How Has Capital Affected Bank Risk Since Implementation of the Basel Accords?

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This Version: August 2011

Abstract

Regulatory capital requirements are the core of risk management embodied in the Basel Accords. In this paper we question the effectiveness of this approach in actually reducing the risk financial institutions accept. We thoroughly analyze a large cross-section of bank holding company data from 1993 to 2008 to determine the relationship between capital and bank risk-taking. To deal with the endogeneity between risk and capital, we employ stochastic frontier analysis to create a new type of instrumental variable. We provide both theoretical and empirical evidence to validate the use of the proposed instrument for bank capital. Our results support the theory that banks respond to more capital by increasing the risk in their earning asset portfolios and off-balance-sheet activity. This perverse result suggests that bank regulation should be thoroughly reexamined and alternative tools developed to ensure a stable financial system.

JEL: G21, G28
Keywords: Bank risk, Capital management, Capital regulation

The authors thank Allen Berger, Robert DeYoung, Mark Flannery, David Lee, and Ozde Oztekin, for providing us with data. The authors also would like to express their gratitude to Jean Helwege, Michael Pagano, Wim Vijverberg and participants of the Financial Management Association annual meeting in New York for providing useful comments.

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1. Introduction

Rarely has the importance of bank capital requirements received more attention than during the recent financial crisis. As the subprime mortgage debacle spread, the balkanized regulatory system designed over half a century ago proved itself to be inadequate for today's financial system. Confidence in the foundation of global banking regulation, mandatory bank capital requirements, was badly shaken. In this study, we thoroughly look at the role of capital in regulatory risk management by examining bank holding company data since the year that the risk-based capital requirements were first implemented. Historically, both theoretical and empirical papers on the relationship between capital and risk have produced mixed results.[1] Yet a new look at the role of bank capital in risk management is now critical if we are to protect the financial system of the 21st century.

This article fits into a long history of literature dealing, in general, with bank risk management and, more specifically, with the question of what constitutes an adequate level of bank capital. It has been well documented that bank holding companies actively manage their capital to reach the target ratios due to both regulatory requirements and peer pressure. A critical question remains: Does increased capital improve the financial soundness of banks? Our contribution consists of the analysis of a large cross-section of bank holding companies over the years that the Basle accords have been implemented. In addition, we introduce a unique, to our knowledge, method to exogenously model an instrumental variable for capital in a regression with risk.

One of the primary goals of bank regulators is to minimize the risk held on and off their balance sheets by financial institutions. In this way, the negative externalities of bank failures and

[1]. For detailed discussion, please see Berger, Herring, and Szego (1995), Gatev, Schuermann, and Strahan (2009), Hovakimian and Kane (2000), Shrieves and Dahl (1992), VanHoose (2007), and Berger, DeYoung, Flannery, Lee, and Ozrekin (2008).

the risk to taxpayers from losses from the federal bank safety net are avoided or reduced. Historically and internationally, a mandatory bank capital requirement is one of the most important tools used by regulators to stabilize the financial industry. The recent financial crisis, however, challenges the effectiveness of these mandatory capital requirements. The inherent characteristics of today's banking industry such as rapid financial innovation, high financial leverage, information asymmetry, liquidity creation, and the federal bank safety net all distort incentives and reward risk-taking. If maintaining a certain level of capital is viewed by bank managers only as a necessary evil, then critical questions emerge: How is capital related to specific measures of risk including credit risk, liquidity risk, interest rate risk, off-balance-sheet risk, market risk, and composite bank risk? Answers to these questions will help to establish the role of capital in regulatory risk management.

Empirical studies of bank capital and bank risk, however, face an inherent problem. To measure the effect of the level of capital on bank risk-taking, it would be useful to regress risk, as the dependent variable, on capital as the independent variable. However, there is an endogeneity problem. The amount of risk a bank can undertake is dependent on its amount of capital and the amount of capital needed is dependent on the amount of risk that a bank wants to undertake. Two alternative solutions to this problem are to use either a simultaneous equation model or to use instrumental variables. However, a simultaneous equation model must be properly identified and no one has yet been able to accomplish this in regard to risk and bank capital. Likewise no one, to our knowledge, has yet found an appropriate instrument for capital that is independent of risk.

We propose a methodology for the development of an exogenous instrument for capital in a regression with risk by using stochastic frontier analysis. First, we determine the maximum possible income that can be achieved from a given level of assets. This is referred to as fitting an upper envelope. Such a frontier is obviously exogenous to any specific bank because it is determined by the data from all banks in the sample. The distance from the frontier to any specific bank's actual income can be considered a measure of bank inefficiency. In other words, this is a measure of how close the bank comes to maximizing its income based solely on the amount of assets employed. Next, to develop the instrument for capital, we create a second frontier conditioned on bank capital as well as the amount of assets employed. The difference between the two frontiers is a function of the bank's capital but independent of the bank's risk, and it is this incremental inefficiency that we propose to use as an instrument for capital. The model includes the random shocks coming from economic variations and luck. The difference in efficiency, our instrumental variable, represents the net effect of the use of bank capital in which the random factors are considered. The sign of the instrumental variable cannot be determined in advance since this instrument represents the net effect of bank capital after controlling for risk exposures. To validate the use of the instrument, we also provide theoretical explanations and empirical findings before we test the relations between bank capital and risks.

