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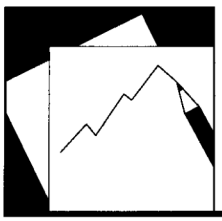

IMF Working Paper

U.S. Bank Behavior in the Wake of the 2007–2009 Financial Crisis

Adolfo Barajas, Ralph Chami,
Thomas Cosimano, and Dalia Hakura

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Middle East and Central Asia Department and IMF Institute

U.S. Bank Behavior in the Wake of the 2007–2009 Financial Crisis

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Abstract

The paper examines the slowdown of lending by large U.S. banks over the period 2007Q3 - 2009Q2, focusing on: (i) whether capital or liquidity was the binding constraint; (ii) factors influencing banks' decision to hold capital; and (iii) their pricing behavior. Using quarterly data for the largest U.S. banks, the paper finds that capital, rather than liquidity, constrained lending. Banks took actions to increase capital by slowing lending and raising profit margins, not fully passing through the Federal Reserve's interest rate cuts. Banks optimally choose capital based on the expected future demand for loans and the marginal cost of capital.

JEL Classification Numbers: E5, G2

Keywords: Commercial banks, capital constraints

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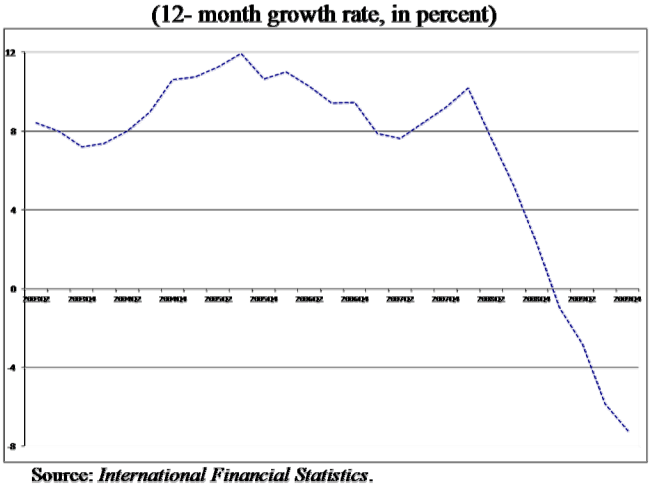
I. INTRODUCTION

One of the more striking consequences of the 2007–2009 financial crisis has been the collapse of lending in the U.S. Based on *IFS* data, private sector credit from commercial banks slowed from annual rates of 8 percent or greater from 2003 through the first quarter of 2008, to just over 2 percent by the end of 2008, and thereafter actually registered negative growth for the first time in the decade (Figure 1). This cycle was even more pronounced for non–bank institutions,[1] which had reached growth rates of close to 19 percent in early 2004, and which in recent months have been contracting in nominal terms by over 11 percent.

Figure 1. Bank Credit to the Private Sector[1]
(12- month growth rate, in percent)



Source: *International Financial Statistics*.
[1] Claims on the private sector by depository corporations.

Early on, policy actions to address the impact of the crisis on commercial banks tended to focus on easing liquidity conditions. Starting in August 2007, the Federal Reserve embarked on a series of interest rate cuts totaling 225 basis points over seven months, and toward the end of the year began a process of expanding access to existing lending facilities and creating others, both for banks and for non–bank financial institutions.[2] As Sarkar (2009) argues, two separate stages can be distinguished. During the first stage, the Fed acted to provide liquidity to solvent institutions, in response to a severe contraction in interbank markets that threatened to bring financial intermediation to a halt via an "illiquidity spiral." This was followed by a second stage, in which credit risk was the primary concern, and liquidity was provided directly to key borrowers and investors.

As the crisis developed, and particularly in the wake of the Lehman Brothers bankruptcy in September 2008, the focus of policy began to move beyond liquidity provision and toward injection of capital. In particular, the well–known Troubled Asset Relief Program (TARP) dedicated a substantial portion of its funds ($250 billion out of the total $700 billion) to the Capital Purchase Program (CPP), designed to purchase preferred stock of financial institutions.[3] After an initial injection of $125 billion into nine large and systemically important institutions on

[1] For commercial banks we use the *IFS* category of "other depository corporations", whose liabilities are included in the definition of broad money, whereas non–banks correspond to the *IFS* category "other financial corporations", whose liabilities are not included in broad money, but who engage in financial intermediation or provide financial services.
[2] See Cecchetti (2008), Madigan (2009), and Sarkar (2009) for a detailed description of the actions taken.
[3] This corresponds to 2 percent of commercial bank assets at the end of 2008.

October 14th, 2008 the program has broadened to include over 550 smaller institutions,[4] with an overall injection of just over $200 billion as of October 2009.[5]

Both types of policies appear to have yielded benefits. There is evidence that specific liquidity provision efforts helped to offset the extreme tightness in market liquidity, which became evident in the summer of 2007. For instance, the Term Auction Facility (TAF), introduced in early December 2007, has been associated with at least temporary reductions in the LIBOR–OIS spread, in the excess deviations from covered interest parity that had spiked during the crisis, and in the divergence of LIBOR over the Federal Funds rates.[6] As for the capital injections undertaken through the CPP, there is evidence that the funds were well–targeted, in terms of being allocated to larger, systemically important banks that had suffered greater capital losses but had relatively strong loan portfolios, that is, healthy but vulnerable banks. Furthermore, the injections themselves were associated with positive valuation effects for the recipient banks – excess stock returns – which were also greater for those banks that had suffered greater capital losses.[7]

However, to date it is not clear whether there has been a positive impact of these two types of policies – either focused on liquidity or capital – specifically on bank lending. In fact, a particular concern has arisen that these policies have done little to reactivate credit, and that instead, excess reserves held by banks have risen to unprecedented levels. From a level of about $1.5 billion throughout 2007 and most of 2008, excess reserves climbed rapidly following the Lehman Brothers bankruptcy, reaching $900 billion by January 2009, and remaining above $800 billion through September 2009 (Keister & McAndrews, 2009).[8]

This paper examines this issue by focusing on the period from 2006 Q1 to 2009 Q2, during which bank credit slowed dramatically, with the aim of assessing to what extent either liquidity or capital constituted the main binding constraint for banks. It draws on theoretical work on the determination of bank credit, particularly that of Peek and Rosengren (1995) and Chami and Cosimano (2001, 2010). The former provides a simple framework of bank intermediation that produces testable implications for bank credit, implications which vary depending on whether capital is binding or not. The latter study identifies a capital channel of monetary policy, whereby interest rate shocks are transmitted to credit supply via the regulatory capital constraint,

[4] See Bayazitova and Shivdasani (2009) for a breakdown of TARP and CPP funds allocated and spent through April 2009.
[5] According to U.S. Treasury figures, redemption of shares has amounted to $70.4 billion, therefore CCP funds outstanding are equal to $134.1 billion as of mid–October 2009.
[6] Sarkar (2009) surveys several empirical studies that have measured the effectiveness of these recent Federal Reserve Liquidity Programs. In addition to TAF, there is evidence that currency swap lines as well as the Term Securities Lending Facility also led to a lowering of different measures of liquidity and credit risk.
[7] Bayazitova and Shivdasani (2009).
[8] However, these authors argue correctly that the reserve buildup alone does not necessarily signal an inability of monetary policy to affect bank lending. To the extent that reserves provided by the Federal Reserve replace funds previously available from the interbank market, the policy may have prevented a sharper *decline* in bank lending.

and where banks' decision to hold capital is modeled as a call option on the future supply of loans.

According to the framework used in this paper, the capital constraint should affect bank activities in general during a period of loss of capital throughout the banking system, as many banks will need to scale back their balance sheets in order to comply with the regulatory minimum capital levels. This was certainly the case during the 1990–91 U.S. recession period studied by Peek and Rosengren, and as we will show, also during the 2007–2009 financial crisis.

The nature of the impact of capital constraint on bank lending can be illustrated with a simple example. Consider two banks, A and B, which have just experienced a loss of capital. Each now has $100 million in assets and, for the sake of simplicity, each also has $4 million in equity capital. However, Bank A has a larger share of its assets as loans ($80 million) than bank B ($40 million). Assuming that risk–weighted assets are simply equal to total loans, the regulatory capital ratios will be 5 percent for bank A and 10 percent for bank B. Thus, bank A is particularly capital constrained, while B is comfortably above the regulatory minimum.[9] Suppose that both banks experience an equivalent and exogenous increase in capital equal to $2 million, thereby enabling a one–for–one expansion in their assets. However, Bank A will not be able to extend new loans, given its low regulatory capital ratio, while Bank B might even be able to use the additional funds in their entirety to expand credit. In order for Bank A to expand credit, its capital will need to be raised at least to the regulatory minimum. In fact, Bank A have to *contract* lending, as the capital injection will still leave the regulatory ratio at 7.5 percent (=(4+2)/80). Thus, Bank A will have to divert funds toward purchase of securities, increasing reserves or other assets with low risk weights, even as its total scale of operations expands. Thus, two main conclusions can be drawn: (i) the capital constraint operates in a nonlinear fashion, with a greater effect on banks closer to the regulatory minimum; and (ii) it affects lending, as opposed to other assets, disproportionately.

The paper undertakes three main empirical exercises. The first is the test proposed by Peek and Rosengren (1995) for assessing whether the capital constraint has been binding, and therefore is a key factor in explaining the decline in credit growth. It relies on cross–section variability, using pre–crisis heterogeneity across banks to determine which types of banks were more likely to restrict credit. In some specifications, conventional liquidity measures of banks are included in addition to the conventional explanatory variables, in order to contrast a liquidity–constraint vs. a capital–constraint hypothesis. The evidence supports the hypothesis that the banks were capital constrained from 2007 to 2009, in the sense that the banks with lower initial capital ratios were more likely to be forced to contract their operations and restrict credit. Furthermore, this result was robust to alternative definitions of the capital constraint: tier 1, total capital or the leverage

[9] In terms of the Chami–Cosimano model, however, it is only necessary for the regulatory capital ratio to be low enough—even if above the regulatory minimum—for Bank A to believe that it might fall below the requirement in the near future. In this case, Bank A would be capital constrained.

ratio. On the other hand, there is no evidence linking initial liquidity to subsequent contractions in banking activities. However, this does not necessarily imply that liquidity was irrelevant to bank behavior; it may be that conventional measures of liquidity—the initial liquid asset ratio—may have understated the true liquidity crunch affecting many banking institutions as a result of the collapse of the interbank market.

