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Nonlinearity of bank capital and charter values

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Abstract

In this paper, we contribute to the literature by exploring nonlinearity between capital buffers and charter values. Adopting linear, quadratic, and semi-parametric spline estimation techniques, we wish to determine the functional form of these relationships. Our findings indicate that between 1986 and 2008 the relationship between bank capital and charter values is non-linear and concave. In particular, we show that charter values *do* encourage prudent capital management policies. However, once charter values rise above a certain threshold, banks maintain a constant capital buffer. This is in line with the too-big-to-fail paradigm but contrasts theoretical predictions that larger charter values necessarily induce banks to hold larger capital buffers.

JEL Codes: G21, G28, G32
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1 Introduction

Traditionally, banking literature has centered on the notion that banks commit moral hazard. Due to various government deposit insurance schemes as well as other safety net protections, banks view themselves

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as partly insulated from risk and therefore do not fully account for the negative consequences of their actions (see Kane, 1989; Barth, 1991; and Gorton and Rosen, 1995). Merton (1977) shows that the existence of deposit insurance derives the put option of the bank[1]. Since the deposit insurance premium depends on the perceived riskiness of the insured institution, the value of the put option can increase with risk, particularly when the premium does not correctly capture bank risk. In moral hazard models, bank shareholders have incentives to transfer wealth from the insuring agency (to maximize the value of the put option) by adopting riskier strategies and reducing invested capital relative to assets (see Keeley, 1990). As a means to offset these risk increasing incentives, bank regulators directly target capital structures by setting minimum requirements for bank capital.

Following the Myers and Majluf (1984) pecking order hypothesis, the higher cost of capital (relative to deposits or debt) would dictate a capital minimization policy on the part of banks. This however contrasts observed bank behavior. Banks typically hold a significant amount of capital in excess of the required minimum (a buffer of capital) as an insurance against risks that need to be managed, indicating that capital standards are rarely binding.[2]

These stylized facts have motivated the literature to search for incentives that act to mitigate the moral hazard behavior of banks. Theoretical analysis of bank capital decisions has highlighted a central role for the charter value, also referred to as the franchise value (see Rojas-Suarez and Weisbrod, 1995; Demsetz, Saidenberg and Strahan, 1996). The charter value, is the value that would be foregone if the bank closes, hence, capturing the banks' private cost of failure. Traditional charter value models have formally shown how a valuable charter can help reduce excessive risk taking, since banks with a valuable charter have much to lose if a risky business strategy leads to insolvency (see among others Marcus, 1984; Keeley, 1990; and Ancharya, 1996). The incentive to preserve the charter value should therefore outweigh the desire of shareholders to maximize the put option value when risk is low, while the opposite is true at higher probabilities of default. A large body of empirical literature has found evidence in favor of the charter value hypothesis (CVH), that high charter value banks are less risky (see Keeley 1990; Demsetz et al. 1996; Galloway et al. 1997; Saunders and Wilson, 2001).

In contrast to the traditional charter value models focussing on the

[1]The right to sell the banks' assets at the face value of its liabilities.

[2]See for example Allen and Rai (1996), Peura and Jokivuolle (2004) Barth et al. (2005) and Berger et al. (2008).

amount of capital held against market risk, the more recent capital buffer theory introduces a dynamic aspect whereby a bank is faced with implicit and explicit costs of maintaining an internally defined target level of capital above the required minimum (see among others Milne and Whalley, 2001; Peura and Keppo, 2006; VanHoose, 2007). The target level of capital can be thought of as being a banks' long-run desired probability of default and is therefore a function of both risk and capital. In this framework, two opposing forces can determine the relationship between bank charter values and the size of the target capital buffer: (i) a charter value effect resulting in a *negative* relationship, and (ii) a moral hazard effect resulting in a *positive* relationship. The charter value effect dominates when the expected loss from charter value outweighs the benefits from deposit insurance schemes. As the charter value starts to fall, banks are encouraged to hold larger capital buffers so as to protect the valuable charter. On the other hand, the "moral hazard effect" dominates when the charter value falls below a certain threshold. In this case, the bank is no longer concerned with future earnings and has little incentive to maintain a capital buffer. The long-run relationship between capitalization and charter values are therefore predicted to be highly non-linear, and dependent on the size of the charter.

Several papers have tried to shed some light on the relationship between bank capital and charter values (see Keeley, 1990; Allen and Rai, 1996). These studies have however, assumed the relationship to be linear. In this paper, we contribute to the literature by exploring non-linearity between capital buffers and charter values. Adopting both quadratic, and semi-parametric spline estimation techniques, we wish to determine the functional form of these relationships, and in particular, identify the size of the charter which constitutes a reversal in the dominating effect. Our findings indicate that between 1986 and 2008 the relationship between bank capital and charter values is non-linear and concave. Moreover, for banks with charter values above the median threshold, the capital buffer is held relatively constant. This finding is in contrast to predictions that banks with higher charters necessarily hold larger capital buffers.

The remainder of the paper is organized as follows: Section 2 outlines the theoretical predictions of the relationships studied. Section 3 describes the data and defines the key variables. Section 4 presents our empirical methodology and results. Section 5 briefly discusses our findings and concludes.

2 Theoretical Predictions

Marcus (1984) shows that incorporating intertemporal considerations into pure static moral hazard models has potential moderating effects on the behavior of banks. Moral hazard models based on static assumptions neglect the notion that banks can generate rents. Such rents can arise from monitoring costs or imperfect competition. In a dynamic framework, the present value of future rents constitute the banks charter value.

In charter value models[3], today's value of a banks equity, C, is given by:

$$V_0(C) = [AN(d_1) - e^{-rT}DN(d_2)] + e^{-rT}CVN(d_2) \tag{1}$$

where $d_1 = \frac{[log(A_0/D)]+(r\sigma^2/2)/T}{\sigma\sqrt{(T)}}$, $d_2 = d_1 - \sqrt{(T)}$, and $N(\cdot)$ is the cumulative standard normal distribution, CV denotes charter value and T is the maturity date.

Additions to capital now increase shareholder wealth at the following rate:

$$\frac{\partial V_0(C)}{\partial A} - 1 = \frac{N(d_1) + e^{-rT}CVn(d_2)}{(A\sigma\sqrt{(T)})} - 1 \tag{2}$$

In contrast to a pure moral hazard model, the sign of the expression is undetermined. An increase in equity reduces the probability of default and the associated loss of charter value, while it also reduces the value of deposit insurance. For a high enough CV, the first effect dominates. Hence a larger CV gives the bank an incentive to hold capital.

Moral hazard models introducing a charter value as a mitigating effect have largely been restricted to the part of capital which is held against market risk, failing to recognize the endogenous nature of bank capital decisions. Milne and Whalley (2001) develop a continuous-time dynamic option pricing model introducing endogenous capital into a model with charter value. The concept of endogenous capital is based on a trade-off banks face when violating the capital requirement. This trade-off is between incurring costs related to recapitalization, or, the loss of charter value consequent of failure.