Our analysis adds to the existing literature in several ways. First, we employ a large panel data set to consider the capital-risk relationship for a wider range of bank holding companies than typically reviewed. Previous empirical studies have commonly used market measures of risk. However, this approach necessarily limits the sample to publically owned banks or bank holding companies. In this study we acknowledge the importance of small banks and bank holding companies, as well as the largest bank holding companies. This concern is significant since public policy related to the banking industry must consider a broad sample of banks and not only the largest organizations. As a result, we turn to the typical accounting measures of a bank's risk and utilize a large panel data set. In a second contribution, stochastic frontier analysis is applied to exogenously generate the effect of the use of capital in banking. Though this method has been applied in the studies of various disciplines, the difference in efficiency of banks allows us to evaluate the relation between banking risk and capital without an endogeneity problem.

Furthermore, the finding of this paper provides bankers and regulators with a different view regarding mandatory capital requirements. We carefully investigate the issues by looking at seven different measures of risk and performance and by applying three different econometric approaches. The empirical evidence indicates that bank holding companies react to high capital by increasing the amount of certain categories of risk. Some results support the proposition that increased capital requirements reduce risk in BHCs; there are, however, results that suggest the opposite, that BHCs increase risk as they employ more equity capital. An important example is that the ratio of BHCs' risky assets to total assets increases as capital increases. In addition, the ratio of nonperforming assets to total loans and leases also increases as capital increases. These results are derived from our use of a panel data estimator. This is obviously an important finding with major public policy implications. If the primary tool used by regulators to ensure a stable financial system is creating perverse results then alternative tools must be developed.

The rest of the paper is organized as follows. Section 2 summarizes the literature that deals with bank capital regulation. Section 3 presents our methodology and Section 4 presents the data, tests of instrumental variable, along with univariate analysis of the data. In section 5 we define the hypotheses to be tested. In Section 6 we present our empirical results, Section 7 provides robustness tests and Section 8 concludes.

2. Literature Review

2.1. Regulation of bank capital

Bank capital is widely regarded as the cushion that prevents a decline in asset values from threatening the integrity of bank liabilities. Surprisingly there were no formal capital requirements in the U.S. until 1981. Historically, regulators used rules of thumb based on peer group analyses to determine capital adequacy. Even in the 1981 legislation there were different capital requirements based on bank size but not on bank risk. The Basle Capital Accord I in 1988 was the first attempt to relate bank capital to bank risk. In 1991 the Federal Deposit Insurance Corporation Improvement Act in the U.S. required regulators to take specific action, known as "prompt corrective action", when a bank's capital ratio fell below certain levels. The Basle Capital Accord II was generally adopted in 2007 and is a current standard for measuring bank risk and the capital needed to support it.[2]

On the other hand, it has been argued that excessively high capital requirements can produce social costs through lower levels of intermediation. In addition, there can be unintended consequences of high capital requirements such as risk arbitrage (increasing risk to offset the increase in capital and thereby maintain the same return on capital), increased securitization, and increased off-balance-sheet activity, all of which could mitigate the benefits of increased capital standards. See Berger, Herring and Szego (1995) and Santos (2001). The extent to which these unintended consequences played a role in our recent crisis is yet to be determined.

If we go back to the middle of the 19th century, we find that bank capital funded over half of bank assets in line with the capital ratios of non-financial firms. See Berger, Herring and Szego (1995). However, for the next 100 years or so, as new legislation was enacted to decrease the risk in banking, banks responded by decreasing their capital ratios. The National Banking Act of 1863 created national banks with the Office of the Comptroller of the Currency as their regulator. In 1913 the Federal Reserve System was enacted to be, among other things, a lender of last resort. In 1933 the Federal Deposit Insurance Cooptation (FDIC) was created to provide a government guarantee

[2] For detailed discussion, see Bank for International Settlements (2004).

on bank deposits. Various other pieces of legislation were designed to prevent banks from excessive competition. The Glass-Steagall Act separated commercial banking from investment banking. Banks and BHCs were prevented from crossing state lines. Regulation Q limited the amount of interest banks could pay on deposits. By the late 1980s the bank equity to assets ratio on a book value basis was barely over 6%. It is natural that international bankers were concerned about decreasing capital ratios and produced the first Basle Capital Accord.

Moral hazard is high on the list of problems receiving attention in this post financial crisis environment. The presence of a federal safety net creates moral hazard because bank management does not have to worry about monitoring by depositors (See Merton, 1977; Buser, Chen, and Kane, 1981; Laeven and Levine, 2009). Absent depositor monitoring banks are free to increase risk. If, however, deposit insurance and other elements of a federal safety net are reasons for increases in bank risk, why do they continue to exist? The answer lies in the contemporary theory of financial intermediation. It has been well established in the literature that there is need for both demand deposit contracts and the possibility of bank runs (Diamond and Dybvig, 1983; Calomiris and Kahn, 1991; Diamond and Rajan, 2000; and Santos, 2001). If the possibility of bank runs is needed, and bank runs are harmful, then government deposit insurance is an optimal solution. There is a related issue. Banks have a unique ability to resolve information asymmetries associated with risky loans. As a result, bank failures can produce a serious contraction in credit availability, especially among borrowers without access to public capital markets. The federal safety net is needed to avoid this credit contraction. Likewise, if a bank is considered "too big to fail" then the government will always bail the bank out and there is no reason for bank management to limit risk.