To identify how banks choose bank capital, a second test is implemented for a model developed by Chami and Cosimano, in which the value of the bank's capital increases when the volatility of loan demand and the amount of capital required by the regulator are increased. As a result, a regression equation is specified which hypothesizes a negative and convex relation between new bank capital and previous changes in bank capital, interest expenses and non–interest expenses. The empirical results confirm the predictions of the theoretical model.

Finally, a test of monopoly power in the U.S. banking system is undertaken, following Cetorelli and Gambera (2001) and Claessens and Laeven (2004). Given that both theoretical models examining the link between capital and bank behavior rely to some extent on the existence of a non–perfectly competitive banking sector, the test determines whether this assumption is valid during the study period. We find that the H–test of Panzar and Rosse (1987) supports a monopolistic–competitive banking behavior. In particular, the bank holding companies systematically increased their net interest margin throughout 2007–2008 as the Federal Reserve reduced short–term interest rates by 5 percentage points.

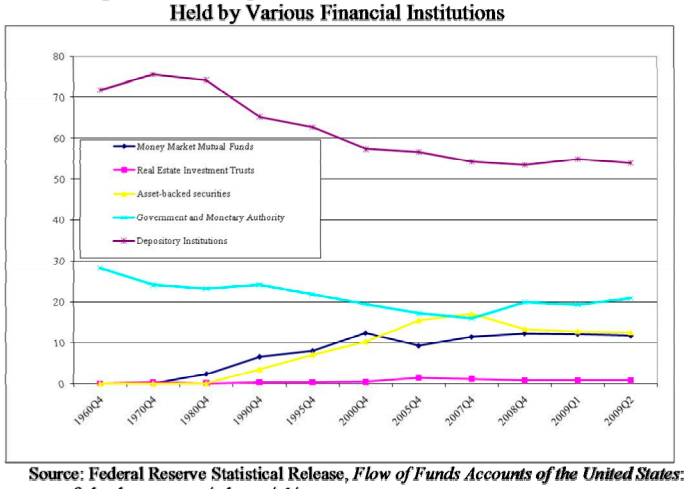
Overall, these results suggest that bank capital is a crucial conduit by which monetary policy affects the lending behavior of banks. In an environment in which banks are required to hold a percentage of their risky assets—loans in particular— in the form of bank capital, banks are not able to expand their lending unless they have additional capital. Furthermore, banks need to have incentives in the form of higher expected future returns before they undertake costly steps to raise additional capital. Thus, the design of monetary policy must be formulated to account for the presence of regulatory capital constraints.

For this reason, the results of this paper may also shed some light on a policy issue that will become increasingly relevant as the economic recovery takes hold: how to unwind some of the extraordinary monetary policy measures taken to confront the crisis. Indeed, another key aspect has been the virtual disappearance of the "shadow banking system", which had grown rapidly in the run–up to the crisis, and largely at the expense of the commercial banks (Figure 2). These non–bank institutions were partially financed by short term funding made possible by the increased popularity of money market mutual funds and asset backed securities, and were not subject to the same deposit insurance, regulations and supervision which are applied to commercial banks.[10] Yet they also funded illiquid assets with short term funding. The subprime

[10] See Gorton (2008, 2009) for a comprehensive discussion of the mortgage backed security market. Gorton and Metrick (2009) discuss the short–term funding of the asset–backed securities.

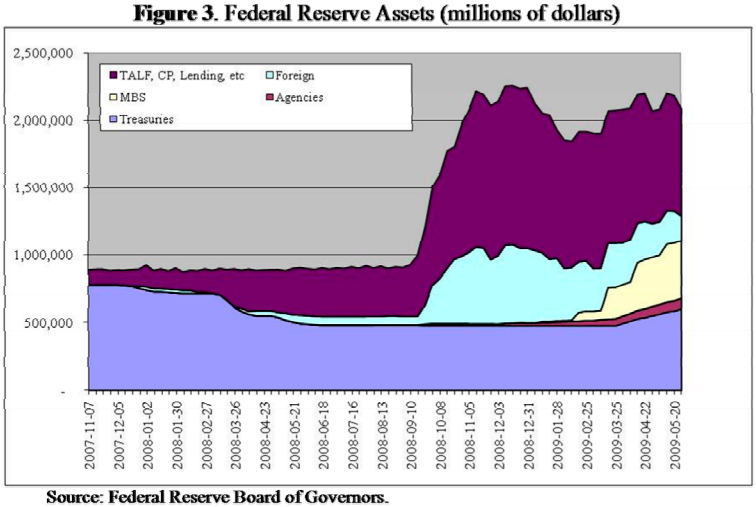
lending crisis led to a bank run on this shadow banking system,[11] the failure of which resulted in the Federal Reserve assuming a large portion of their assets, increasing its balance sheet by $1,142 billion (Figure 3). Given the importance of capital in determining the banking system's ability to expand, as well as the main factors influencing the banking system's willingness to raise capital, this paper suggests how these excess funds currently on the Federal Reserve balance sheet might be effectively privatized and sold to the banks.

Figure 2. Percentage Distribution of U.S. Financial Assets Held by Various Financial Institutions



Source: Federal Reserve Statistical Release, *Flow of Funds Accounts of the United States*: www.federalreserve.gov/releases/z1/.

Figure 3. Federal Reserve Assets (millions of dollars)



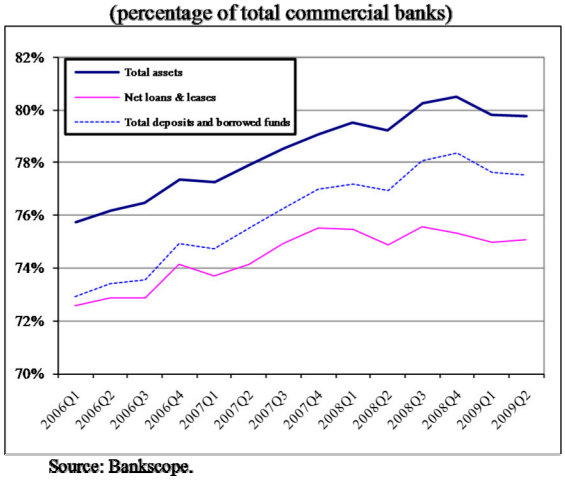
Source: Federal Reserve Board of Governors.

The remainder of the paper is organized as follows. Section II describes the data and presents some descriptive statistics; Section III presents the specification of the two empirical tests; Section IV presents the results; and Section V concludes.

II. Data and Descriptive Statistics

For our empirical analysis, we rely on Bankscope bank–level quarterly data from 2006 Q1 to 2009 Q2. Our main focus is on the largest bank holding companies in terms of total assets, for two main reasons. The first is that these institutions represent the vast majority of commercial bank assets. One can see this by looking at call report data for the 88 commercial banks with over $10 billion in assets (see FDIC website: http://www.federalreserve.gov/releases/h8/20081229/). These commercial banks held over 76 percent of

Figure 4. Market Share of Banks with Over $10 Billion in Total Assets (percentage of total commercial banks)



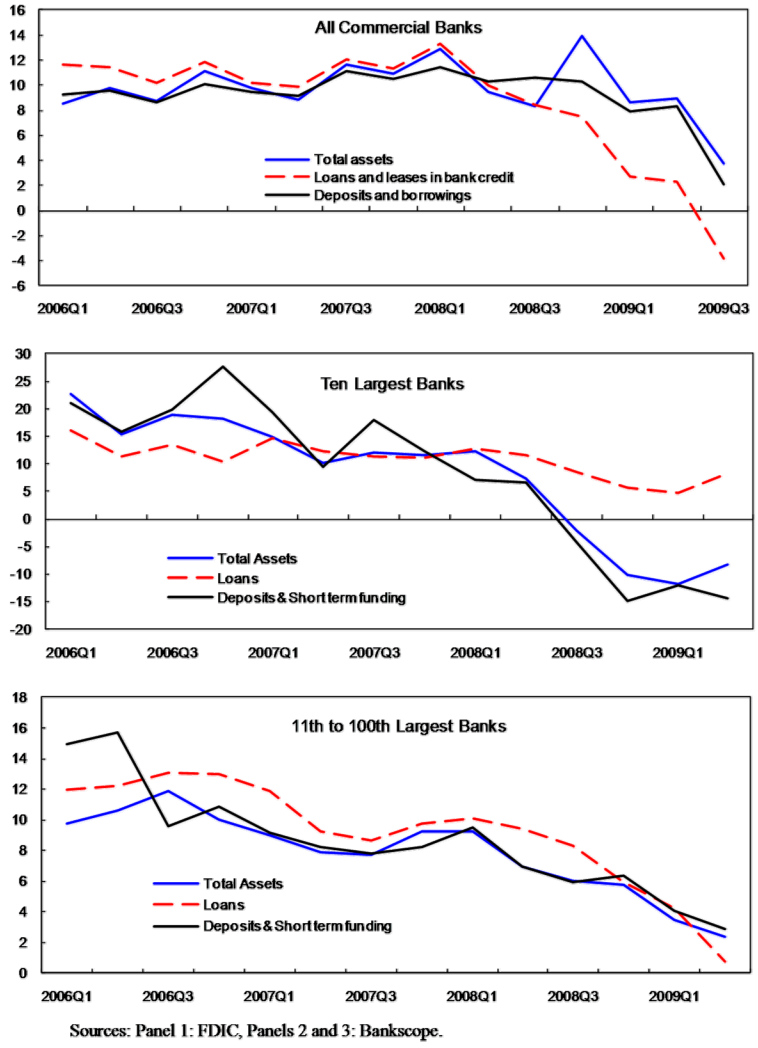
Source: Bankscope.

[11] See Brunnermeier (2008), and Diamond and Rajan (2009) for a more detailed discussion.

all commercial bank assets, and over 73 percent of loans and deposits during the fourteen quarters ending in 2009 Q2 (Figure 4).