In the model, regulation occurs at random intervals as per Merton (1978). Auditors are interested in the level of capital, c, compared to the required minimum, $\hat{c}$. If $\hat{c} > c$, then the bank must decide whether to recapitalize at the cost of $x + \Delta c$ (where x denotes the fixed cost of

[3] Assuming the following diffusion process: $dA = RAdt + \sigma Adz$ with R as the instantaneous expected growth rate of assets, A, and σ, the instantaneous standard deviation of the rate of return. dz is a Wiener process.

recapitalization) or to liquidate. In the case of liquidation, debt holders are repaid in full from deposit insurance, and shareholders receive nothing.

As long as capital is in excess of the requirement, banks act to maximize shareholder wealth. If however, the capital buffer is depleted and the supervisor notices, then a bank can either recapitalize or fail. Recapitalization is optimal if the gain in shareholder value outweighs cost of recapitalization. Non-linearity between bank capital and charter values in the model therefore represents a trade-off between two varying effects. The first, a charter value effect whereby charter value is high. In this case the bank will always wish to hold a buffer of capital to reduce the expected cost of violating capital requirements. Earnings are either retained in full, or if the long-run target level of capital, $\hat{c}$, is reached, then all earnings are paid out as dividends. When no costs are associated with regulatory violation, the charter value becomes the value of the bank. Shareholders of well capitalized banks, those with capital at the long run optimum $\hat{c}$, are fully insured against costs associated with regulatory violation. Once the charter value falls below a certain threshold, banks have little incentive to hold adequate capital.[4]

If on the other hand, the charter value is too low, a moral hazard effect dominates. The bank is no longer concerned with future earnings and the model reverts back to a simple pure static moral hazard case. Gambling for resurrection, if successful results in excess returns, on the other hand, if unsuccessful, a bail out by deposit insurance is guaranteed. The existence of state guarantees create additional incentives for capital transfer to shareholders[5]. The threshold between the dominance of these effects is dependent on either a greater ability to increase the uncertainty of cash flows which increases the potential gains of exploiting moral hazard[6], or a higher frequency of audit which lowers potential gains.

3 Data

To test the predicted long-run relationship between bank capital and charter values, we construct an unbalanced panel of quarterly US bank holding company (BHC)[7] and commercial bank balance sheet data be-

[4]very low expected earnings offering little/no protection.

[5]Milking the property whereby extra dividends are paid during times of financial stress. This mechanism gives shareholders funds that should otherwise go to bondholders or towards bankruptcy costs.

[6]Since the put option value is always increased by a widening of the distribution of returns.

[7]A bank holding company, under the laws of the United States, is any entity that directly or indirectly owns, controls, or has the power to vote 25% or more of a class of securities of a U.S. bank. Holding companies do not however, administer, oversee,

tween 1986Q2 and 2008Q2. All bank-level data is obtained from the Consolidated Report of Condition and Income (referred to as the Call Reports) published by the Federal Reserve Bank of Chicago.[8] In addition, we obtain information for the Fed Funds Y-9 form, filed by BHCs. By identifying the high-holder to which the individual commercial banks belong, we are able to merge the two datasets.[9] Moreover, since our analysis concerns market value data, only publicly traded BHCs are kept in the sample. All market data is obtained from the Center for Research on Securities Prices (CRSP). The final panel contains bank balance sheet and income data for over 600 BHCs. See Appendix I for more information on the construction of the data set.

3.1 Principal Variables of Interest

Bank Capital Buffers: Buffer capital, buf_{it}, is defined as the amount of capital bank i holds in excess of that required by regulation at time t. In the US, bank capital is currently regulated via the Basel I Accord, requiring banks to hold a tier one capital ratio of at least four percent, a total capital ratio (tier one[10] + tier two[11]) of at least eight percent and a leverage ratio (tier one capital over total assets) of at least four percent.

Two components together constitute the capital ratio. The numerator, measures the absolute amount of capital held which is inversely related to the probability of failure. The denominator captures the riskiness of the bank. Together, the ratio provides an indication about the adequacy of capital in relation to some indicator of absolute risk.

Under both the total capital and tier one ratio requirements of Basel I, the calculated risk is captured via risk weighted assets. This measure includes off-balance sheet exposures and additionally adjusts for differentials in credit risk according to the type of instrument and counterparty. The denominator of the leverage ratio however, is the total assets of the bank, assuming that the capital needs of a bank are determined by the

or manage other establishments of the company or enterprize whose securities they hold. They are primarily engaged in holding the securities of (or other equity interests in) companies and enterprizes for the purpose of owning a controlling interest or influencing the management decisions.

[8]This data is publicly available at www.chicagofed.org.

[9]Once the initial dataset is obtained, we further clean the data by keeping only those bank holding companies for which we have three consecutive quarters of data.

[10]Tier one capital is the book value of its stock plus retained earnings. It is the core measure of a banks financial strength from a regulators point of view. It consists of the types of financial capital considered the most reliable and Liquidity and therefore acts as a measure of the capital adequacy of a bank.

[11]Tier two capital is supplementary capital consisting of undisclosed reserves, revaluation reserves, general provisions, hybrid instruments and subordinated term debt.

level of assets. The inaccuracy of the leverage ratio as a sole measure of capital adequacy is highlighted through the existence of risky off-balance sheet activities which are not captured by this measure.

There is however no reason to expect that the capital measures defined by regulators necessarily reflect the internally defined measure that banks target in the management of their operations. Economic capital is the amount of risk capital, assessed on a realistic basis, which a firm requires to cover the risks that it is running or collecting as a going concern, such as market risk, credit risk, and operational risk. It is the amount of money which is needed to secure survival in a worst case scenario. Typically, economic capital is calculated by determining the amount of capital that the firm needs to ensure that its realistic balance sheet stays solvent over a certain time period with a pre-specified probability. However, obtaining a proxy measure of economic capital that is accurate as well as comparable across institutions is extremely difficult. Therefore, in this paper, we assume that banks manage their capital in such as way as to reduce both likelihood of regulatory violation as well as the implicit and explicit costs associated. We therefore adopt the total capital ratio as the basis on which we calculate the buffer of capital. The measure of risk-weighted assets (rwa) in the denominator requires banks to charge more capital for riskier assets, discouraging them from holding risky assets. If the risk weights accurately measure the riskiness of assets, then the risk weighted capital ratio should successfully distinguish between risky and safe banks, and effectively predict bank failure. Data on rwa are not, however, available as far back as 1986. Therefore, in order to order to analyze capital management decisions dating back prior to the implementation of Basel I, we create a proxy series as per the methodology put forward by Beatty and Gron (2001). Our estimated rwa variable, defined as $erwa$ is calculated as $total\ loans + (0.2 * agency\ securities) + (0.5 * municipal\ securities) + (1 * corporate\ securities)$.

Moreover, we proxy missing values of tier one capital with the series for total equity. Comparing pre- and post- Basel periods we find that the correlations for both series are good. Between 1990 and 2006, the correlation between the $erwa$ to total assets series and the true risk weighted assets to total assets is around 83 percent. The correlation between the ratio of common equity to total assets and the tier one capital to total assets ratio is around 97 percent.