2.2. Dissenting opinions

It needs to be noted that not everyone is in agreement that the use of capital requirements is the best way to reduce risk in banking. Marcus (1984) and Keeley (1990) argue that a bank's charter value mitigates against increased risk. Banks operate in a regulated environment and therefore a charter to operate contains market power. Excessive risk increases the cost of financial distress and this can cause a loss of charter value. Kim and Santomero (1988) argue that a simple capital ratio cannot be effective and any ratio would need to have exactly correct risk weights in a risk based system. Gorton and Pennacchi (1992) discuss “narrow banking”, and propose splitting the deposit services of banks from the credit services. In other words, the financial system would include money market accounts and finance companies. The money market accounts would only invest in short term high quality assets and leave the lending to the finance companies that would not take in any deposits.

Prescott (1997) reviews the pre-commitment approach to risk management. Briefly, banks commit to a level of capital and if that level proves to be insufficient the bank is fined. This is used currently in the area of capital in support of a trading portfolio but cannot be used for overall capital ratios since a fine against a failed bank is not effective. Esty (1998) studies the impact of contingent liability of stockholders on risk. In the late 19th and early 20th century bank stockholders were subject to a call or an assessment for more money if needed to meet the claims on a bank. There was a negative relation between increases in risk and the possible call on bank stockholders. Calomiris (1999) makes a strong case for requiring the use of subordinated debt in bank capital structures. The need to issue un-guaranteed debt and the associated market discipline would act as an effective limit to the amount of risk a bank would be able to assume. John, Saunders, and Senbet (2000) argue that a regulatory emphasis on capital ratios may not be effective in controlling risk. Since all banks will have a different investment opportunity set, an efficient allocation of funds must incorporate different risk taking for different investment schedules. These authors go on to argue that senior bank management compensation contracts may be a more promising avenue to control risk using incentive compatible contracts to achieve the optimal level of risk.

2.3. Empirical studies

While there is a long history of regulatory focus on bank capital adequacy there is no agreement that such a focus is optimal.

2.3.1. Capital Regulation Does Control Risk

Marcus and Shaked (1984) show how Merton's (1977) put option pricing formula can be made operational and then used the results to estimate appropriate deposit insurance premium rates. The results of their empirical analysis indicated that the FDIC premiums at that time were higher than was warranted by the ex-ante default risk of the sample banks. This implies that banks are not transferring excessive risk to the deposit insurance safety net and capital regulation is effectively working.

Duan, Moreau, and Sealey (1992) address the question of the impact of fixed-rate versus risk-based deposit insurance premiums directly. The authors tested for specific risk-shifting behavior by banks. If banks were able to increase the risk-adjusted value of the deposit insurance premiums, then they had appropriated wealth from the FDIC. This is because the FDIC, at the time, could not increase the insurance premium even though risk had increased. Their empirical findings were that only 20 percent of their sample banks were successful in risk-shifting behavior and therefore the problem was not widespread. This also implies that capital management has been effective.

Keeley (1992) empirically studied the impact of the establishment of objective capital-to-asset ratio requirements in the early 1980's. His evidence documents an increase in the book value capital-to-assets ratio of previously undercapitalized banks and this, of course, was the goal of the new capital regulations. His study, however, is unable to confirm the same result when looking at the market value capital ratios. While the market value capital-to-assets ratios also increased, there was no significant difference between the undercapitalized banks compared with the adequately capitalized banks. Nevertheless, this was more evidence that capital regulation was working.

2.3.2. Capital Regulation Does Not Control Risk

Hovakimian and Kane (2000) use the same empirical design as Duan, Moreau and Sealy (1992) but for a more recent time period and they obtain opposite results. They also start with the argument of Merton (1977) that the value of deposit insurance increases in asset return variance and leverage. They regress the change in leverage on the change in risk and find a positive rather than a negative coefficient. The coefficient must be negative if capital regulation forces banks to decrease leverage with increases in risk. In a second test they regress the change in the value of the deposit insurance premium on the change in the asset return variance. Here again the coefficient must be negative (or zero) if there is any restraint. In this equation, the coefficient measures how much the bank can benefit from increasing the volatility of its asset returns. The option-model evidence presented shows that capital regulation has not prevented risk-shifting by banks and that it was possible for banks to extract a deposit insurance subsidy.

2.4. More on bank capital and risk

In Hughes, Mester, and Moon (2001) the authors study the joint impact of two functions of bank capital. First is capital's influence on market value conditioned on risk and, second, its impact on production decisions incorporating endogenous risk. Efficient BHCs are determined according to frontier analysis and then these BHCs are assumed to be value maximizing firms. The conclusion is that these value maximizing firms do achieve economies of scale but the analysis of production must include capital structure and risk-taking.