A second reason for concentrating on these larger institutions is that most of the problems in the financial crisis centers on them. Figure 5 reports the behavior of total assets (*TA*), loans, and deposit and short term funding (*DSTF*) for three groups of banks: the total commercial banking system, the ten largest bank holding companies, and the ninety next largest (i.e., the 11th–100th) bank holding companies.[12] While *TA* and *DSTF* of the banking system as a whole grew at roughly the same pace up until late 2008, overall deleveraging and scaling back of banking activities becomes clearer once we focus on the subset of larger institutions. For the 11 to 100 largest bank holding companies, there were visible slowdowns in all three measures of banking activity; in fact *TA* and *DSTF* slow more sharply than loans. For the ten largest institutions, the slowdown was even more severe, with the former two variables going from a growth of over 20 percent in early 2006 to an annual decline of 10 percent by the end of 2008.

Figure 5. Annual Growth Rate of Assets, Loans, and Deposits by Groups of Banks



Sources: Panel 1: FDIC, Panels 2 and 3: Bankscope.

The data also show the distinctive behavior of bank loans. As discussed above, the aggregate scale of banking activities—as measured by *TA* and *DSTF*—did not exhibit the type of slowdown through end–2008 that one might associate with a financial crisis, a point made by Chari, Christiano, and Kehoe (2008). However, bank

[12] We started with the largest 120 bank holding companies. If a bank did not have all the data for a particular date, then it was not included in the statistics for t hat date. As a result, we had 100 companies most of the time. The top ten holding companies refer to the largest in the last quarter, so that there were more holding companies in the last two quarters of the sample period. The alternative would to start with the top ten at the beginning of the sample so as to include several of the holding companies that either failed or merged with others by the end of the sample. We also ran the same test with all the holding companies in Bankscope but did not see an appreciable difference in the results.

loans clearly show a deceleration of almost 6 percentage points, similar to that shown in the aggregate *IFS* data. Furthermore, the slowdown was even more pronounced for the ten largest banks—by ten percentage points—and appeared to intensify for most banking institutions in 2009, registering an annual decline of 4 percent by the second quarter for the total banking system.

Table 1 shows end–year averages of selected banking indicators for all commercial banks and the largest 88 commercial banks, those with over $10 billion in assets. Table 2 provides the same information for the large bank holding companies, highlighting other differences between the group of ten largest and the next largest 11–100 holding companies. Table 3 examines these ratios for the bank holding companies that received funding from the TARP program. The focus in this table is on seeing whether the ratios differed significantly at end 2008 for the holding companies that paid back the funds by June 2009 from those that did not.

Although regulatory minimum capital requirements were being met on average, Tables 1 and 2 show how the crisis led to a noticeable fall in bank capital between 2006 and the last quarter of 2008. The equity asset ratio declined for both commercial banks and for the largest bank holding companies. However, the total capital ratio remained above the regulatory minimum and did not suffer a similar decline across all groups.[13] In particular, the largest bank holding companies registered noticeable increases, partly as a result of TARP injections[14] and also as a result of their actions to change the composition of assets away from those with the highest risk weighting, namely, loans.

Also apparent from Tables 1 and 2 is an incipient recovery in bank capital during the first half of 2009, with all three capital ratios increasing for the system as a whole and for all subgroups analyzed.

As expected, commercial bank profitability (Table 1) was notably affected by the crisis. For the system as a whole and for the 88 largest banks, *ROE* registered a drop of about 12 percentage points between 2006 Q4 and 2008 Q4, from about 13 percent to just over 1 percent. Further insight into the changes in bank profitability can be obtained from a simple equation in which the return on equity (*ROE*) is expressed as a product of the equity multiplier (*A*/*E*) and the return on assets (*ROA*), and decomposed further as in Koch and MacDonald (2007):

$$ROE = \frac{A}{E} \cdot ROA = \frac{A}{E}\left[\frac{NIM}{A} + \frac{NII}{A} - \frac{NIE}{A} + \frac{SG}{A} - \frac{PLL}{A} - \frac{TAX}{A}\right] \qquad (1)$$

[13] Tier 1 capital refers to equity, whereas total capital includes subordinated debt as well. Both ratios are calculated as a percentage of risk–weighted assets.

[14] Note that TARP injections are included within total capital, but not counted as equity.

Here, *E* is equity; *A* is total assets; *NIM* is the net interest margin, calculated as the difference between interest income (*II*) and interest expense (*IE*); *NII* is non–interest income; *SG* is security gains (losses); *NIE* is non–interest expense, *PLL* is provisions for loan losses, and *TAX* is the taxes paid. These variables are displayed in Table 1 for all commercial banks and for the 88 largest commercial banks (with assets greater than $10 billion), while Table 2 contains the same information for the large bank holding companies

As this decomposition shows, most of the decline in profitability can be attributed to a 1–percentage point increase in the loan loss provision ratio amplified by an equity multiplier (A/E) of just over 10. On the other hand, the net interest margin decreased only slightly, by about 0.2 percentage points, almost entirely offset by a similar decline in non–interest expense. This latter fall is consistent with a significant decline in off balance sheet items, on which the banks collect fees. Also of note was the increase in liquidity during this period, with the liquid asset ratio rising by 2–3 percentage points, while the equity–asset ratio declined by less than 1 percentage point.

For the largest ten bank holding companies (Table 2), the fall in profitability was more dramatic, with *ROE* falling into negative territory by the end of 2007, and eventually declining by about 43 percentage points between 2006 and 2008. For these institutions, the bulk of the profit collapse came from securities losses,[15] which accounted for close to 30 percentage points, once the amplifying effect of the equity multiplier of about 16 is taken into account. The contraction in the net interest margin— primarily as a result of lower interest income—contributed about 4 percentage points, as did an increase in noninterest expenses. Finally, a substantial increase in provisions for loan losses contributed the remaining 5 percentage points. Thus, the main difference between the large commercial banks and the large bank holding companies comes from substantial losses on marketable securities in addition to the provision for loan losses.[16]

Other key differences are that the top 10 bank holding companies have on average been more liquid and less exposed to off–balance sheet items. The liquid asset ratios of banks decreased from 2006 Q4 to 2008Q4, but not significantly. Off–balance sheet items declined significantly in percent of total assets for the largest 10 banks in 2008 Q4, although they are lower than those for the top 11–100 bank holding companies. However, these numbers mask the fact that that the seemingly comfortable liquidity ratio reflected extensive use of repo funding which eventually became seriously impaired (see Chailloux 2009 and Gorton and Metrick 2009).

[15] In Tables 1 and 2 we aggregate three items into one line: noninterest income plus securities gains, minus taxes. There is little reason to think that there was a collapse in noninterest income or a large increase in taxes paid by banks, the bulk of the change in this line item can be attributed to securities losses.

[16] Accounting conventions are another possible source of differences between bank holding companies and commercial banks; the latter are not obliged to mark to market all of their assets and, therefore, may not be recognizing all of their losses in real time. Unfortunately, this cannot be verified from the data.

Focusing on a subset of the larger bank holding companies, those that had received TARP funding as of 2008 Q4, Table 3 shows that the ones that ended up repaying the funds as of mid–2009 showed stronger ex ante indicators across the board. Average capital and liquid asset ratios were significantly higher, as was the return on average equity.

III. Specification of the Empirical Tests

In this paper we trace out the response of the large bank holding companies as they dealt with a significant loss of equity capital, given the regulatory constraints on their activities: they must hold at least 4 percent of risk adjusted assets as tier 1 capital and 8 percent as total capital in order to comply with the Basel Accord minimum standards; at least 6 and 10 percent, respectively to be classified as "well capitalized" by the FDIC; and must also maintain a minimum equity–asset ratio of 3 percent.

The observed reduction in the bank capital occurred at the same time as a scaling back of banking activities, as both loans and *DSTF* slowed noticeably. We test whether bank capital played a part in this scaling back, by using a specification pioneered by Peek and Rosengren (1995) (PR, hereafter) in their analysis of credit stagnation in New England surrounding the 1990–91 recession. Starting from a model of profit–maximizing bank behavior subject to minimum capital requirements, their study derives a testable equation linking deposit and loan growth to initial capital levels as well as their changes. A "capital crunch" is defined as a situation in which the amount of capital is in fact constraining banks' ability to expand their activities. During a situation of widespread loss of capital across the banking system, one should observe that those bank holding companies with lower initial capital and larger capital losses are also the ones with greater contractions in deposits and loans. In addition, changes in total capital should have a significantly larger effect on loans and deposits for banks with lower initial capital.

It should be pointed out that there is a crucial difference between the time period analyzed in this paper, and that examined by the original PR study. In their case, the Basel Accord minimum capital requirements had been adopted only recently—in fact, 1992 was the deadline for full implementation in the U.S.— and at the same time, the banking system was hit with a recession and a negative capital shock. Therefore, PR set out to test whether the new capital requirements had imposed a burden on banks that had not existed during previous recessions. In our case, the Basel Accord has now been in place for close to two decades while, in addition to the capital and real sector shocks, the banking system was subject to a liquidity shock—primarily, the collapse in interbank funding. Thus, in our econometric analysis we included liquidity as an additional regressor, to test whether liquidity constituted a significant constraint on bank activities.

As discussed earlier, from 2006 to 2008 the largest bank holding companies met their capital requirements. However, even when not immediately binding, these regulations may have affected banks' ability to lend nonetheless. Chami and Cosimano (2010) (CC, hereafter) develop a model in which banks' forward–looking behavior leads to sensitivity to bank capital even if the regulatory constraint is not binding. The amount of capital is negatively related to the past

change in capital and positively related to the expected need for capital. This need for capital, in turn, is decreasing in the interest and non–interest expenses of the bank, which reduce the bank's optimal holding of loans.

