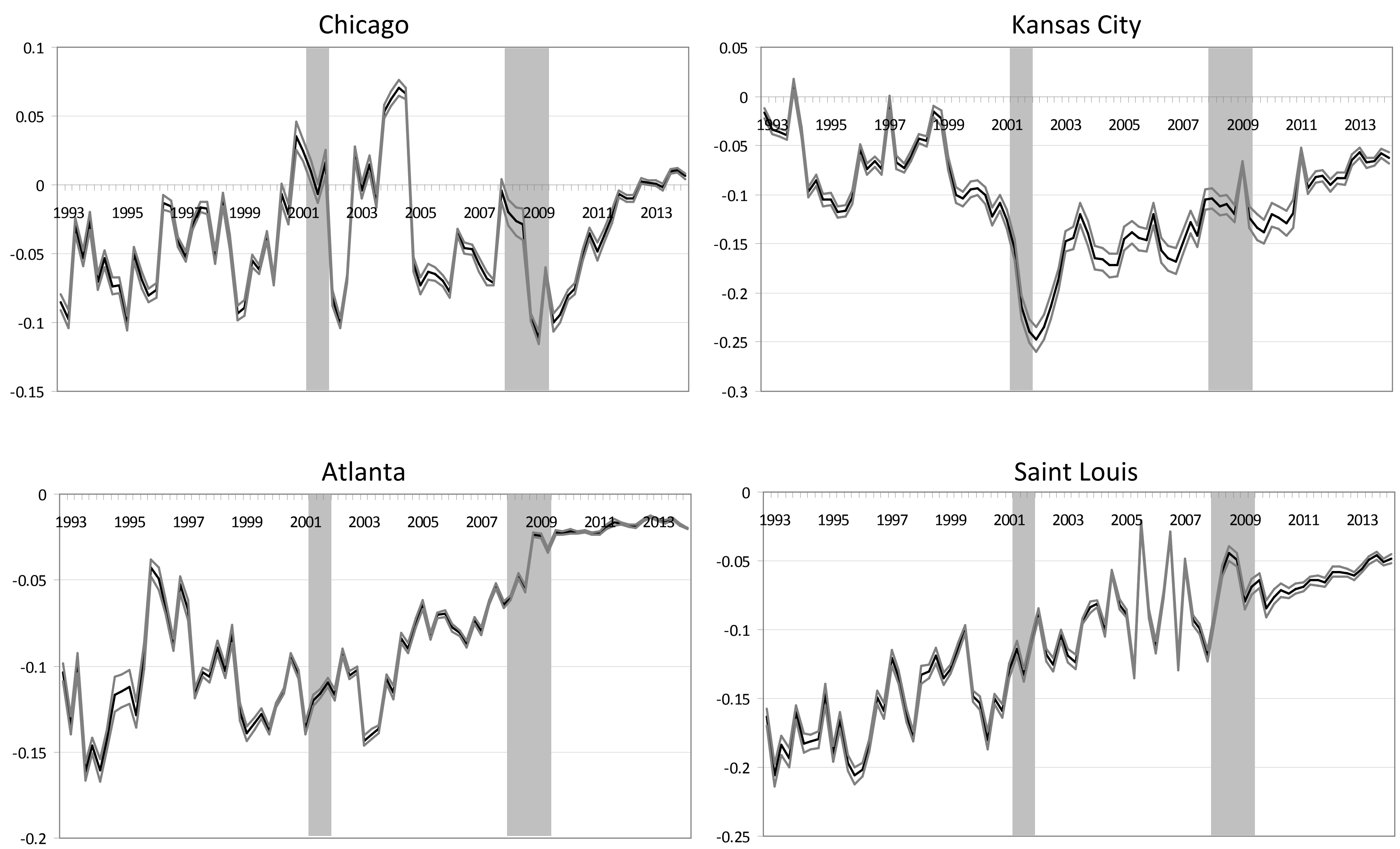

Figure 14: Cross section dispersion of nonperforming loan ratio for small and large banks (different specializations)