Berger, DeYoung, Flannery, Lee, and Ozrekin (2008) note that U.S. banks hold significantly more equity capital than the minimum amount required by regulators. Their evidence documents the active management of capital levels by BHCs including setting target levels of capital above regulatory minimums and moving quickly to achieve their targets. Over the 15-year period of their study BHCs regularly used new issues of shares and share repurchase programs to actively manage their capital levels. Several reasons for differing capital ratios among BHCs are given by the authors. Banks with high earnings volatility would likely hold more capital. Banks whose customers are more sensitive to default risk via counterparty exposure may be forced to hold more capital. Firms with high charter values will want to minimize their costs of financial distress by maintaining high capital ratios. On the other hand, larger banks by asset size tend to be more diversified, enjoy scale economies in risk management, have ready access to capital markets, and are possibly viewed as "too big to fail" with attendant implicit government guarantees.

Flannery and Rangan (2008) also document a large increase in bank capital during the 1990s. The authors note the timing correlation with deregulation of the banking industry and the related increase in risk exposure. They suggest that increased diversification may have been offset by the increased risk of the newly permissible activities. As a result it was counterparty risk that was the driving force for higher capital levels.

3. Methodology

3.1 Instrumental variable for capital

Our paper differs from previous studies that deal with the endogeneity between risk and capital using traditional methods such as a simultaneous equation approach or two- or three-stage regression analysis.[3] In this study, we follow the method and concept of Hughes, Mester, and Moon (2001), Hughes, Lang, Mester, Moon, and Pagano (2003) and others, and use stochastic frontier analysis to estimate the inefficiency of our sample of bank holding companies.[4] We then create a unique instrumental variable for bank capital to be used in regressions of capital and risk. The question we ask is: "How efficient is a bank in converting the resources with which it has to work into profit?" The frontier developed is exogenous to any specific bank since it is based on the results of all banks in the sample. From this frontier we measure the inefficiency of each bank as the distance between the frontier and that specific bank's pre-tax income. This measure is adjusted for those elements that are beyond the control of any bank, such as luck and white noise, by the frontier analysis process.

Our unrestricted frontier model determines the highest possible profitability based solely on the book-value of assets employed. The unrestricted model is specified as:

$$
\begin{aligned}
&PTI(BVA, \sigma_{BANK}) = a + b_1 BVA + b_2 (BVA)^2 + e, \\
&e = \xi - \varsigma, \qquad\qquad (1) \\
&\xi \sim iid\ N(0, \sigma_{\xi}^2),\ \varsigma(\geq 0) \sim iid\ N(0, \sigma_{\varsigma}^2),
\end{aligned}
$$

where PTI is pre-tax income, BVA is of book value of assets, ξ is statistical noise, ς is systematic shortfall (under management control), and $\varsigma \geq 0$. A quadratic specification is used to allow for a non-linear relation between the pre-tax income and the book value of assets.

Our next step is to develop a second frontier based on the level of bank holding company capital as well as the amount of assets. The implication of using the unrestricted model is that we

[3] Please note that below we also use two-stage least squares OLS but it is used to mitigate the endogeneity between different elements of risk.
[4] See Jondrow, Lovell, Materov, and Schmidt (1982) for a discussion of fitting production frontier models.

are measuring the unconditional inefficiency of the banking organization. By also conditioning the model on capital we can develop a measure of the incremental efficiency or inefficiency of an organization due to its capital level. It is this incremental inefficiency due to a bank's capital level that we propose to use as an instrument for capital in a regression of risk on capital. Specifically, our restricted model, again in a quadratic form, is as follows:

$$PTI(BVA, BVC, \sigma_{BANK}) = \alpha + \beta_1 BVA + \beta_2 (BVA)^2 + \beta_3 BVC + \varepsilon,$$

$$\begin{aligned} &\varepsilon = v - u, \\ &v \sim iid\ \ N(0, \sigma_v^2) \quad u(\geq 0) \sim iid\ \ N(0, \sigma_u^2), \end{aligned} \tag{2}$$

where *BVC* is the book value of capital, v is statistical noise, and u denotes the inefficiency of a bank considering its use of both assets and capital.

The two assessments of inefficiency allow us to measure the difference in profitability due to the use of capital by calculating the difference in the inefficiency between the restricted and unrestricted model. Specifically,

$$\delta = u - \varsigma\ . \tag{3}$$

This becomes our instrumental variable for capital. While any measure of profitability endogeneously includes risk, our instrument, the difference between two measures of profitability conditioned only on capital, is related to capital but not to risk which is included in both models.

This instrument adeptly deals with the endogeneity problem between the bank risks and capital. The amount of capital that a bank needs depends on the amount of risk that the bank has assumed, but the amount of risk a bank can assume depends on the amount of capital the bank has on its balance sheet. They are jointly determined, or endogenous, in the same way that price and quantity are determined in a model of supply and demand subject to an equilibrium condition. The instrumental variable for capital represents the net effect of the bank equity after controlling the impact of risk on the profit. Since the relationship between input and output variables in the stochastic frontier is non-linear, there is no econometric requirement that the sign of an instrument must be equal to the sign of the endogenous variable it is replacing.[5] The amount of equity capital of a bank is proportional to its asset value, but the combinations of risks that banks take vary from one bank to another. Therefore, there is a possibility that banks of the same size and the same capital can generate a different δ since their operational efficiencies may differ. Alternatively, for banks of different size and capital, it is possible that they have the same δ because the net effect of using capital is similar.