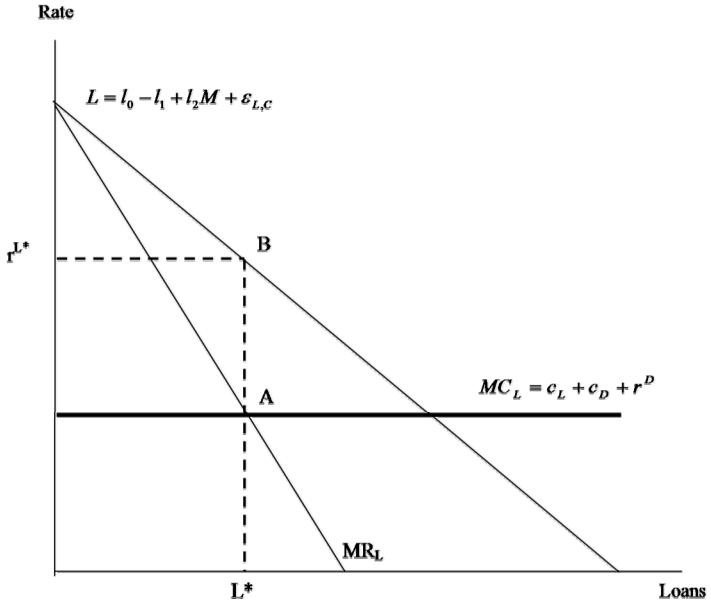
We briefly describe the CC model as illustrated by Figure 6. In the case when capital constraints are not binding, the bank chooses loans such that marginal revenue of loans MR_L is equal to its marginal cost MC_L. Marginal cost consists of the interest rate on deposits r^D plus non–interest factor costs related to loans and deposits, respectively, C_L and C_D. The profit–maximizing level of loans (L) and the corresponding loan rate (r^L) are given by:

$$L = \frac{1}{2}\left[l_0 + l_2 M + \varepsilon\right] - \frac{l_1}{2}\left[C_L + C_D + r^D\right] = \bar{L} + \frac{\varepsilon}{2}, \text{and}$$
$$r^L = \frac{1}{2l_1}\left[l_0 + l_2 M + \varepsilon\right] + \frac{1}{2}\left[C_L + C_D + r^D\right] \quad (2)$$

Here l_1 is the interest sensitivity of demand for loans, l_2 is the effect of economic activity M on the demand for loans and l_0 is the fixed demand for loans. Given the balance sheet identity— total deposits (D) plus capital (K) must be equal to total loans— the corresponding profit–maximizing level of deposits is equal to:

$$D = \bar{L} + \frac{\varepsilon}{2} - K \quad (3)$$

Figure 6. Profit-Maximizing Loans and Lending Rate



When the capital constraint is binding, then the optimal level of loans and deposits will be given by:

$$L^* = \frac{K}{\theta} \text{ and } D^* = L^* - K = \frac{1-\theta}{\theta} K \,, \tag{4}$$

where K can refer to either Tier 1 or Total Capital in the previous quarter and θ is the regulatory capital ratio. Given the constrained level of loans, the bank chooses a loan rate so as to meet the demand for loans, as in Figure 6.

$$r^L = \frac{1}{l_1}\left[l_0 + l_2 M + \varepsilon - \frac{K}{\theta} \right] \tag{5}$$

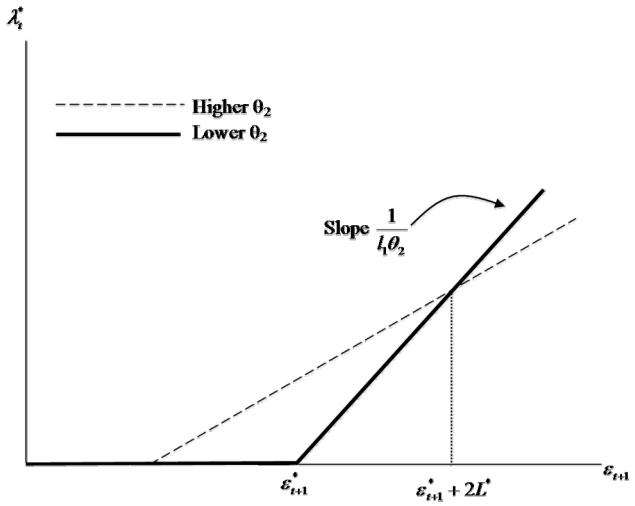
It is unusual for the capital constraint to be actually binding for a bank in a given period, as banks choose overwhelmingly to hold levels of capital well above the regulatory minimum. For example, the average total capital ratio in Table 2 for the top ten bank holding companies was 13 percent more than a year into the financial crisis. However, a decrease equal to two standard deviations would place the total capital ratio below the required 10 percent.

The CC model shows that, even if not strictly binding, the capital constraint does affect the optimal decisions of the bank. Capital can be seen as a call option for the bank in which the strike price is the shock to the demand for loans in the future, such that

$$\varepsilon^* = 2\left[L^* - \overline{L} \right] \tag{6}$$

The payoff to this call option is drawn in Figure 7. If there is a low demand for loans such that the shock to demand is below the critical level, then total capital serves no purpose so its payoff is zero. When the demand for loans is above its critical level, then total capital has a positive option value, and therefore the bank will tend to hold more capital than required in order to gain flexibility to meet future loan demand. Future total capital K' is a negative function of the strike price and a positive function of its standard deviation σ.

Figure 7.
The Regulatory Capital Constraint



$$K' = H\left(L^* - \overline{L}, \sigma \right) \tag{7}$$

Therefore, banks will hold more capital the higher the regulatory requirement, and the higher the volatility of demand for loans.

To test the CC model for bank capital, we specify an equation in which the dependent variable is one of the three measures of bank capital: Total capital, Tier 1 capital, and the leverage (equity–asset) ratio. A decrease in total capital in the past, which lowers the strike price of total capital, should lead to a statistically significant increase in current total capital. In addition, this impact should be smaller when the bank has more initial capital, consistent with the convex property of call options. Furthermore, a decrease in interest and non–interest expenses should lead to an increase in bank capital at a decreasing rate, since the optimal level of loans is higher and the strike price of bank capital is lower.

Finally, we test for market power in the banking industry, a key ingredient in both the PR and CC models of bank behavior. We follow Cetorelli, Gambera and Claessens (2004) and estimate the Panzar and Rosse (1987) H–statistic to test for monopoly power. The H–statistic measures the sum of elasticities of revenue with respect to input prices, and takes different values depending on the market structure. During our particular study period, a key input price, the short–term interest rate, was driven down sharply as a result of aggressive countercyclical monetary policy. Between August 2007 and December 2008, the effective federal funds rate was lowered by 5 percentage points, from 5.25 percent to 0.25 percent. The market power test therefore assesses to what degree banking revenues responded to this change.

A. The Peek and Rosengren Test

The empirical test developed by Peek and Rosengren (1995) is based on the following regression equation:

$$\frac{\Delta D}{A} = a_0 + \left(a_1 + a_2 \frac{K}{A} \right) \times \Delta \frac{K}{A} + a_3 \frac{K}{A} + a_r Log(A) + a_5 Fee + \varepsilon \qquad (8)$$

Here A denotes total assets. As argued above, a capital crunch would imply that $a_1 > 0$ and $a_2 < 0$, that is, a decline in capital will cause all banks to reduce their deposits, but proportionally more so for poorly capitalized banks. The equation also tests whether initial capital in itself constitutes a constraint on banks' activities, independently of the *change* in capital over the study period. If this is the case, then one would expect $a_3 > 0$ as well. The other two variables are included as controls, namely, the logarithm of assets to reflect possible advantages and greater flexibility in lending for larger institutions[17]; and fee income (*Fee*) to reflect the possible insulating effect of greater off–balance sheet activities.[18] We also use a similar regression with bank loans as the dependent variable, and again the PR theory would predict a positive direct effect of changes in

[17] Peek and Rosengren point out that national banks are restricted to lend less than 15 percent of bank assets, which might impose a greater burden on smaller banks' ability to make larger loans.

[18] Peek and Rosengren also include the shares of commercial and industrial loans (*CI*) and real estate loans (*RE*) to account for differences in sectoral demand for loans, however we did not have the data to test this.

capital (a_1>0), which is weakened to the extent that initial capital is greater (a_2<0).[19] In the case of banks with insufficient capital, the regulations would require loan growth to be slower relative to well–capitalized banks, therefore, one would expect a_3>0.

B. The CC Test of the Choice of Capital

We test the CC model by examining how the strike price of the total capital influences its option value and, hence, the banks' choice of total capital. Following the logic of the PR regressions, we can estimate the following relation:

$$\frac{K^{'}}{A} = c_0 + \left(c_1 + c_2 \frac{K}{A}\right) \times \Delta \frac{K}{A} + \left(c_3 + c_4 \frac{K}{A}\right) r^D + \left(c_5 + c_6 \frac{K}{A}\right)\left(C_L + C_D\right) + c_7 \log\left(A\right) + \varepsilon \qquad (9)$$

Call options are generally decreasing and convex in the strike price.[20] As a result, we expect $c_1 + c_2 \frac{K}{A} < 0$ and $c_2 > 0$ so that $c_1 < 0$ and $c_2 > 0$, given that an increase in total capital raises the strike price $L^* - \overline{L}$. It is straightforward to find the expected signs for other parameters in the regressions as well. First, an increase in the deposit rate reduces the optimal amount of loans $\overline{L}$ so that the strike price increases, therefore we expect $c_3 < 0$ and $c_4 > 0$. An increase in the marginal costs of loans and deposits has the same impact as the deposit rate, so that $c_5 < 0$ and $c_6 > 0$. The log of assets is included as a control variable to capture differences in behavior for large and small banks.

C. Capital Constraints, Interest Rates and Market Power

We also look at the effect of capital constraints on the loan rate and net interest margin using a similar specification:

$$r^L = b_0 + \left(b_1 - b_1 Du\right) r^D + \left(b_2 - b_2 Du\right)\left(C_L + C_D\right) + b_3 Du \frac{K}{A} + b_4 \log\left(A\right) + \varepsilon \qquad (10)$$

The CC model implies that $\frac{\partial r^L}{\partial r^D} = \frac{1}{2} > 0$, thus we expect $b_1 > 0$. This effect of the deposit rate should be reversed for the net interest margin, $r_L - r_D$. The loan rate also responds positively to the marginal cost of loans or deposits $\frac{\partial r^L}{\partial\left(C_L + C_D\right)} = \frac{1}{2} > 0$, therefore $b_2 > 0$, an effect we expect to be identical for the net interest margin. Our measure of marginal costs is the sum of non–

[19] Note that, notwithstanding the sweeping changes in banking activities over the past decade, loans continue to be funded primarily by deposits; during 2007–2009 loan–deposit ratios averaged 62 percent for the ten largest banks, and 90 percent for the next largest 90 banks.