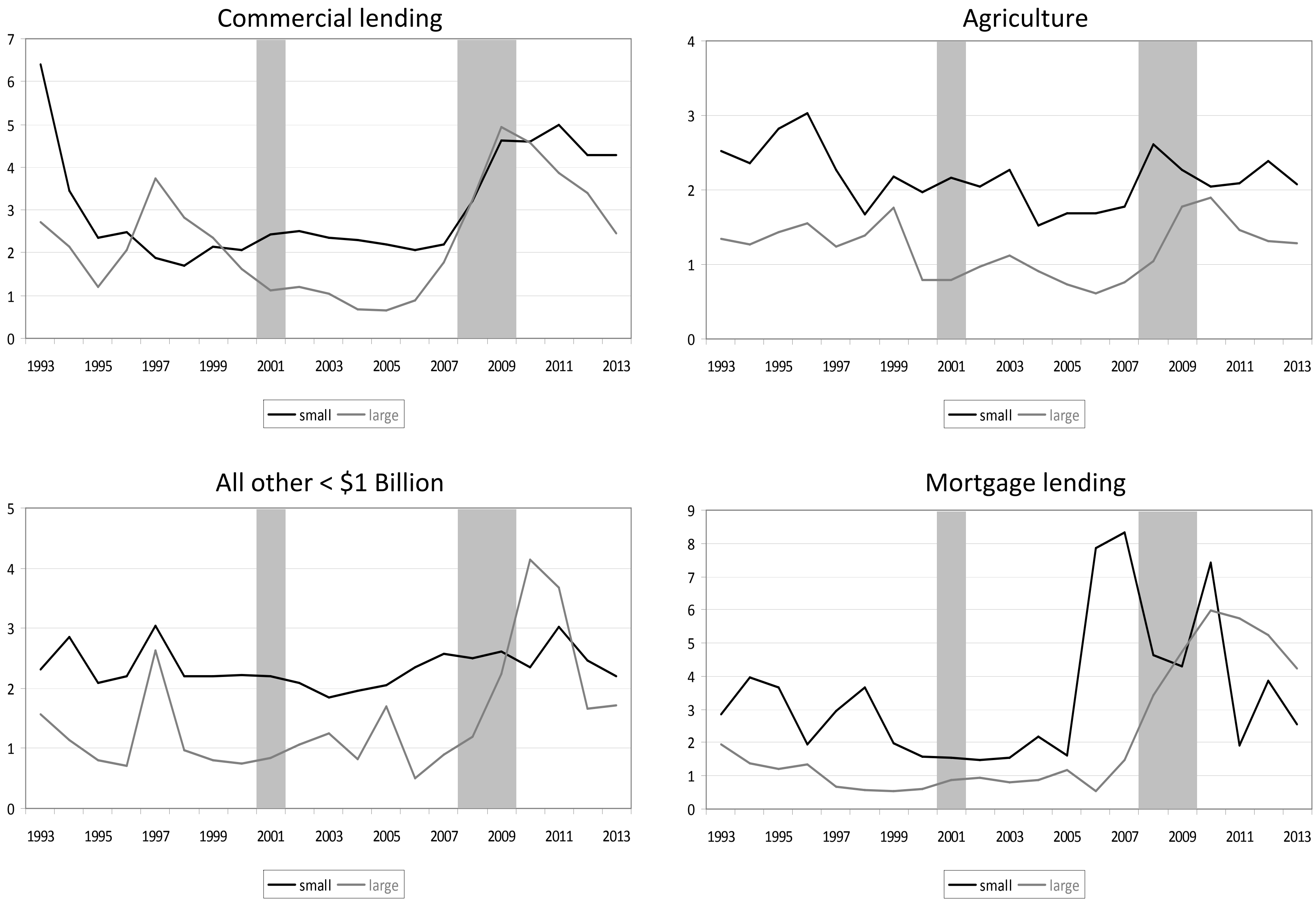

Figure 15: Cross section dispersion of nonperforming loan ratio for small and large banks (different charter classes)