3.2 Panel data estimation

The panel data estimator considers both the variations across banks and over the sample period. Our data cover a large cross-section of BHCs over a comparatively small number of years. Accordingly, a panel data estimator is an appropriate approach to determine the effect of capital on risk over time. Using a panel data approach we also increase our sample data employed and produce a single result for the entire time period. In addition, we are able to condition our results on changes in the business cycle.

We use Two-Stage Least-Squares (TSLS) regression with the panel data to deal with the endogeneity between the various risk measures we are analyzing. There are two kinds of endogeneity among variables that need to be dealt with: the endogeneity between risk and capital (see section 3.1) and another one between the various risk factors that are in our analysis. The rationale is that bank managers tend to "coordinate" risk-taking behavior in various sections and business lines. For instance, Schrand and Ünal (1998) suggest that financial institutions might

[5] In Section 4.4., we will defend our instrument for capital by providing the results of econometric tests. If we find high correlation of the instrument with actual bank capital, the endogenous variable, and no or low correlation of the instrument the error term, we have a valid instrument.

decrease certain kinds of risk while increasing other categories of risk in order to maintain a certain level of 'total' or firm-wide exposure. To control for the impact of size on a bank's risk-taking behavior, the book value of assets is considered in the model (Gatev, Schuermann, and Strahan, 2009).

There are several reasons supporting the use of TSLS. First, since the banking risks are likely to be interdependent, the error term may be correlated with the independent variables. This violates the OLS regression assumption of recursivity. In other words the different risk factors are endogenous. Second, though structural equation models (SEMs) can also be used in estimating parameters, TSLS is an alternative to maximum likelihood estimation (MLE) and has less parameter estimation required in order to dealing with endogeneity. Furthermore, in our analysis, there will be more than one endogenous variable rather than a single dependent variable. Using this approach we again investigate the relationship of banking risk and capital while controlling for other exposures.

We use macroeconomic variables as instruments for the risk categories we are studying. The specific instrumental variables used to estimate each risk category are detailed in Section 4. Our first stage regression model is:

$$y_k = a_{k0} + a_{k1}\ln(BVA) + a_{k2}\delta + \sum_{i=1}^{M} b_i IV_{k,i} + e_k, \qquad (4)$$

where y_k is one of the measures of risk or behavior (e.g., Total Equity/ Total Asset) for bank i ; a_{k1} is the coefficient of natural logarithm of bank's book value; $IV_{k,i}$ is the ith instrumental variable for the risk measure y_k, and e_k is the error term.[6]

[6] The definition of measures of risk or performance and instrumental variables is presented in Section 4.

At stage two, the predicted values $\hat{y}_j$ that are derived in the first stage (other than the risk proxy being tested) are then used as regressors to test the relation between banking capital and the risk category represented by the risk proxy being tested. Specifically,

$$y_k = c_t + d_k \delta_i + f_k \ln(BVA) + \sum_{\substack{j=1 \\ j \neq k}}^{J} h_j \hat{y}_j + \zeta_k . \qquad (5).$$

The impact of the use of bank capital on risk-taking behavior can be captured by δ_k.

3.3 Two-stage Least-squares regression on a year-by-year basis

In addition to our panel data analysis, we also perform year-wise TSLS regression analysis as a test of the robustness of our results from the panel data set. In a year-by-year analysis macroeconomic variables are the same for all BHCs and we produce a singular matrix.

Accordingly, we select one risk measure from each group as the proxy for the same class of risk and then identify instrumental variables that can be used as regressors to estimate the risk proxies at the first-stage regressions. The instrumental variables used are detailed in Section 4. Specifically, the first-stage regression model is:

$$y_{k,t} = a_{k0.t} + a_{k1,t} \ln(BVA) + a_{k2,t} \delta + \sum_{i=1}^{M} b_i IV_{k,i} + e_k . \qquad (6)$$

For the analysis in each year, the predicted values $\hat{y}_j$ that are derived in the first stage are used as regressors to test the relation between banking capital and the risk category represented by the risk proxy being tested. Specifically,

$$y_{k,t} = c_t + d_{k,t} \delta_{i,t} + f_{k,t} \ln(BVA) + \sum_{\substack{j=1 \\ j \neq k}}^{J} h_{j,t} \hat{y}_{j,t} + \zeta_{k,t} . \qquad (7)$$