Prior to the introduction of Basel I in 1992, US regulators employed a simple leverage ratio to assess capital adequacy: primary capital[12] had to exceed 5.5 percent of assets, while the total amount of primary plus

[12]The sum of equity plus loan loss reserves.

secondary[13] capital had to exceed six percent of assets. According to the Federal Reserve Boards definition of zones for classifying banks with respect to supervisory action, we consider a ratio of total capital to risk weighted assets equal to seven percent to be the regulatory minimum. This requirement was effective until December 31, 1990, when banks were required to hold a minimum of 3.25 percent of their risk-weighted assets as tier one capital and a minimum of 7.25 percent of their risk-weighted assets in the form of total capital. From the end of 1992, the minimum tier one and total capital ratios were raised to four and eight percent respectively under Basel I. Capital requirements throughout the sample period are detailed in Table 1.

Charter value: The charter value of a bank is defined as the net present value of its future rents. Charter value can hence be thought of as being the market value of assets, minus the replacement cost of the bank (Keeley, 1990; Demsetz et. al., 1996 and Gropp and Vesala, 2001). As is common in the literature, we proxy the charter value of the bank by calculating Tobins q as follows:

$$q = \frac{bva + mve - bve}{bve} \tag{3}$$

Where bva, bve and mve depict the book value of assets, the book value of equity and the market value of equity respectively. The benefit of using Tobins q to capture charter value is that it is a market based measure meaning greater market power in both asset and deposit markets are reflected in a higher q value. Moreover, it allows for comparability among banks of varying sizes in our analysis.

Descriptive statistics of the main variables of interest are presented in Table 2. The sample is split by both capitalization, as well as by q, using an average value at the end of the sample. Banks can therefore either be above or below average. In addition to the sub-samples by capitalization and charter value, we further split the sample by asset size. BHCs in the top tenth percentile by maximum total assets are classified as *big*. Those in the tenth to fiftieth percentile are *medium*, and finally, BHCs in the bottom fiftieth percentile are considered *small*. Figures 1, and 2 plot the total capital ratios and q values of banks in each size sub-sample over the entire period respectively.

From Figures 1, and 2 we note substantial variations over time. In the late eighties, interest rates were rising, regulatory pressure was generally lax, and the banking industry was plagued with portfolio problems. Charter values at this time remain relatively low and consistent across the three size classes. Bank capital rose slightly. During the early 1990s,

[13]Primarily qualifying subordinated debentures.

corresponding with a period of economic recovery and falling interest rates, we note slow rising charters, particularly among the larger BHCs. It is quite possible that the too-big-to-fail provision in the FDICIA provided an implicit subsidy to large banking firms, contributing to their higher charters evident at this time. Moreover, capital started to build up, corresponding with a sharp rise in portfolio risks. These observations might be explained through the introduction of the risk based capital requirements in the US at this time.

Smaller BHCs held considerably larger capital buffers than their larger counterparts, an observation that remains evident throughout the sample period. This finding is consistently predicted by the literature (see among others, Saunders et al., 1992; Gorton and Rosen, 1995; Esty, 1997; Salas and Saurina, 2002). Most obviously, large geographically diversified banks will have a much smaller probability of experiencing a large decline in their capital ratios, and a significantly greater ease with which to raise equity capital at short notice. This diversification effect increases with size and can perhaps explain the desire of smaller institutions to retain earnings as a precaution against unknown future needs. This effect is reinforced by asymmetric information between lenders and borrowers and by government support for banks that are at risk (too big to fail). Banks help overcome information asymmetries by screening and monitoring borrowers, but these are costly activities and banks are likely to balance the cost of (and gain from) these activities against the cost of excess capital. In the presence of scale economies in screening and monitoring, one would expect large banks to substitute relatively less of these activities with excess capital. Despite taking less risks, the larger capital buffers of smaller banks may reflect their difficulty in raising equity capital at short notice, thereby retaining earnings as a precaution against unknowns future needs. In all cases however, we note a significant jump in capital buffers between 1992 and 1995.

The mid- to late 1990s were plagued with massive consolidation in the banking industry. Rising concentration and hence market power appears to have raised the charter values of all BHCs significantly. Perhaps also because of scale economies, large BHCs saw their charter values rising much faster than medium and small BHCs. The anticipation and the eventual passage of the Gramm-Leach-Bliley Financial Modernization Act (GLB)[14] apparently further widened large banks' charter values relative to their smaller counterparts. Large BHCs were in a much bet-

[14]The GBLA legalized the integration of commercial banking, securities brokerage and dealing and insurance activities, greatly expanding banking power and thus allowing banks to realize potential scope economies by engaging in a mix of financial services.

ter position to take advantage of the expansion of banking powers, and hence scope economies, than medium and small BHCs. The fact that very large BHCs continued to get even larger may have further substantiated their implicit too-big-to-fail subsidies. The capital buildup congruently continued its upward trend before stabilizing towards the late 1990s. Bank risks additionally continued to fall until this time, perhaps indicating a relationship between risk and capital borne from Basel I.

Towards the end of the sample period, there is some convergence in the average charters across the three size classes. Possible explanations for this variation include the over estimation of scope economies offered by GLB Act at the time of its implementation. Alternatively, technological advances in banking may have gradually filtering down to smaller institutions resulting in a removal of differences in this respect. Despite the slight convergence, the average charter values of large BHCs remained significantly above those of medium BHCs which was in turn remained higher than the average charters of small BHCs.

4 Estimation: Methodology and Results

Despite the benefits of adopting Tobins q to capture bank charter value, we acknowledge some of the drawbacks associated. For example, due to the inclusion of bva in its calculation, Tobins q measures only historical costs rather than the current costs of assets. Deviations from one may therefore arise due to differences in expected and actual asset returns. Moreover, endogeneity between q and bank capital may exist, since banks will try to maintain a target probability of default depending on risk and capital, which is primarily driven by the value of q. To account for these factors, our analysis consists of two parts. In the first-step, we regress our dependent variable q_{it} on a set of control variables that capture a banks' revenue mix, loan portfolio and deposit composition assumed to determine a banks' charter. We are then able to extract predicted values for q_{it} ($\hat{q}_{it}$) as inputs into our second-step equation, allowing us to address the aforementioned estimation issues. The first-step equation to be estimated can be formalized as follows:

$$q_{it} = \zeta_0 + \zeta_1 X_{0it} + \kappa_{0it} \tag{4}$$

where κ_{0it} is the error term consisting of a bank specific component (μ_{0i}) and white noise ($\varkappa_{0it}$). X_{0it} represents a vector of variables that determine the banks charter value including net interest margin (nim), capturing bank profitability; the ratio of loans to total assets ($loans$), measuring risk; the lagged debt to asset ratio ($debt_{t-1}$), to control for financial leverage; the ratio of bank deposits to total liabilities (td), to capture the cost of funds, *and* deposit growth rates (*gdep*), as a measure of bank growth possibilities. The definitions of control variables and their expected signs are detailed in Table 3.