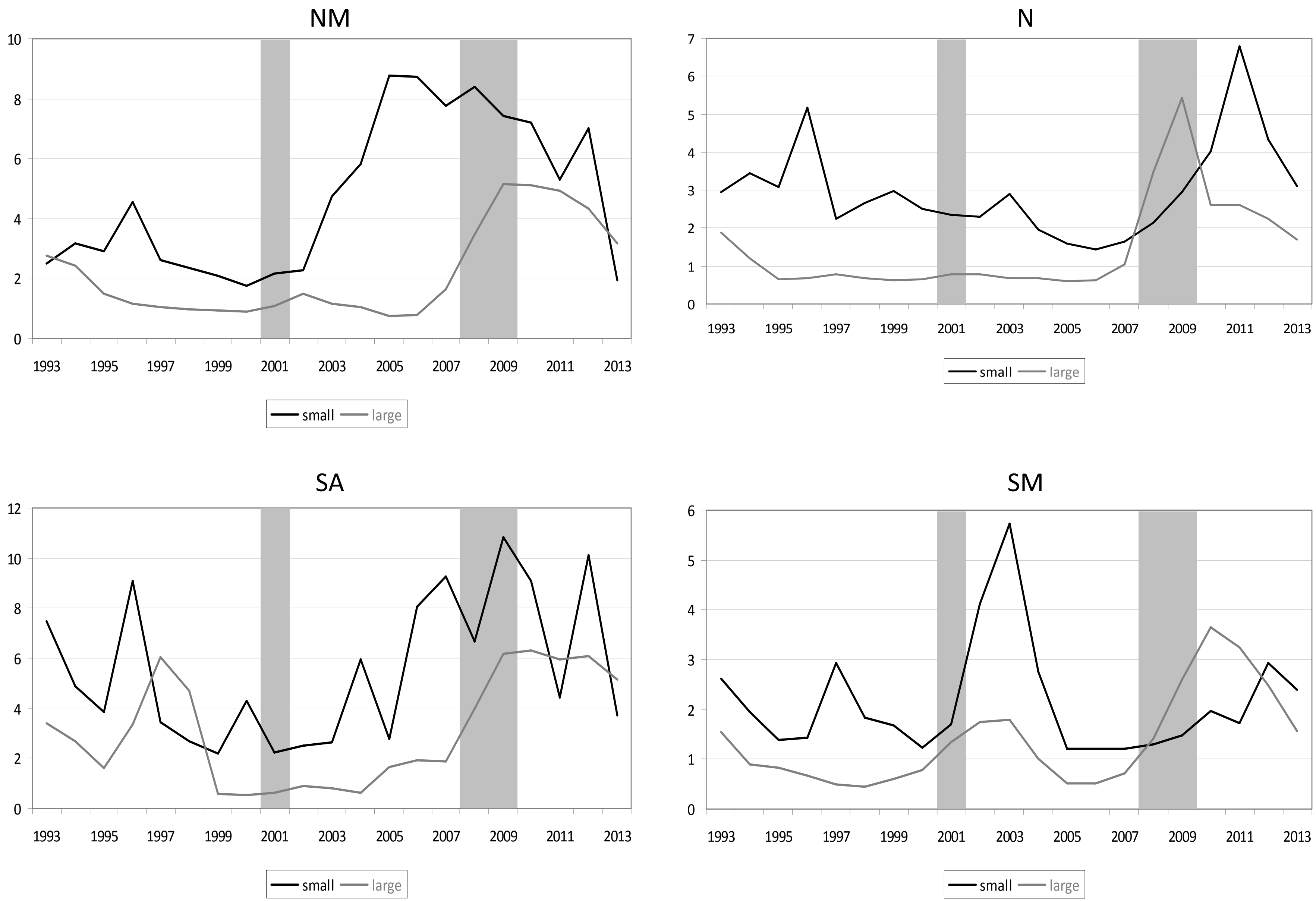

Figure 16: Cross section dispersion of nonperforming loan ratio for small and large banks (different FED districts)