[20] See Hull (2006) page 389 for proof of convexity of European call option in the strike price.

interest expenses and provision for loan losses relative to total assets. In addition, *Du* is a dummy variable equal to one when the capital constraint is binding. As the model predicts, both the effects of the deposit rate and marginal costs disappear when the capital constraint is binding, that is, *Du* = 1. Finally, an increase in the capital to asset ratio should reduce the loan rate only when the capital constraint is binding, thus $b_3 < 0$.

This regression can also provide information about the degree of monopoly power in bank holding companies. This is particularly important given that there has been a recent increase in concentration as shown by the rising share of the 88 largest banks (Figure 4). While concentration does not necessarily imply collusive behavior, Claessens and Laeven (2004) advocate using the Panzar and Rosse (1977, 1982, and 1987) H–statistic, which measures the extent to which changes in marginal cost are reflected in prices and revenue.[21] In our study period the banks faced lower marginal cost in the form of lower interest expenses. For a monopolist this would lead to an increase in output and revenue. As a result, the H–statistic is designed to measure this property.

The above regression equation (10) can therefore be used to estimate the H–statistic. We use the interest revenue of the bank relative to the bank's assets as the output price. The H–statistic is sum of the elasticity of this price to input prices, and is therefore represented by $b_1 + b_2$. It should take the value of unity for perfect competition or perfect contestability; a negative value for monopoly or certain types of oligopoly; and a positive value between zero and unity for monopolistic competition. Claessens and Laeven (2004) also implement what is called the E–statistic or equilibrium test of long run equilibrium. However, we would not expect the banks to be in long run equilibrium given the short time interval since the subprime crisis started. Estimating the E–statistic involves replacing the bank's interest revenue with its return on assets as the dependent variable. The E–statistic is estimated as $b_1 + b_2$ from that regression, and is expected to be zero in long run equilibrium.

IV. Estimation Results

In this section we estimate the various regressions suggested by the banking analysis: (i) the effect of capital on credit growth, (ii) the CC test of choice of bank capital; and (iii) the market power test.

A. Bank Capital Constraints and Credit Growth

The hypothesis being tested in regression equation (8) is that negative shocks to capital will cause poorly capitalized banks to shrink their operations by more than better–capitalized banks. Therefore, it is expected that the coefficient on the interaction of the change in the capital–to–

[21] See also Cetorelli and Gambera (2001).

asset ratio with the initial capital–to–asset ratio will be negative, so that a given change in the capital–to–asset ratio leads to a larger reduction in loan growth rates (or deposit growth rates) the smaller the initial capital–to–asset ratio.

The regression sample period is from 2007 Q3 to 2008 Q4. Depending on the specification, we include the largest 79 to 87 bank holding companies, those for which data for all variables is available. The dependent variable in the regressions is defined as either the annual growth rate of loans or of *DSTF*, scaled by initial assets (*A*). Thus, the first time observation is for the growth rate between 2006 Q3 and 2007 Q3. The next observation is the growth rate between the 2006 Q4 and 2007 Q4, and so forth. Annual changes are used to avoid seasonality issues.

A key issue is whether loan demand effects are properly controlled for. The advantage of using a wide cross section of banks is that macroeconomic demand shocks taking place during the crisis were common to all banks in the sample, and therefore the regressions should reflect the different impacts across banks according to their initial capital. However, some banks may be subject to sectoral or idiosyncratic demand shocks. Peek and Rosengren point out that these could be related to shocks to bank capital if a bank's borrowers are tied to the bank through historical relationships. While weak loan demand would cause a portfolio shift away from loans, it will not necessarily cause the bank to shrink its entire balance sheet unless no other profitable opportunities are available. Focusing on deposits rather than loans can ameliorate this problem. Even so, one cannot be sure that demand effects have been controlled for completely.

The regressions estimating equation (8) use the three alternative measures of capital as the main explanatory variable, and include either the growth rate of loans or of *DSTF* as the dependent variable. Estimation is done with OLS and, in order to address the possible endogeneity of the change in the capital–to–asset ratio, the one–year lagged change is included in the regressions instead of the current year change. Other control variables included in the regressions are the initial ratios of off–balance sheet items to total assets, liquid assets to total assets, TARP funds received in the quarter to total assets (equal to zero in all quarters except in 2008 Q4), the logarithm of total assets to capture market share and bank–specific growth over time, three dummy variables that further distinguish between the banks according to size,[22] and period dummies to capture common shocks to all banks. The intercept is excluded from the regressions. Finally, two time sample periods were considered: the capital loss period, from 2006Q4 to 2008Q4, and the full sample period, which also included the first two quarters of 2009. The main results are reported in Table 4.

[22] The size dummies were constructed according to whether a bank holding company's total assets over the 2006–2008 period: (i) on average exceeded $460 billion, (ii) on average exceeded $17 billion but were less $460 billion, and (iii) whose assets were on average less than $17 billion. These dummies are broadly capturing the largest 10 bank holding companies, the top 11–50 bank holding companies, and the other large bank holding companies. The regressions also were run with the size dummies included but the logarithm of assets excluded, and vice versa. The size dummies were mostly significant, whereas the logarithm of assets was only occasionally significant in these alternative specifications, suggesting that there is a non–linear relationship between bank size and lending behavior.

As expected, the coefficients on the lagged change in the capital–asset ratio and its interaction with initial capital are positive and negative respectively, and both are significant. This applies both to the growth rate of loans and deposits. Furthermore, the results are robust to the specific capital ratio used—suggesting that the type of capital (equity or other) does not make a significant difference in terms of limiting bank activities. In short, the results support the idea that capital was a significant constraint on bank lending during the crisis; it was the more capital constrained banks that had lower growth, both in terms of deposits or lending.

Also of note is that these relationships were stronger during the capital loss period, both in the absolute size of the estimated coefficients as well in their significance. This is to be expected; the capital constraint is more likely to be binding during a period of generalized capital loss, whereas once some banks begin to improve their capital ratios beyond the regulatory minimum, their initial levels of capital become less informative about their subsequent level of operations. In other words, while we expect well–capitalized banks to be relatively insulated on the downside (capital loss), therefore not having to shrink their operations by as much as poorly capitalized banks, this relationship is not symmetrical. On the upside we would not necessarily expect well–capitalized banks to grow by *less* than their poorly capitalized counterparts. Note that the original studies by Peek and Rosengren limited their analysis to periods of clear–cut capital losses.

Liquidity, on the other hand, does not seem to have been a determining factor in banks' lending during the crisis. Banks that had higher initial liquid asset ratios did not display significantly higher subsequent deposit or loan growth. That is, they were in no better position to cushion the adverse shocks to their balance sheets brought on during the crisis. One caveat, however: this result may also reflect an inability of the initial liquid asset ratio to truly capture the funding difficulties encountered by many banks as a result of severe disruptions in the interbank market.

We also ran an IV estimation of this regression (not reported here, but available upon request), with similar results. The capital ratios were instrumented using their one–year lagged values, and either the one–year lagged ratio of bank profits or return on equity. The current year changes in the capital to asset ratios are included in the second stage regression estimations.

As shown in Table 4, we augmented the basic PR specification to include the amount of TARP capital injections received by each bank, in order to test whether they were effective in expanding bank activities, and lending in particular. The ratio of TARP funds to total assets was not significant in any of the regressions, showing that the TARP funds distributed to banks in 2008 Q4 did not have an impact on the supply of loans, even with a one–quarter lag, as specified in the full sample period estimations. This finding is robust to excluding from the sample the banks that received TARP funds and have now repaid them, and is consistent with Taliaferro (2009), which uses a variance decomposition methodology and finds that of every new dollar of TARP capital injections— i.e., CPP flows—only between 10 and 18 cents has gone toward new lending, whereas about 67 cents have gone to boosting banks Tier 1 capital ratios.

In terms of the other control variables, the regressions yield mixed findings on the ratio of off–balance sheet items to total assets. A priori, the expected sign of the coefficient on this variable is ambiguous. On the one hand, banks that have higher off balance sheet items—higher committed lines of credit—would tend to take precautions and hence have a lower growth of loans. On the other hand, there could be a positive relationship with future loans growth if there is a large increase in the demand for loans from previously committed lines of credit—as would have been the case if companies were no longer able to borrow from capital markets in the crisis.[23] Since off balance sheet items could be correlated with the non–interest, fee income, the regressions are estimated with both of these variables as well as dropping one of these variables. The coefficient on the lagged ratio of off–balance sheet items to total assets is positive in the regressions for loan growth for the capital loss period, and negative in all the other regressions. However, the coefficient on this variable is not significant in all of the regressions. Finally, the dummy variables that capture the size of banks are significant in all the regressions. F tests show that the coefficients on the dummy variables are significantly different from each other in most of the regressions.

B. The Choice of Bank Capital

The second regression deals with whether or not bank holding companies optimally choose the amount of bank capital, as specified in Equation (9). In the first three columns of Table 5, we report results for the current capital asset ratio—all three measures—regressed against the change in capital over the previous four quarters, lagged by four quarters, interest and non–interest expense to asset ratios, non–performing loans, and total assets. In some estimations we also included the quarterly bank–specific stock return as an explanatory variable, to capture the attractiveness of bank equity from the point of view of a potential shareholder. This variable reduces our sample size appreciably—from about 450 to just over 290 observations—due to the fact that it was available for only a subset of banks in our sample. Finally, we also estimated the capital choice equation for the two periods, the capital loss subperiod and the full sample period.