In the second-step, we focus on the relationship between q_{it} and buffer. As explained above, we include the predicted values $\hat{q}_{it}$ from the first-stage as inputs into the second-step regression. The hypothesis to be tested is that the long-run relationship between the capital buffer and q_{it} is highly non-linear such that high charter value banks will hold higher capital buffers. While banks with capital approaching the requirement will have little incentive to hold much capital as protection. The second-step equation to be estimated can be presented as:

$$buf_{it} = f(\hat{q}_{it-1}) + \alpha_1 X_{1it} + \kappa_{1it} \tag{5}$$

The key variable in our non-linear regression model is the lagged explanatory variable measuring bank charter value $\hat{q}_{it-1}$. We assume that the non-linear relationship between $\hat{q}_{it-1}$ and the capital buffer is determine by the unknown function $f(\cdot)$.

In addition to capturing the relationship between $\hat{q}_{it-1}$ and capital, the model includes several other control variables that may influence the target capital buffer of bank i at time t. Variables included in the X_1 vector are *risk*, *size*, *roa* and *liquid*. Each is described in detail in Table 3. The error term, κ_{1it}, is assumed to consist of a bank specific component (μ_{1i}) and white noise ($\varkappa_{1it}$).

Equations (4.) and (5.) are estimated using pooled time-series cross-section observations, including a full set of time dummies to allow for the intercept to shift over time. These dummies capture unobserved bank-invariant time effects not included in the regression, but their coefficients are not reported here for brevity. In addition to estimating equations (4.) and (5.) as presented above, we re-run the equations including the lagged dependent variable in each case. Here, we adopt the one- and two-step Blundell-Bond system GMM estimators. However, since they produce quite similar estimates, we present only the (asymptotically) more efficient two-step estimates. However, the two-step estimates of the standard errors tend to be severely downward-biased (Arellano and Bond 1991; Blundell and Bond 1998). To compensate, we use the finite-sample correction to the two-step covariance matrix derived by Windmeijer (2005).

4.1 Methodology

Since the functional form $f(\cdot)$ is assumed to be unknown, we adopt three varying approaches to estimate the relationships between charter value and the capital buffer in equation (5.). The first, *Model I*, assumes $f(\cdot)$

to be a simple linear function. The second, *Model II*, models $f(\cdot)$ as a quadratic function. These two approaches provide a baseline against which we can compare the more efficient spline estimator. In our final approach, *Model III*, we adopt a semi-parametric methodology, whereby we estimate a standard regression that includes spline variables for each of the charter value splines. For equation (5.), the semi-parametric spline approach allows the relationship between the capital buffer and charter value to vary depending on the size of the charter.[15]

The idea is that any continuous function can be approximated arbitrarily well by a piecewise linear function that is a continuous function composed of straight lines. One linear segment represents the function for $\hat{q}_{it-1}$ below s_1. Another linear segment represents the function for values between s_1 and s_2, and so on. The linear segments are arranged so that they join at s_1, s_2,..., which are called knots. The knots, in our case placed the 25th percentile, the median and the 75th percentiles, are used as threshold values from which the spline variables are created.[16]

Under *Model III*, spline variables are substituted for $\hat{q}_{it-1}$ in equation (5). The benefit of estimating a GMM equation with spline variables rather than a non parametric equation to capture non-linearity, is that it allows the inclusion of all relevant variables already included in the previous estimations as control variables.

4.2 Results

The results from estimating equations (4.) and (5.) are presented in panels 1 and 2 of Table 4 respectively. Equation (4.) is presented in columns one and two. For equation 5, columns three and four correspond to *Model I*, while columns five and six correspond to *Model II*. These are the simple parametric versions of our model. Columns seven and eight relate to the semi-parametric case, *Model III*.

Equation (5.) For the linear case (*Model I*), the effect of charter value on the capital buffer is positive and highly significant as expected, such that banks with higher $\hat{q}_{it-1}$ values hold larger capital buffers. In addition, *risk* is positive and significant in line with previous findings in the literature (see Shrieves and Dahl, 1992; Jacques and Nigro, 1997; Rime, 2001).

[15]For a brief examination of the linear spline, see Greene (1993, pp. 235-238). A more detailed treatment is found in Seber and Wild (1989, pp. 481-489).

[16]See Poirier (1974) and Garber and Poirier (1974) for a detailed discussion.To create the spline variables, we start by constructing a set of dummy variables which are set equal to one if the $\hat{q}_{it}$ value falls in the desired range, and zero otherwise. The dummy variables are then multiplied by $\hat{q}_{it}$ to obtain the $\hat{q}_{it}spline$ variables for equation (5.)

The inadequacy of the linear model however, is highlighted by the improvement in the fit of the quadratic model. Since the variables $\hat{q}_{it-1}$ and its square $\hat{q}^2_{it-1}$ exhibit some evidence of collinearity, we center $\hat{q}_{it-1}$ at its mean. Hence, in *Model II* $\hat{q}_{it-1}$ is replaced by $\hat{q}CEN_{it-1}$. The coefficients on the quadratic estimates hint at a concave relationship between the two variables. In particular, we find a significant negative coefficient on the squared term ($\hat{q}^2_{it-1}$). For both the linear and the quadratic estimations, the coefficients attached to the variables of interest remain largely unchanged regardless of the estimation methodology imposed. The only difference is that the significance of the control variables; $size, roa$ and $liquid$ and is reduced under the GMM approach. The coefficients on the lagged dependent variables are positive as expected, and statistically significant in each case.

While the quadratic estimate provides a fairly good fit, one major limitation is that it imposes an arbitrary functional specification. For the estimations in column seven and eight, we therefore substitute our spline variables for $\hat{q}_{it-1}$ and additionally include all control variables as in the previous models. The coefficient on each spline variable corresponds to the slope of the piecewise linear function in the relevant interval.

Despite the clear improvement in the fit of the model, we additionally find that all spline variables are significant at the one percent level. The spline coefficients show a clear hump shaped relationship between charter value and buffer capital, in line with the concave form noted in the quadratic estimation. These results indicate that banks with charter values above the median level maintain a constant capital buffer. However, as the charter value decreases, banks build up their capital buffers since with lower expected earnings they are less able to cushion negative capital shocks out of current earnings. The larger capital buffer serves as an insurance against negative capital shocks. As the charter value continues to fall, the relationship is reversed. The incentive for the bank to protect its charter value is lost and the capital buffer falls rapidly towards zero. This is partially consistent with the predictions of the theoretical literature whereby it is assumed that as long as charter value is a degree greater than the cost of recapitalization, then a decline in expected earnings increases desired capital protection against poor earnings and more capital is needed to protect the charter value. However, we see that high charter value banks are not necessarily holding larger buffers of capital as predicted (see Marcus, 1984; Keeley, 1990; Demsetz, Saidenberg and Strahan, 1996; Hellman, Murdoch and Stiglitz, 2000), but rather that the capital buffers remain relatively constant after a certain charter threshold. Banks with charter values slightly below the median range are holding the largest capital buffers. One possible explanation for the finding might be that for higher charter banks, it is generally easier to raise new equity in the future, reducing the need for holding large levels of precautionary capital. Alternatively, this finding indicates that banks with charter values above a certain threshold view themselves as too-big-to fail. The existence of government insurance schemes erodes the need for them to protect further against failure.