3.4 Generalized method of moments

Our final robustness test is the use of generalized method of moments (GMM) regression to verify the relation between each variable and bank capital. The results of our analysis using panel-data are supported in year-by-year TSLS regressions. There are several reasons, however, why we should consider the results from GMM regressions. First, the departure from normality of the variable δ due to the combined error terms should be taken into account in the analysis. There is no theory to support a Gaussian distribution of these variables. Furthermore, in practice, the ranges of the independent and dependent variables are bounded within certain intervals. Unlike other estimators, GMM is robust and does not require information on the exact distribution of the disturbances. We follow Hamilton (1994) to construct our GMM estimation. We again control for the impact of size on a bank's risk-taking behavior by including the book value of assets as a control variable. The relationship between the variables specifying bank behavior and the use of equity is analyzed by the following GMM regression.

$$y_{k,t} = c_t + b_{k,t}\delta_{i,t} + \gamma_{k,t}\ln(BVA) + \eta_{k,t} \ , \qquad (8)$$

where c is a constant; $b_{k,t}$ is the coefficient of instrumental variable of capital, $\delta_{i,k}$, for k's regression in year t; and $\eta_{k,t}$ is the error term.

4. Data

We obtain our data on bank holding companies from Federal Reserve reports FR Y-9C for the years 1993 to 2008.[7] Data on risk-weighted assets, tier-1 capital and tier-2 capital were not included with the FR Y-9C reports from 1993 to 1996. We were graciously provided this missing information by the authors of Berger et al, (2008).

Table 1 displays the descriptive statistics of the sample BHCs in our analysis. The total of 24,973 bank-year observations includes BHCs ranging in number from 2,256 in 2005 to 678 in 2008. From 2005 to 2006, there is an especially large drop in the number of BHCs included in our data. This is primarily due to a change in the reporting criteria for the FR Y-9C report. Starting in 2006 the threshold for required reporting by a BHC was increased from BHCs with $150 million in total assets to BHCs with $500 million in total assets. Note that in spite of the 57% drop in the number of BHCs reporting in 2006 compared with 2005, the total assets represented in the sample for these two years decreased by only 14%.

[INSERT Table 1 ABOUT HERE]

Our data start in 1993 because 1992 was the final year in which capital ratios were still adjusting in order to conform to the Basle I Capital Accord. As a result, 1993 represents the first year that does not include any mandated changes in the capital ratios. The entire period of 1993 to 2008 contains a number of significant events affecting the banking industry. For instance, the Riegle-Neal Interstate Banking and Branching Act was passed in 1994 eliminating geographic restrictions on bank expansion. In 1999 the Graham, Leach, Bliley Financial Services

[7] Data on risk-weighted assets, tier-1 capital and tier-2 capital were not provided with the FR Y-9C reports from 1993 to 1996. We were graciously provided this missing information by the authors of Berger, DeYoung, Flannery, Lee, and Oztekin (2008).

Modernization Act was passed effectively repealing the Glass-Steagall Act. Together these two acts overturned 65 years of legislation and regulation intended to keep banks financially sound.

From an economic point of view, the early portion of our time period represented a time of recovery from recession. The economy then moved from recovery to growth and the decade ended in a tech stock boom followed by a bursting of the tech stock price bubble and an attendant recession. The new decade brought traditional financial policies intended to stimulate the economy which, in hindsight, probably helped to lay the foundation for the housing price bubble which precipitated the 2007 - 2009 financial crisis. The time period from 1993 to 2008 seems to be a very appropriate period in which to analyze bank capital ratios.

Previous empirical studies have used market measures of risk and various risk measures derived from a market model based on return data. However, this approach limits the sample to publically owned banks or bank holding companies. In this study we wish to determine the impact of capital on various measures of risk and acknowledge the importance of small banks and bank holding companies, as well as the largest bank holding companies. This concern is significant since public policy related to the banking industry must consider the broadest sample and not only the largest organizations. As a result, we utilize a large panel data set and turn to the typical accounting measures of a bank's risk.

4.1. Overall observations of BHC data

We see the significant events and the economic activity listed above in the statistics in Table 1. First, the size of BHCs measured by either their asset values or equity has increased while the number of banks has decreased. This trend is still evident after adjusting for changes in the reporting criteria for the FR Y-9C report. The government deregulation noted above has resulted in increased concentration in the banking industry. We note also the significant cross-sectional variation in scale of BHCs that suggests the utilization and operation of their resources vary considerably.

We also see variation in this trend consistent with prevailing economic activity. In Table 1, for the basic leverage ratio of equity to assets (E/A), we see a generally rising ratio. In 1993, the ratio was 8.5% while in 2008 it was 9.2%. These ratios appear to be in line with mandatory capital requirements. The decline from 9.4% in 1998 to 8.9% in 1999 reflects the tech stock problems of that time period. In Table 1, we also see a rising trend in the ratio of risk-based assets to total assets, which is consistent with Berger, DeYoung, Flannery, Lee, and Oztekin (2008). Here, however, the trend is far more pronounced rising from 43.80% in 1993 to 76.00% in 2008. Confirmation of these two trends comes from the trend in RC/RA, the ratio of Tier 1 plus Tier 2 capital to risk based assets. This ratio declines from 16.10% in 1993 to 14.50% in 2008. While these ratios are substantially above the Basle Capital Accord standards, the trend is clearly down.