The results show that banks reacted to past capital losses by increasing their capital levels, and did so to a greater degree the more capital constrained they were initially. Thus, the choice of capital in a given period was negatively related to the prior change in capital, and positively related to the interaction between this change and the initial level. As in the case of the regressions for loan and deposit growth, the strongest estimated effects arise from the capital loss period, although in the case of the equity–asset ratio, they remain statistically significant throughout the full sample period.

Regarding the other explanatory variables, the quarterly stock return appears to be positively and significantly related to both the Tier 1 and total capital ratios, thus reflecting the greater ease of

[23] Gao and Yun (2009) examine the extent to which firms switched from commercial paper to lines of credit in response to the financial crisis.

raising capital to meet regulatory standards when stockholder returns are relatively high. The interest and non–interest to asset ratios, as well as the non–performing loans have the same sign pattern as expected, although only interest expense is statistically significant. In the case of the equity–asset ratio the non–interest expense is also statistically significant.

The size of the bank—total assets—does not appear to alter the decision to hold total capital, whereas larger banks tend to have smaller tier1 and equity–asset ratios. The coefficients on the time dummy variables indicate that in 2008 Q4 there was a generalized uptick in regulatory bank capital that persisted through the first half of 2009, which could be explained partly by the TARP injections, as well as by efforts by banks to redistribute their balance sheet so as to lower their risk–weighted assets. On the other hand, the equity asset ratio did not appear to change significantly, and there is even evidence of a small decline in 2009Q2. Finally, this model explains at least 63 percent of the variation in total bank capital.[24] Thus, the results generally support the hypothesis that bank holding companies treat total capital much as the CC model would predict, where holding capital allows greater flexibility to issue more loans in the future.

C. Tests of Monopoly Power

Next we address the operating assumption of the Peek and Rosengren and Chami and Cosimano (2001, 2010) that the bank holding companies have some degree of monopoly power. In Table 6 we report the Claessens and Laeven regression to estimate the H–statistic, where net interest income divided by total assets represents the output price for the bank holding company. The regressors are: two input prices (interest and noninterest expenses to assets), the nonperforming loan ratio, the log of bank assets, the three size dummy variables, and period dummies. In addition, the input prices as well as the nonperforming loan ratio are interacted with a binding capital constraint dummy which takes the value of unity if the total capital ratio is below the minimum for a bank to be considered well capitalized (i.e., below 10 percent).

We confirm the hypothesis that interest and noninterest expense ratios have a positive effect on banks' lending rates, while nonperforming loans do not have a significant impact. Also, the interaction terms show evidence that the response of lending rates to noninterest expenses is asymmetrical, depending on whether the capital constraint is strictly binding or not. Indeed, when the capital constraint is not binding, lending rates react positively to an increase in noninterest expenses, whereas this effect virtually disappears when the capital constraint is binding.

We test whether the sum of the coefficients on interest and non–interest to asset ratio—the H–statistic—is either zero or one. We reject these hypotheses both when the capital constraint is binding and when it is not, with F–statistics of 6 or greater and consequently, p–values of 0.000.

[24] Here we refer to the specifications excluding the quarterly stock return, which include the entirety of our sample of banks.

Thus, the sum of coefficients must lie between zero and one, a finding consistent with monopolistic competition among the largest bank holding companies.[25]

V. CONCLUSIONS

This paper has examined the behavior of large bank holding companies from 2006 Q1 to 2009 Q2 in response to the financial crisis of 2007–2009. First, the Peek and Rosengren (1995) test was undertaken to identify whether or not banks were subject to capital or liquidity constraints. The main conclusion was that, indeed, capital rather than liquidity was the primary constraint holding back these institutions' ability to expand their operations. Given similar negative shocks to their capital, banks with less capital initially would have smaller growth of deposits and loans. On the other hand, initial liquidity—at least when measured by the liquid asset ratio—did not have this same effect. Finally, these results held irrespective of whether total capital, tier 1, or equity to capital ratios were used in the test.

Next, we implemented a new test of the Chami and Cosimano (2001, 2010) model of bank regulatory capital, according to which banks hold additional capital when they anticipate that the regulatory constraint might bind in the future. We find that, consistent with this model, demand for additional capital is greater when banks have less initial capital and lower interest expense, as well as non–interest expenses. In addition, this demand for bank capital is convex in each of these variables. The overall predictive power of this model was quite satisfactory for all three measures of capital and the main predictions of the model were confirmed. Thus, there is strong evidence that banks optimally choose their capital position.

Finally, we implemented the H–test of Panzar and Rosse (1987) as applied to banks by Cetorelli and Gambera (2001) and Claessens and Laeven (2004). In this case we reject the two extremes of competitive and monopolistic behavior in the banking industry, thus monopolistic competition best characterizes the pricing behavior practiced by the large bank holding companies. In particular, they were able to increase the net interest margin as the Federal Reserve lowered the cost of funding by 5 percent from 2007 through December 2008, thus, allowing them to build up bank capital optimally over time. Our results also imply that bank lending is not likely to expand appreciably until this buildup of bank capital has been completed.

The results in this paper can help in designing a policy by which the Federal Reserve privatizes the excess assets that they have acquired over the crisis. As pointed out by Cochrane (2009), the flight to safe liquid assets throughout the crisis has increased the present value of all future expected surpluses of the U. S. government since they are now being discounted at a lower effective rate of return. This has allowed the Federal Reserve to acquire $1,142 billion of

[25] Table 6 is for the time period 2006 Q1 to 2008 Q4. Including 2009 Q1 and Q2 does not significantly change the results.

additional assets that were held by the shadow banking system.[26] As the crisis abates, the liquidity premium will disappear so that the U.S. government will have to privatize these assets to avoid a further increase in the U. S. debt/GDP ratio.

In privatizing these assets the Federal Reserve will want to avoid a replay of the financial crisis so that the assets must be sold to private intermediaries subject to prudential regulations. This means that $114.2 billion in total capital—10 percent of the required balance sheet expansion—must be added to the banking system for these institutions to be well qualified under current regulations of commercial banks. The results here imply that the banks must be given a clear signal that they will be able to acquire these assets at a competitive risk adjusted rate of return.[27] Given such clear signals, the banks would find it optimal to raise sufficient capital to fund these assets without taking on excessive risk. In addition, the higher loan rate required to fund these loans will help to alleviate excessive risk taken by borrowers.

[26] While this amount is $152 billion below the peak in December 2008, the $793 billion decline in TALF, CP and Foreign Swaps has been replaced by $507 billion in private and agency mortgage backed securities.

[27] See Koch and MacDonald (2007, Chapter 13) for a discussion concerning the pricing of loans by banks.

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Table 1. Selected Banking Indicators by Groups of Banks (percentages)

	All Commercial Banks				Banks with over $10 billion in Total Assets			
	Capital loss period				Capital loss period			
	2006 Q4	2007 Q4	2008 Q4	2009 Q2	2006 Q4	2007 Q4	2008 Q4	2009 Q2
Equity-asset ratio	10.2	10.2	9.4	10.7	10.0	10.0	9.1	10.8
Total Capital Ratio	9.5	9.4	9.3	10.2	9.3	9.1	9.1	10.2
Tier 1 ratio	7.5	7.3	7.1	8.1	7.0	6.7	6.6	7.8
Liquid assets to total assets	15.1	12.8	17.3	17.3	14.2	11.7	17.2	17.1
Decomposition of bank profitability								
Return on average equity	13.0	9.1	1.4	0.7	13.4	9.1	1.6	1.3
Equity multiplier[1]	9.79	9.78	10.66	9.35	9.96	10.00	10.98	9.26
Net interest margin (*NIM /A*)	3.0	2.9	2.7	2.9	2.7	2.7	2.6	2.9
Noninterest expenses (*NIE /A*)	3.0	3.0	2.8	2.9	3.0	3.0	2.7	2.9
Noninterest income plus securities gains, net of taxes (*NII + SG - TAX*)/A[2]	1.7	1.6	1.5	2.1	1.9	1.8	1.7	2.2
Loan loss provisions (*PLL*)	0.3	0.6	1.3	2.0	0.3	0.6	1.4	2.1
Off balance sheet items to total assets	65.5	65.0	52.5	48.1	72.5	70.4	56.2	52.1

Source: http://www2.fdic.gov/sdi/sob/.

This table shows selected banking indicators during between 2006 and mid-2009, where the subperiod up to end-2008 concentrates the capital losses in the banking system.

[1] Defined as the inverse of the equity-asset ratio.

[2] Calculated as a residual from the definition of return on equity:

$$ROE = \frac{A}{E}\left[\frac{NIM}{A} - \frac{NIE}{A} + \frac{NII}{A} + \frac{SG}{A} - \frac{TAX}{A} - \frac{PLL}{A}\right]$$