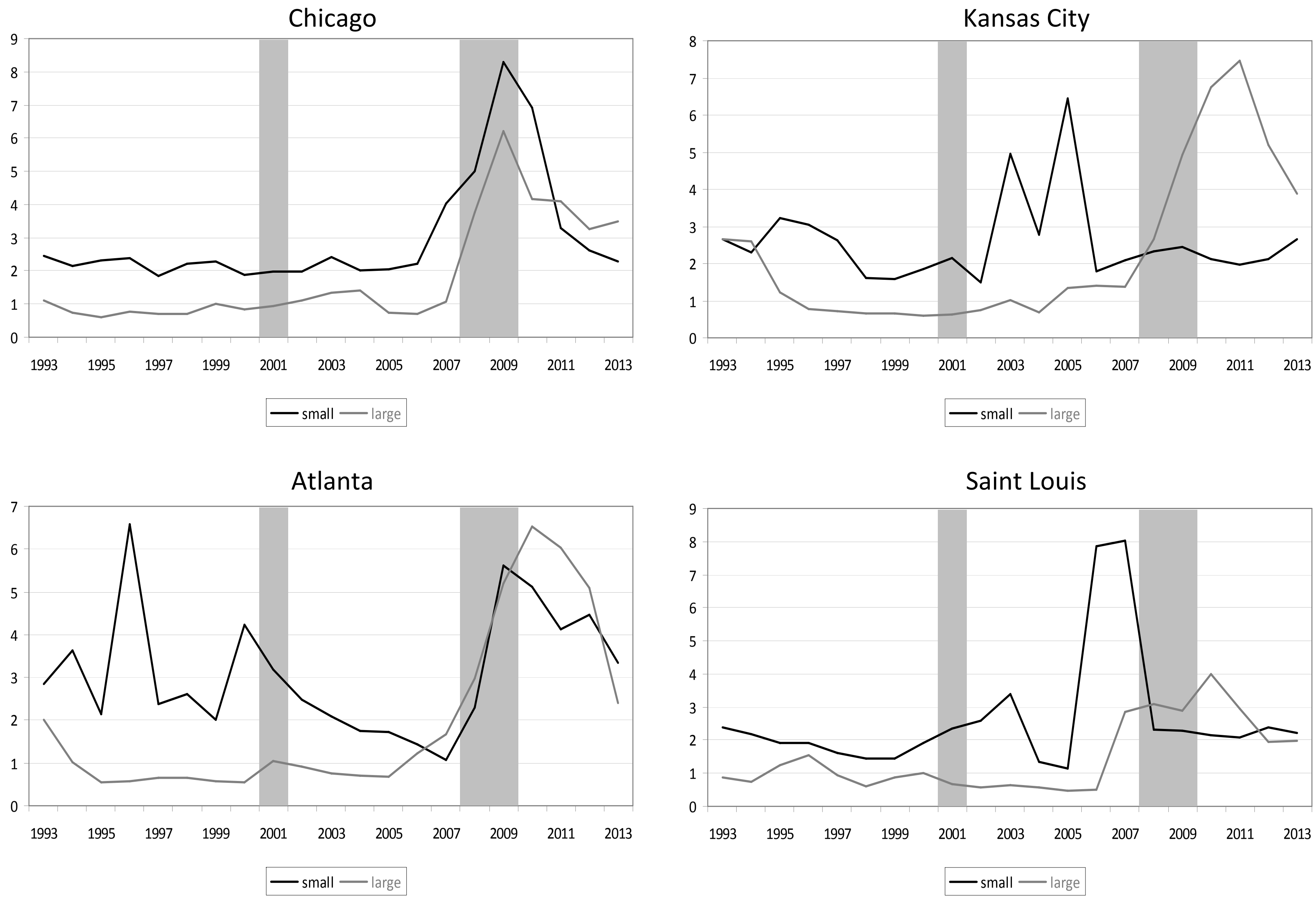

Figure 17: Insured deposits over total liabilities (different specializations)