Another dramatic trend over this time period is the increase in off-balance-sheet activity. In Table 1, the off-balance-sheet activities to total assets ratio (OBS) has increased from 12.00% in 1993 to 31.50% in 2008. While this trend is not a surprise we need to ask if there is capital to support this expansion and consider the make-up of the components of off-balance-sheet activities. It is unclear whether the impact of increased use of off-balance-sheet activities by BHCs may decrease or increase risk.

The time-varying over-all performance measures of our sample of BHCs such as pre-tax income(PTI), return on equity (ROE), nonperforming assets ratio (NPA), and the interest sensitive gap (Gap) are shaped by major economic occurrences and policies. Return on equity has varied in a relatively narrow band over this time period. With the exception of 2007 and 2008, the return on equity ranged from 12.20% to 13.50%. In line with the financial crisis that started in 2007 ROE declined to 11.00% in 2007 and to 8.40% in 2008. It is also noteworthy that the highest return on equity was in the first year of our sample period, 1993. Non-performing assets appear to move in concert with business cycles. The recovery and expansion period of 1993 to 1998 is marked by a steady decrease in the ratio of non-performing assets to equity. This is followed by an increase in this ratio during the tech-stock bubble and recession after which we see another decline until the crisis of 2007 and 2008.

Since the industrial structure of financial services changes intertemporally, we analyze the risk and use of capital by BHCs year by year. The analysis suggests banks progressively depend more on aggressive funding sources and new product lines over our sample period. Given that financial leverage (e.g., Equity/ Asset ratio) must remain approximately stable due to regulatory requirements, bankers may try to improve their ROE by (1) enhancing overhead efficiency (OHE), (2) engaging in more off-balance sheet activities (OBS), and (3) using interest-sensitive gap management in an attempt to decrease their total risk-based capital ratio (Cap) while maintaining an attractive ROE. The above developments in the banking industry generate potential improvement in performance but also intensify uncertainties and complexities of bank management. Therefore, a study to investigate the impact of the use of capital on the riskiness of banks is an indispensible element in bank management.

4.2. Instrumental variable

The statistical summary of our instrumental variable for each year is shown in Table 2. The dispersion of δ is substantial both cross-sectionally and intertemporally. For our sample, the distribution of δ in the same year tends to be skewed to the left-hand side and leptokurtic (i.e. has positive excess kurtosis). Therefore, we look at non-parametric statistics. We also test the validation of our instrumental variable to ensure the correctness of our empirical results. The validation test is discussed in Section 4.4.

[INSERT Table 2 ABOUT HERE]

Our findings are consistent with the results documented by Hughes, Mester, and Moon (2001), John, Saunders, and Senbet (2000), Keeley (1990), and Kim and Santomero (1988), the use of equity capital by banks, on average, triggers a loss in efficiency. But this is not true in all cases. Laeven and Levine (2009) confirm that the effect of regulation on bank risk-taking can be positive or negative depending on the bank's ownership structure. Also, Marcus (1984) argues that there is a bimodal distribution of bank risk. When bank charters have value due to barriers to entry into the industry, then banks choose either a high-risk strategy or a low-risk strategy. A midrange policy is sub-optimal. Decreases in charter value make the high-risk strategy more attractive. Banks adopt either a low-risk strategy to protect high charter value or a high-risk strategy to exploit the federal safety net.

4.3. Measures of bank risk

We investigate the risks faced by banks from various aspects. Table 3 displays the measures of risk used in this study: credit risk, liquidity risk, interest-rate risk, off-balance sheet (OBS) risk, market risk, composite risk and leverage risk. Credit risk is concerned with the quality of a bank's assets. Historically this has focused on a bank's loan portfolio but recent events have shown the importance of looking at all bank assets in light of potential default risk. Liquidity risk measures the ability of a bank to meet all cash needs at a reasonable cost whenever they arise. The absolute value of the gap between the interest-sensitive assets and liabilities, which is used to estimate interest-rate risk, is the extent to which banks have exposed themselves to market driven changes in the level of interest rates. We also collect data on off-balance-sheet activities and investigate their relationship with bank capital. Market risk is the risk of changes in asset prices that are beyond the control of bank management. Our composite risk measures are designed to capture the relationship between risky assets as a percentage of total assets and risk-free assets as a percentage of total assets. Finally, leverage risk is the risk arising from the capital structure decisions of the BHCs. The first six measures of risk relate to the various elements of business risk confronting bank management. Leverage risk, on the other hand, relates directly to the financial decisions taken in terms of the amount of capital employed. From another perspective it can be said that minimum capital requirements (i.e. maximum leverage standards) are mandated by regulators to mitigate the various elements of business risk that the BHC accepts.

[INSERT Table 3 ABOUT HERE]

Table 4 displays the Spearman correlation coefficients between bank size, risk, and performance with the instrumental variable for capital over the sample period. We look at this non-parametric test due to the non-normal distribution of the instrument and variables. In Panel A, the generally insignificant correlation between our instrument and the book value of assets in combination with the generally significant correlation of our instrument and the book value of equity justifies the use of δ as an instrument for capital. In addition, measured by book value of equity and pre-tax income, large BHCs tend to suffer a greater loss in efficiency than their smaller counterparts at a statistically significant level. On the other hand, the value of assets does not necessarily demonstrate a negative relation with bank efficiency. These findings suggest that the inefficiency of BHCs comes from the use of equity capital but is not directly led by the expansion of business scale and/or scope. Therefore, a careful investigation of the impact of capital on banking risks is appropriate.