A positive and significant relationship continues to exist between capital and risk; as bank risk increases the capital buffer rises. The other control variables, $roa, size$ and $liquid$ generally have the correct sign, but are barely significant.

4.3 Cross-Sectional Estimations

To assess the sensitivity of the results to pooling over the sample period, we additionally estimate cross-section regressions for each time period. Since the results are broadly unchanged from those obtained under the pooled estimations we do not report them here. Instead, we graph the evolution of coefficients for $\hat{q}_{it-1}$ on buf_{it} for $Model\ I\ Model\ II$ and $Model\ III$ in Figures 3, 4 and 5 respectively.

In Figure 3, we observe that the positive relationship documented in Table 4 has remained relatively constant over time. We do however note a slight increase in the linear impact of charter value on bank capital around the time of the capital buildup (between 1990 and 1994). The coefficients however always remain between 0.10 and 0.25 indicating that the variation has not been substantial.

Figure 4, corresponding to the quadratic estimation ($Model\ II$) again shows that the form of the relationship has not varied significantly over time. The negative coefficient on the squared term corresponding to the shape of the curve, documented here, indicates a consistently concave form. We do however note a slight change in the shape of the curve after 1995 when the slope becomes even steeper and remains that way until the end of the sample.

Finally, coefficients reported in Figure 5 correspond to the spline estimation ($Model\ III$). Bearing in mind that the coefficients on the spline variables correspond to the slope of the piecewise linear function in the relevant interval, we note that the relationship between bank capital and charter value for high charter banks have remained close to zero since 1995. This is in line with the panel estimation finding. The non-linear effect is evident when we compare coefficients for the different splines. In particular, we note that slope coefficients for low charter banks (banks with charter values below the 25^{th} percentile) are consistently positive while those for charters between the 25^{th} percentile and the median are consistently negative.

Our cross-sectional estimations show that coefficients on the variables of interest have not varied substantially over time. We can therefore conclude that our panel estimations do not suffer significantly from pooling over the sample period.

4.4 Robustness Check

As an additional robustness check, we vary the placement on the knots for the creation of our spline coefficients. In our initial estimation, the knots for creating spline variables were placed at the 25th percentile, the median and the 75th percentile. To further assess the validity of the finding that past a certain charter threshold, banks will hold a stable amount of capital (rather than the predicted increase in capital corresponding to larger charters), we create new spline variables as per Section 4.1, varying the location of the knots. Three further specifications are estimated: In $Specification\ I$, knots are placed at the 20th, 40th, 60th and 80th percentiles. In $Specification\ II$ we place the knots at each decile until the median (10th, 20th, 30th, 40th and median) and then at the 75th percentile. Finally, in $Specification\ III$, the knots are placed at the 25th percentile, the median and then at each remaining decile (60th, 70th, 80th and 90th). These breakdowns allow a detailed assessment of how the relationship between bank capital and charter value varies depending on the size of the charter, and allows us to further assess the robustness of our estimation results obtained in the previous section. Table 5 defines the splines utilized in each of the specifications. The results from the robustness estimations are presented in Table 6.

Again, the results are broadly in line with the panel estimations and cross-sectional findings. The detailed analysis confirms the finding that large charter banks maintain a constant capital buffer. For each specification, spline coefficients above the median range are very near to zero. Moreover, the signs on the slope coefficients below the median range additionally confirm the shape of the curve depicted by the panel estimations. That is, as charter values start to fall, capital is built up. The relationship is only reversed after charters fall below the 20th percentile range. After this time, the capital buffer falls rapidly towards zero. $Specification\ II$ however indicates that the capital buffer never actually equals zero, rather once charter values fall below the 10th percentile, capital buffers remain consistently small but above zero nevertheless.

5 Discussion

This paper analyzes the long-run relationship between bank capital and charter values for a set of US BHCs between 1986 and 2008. Adopting a two-step approach, we first model bank charter values as a function of a banks revenue mix, loan portfolio and deposit composition. The predicted values from this equation are then used as inputs in the second equation that targets the relationship between capital and charter values. Assuming the functional form to be unknown, we adopt three varying approaches. Under the first approach, the relationship is considered to be linear; the second, estimates charter value as a quadratic form; finally, we estimate a semi-parametric spline function allowing us to determine the slope of each piecewise linear function at the relevant interval. Each approach is estimated using pooled time-series cross-section observations. Our results show that the relationship between capital and charter values is highly non-linear as predicted by theory. Contrary to predictions however, we show that higher charter value banks do no necessarily hold more capital. One possible explanation is that beyond a certain charter level, it is easier for banks to raise new equity thereby reducing the need for them to manage large capital buffers. Alternatively, higher charter value banks may view themselves as partially insulated from failure due to the existence of government safety nets and the too-big-to-fail paradigm. Our results further indicate that when charters start to fall, banks build up capital in an attempt to protect their charter. Falling charters reflects the notion that expected earnings are falling and hence banks are less able to cushion negative capital shocks out of current earnings. A buildup of capital at this time insures against negative capital shocks. The relationship between capital and charter values is however reversed when charter values continue to fall. The capital buffer then very quickly falls towards zero as a means perhaps to "gambling for resurrection".

Our results indicate that the charter value in itself *does* act as a disciplining mechanism for bank capital management. Banks with a valuable enough charter will manage capital so as to maintain a cushion for protection against negative shocks. Our analysis has however, been limited to assessing capital ratios as defined by the 1988 Basel Capital Accord. Current turmoil suggests that securitization and financial market innovation may have resulted in these capital buffers not reflecting the true capitalization of the banks, particulary in the US. The rise in unknown risks, rather than the measurable risks that financial institutions are specialized in managing, may therefore not have been adequately captured by the existing regulatory requirements. While charter values appear to encourage prudent capital management policies, it is evident that this is only on the part that is captured by existing regulation. Our results therefore have important policy implications for regulatory and supervisory authorities. Since bank capital management is evidently endogenous by nature, it is essential that amendments to bank capital requirements are able to capture the true nature of risks and exposures inherent.

6 Tables and Figures

Table 1: Capital Requirements.