Table 2. Selected Banking Indicators by Size of Bank Holding Company

	Ten Largest Banks				11th to 100th Largest Banks			
	Capital loss period				Capital loss period			
	2006 Q4	2007 Q4	2008 Q4	2009 Q2	2006 Q4	2007 Q4	2008 Q4	2009 Q2
Equity-asset ratio								
Mean	6.2	6.2	5.9	7.7	9.5	9.6	8.8	9.9
Median	6.7	6.6	6.2	7.6	9.3	9.4	8.7	9.9
Standard deviation	2.3	2.1	1.8	2.1	3.0	3.2	3.0	3.1
Number of observations	5	7	9	9	79	95	99	78
Total Capital Ratio								
Mean	11.0	11.0	13.0	13.6	12.9	12.3	13.4	13.4
Median	11.1	10.7	12.6	13.6	12.2	11.7	13.2	13.4
Standard deviation	1.0	1.0	1.9	2.6	3.4	3.4	3.2	3.7
Number of observations	3	5	6	6	76	93	93	78
Tier 1 ratio								
Mean	8.7	7.9	9.9	10.3	11.1	10.1	11.1	11.3
Median	8.6	7.6	10.0	9.8	10.2	9.5	10.7	11.2
Standard deviation	0.7	1.1	2.0	1.6	3.7	3.7	3.5	3.9
Number of observations	3	5	6	6	76	93	93	78
Liquid assets to total assets								
Mean	39.4	31.5	30.3	19.1	4.7	3.2	3.5	7.0
Median	34.6	24.2	18.2	13.8	0.0	0.2	0.3	3.8
Standard deviation	33.4	29.3	31.2	14.1	18.4	11.4	12.9	10.8
Number of observations	5	7	9	9	72	86	88	78
Return on average equity								
Mean	22.9	-2.5	-20.1	-5.5	10.9	3.6	-14.3	-9.2
Median	24.2	9.8	-21.0	4.5	11.4	7.0	0.2	1.2
Standard deviation	18.3	25.4	22.5	29.9	7.3	21.4	54.9	35.5
Number of observations	5	7	9	9	79	95	99	78
Decomposition of bank profitability (mean of return on average equity)								
Equity multiplier[1]	16.01	16.00	17.08	12.99	10.47	10.45	11.32	10.10
Net interest margin (*NIM/A*)	2.5	2.5	2.3	1.9	3.5	4.0	4.5	3.1
Interest expense to total assets	0.8	0.8	0.4	0.3	0.8	0.8	0.5	0.4
Noninterest expenses (*NIE/A*)	1.1	1.0	1.3	1.3	0.7	0.9	1.3	1.3
Noninterest income plus securities gains, net of taxes (*NII + SG - TAX*)/A[2]	0.1	-1.4	-1.7	-0.6	-1.7	-2.6	-3.9	-2.2
Loan loss provisions (*PLL*)	0.2	0.2	0.5	0.4	0.0	0.2	0.5	0.5
Offbalance sheet items to total assets								
Mean	0.7	0.0	0.4	…	1.5	1.3	1.2	…
Median	0.0	0.0	0.0	…	1.0	0.7	0.7	…
Standard deviation	1.3	0.0	1.1	…	1.8	1.8	1.6	…
Number of observations	3	5	7	…	78	94	98	…

Source: Bankscope

This table shows selected banking indicators during between 2006 and mid-2009, where the subperiod up to end-2008 concentrates the capital losses in the banking system.

[1] Defined as the inverse of the equity-asset ratio.

[2] Calculated as a residual from the definition of return on equity:

$$ROE = \frac{A}{E}\left[\frac{NIM}{A} - \frac{NIE}{A} + \frac{NII}{A} + \frac{SG}{A} - \frac{TAX}{A} - \frac{PLL}{A}\right]$$

Table 3. Selected Banking Indicators for Bank Holding Companies that Received TARP Funding in 2008Q4

	As of 2009 Q2, Banks that had: repaid TARP	not repaid TARP		As of 2009 Q2, Banks that had: repaid TARP	not repaid TARP
	Equity to total assets ratio			Total Capital Ratio	
Mean	8.3	8.6	Mean	16.7	14.3
t test mean A=mean B	0.7114		t test mean A=mean B	0.0113	
Median	7.6	8.7	Median	16.6	14.3
Std. Dev.	2.5	2.0	Std. Dev.	2.5	1.5
MIN	6.0	3.7	MIN	14.3	11.8
MAX	14.2	14.9	MAX	21.6	20.2
No. of obs.	10	41	No. of obs.	7	38
	Tier 1 ratio			Offbalance sheet items to total assets	
Mean	13.4	11.6	Mean	1.1	0.9
t test mean A=mean B	0.1330		t test mean A=mean B	0.7396	
Median	13.1	11.6	Median	0.0	0.3
Std. Dev.	3.3	1.7	Std. Dev.	2.1	1.3
MIN	10.6	7.8	MIN	0.0	0.0
MAX	20.3	15.3	MAX	5.0	5.6
No. of obs.	7	36	No. of obs.	8	38
	Liquid assets to total assets			Loan loss provisions to total assets	
Mean	27.1	1.8	Mean	0.4	0.5
t test mean A=mean B	0.0683		t test mean A=mean B	0.3275	
Median	4.2	0.3	Median	0.3	0.5
Std. Dev.	38.7	3.3	Std. Dev.	0.5	0.4
MIN	0.6	0.0	MIN	0.0	0.1
MAX	94.5	13.5	MAX	1.3	2.0
No. of obs.	7	35	No. of obs.	9	41
	Return on average equity			Net interest margin	
Mean	0.2	-20.3	Mean	2.6	3.2
t test mean A=mean B	0.0635		t test mean A=mean B	0.2098	
Median	3.8	-10.0	Median	2.6	3.1
Std. Dev.	15.8	61.2	Std. Dev.	1.6	0.5
MIN	-23.2	-150.4	MIN	0.4	2.1
MAX	28.2	251.2	MAX	5.6	4.5
No. of obs.	10	41	No. of obs.	10	41
	Interest expense to total assets			Noninterest expense to total assets	
Mean	0.5	0.5	Mean	1.5	1.5
t test mean A=mean B	0.6894		t test mean A=mean B	0.9743	
Median	0.4	0.5	Median	1.1	1.2
Std. Dev.	0.2	0.2	Std. Dev.	1.3	0.8
MIN	0.2	0.2	MIN	0.2	0.5
MAX	0.9	1.5	MAX	4.9	3.6
No. of obs.	10	41	No. of obs.	10	41

Source: Bankscope.

This table contains summary statistics of selected banking indicators for bank holding companies that had received TARP funding as of 2008 Q4. All figures presented refer to 2008 Q4, and banks are grouped according to whether or not they had repaid their TARP funds by 2009 Q2.

Table 4. Determinants of the Growth Rate of Bank Loans and Deposits

	Growth rate of loans		Change in Deposits and Short-Term Funding		Growth rate of loans		Change in Deposits and Short-Term Funding		Growth rate of loans		Change in Deposits and Short-Term Funding	
	Capital loss period	Full sample period	Capital loss period	Full sample period	Capital loss period	Full sample period	Capital loss period	Full sample period	Capital loss period	Full sample period	Capital loss period	Full sample period
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Initial total capital ratio	0.44 **	0.48 ***	0.38 **	0.16								
	(0.20)	(0.17)	(0.18)	(0.19)								
Change in total capital ratio (lagged)	2.36 **	1.48	1.90 *	1.13								
	(1.08)	(1.10)	(1.00)	(0.97)								
Change in total capital ratio (lagged) *initial total capital ratio	-0.07 *	-0.04	-0.07 **	-0.05								
	(0.04)	(0.04)	(0.03)	(0.03)								
Initial tier1 ratio					0.36 *	0.39 **	0.28	0.01				
					(0.20)	(0.18)	(0.18)	(0.19)				
Change in tier 1 ratio (lagged)					3.83 ***	3.24 ***	2.73 ***	2.26 **				
					(1.17)	(1.15)	(0.96)	(0.95)				
Change in tier1 ratio (lagged) *initial tier1 ratio					-0.12 ***	-0.11 ***	-0.10 ***	-0.09 ***				
					(0.04)	(0.04)	(0.03)	(0.03)				
Initial equity to asset ratio									0.61 **	0.56 **	0.36	0.50 **
									(0.29)	(0.26)	(0.26)	(0.23)
Change in the equity to asset ratio (lagged)									5.18 **	4.50 **	7.16 ***	5.62 ***
									(2.24)	(1.88)	(1.96)	(1.63)
Change in equity to asset ratio (lagged) *initial equity to asset ratio									-0.47 ***	-0.46 ***	-0.48 ***	-0.40 ***
									(0.17)	(0.16)	(0.11)	(0.10)
Logarithm of assets	-5.69 ***	-4.50 ***	-5.28 ***	-4.16 ***	-5.83 ***	-4.46 ***	-5.37 ***	-4.20 ***	-5.09 ***	-4.14 ***	-4.68 ***	-3.57 ***
	(1.43)	(1.60)	(1.25)	(1.20)	(1.48)	(1.61)	(1.31)	(1.23)	(1.38)	(1.58)	(1.21)	(1.17)
Noninterest income to total assets (initial)	8.52 **	8.44 ***	5.51	4.75 *	7.54 **	7.64 ***	4.84	4.38 *	6.24	7.68 ***	2.84	2.45
	(3.80)	(2.62)	(3.91)	(2.48)	(3.65)	(2.60)	(3.82)	(2.47)	(3.90)	(2.84)	(3.87)	(2.59)
Offbalance sheet items to total assets (initial)	0.22	-0.44	-0.08	-0.27	0.15	-0.50 *	-0.13	-0.31	0.20	-0.52 *	-0.15	-0.33
	(0.26)	(0.27)	(0.30)	(0.25)	(0.26)	(0.28)	(0.30)	(0.25)	(0.27)	(0.27)	(0.31)	(0.26)
Liquid assets ratio (initial)	0.28	0.08	0.14	0.03	0.27	0.07	0.14	0.04	0.26	0.10	0.12	0.05
	(0.20)	(0.18)	(0.10)	(0.09)	(0.19)	(0.44)	(0.10)	(0.09)	(0.20)	(0.17)	(0.10)	(0.09)
Tarp money/total assets[1]	-0.69	1.78	-0.56	1.05	-0.53	1.96	-0.48	1.15	-1.74	1.34	-1.26	0.97
	(1.40)	(2.60)	(1.29)	(1.69)	(1.42)	(2.61)	(1.30)	(1.69)	(1.53)	(2.53)	(1.38)	(1.64)
dummy=1 for banks whose assets>$460 billion	47.09 ***	48.95 ***	40.62 ***	40.57 ***	49.48 ***	50.53 ***	42.87 ***	41.86 ***	41.62 ***	46.83 ***	36.89 ***	32.59 ***
	(10.85)	(12.63)	(9.55)	(9.95)	(11.08)	(12.68)	(9.86)	(10.16)	(10.11)	(12.75)	(8.91)	(9.73)
dummy=1 for banks whose assets>$17 billion and <$460 billion	36.22 ***	32.90	34.65 ***	31.00 ***	38.15 ***	34.69 ***	36.59 ***	32.31 ***	29.72 ***	29.99 ***	29.75 ***	22.19 ***
	(8.68)	(7.23) ***	(7.91)	(6.32)	(8.56)	(7.18)	(7.90)	(6.40)	(8.26)	(6.97)	(7.79)	(6.09)
dummy=1 for banks whose assets<$17 billion	28.36 ***	25.59 ***	23.16 ***	22.47 ***	29.83 ***	27.26 ***	24.77 ***	23.73 ***	23.93 ***	24.40 ***	20.03 ***	15.38 ***
	(6.99)	(5.41)	(6.59)	(4.90)	(6.88)	(5.09)	(6.56)	(4.97)	(6.52)	(4.98)	(6.25)	(4.46)
R-squared	0.422	0.3146	0.3205	0.2524	0.4359	0.3236	0.3284	0.2594	0.4183	0.3185	0.3336	0.27
Number of observations	432	587	432	587	432	587	432	587	436	591	436	591

This table shows the results of OLS regressions for the growth rate loans and deposits and short-term funding, both expressed as a percentage of initial total assets. Explanatory variables include the change in the capital ratio and its interaction with the initial capital ratio; the logarithm of total assets, and initial ratios of non-interest income, off-balance sheet items, and liquid assets to total assets. In addition, three dummy variables are included to capture differences across groups of banks according to size, and period dummies are included to incorporate common shocks to all banks. Three alternative measures of the capital ratio are used: equity to assets, the total capital ratio, and the tier 1 ratio. Two alternative sample periods are used: the capital loss period, from 2006Q4 to 2008Q$, and the full sample period, from 2006Q4 to 2009Q2. Robust standard errors are shown in parentheses, and significance levels of 1(***), 5 (**), and 10 (*) percent are indicated.