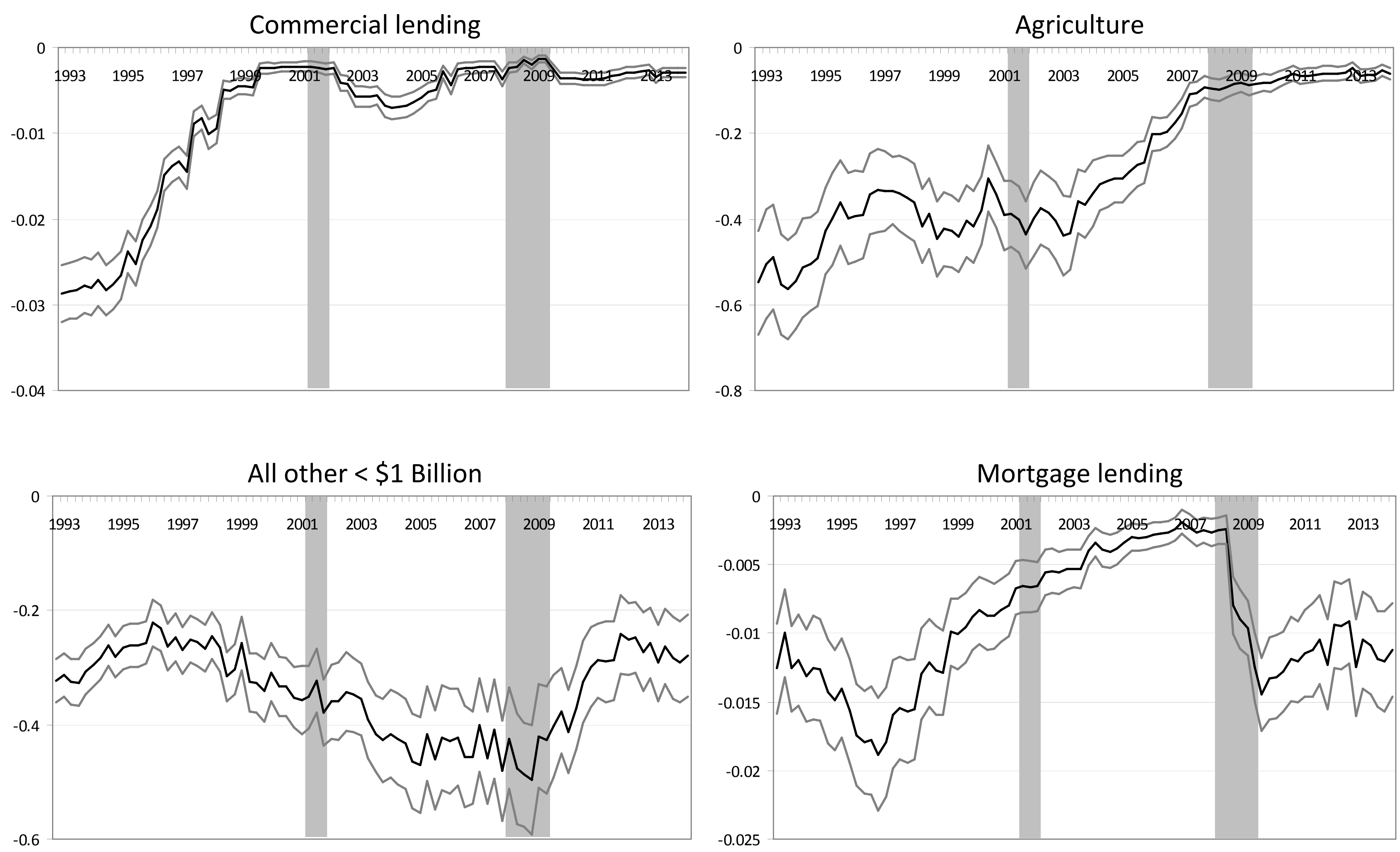

Figure 18: Insured deposits over total liabilities (different charter classes)