	Tier one ratio	Total capital ratio
1986 to end 1990		7%
1991 to end 1992	3.25%	7.25%
end 1992 to 2008	4%	8%

Figure 1: *Total capital*

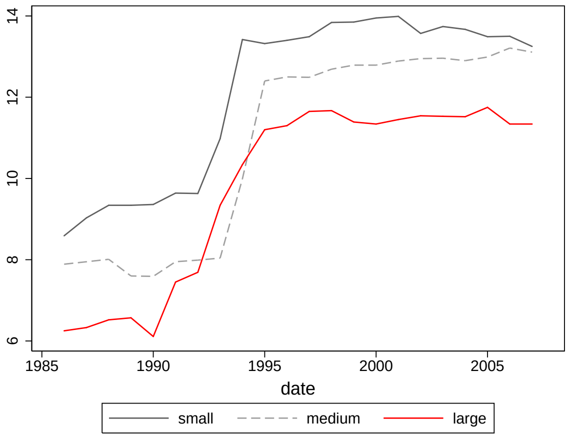


Figure 2: *q Values*

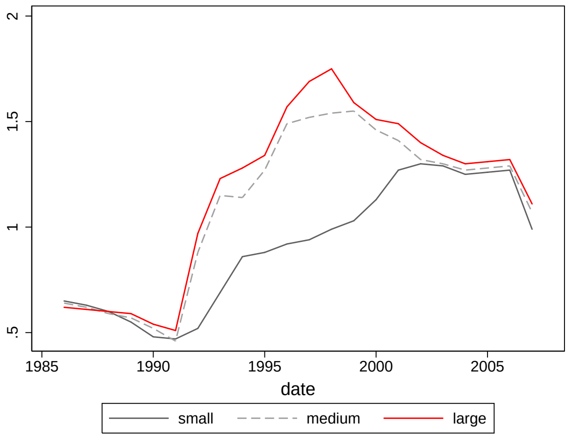


Table 2: Sample Distribution.

Observations		*Mean*	*Std. Dev*
Big Banks	buffer capital	1.80	0.09
	risk	0.74	0.10
	charter value	1.20	0.11
Medium Banks	buffer capital	2.89	0.06
	risk	0.56	0.05
	charter value	1.11	0.09
Small Banks	buffer capital	4.11	0.04
	risk	0.42	0.01
	charter value	0.91	0.04
Highly Capitalized Banks	buffer capital	5.10	0.07
	risk	0.48	0.16
	charter value	1.19	0.08
Low Capitalized Banks	buffer capital	1.32	0.10
	risk	0.82	0.10
	charter value	1.04	0.06
High Risk Banks	buffer capital	3.92	0.08
	risk	0.54	0.13
	charter value	1.01	0.08
Low Risk Banks	buffer capital	4.01	0.03
	risk	0.21	0.03
	charter value	1.21	0.04
High Charter Value Banks	buffer capital	4.01	0.08
	risk	0.59	0.10
	charter value	1.55	0.04
Low Charter Value Banks	buffer capital	2.94	0.09
	risk	0.70	0.21
	charter value	0.85	0.10
Total Sample	buffer capital	5.31	0.10
	risk	0.68	0.21
	charter value	1.08	0.05

Table 3: Control Variables.

Variable	*Description*
Equation (4.)	
nim	ratio of net interest income to total assets.
loans	ratio of total loans to total assets.
$debt_{t-1}$	lagged ratio of total liabilities over total assets.
td	ratio of bank deposits to total liabilities.
gdep	deposit growth rate.
Equation (5.)	
risk	risk weighted assets as per Section 3.1.
size	log of total assets.
roa	the of ratio return on assets to total assets.
liquid	ratio of cash plus securities to total assets.

Table 4: Total Sample Panel Regressions

	First-step equation		Second-step equation					
			Model I: Linear		Model II: Quadratic		Model III: Spline	
	fixed effects	*GMM*	*fixed effects*	*GMM*	*fixed effects*	*GMM*	*fixed effects*	*GMM*
Panel I: Equation (4.): $q_{it} = \zeta_0 + \zeta_1 X_{0it} + \kappa_{0it}$								
nim	0.40 (1.92)**	0.49 (2.04)**						
loans	0.07 (0.98)	0.10 (2.87)***						
debt_{t-1}	-0.04 (3.12)***	-0.06 (1.88)*						
td	0.06 (1.85)*	0.08 (1.99)**						
gdep	0.13 (0.11)	0.17 (2.12)***						
R^2	0.37							
J test		78.95 (3.12)						
a(1)		0.74 (0.00)						
a(2)		2.02 (1.19)						
Panel II: Equation (5.):$buf_{it} = f(\hat{q}_{it}) + \alpha_1 risk_{it} + \alpha_2 \hat{q}_{it} risk_{it} + \alpha_3 X_{1it} + \kappa_{1it}$								
buf_{t-1}				0.09 (4.33)***		0.08 (3.29)***		0.05 (7.67)***
$\hat{q}_{it-1}$			0.69 (5.45)***	0.74 (3.40)***				
$\hat{q}CEN_{it-1}$					0.82 (5.00)***	0.76 (3.99)***		
$\hat{q}^2_{it-1}$					-0.59(4.39)***	-0.63(6.40)***		
spline1							0.57(2.04)**	0.69(1.98)**
spline2							-0.36(1.79)*	-0.41(2.19)**
spline3							0.00(1.87)*	0.02(1.96)**
spline4							0.01(3.86)***	0.03(4.68)***
risk			0.77 (7.02)***	0.64 (4.39)***	0.89 (8.92)***	0.44 (12.17)***	0.73 (9.29)***	0.86 (14.35)***
$\hat{q}_{it-1} risk_{it}$			0.38 (2.05)**	0.29 (2.00)**	0.41 (0.99)	0.39 (0.71)	0.47 (1.01)	0.38 (0.99)
size			-0.21 (1.84)*	-0.12 (1.54)	-0.22 (1.07)	-0.15 (1.83)*	-0.19 (0.99)	-0.24 (0.56)
roa			0.21 (1.98)**	0.18 (1.23)	0.28 (1.14)	0.18 (1.34)	0.25 (1.86)*	0.33 (2.11)**
liquid			0.02 (2.35)***	0.05 (0.99)	0.03 (1.95)**	0.07 (1.22)	0.06 (2.12)**	0.03 (2.49)***
R^2			0.29		0.38		0.47	
J test				64.34 (3.20)		34.23 (5.30)		28.40 (3.01)
a(1)				2.01 (0.00)		1.39 (0.00)		-2.30 (0.00)
a(2)				1.03 (0.33)		2.01 (0.21)		1.38 (0.88)

Note: *, ** and *** denote significance at the ten, five and one percent levels respectively. Each regression includes time dummies as a control that are not reported here. Coefficients depicted are estimates of equation (5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 risk_{it} + \alpha_2 \hat{q}_{it} risk_{it} + \alpha_3 X_{1it} + \kappa_{1it}$. Spline1 refers to: $\hat{q}_{it} < 25^{th}$percentile; spline2, to: 25^{th} percentile $<\hat{q}_{it} <$ median; spline 3, to: median $<\hat{q}_{it} < 75^{th}$percentile; and spline4 to: $\hat{q}_{it} > 25^{th}$percentile.