Table 5. Regressions for the Choice of Bank Capital

Dependent variable:	Total capital ratio			Tier 1 capital ratio			Equity-asset ratio		
	Capital loss period		Full sample period	Capital loss period		Full sample period	Capital loss period		Full sample period
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Explanatory variables:									
Change in capital ratio (lagged)[1]	-0.194 *	-0.739 ***	-0.089	-0.149 *	-0.673 ***	-0.063	-0.637 ***	-0.558 *	-0.547 **
	(0.101)	(0.221)	(0.124)	(0.090)	(0.199)	(0.110)	(0.238)	(0.289)	(0.240)
Change in capital ratio (lagged)· Initial capital[1]	0.008 *	0.044 ***	0.006	0.007	0.046 ***	0.005	0.056 ***	0.059 **	0.056 **
	(0.005)	(0.014)	(0.006)	(0.004)	(0.013)	(0.006)	(0.022)	(0.024)	(0.024)
Quarterly stock return		0.519 *			0.738 **			0.196	
		(0.270)			(0.310)			(0.250)	
Interest expense ratio	-8.621 **	-9.171 ***	-8.675 ***	-7.698 ***	-9.426 ***	-8.630 ***	-8.889 ***	-13.470 ***	-8.886 ***
	(0.744)	(1.608)	(0.848)	(0.686)	(1.481)	(0.808)	(0.833)	(0.808)	(0.753)
Interest expense ratio · Initial capital[1]	0.696 **	0.856 ***	0.671 ***	0.711 ***	0.959 ***	0.747 ***	0.807 ***	1.224 ***	0.834 ***
	(0.055)	(0.125)	(0.063)	(0.051)	(0.121)	(0.061)	(0.084)	(0.072)	(0.074)
Noninterest expense ratio	-2.226 *	0.130	-3.784 ***	-1.728 **	0.193	-2.088 ***	-3.516 ***	-2.506 ***	-3.170 ***
	(1.201)	(1.124)	(1.306)	(0.865)	(1.179)	(0.815)	(0.571)	(0.456)	(0.484)
Noninterest expense ratio · Initial capital[1]	0.196 *	-0.006	0.326 ***	0.182 **	-0.011	0.208 ***	0.297 ***	0.187 ***	0.274 ***
	(0.104)	(0.093)	(0.112)	(0.092)	(0.118)	(0.084)	(0.056)	(0.045)	(0.048)
Nonperforming loan ratio	0.001	0.004	-0.003	-0.002	-0.001	-0.004	-0.002	0.011 ***	-0.001
	(0.008)	(0.012)	(0.008)	(0.008)	(0.008)	(0.003)	(0.001)	(0.003)	(0.001)
Nonperforming loan ratio · Initial capital[1]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001 ***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
Logarithm of assets	-0.034	0.534 ***	-0.029	-0.250 **	0.140	-0.193	-0.262 **	-0.034	-0.185
	(0.123)	(0.160)	(0.146)	(0.123)	(0.145)	(0.135)	(0.126)	(0.096)	(0.122)
Dummy=1 for banks whose assets>$460 billion	0.012		0.294	0.605		0.506	0.450		0.407
	(0.652)		(0.789)	(0.602)		(0.698)	(0.636)		(0.646)
Dummy=1 for banks whose assets>$17 billion and <$460 b	-0.005	2.154 ***	-0.016	-0.040	0.678	-0.030	0.321	-1.218 **	0.328
	(0.308)	(0.617)	(0.345)	(0.398)	(0.518)	(0.329)	(0.268)	(0.514)	(0.282)
Dummy=1 for banks whose assets<$17 billion		2.878 ***			1.312 *			-0.454 **	
		(0.913)			(0.774)			(0.209)	
Dummy for 2007Q3	-1.306 ***	-2.087 ***	-1.424 ***	-1.256 ***	-1.938 ***	-1.102 ***	0.935 ***	0.745 **	1.031 ***
	(0.335)	(0.391)	(0.370)	(0.345)	(0.424)	(0.385)	(0.378)	(0.311)	(0.334)
Dummy for 2007Q4	-1.309 ***	-2.023 ***	-1.382 ***	-1.343 ***	-1.862 **	-1.212 ***	0.796 **	0.696 **	0.849 ***
	(0.315)	(0.349)	(0.344)	(0.319)	(0.383)	(0.358)	(0.325)	(0.300)	(0.286)
Dummy for 2008Q1	-1.179 ***	-1.902 ***	-1.252 ***	-1.206 ***	-1.823 **	-1.135 ***	0.502 *	0.391	0.543 **
	(0.273)	(0.315)	(0.291)	(0.275)	(0.338)	(0.296)	(0.285)	(0.248)	(0.261)
Dummy for 2008Q2	-0.984 ***	-1.341 ***	-1.088 ***	-1.066 ***	-1.323 **	-1.060 ***	0.422 ***	0.317	0.451 **
	(0.270)	(0.292)	(0.280)	(0.270)	(0.310)	(0.281)	(0.238)	(0.227)	(0.229)
Dummy for 2008Q3	-0.931 ***	-1.605 ***	-0.960 ***	-0.938 ***	-1.692 **	-0.924 ***	0.295	0.248	0.313
	(0.266)	(0.335)	(0.272)	(0.275)	(0.353)	(0.279)	(0.234)	(0.304)	(0.232)
Dummy for 2008Q4			0.446			0.465			0.990 ***
			(0.348)			(0.362)			(0.267)
Dummy for 2009Q1			0.236			0.425			1.225 ***
			(0.395)			(0.400)			(0.257)
Constant	13.073 ***	8.937 ***	13.423 ***	12.029 ***	9.989 **	12.189 ***	10.878 ***	11.190 **	10.189 ***
	(0.408)	(1.250)	(0.462)	(0.386)	(1.094)	(0.436)	(0.536)	(0.466)	(0.497)
	0.728	0.585	0.630	0.784	0.671	0.683	0.831	0.871	0.785
Number of observations	454	292	613	454	292	613	461	295	620

This table shows the results of OLS regressions for three alternative measures of the capital ratio: equity to assets, the total capital ratio, and the tier 1 ratio. In each case, the corresponding lagged capital ratio is included as a regressor. Other explanatory variables include the change in the capital ratio, the noninterest expense to asset ratio; the nonperforming loan ratio; as well as the interactions of these three variables with the initial capital ratio; the quarterly bank-specific stock return; and the logarithm of total assets. Dummy variables distinguishing banks according to three size categories are included, as well as period dummy variables. Robust standard errors are shown in parentheses, and significance levels of 10 percent (*), 5 percent (**), and 1 percent (***) are indicated.

[1] The change in the capital ratio (lagged) is defined as the difference between its value four quarters back and its value eight quarters back, whereas initial capital is defined as the capital ratio four quarters back.

Table 6. Test of Monopoly Power

Time period: 2006 Q1 - 2008 Q4	Dependent variable: Interest income ratio
Explanatory variables:	
Interest expense ratio	0.51 ***
	(0.07)
Interest expense ratio · Capital Constraint Dummy	0.07
	(0.119)
Noninterest expense ratio	0.09 ***
	(0.029)
Noninterest expense ratio · Capital Constraint Dummy	-0.09
	(0.082)
Ratio of nonperforming loans to assets	0.00
	(0.000)
Nonperforming loan ratio · Capital Constraint Dummy	0.00
	(0.001)
Capital Constraint Dummy	-0.07
	(0.176)
Logarithm of assets	-0.01
	(0.014)
Dummy=1 for banks whose assets>$17 billion and <$460 billion	-0.02
	(0.062)
Dummy=1 for banks whose assets<$17 billion	0.06
	(0.080)
Dummy for 2007Q3	0.23 ***
	(0.029)
Dummy for 2007Q4	0.18 ***
	(0.029)
Dummy for 2008Q1	0.12 ***
	(0.025)
Dummy for 2008Q2	0.08 ***
	(0.023)
Dummy for 2008Q3	0.07 ***
	(0.026)
Constant	0.84 ***
	(0.138)
R-squared	0.5746
Tests on the coefficients:	*F-statistic (p-value)*
H_0: Sum of the coefficients on input prices = 0	
Capital constraint not binding	45.87 (0.000)
Capital constraint binding	12.26 (0.000)
H_0: Sum of the coefficients on input prices = 1	
Capital constraint not binding	20.89 (0.000)
Capital constraint binding	6.56 (0.010)

This table shows the results of OLS regressions for the interest income ratio to total assets. Other explanatory variables include the intererest and noninterest expense ratios, as well as their interactions with a capital constraint dummy which takes the value of 1 if the total capital ratio is below 10 percent, and zero otherwise. The logarithm of total assets, dummy variables distinguishing banks according to three size categories are included, and time dummy variables are included as regressors. Robust standard errors are shown in parentheses, and significance levels of 10 (*), 5 (**), and 1 (***) percent are indicated.