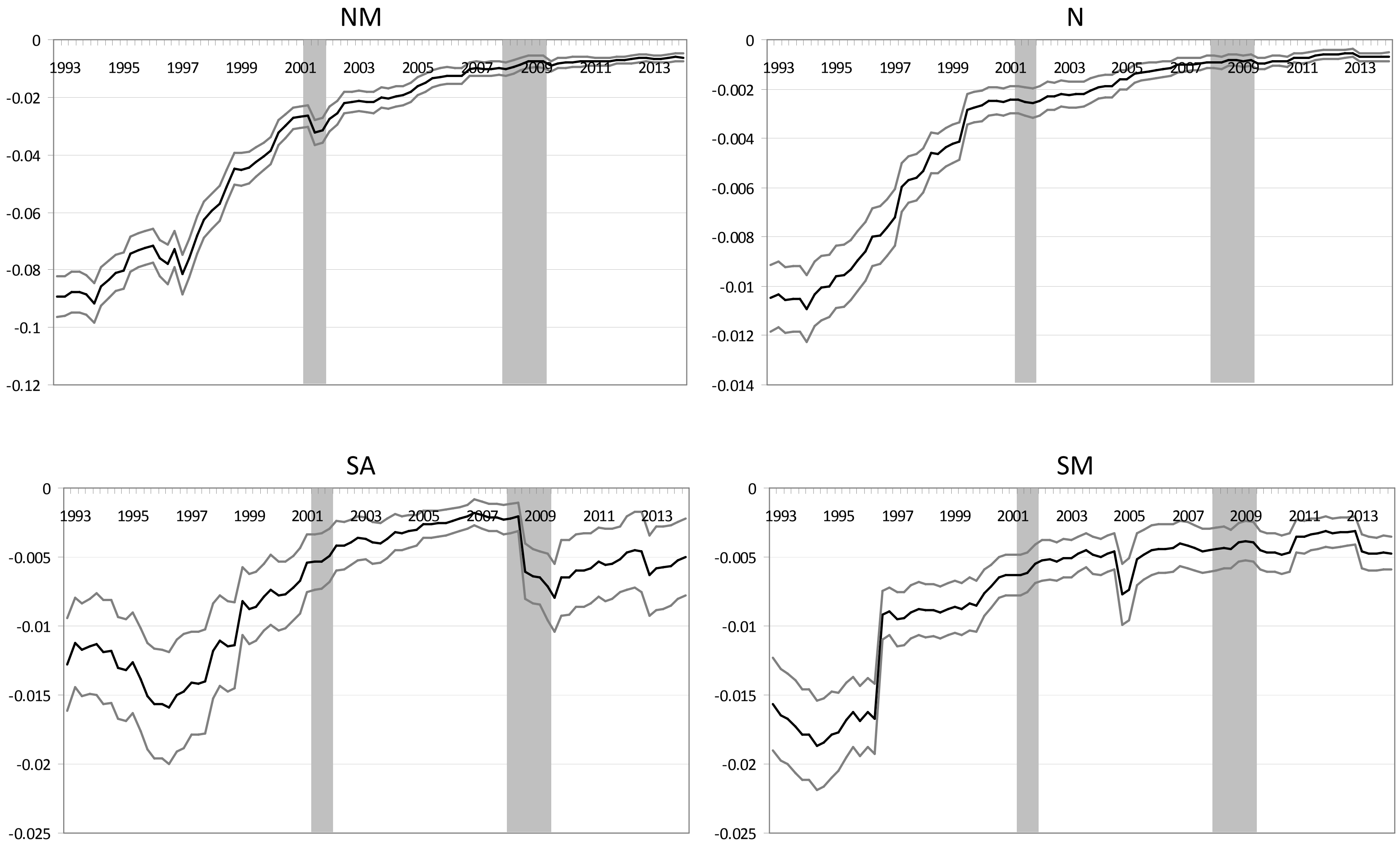

Figure 19: Insured deposits over total liabilities (different FED districts)