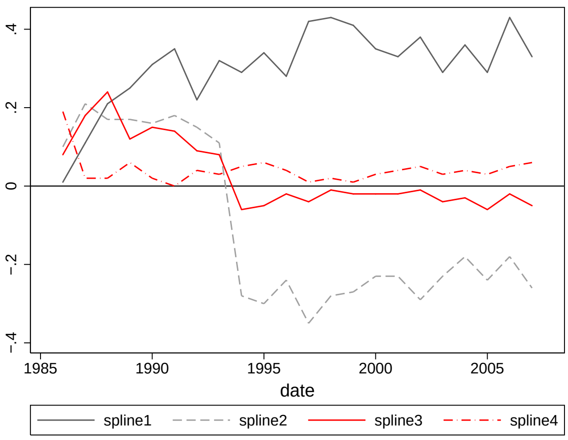
Table 5: Robustness Checks: Spline Definitions

spline name	*definition*
Specification I	
$spec1_1$	$\hat{q}_{it} < 20^{th}$percentile
$spec1_2$	20^{th} percentile $<\hat{q}_{it} < 40^{th}$percentile
$spec1_3$	40^{th}percentile $<\hat{q}_{it} < 60^{th}$percentile
$spec1_4$	60^{th}percentile $<\hat{q}_{it} < 80^{th}$percentile
$spec1_5$	$\hat{q}_{it} > 80^{th}$percentile
Specification II	
$spec2_1$	$\hat{q}_{it} < 10^{th}$percentile
$spec2_2$	10^{th} percentile $<\hat{q}_{it} < 20^{th}$percentile
$spec2_3$	20^{th}percentile $<\hat{q}_{it} < 30^{th}$percentile
$spec2_4$	30^{th}percentile $<\hat{q}_{it} < 40^{th}$percentile
$spec2_5$	40^{th}percentile $<\hat{q}_{it} <$ median
$spec2_6$	median $<\hat{q}_{it} < 75^{th}$percentile
$spec2_7$	$\hat{q}_{it} > 75^{th}$percentile
Specification III	
$spec3_1$	$\hat{q}_{it} < 25^{th}$percentile
$spec3_2$	25^{th} percentile $<\hat{q}_{it} <$ median
$spec3_3$	median $<\hat{q}_{it} < 60^{th}$percentile
$spec3_4$	60^{th}percentile $<\hat{q}_{it} < 70^{th}$percentile
$spec3_5$	70^{th}percentile $<\hat{q}_{it} < 80^{th}$percentile
$spec3_6$	80^{th}percentile $<\hat{q}_{it} < 90^{th}$percentile
$spec3_7$	$\hat{q}_{it} > 90^{th}$percentile

Figure 3: *Model I: Linear coefficients*

Figure 4: *Model II: Quadratic coefficients*

Figure 5: *Model III: Spline coefficients*



Note: Coefficients depicted are estimates of equation (5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 risk_{it} + \alpha_2 \hat{q}_{it} risk_{it} + \alpha_3 X_{1it} + \kappa_{1it}$. Spline1 refers to: $\hat{q}_{it} < 25^{th}$percentile; spline2, to: 25^{th} percentile $< \hat{q}_{it} <$ median;
spline 3, to: median $< \hat{q}_{it} < 75^{th}$percentile; and spline4 to: $\hat{q}_{it} > 25^{th}$percentile.

Table 6: Robustness Checks

Second-step equation						
	Specification I		**Specification II**		**Specification III**	
	basic fixed effects	*GMM*	*basic fixed effects*	*GMM*	*basic fixed effects*	*GMM*
Equation (5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 risk_{it} + \alpha_2 \hat{q}_{it} risk_{it} + \alpha_3 X_{1it} + \kappa_{1it}$						
buf_{it-1}		0.04 (2.67)***		0.06 (3.65)***		0.07 (4.45)***
$spec1_1$	0.35 (1.87)**	0.39 (2.05)**				
$spec1_2$	-0.33 (1.98)**	-0.27 (2.15)**				
$spec1_3$	-0.12 (1.78)*	-0.12 (1.77)*				
$spec1_4$	0.02 (2.13)**	0.01 (2.09)**				
$spec1_5$	0.00 (4.09)***	0.01 (6.97)***				
$spec2_1$			0.04 (1.58)*	0.06 (1.97)**		
$spec2_2$			0.57 (1.89)**	0.46 (1.69)**		
$spec2_3$			-0.04 (3.67)***	-0.03 (5.56)***		
$spec2_4$			-0.10 (6.56)***	-0.07 (6.90)***		
$spec2_5$			-0.12 (7.66)***	-0.12 (5.78)***		
$spec2_6$			0.00 (1.89)**	-0.01 (1.47)*		
$spec2_7$			0.01 (1.52)*	0.00 (1.57)*		
$spec3_1$					0.32 (1.87)**	0.29 (1.73)*
$spec3_2$					-0.22 (8.75)***	0.17 (7.30)***
$spec3_3$					-0.05 (1.50)*	-0.04 (1.90)**
$spec3_4$					-0.02 (1.89)**	-0.01 (1.80)**
$spec3_5$					0.04 (2.93)***	0.03 (3.99)***
$spec3_6$					0.00 (3.23)***	0.05 (4.43)***
$spec3_7$					0.01 (2.93)***	0.00 (3.99)***
risk	0.76 (11.89)***	0.98 (12.22)***	0.87 (14.97)***	0.92 (12.35)***	0.89 (11.69)***	0.68 (12.19)***
$\hat{q}_{it-1} risk_{it}$	0.27 (1.15)	0.15 (0.75)	0.12 (0.96)	0.23 (1.33)	0.33 (0.89)	0.41 (1.26)
size	-0.10 (1.72)*	-0.08 (1.11)	-0.14 (2.02)***	-0.31 (1.96)**	-0.16 (1.75)*	-0.23 (2.02)***
roa	0.02 (1.94)*	0.08 (0.92)	0.04 (1.74)*	0.03 (1.68)*	0.06 (2.00)**	0.03 (1.55)
liquid	-0.16 (2.71)***	-0.10 (1.71)*	-0.22 (1.77)*	-0.21 (0.72)	-0.14(2.28)**	-0.11(1.98)*
R^2	0.21		0.33		0.35	
J test		32.34 (5.40)		43.10 (3.29)		29.20 (2.93)
a(1)		-2.30 (0.00)		2.10 (0.00)		-1.93 (0.00)
a(2)		1.29 (0.93)		-1.02 (0.36)		2.10 (0.73)

Note: *, ** and *** denote significance at the ten, five and one percent levels respectively. Each regression includes time dummies as a control that are not reported here. Coefficients depicted are estimates of equation (5.): $buf_{it} = f(\hat{q}_{it}) + \alpha_1 risk_{it} + \alpha_2 \hat{q}_{it} risk_{it} + \alpha_3 X_{1it} + \kappa_{1it}$. Spline variables are as defined in Table 5.

Appendix I: Data Manipulations

Commercial bank dataset

All bank-level data is obtained from the Consolidated Report of Condition and Income (referred to as the Call Reports) published by the Federal Reserve Bank of Chicago. Since all insured banks are required to submit Call Report data to the Federal Reserve each quarter we are able to extract income statement and balance sheet data for around 14,000 commercial banks. The dataset spans from $1976Q1 - 2006Q2$.

This particular dataset poses several problems for us to deal with in terms of cleaning the data and obtaining a consistent set of data series. There are several reasons for this. First, through time, definitions change for some of the variables of interest, therefore, looking merely at the Report documentation that that banks are required to fill in is not always sufficient. Therefore it is necessary, on some occasions, to join series together in order to yield sensible series through time. Moreover, most of the large banks only provide data on a consolidated foreign and domestic basis requiring the exploration of which series to use.

RCON vs. RCFD series In general, larger banks only provide data on a consolidated foreign and domestic basis. Therefore, it is necessary to use the $RCFD$ series rather than the $RCON$ series for each variable. For banks that do not have foreign operations however, it is possible to assume that the two series ($RCON$ and $RCFD$) will be identical, although it is necessary to bear in mind that foreign deposits in this case are not available.

The definition for total securities changes several times through our sample. It is therefore necessary for us to combine various individual series through time to create a consistent variable to work with. Prior to 1984, it is not possible to combine all of the items that are now considered as investment securities. We therefore need to approximate the securities variable. Pre-1984 we combine $RCFD0400$ (US Treasury securities), $RCFD0600$ (US Government agency and corporation obligations), $RCFD0900$ (obligations of states & political subdivisions) and $RCFD0380$ (other bonds, stocks and securities). In 1984q1 however, we are able to separately add up the items making up investment securities because a) trading account securities for sale at book value ($RCFD1000$) is replaced by *securities for sale at market value* ($RCFD2146$) and b) there is no guarantee that the securities are held to maturity match across the break in 1984. i.e. there is no guarantee that $RCFD0402$ (securities issued by states and political subdivisions in the US) + $RCFD0421$ (other domestic securities) + $RCFD0413$(foreign securities) = $RCFD0900$ (obligations of states and political subdivisions) + $RCFD0950$(other securities). For the pre and post 1984 series to be consistent, these two summations must be equal. We therefore combine the series $RCFD0390$ (book value of securities) and $RCFD2146$ (assets held in the trading account) for the period 19841 to 1993q4. After this time, $RCFD0390$ (book value of securities) is no longer available. From 1994q1 we therefore proceed by summing up $RCFD1754$ (total securities held to maturity), and $RCFD1773$ (total securities available for sale). Moreover, $RCFD1754$ (total securities held to maturity), and $RCFD1773$ (total securities available for sale) excludes securities held in the trading account, which is part of $RCFD3545$ (total trading assets). We therefore create an additional securities variable (securties2) which is the summation of $RCFD1754$ (total securities held to maturity), $RCFD1773$ (total securities available for sale) and $RCFD2146$ (assets held in trading accounts). We generally make use of the securities2 variable since this eliminates a break in the series in 1993.

For total loans, we again see that there is a break in the series in March 1984. In the third quarter of 1984, the series includes the variable $RCFD2165$ (lease financing receivables). From March 1984 we adopt $RCFD1400$ (total loans & leases, gross) as our total loans variable. Prior to this however, we replace the series with a sum of $RCFD1400$ (total loans & leases) and $RCFD2165$ (lease financing receivables). Similarly for net loans we have $RCFD2122$ (total loans, net of unearned income) for the period between 1984q1 and 2006q2. Prior to this, we again combine $RCFD2122$ (total loans, net of unearned income) with $RCFD2165$ (lease financing receivables).

Commercial and Industrial loans has a change in definition as well. From 1976 until 1984q3, we make use of the $RCFD1600$ (commercial and industrial loans). Here, each bank's own acceptances are included. From 1984q3 however, the series starts to include holdings of bankers' acceptances which are accepted by other banks. We therefore replace this series with a combination of the $RCFD1755$ (acceptances of other banks) and $RCFD1766$ (commercial and industrial loans, other). It remains impossible to create a consistent series here that would exclude banker's acceptances.

A further change in definition occurs with the Fed Funds series. Considering first the Fed Funds Sold series. From 1976 until 2002q1 we are able to make use of $RCFD1350$ (Fed Funds Sold). However, the series discontinues thereafter. We subsequently form a continuation by summing $RCONb987$ (Fed Funds sold in domestic offices) and RCFDb989 (securities purchased under agreement to sell).

Similarly, for Fed Funds Purchased, the series $RCFD2800$ (Fed Funds

Purchased) discontinues at the end of 2001. We are then able to replace the series in 2002q2 with $RCFDb993$ (Fed Funds purchased in domestic offices) summed with RCFDb995 (securities sold under agreement to repurchase).

Other issues in the commercial bank dataset In most of the graphical analysis we find a kink in the series in 1997q1. Looking closer at the cause of this disturbance in the data, we find that the number of institutions falls in 1997q1 to 8,648 from 9,772 in 1996q4. The number subsequently rises again in 1997q2 when the number of reporting institutions jumps again to 9,248. This jump is depicted in the graph below, documenting the evolution of the number of banking institutions over time. Investigating the issue further, we find that there appears to be a fault in the dataset for this period. It seems that information reported for around 800 banks are all returned with 0 values. We have not corrected the data in any way to deal with this issue that is visible in all most all graphical analysis conducted here.

Dealing with mergers With respect to the treatment of bank mergers in the data, several possible alternative approaches are considered: *Option 0*: All observations affected by a merger are simply dropped from the sample. Note however,if using any lagged growth rates or differences in the model, this means dropping future observations as well as the observation when the merger takes place. This option is applied by many existing studies in the banking literature (see for example Kashyap and Stein, 2000). *Option 1*: This option is preferable when a large bank acquires a very much smaller bank. Here, all past balance sheet and income observations are re-scaled, using a constant ratio, from the beginning of the sample up to the quarter preceding the merger. This ratio is equal to the increase in total assets triggered by the merger. *Option 2*: This option is preferable to Option 1 when two merging banks are of similar size. Here, the merged entities are reconstructed backwards as the sum of the merging banks. In this case a new new bank id, different from any existing id, is created and applied to all subsequent observations.

In this paper, we adopt a mixture of Options 1 and 2; When merging banks are of different sizes we adopt Option 1 while for a small number of mergers where the merging banks are of similar size, we create a new bank id as per Option 2.

Merging the Commercial and BHC datasets The following steps were undertaken to merge the holding company data with with commercial bank data from the Federal Reserve Bank of Chicago. We start with the commercial bank data set and start by identifying those banks that belong to foreign call family:

1.

We start by generating a foreign call identity as follows:

gen fgncall_ind = 0

replace fgncall_ind = 1 if fgncallfamily > 0 & fgncallfamily ~ = .

We then created a variable called *identifier* which tells us the name of the financial high holder. (this is equal to the rssd9348 variable in the dataset:

gen identifier = high holder $/* = rssd9348 */$

If however, the high holder is a foreign call family, the variable gives the number of it instead:

replace identifier = $fgncallfamily$ if $fgncall\_ind$ == 1

2.

We then make use of the *identifier* variable to collect holding company data from the BHC data.

By changing the name of $rssd9001$ to identifier in BHC data. Moreover, we drop all observations equal to 0.

3.

Finally we merge this dataset back to the commercial bank data. First we copy the commercial bank dataset and the BHC data into the same directory. Opening the commercial bank data, we type the following:

merge $rssd9001$ dateq using BHCpanel, unique sort
$update\_merge(\_mergeBHC)$

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