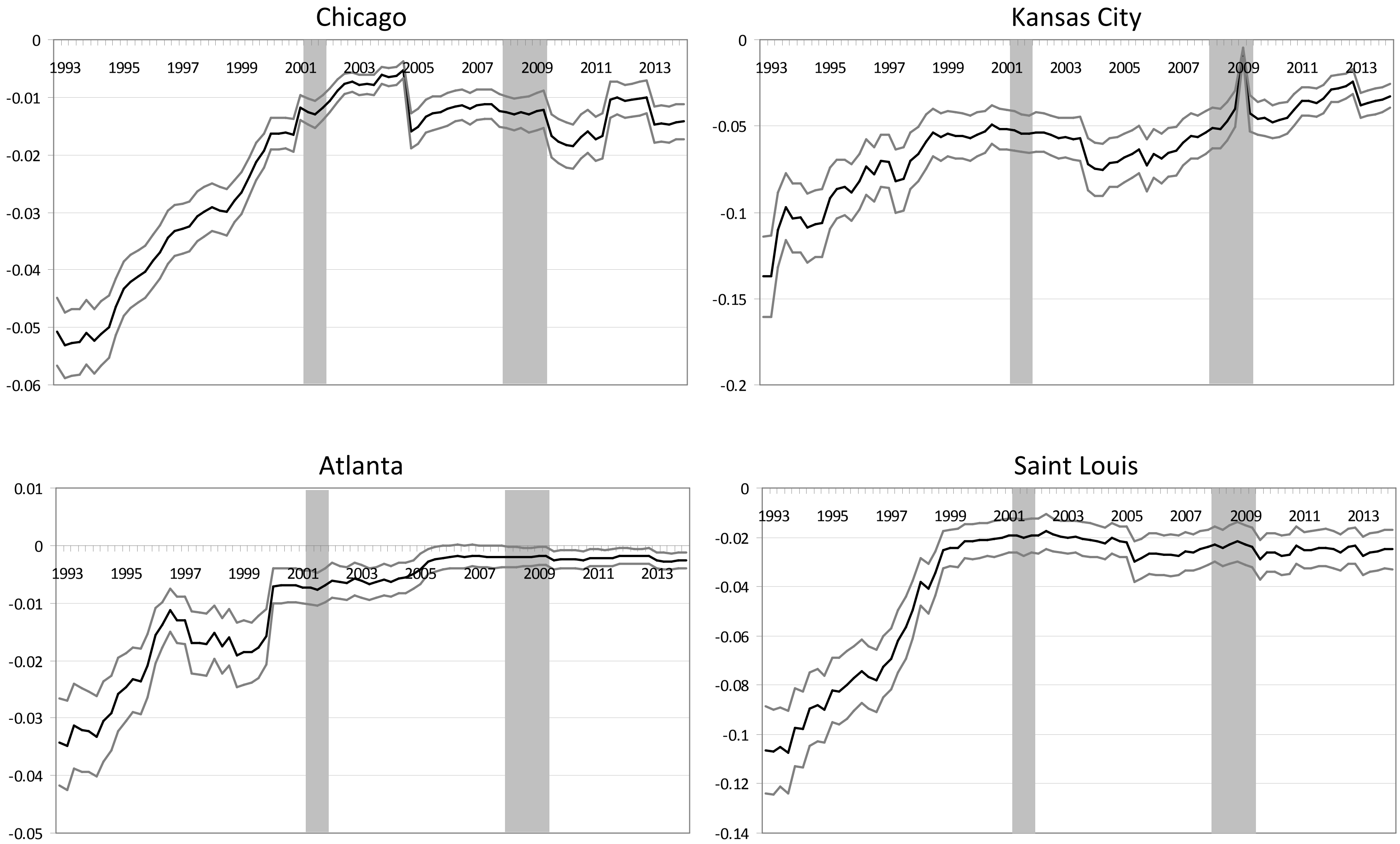

Figure 20: Average total loans over total assets for small and large banks (different specializations)

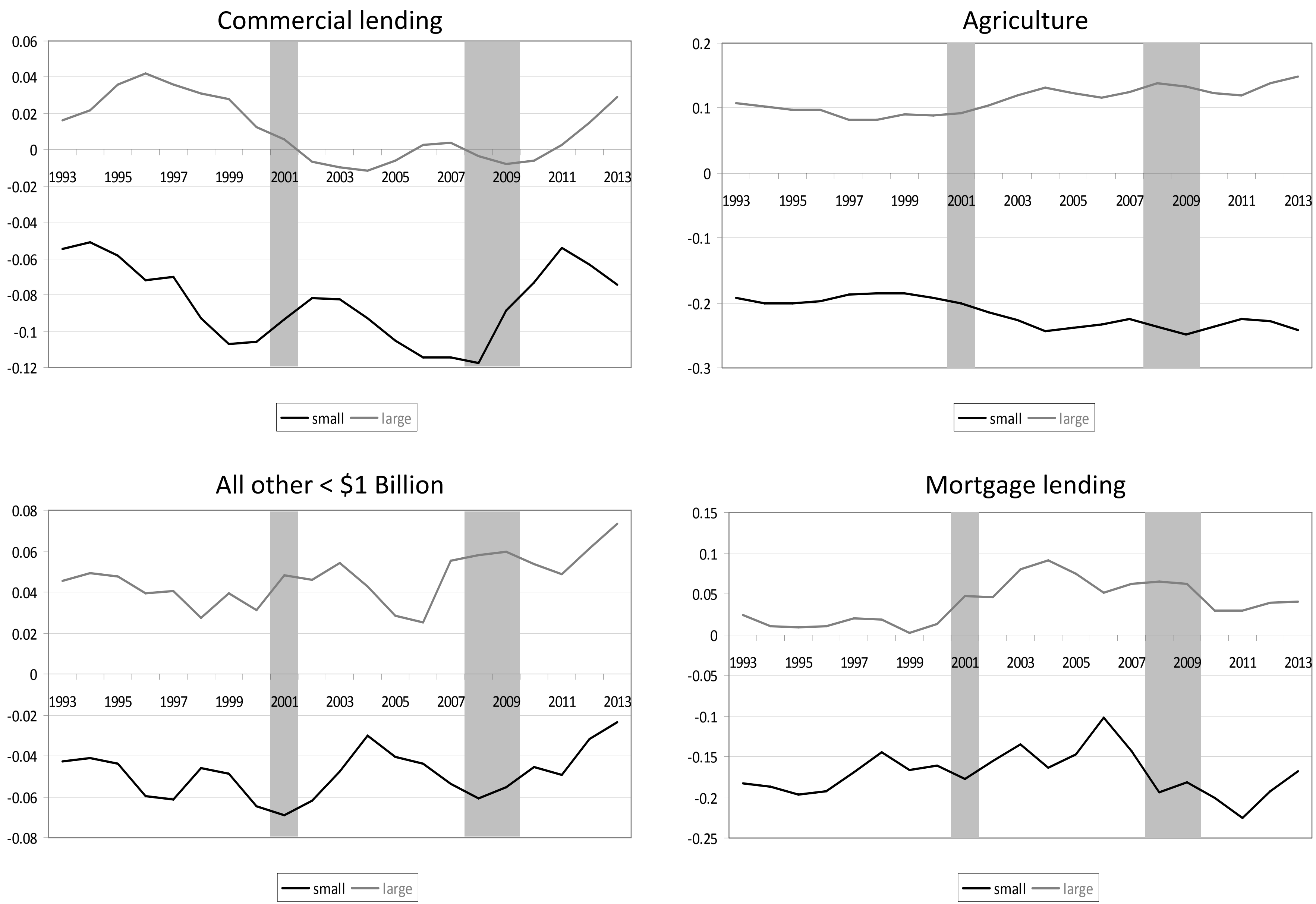

Figure 21: Average total loans over total assets for small and large banks (different charter classes)

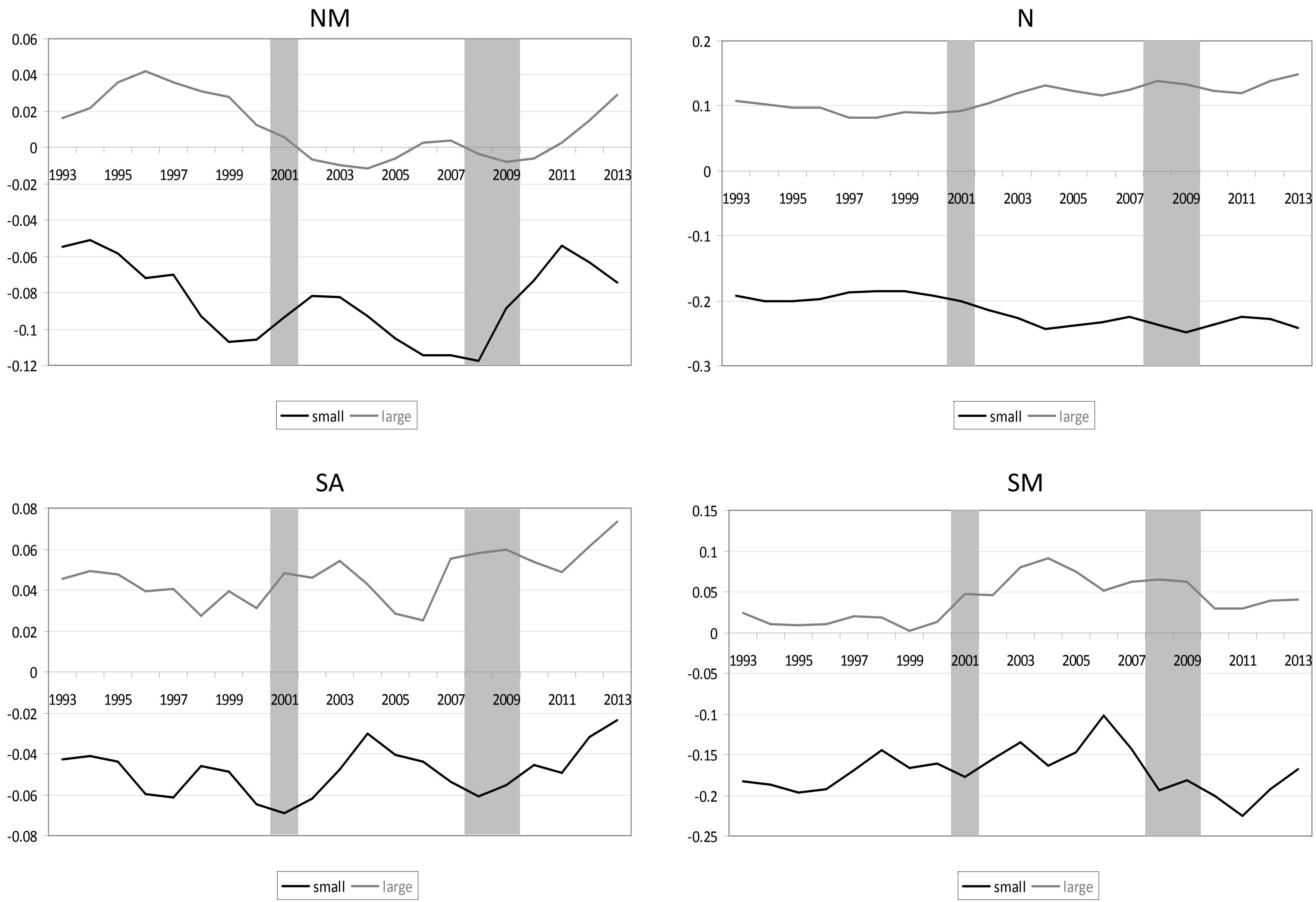

Figure 22: Average total loans over total assets for small and large banks (different FED districts)