[INSERT Table 4 ABOUT HERE]

In Panels B to H, we also show the correlation between our various measures of bank risk and bank capital. In Panel I, we show the correlation between measures of bank performance and bank capital. We find that higher capital, on average, is associated with lower ROE, over-head efficiency, and tax efficiency, but higher yields that involve assets in the measure, such like ROA, PTI/A ratio. The above finding suggests that the marginal efficiency of capital tends to decrease while asset returns increase.

4.4 Validity of instrument for bank capital

The problem with endogenous variables is that they are correlated with the error term and OLS is inconsistent. In other words, $E[\varepsilon_i \mid X] \neq 0$. A traditional solution is the use of an instrumental variable estimator such as a two-stage least squares estimator. As an example, let's say we have a model $y_i = x_i^{'} \beta + \varepsilon_i$, and we think the K variables x_i may be correlated with the error term ε_i. We need to identify a set of L variables z_i, where L is at least as large at K, such that z_i is correlated with x_i but not with ε_i. We cannot estimate β consistently by using the least squares estimator. But we can construct a consistent estimator of β by using the relationships among z_i, x_i, and ε_i . In Stage 1 we obtain the ordinary least squares predictions of Y, $\hat{Y}$, from a regression. In Stage 2 we estimate the coefficients by ordinary least squares regression of Y on $\hat{Y}$ and X.

The econometric evidence suggests that the instrument for capital generated by the two stochastic frontiers is free from any endogeneity problem with risk measures. First, we look at Panel A of Table 4 and note the strong correlation of our instrument with the BHCs' book value of equity. Next, we test whether the instrument for capital is uncorrelated with the error term of the second-stage regression shown as Equation (7). If there is an endogeneity problem between the risk and our instrumental variable, then there is correlation between the error term of the regression and the instrument. We use panel data for the entire sample period to generate the error term of each risk measure regressed on all independent variables, including the instrument for capital. As shown in Table 5, all variables demonstrate zero correlation with statistical significance. The instrument used in our paper soundly deals with the endogeneity problem between the capital and risk.

[INSERT Table 5 ABOUT HERE]

To further validate this instrumental variable, we first regress capital (*BVC*) on our control variables, the book value of assets (*BVA*) and the book value of assets squared (BVA^2). We then include our instrumental variable (δ) in the regression and look at the significance of the coefficient on the instrument. Specifically,

$$BVE = b_o + b_1 BVA + b_2 BVA^2 \quad , \qquad \text{(9) and}$$

$$BVE = b_o + b_1 BVA + b_2 BVA^2 + b_3 \delta \, . \qquad \text{(10)}$$

In Table 6, the coefficients for BVA and BVA^2 in both models are statistically significant. In all years, the coefficient on δ is highly significant as evidenced by the very strong *t* statistics. A highly significant coefficient of the instrument implies an instrument with high explanatory power. We note that for some of our sample BHCs, the inclusion of capital in our second stage frontier produces a reduction in efficiency while for other BHCs the inclusion of capital actually increases efficiency. There is no econometric requirement that the sign of an instrument and the sign of the endogenous variable it is replacing must be the same.

[INSERT Table 6 ABOUT HERE]

The above findings are consistent with the literature on bank capital and support the use of the proposed instrument. Due to the endogeneity problem, an appropriate instrumental variable for capital is needed when we study the relation between bank risks and capital. The above empirical evidence shows that δ can adeptly gauge the net effect of bank capital but is free from endogeneity problem with risk measures.

5. Hypotheses

We wish to analyze the different dimensions of risk that bank holding companies manage. Credit risk embraces the broad category of asset quality. The overarching hypothesis is that risk protection should increase as capital increases. All of our proxies for credit risk are ratios that increase as risk increases. As a result we expect to find a negative relationship with capital. In other words, if an increase in capital reduces risk, then we should find an inverse relationship between credit risk and capital. Our regressions should produce a negative coefficient on our instrument for capital.

Hypothesis 1: Credit risk declines as the level of capital increases.

Liquidity is defined as the ability to meet any and all cash needs precisely when they are due and at a reasonable cost. Liquidity risk is a measure of the bank's ability to accomplish this objective. Our proxies for liquidity risk are ratios that fall into two groups. One group is defined so that a higher ratio implies higher liquidity risk, such as the ratio of short-term purchased funds to total assets, while for the second group of ratios a high ratio implies lower liquidity risk, such as the ratio of cash to total assets. Therefore, we expect to find a negative relationship with our proxy for capital with the first group of ratios and positive with the second.

Hypothesis 2: Liquidity risk protection increases as the level of capital increases.

Though the level of interest rates is beyond the control of any BHC, bankers can and should manage the interest rate risk associated with the mismatch between fixed and variable rate assets and liabilities. Accordingly, our proxy for interest rate risk is the absolute value of the interest sensitive gap that is defined as interest sensitive assets minus interest sensitive liabilities. A large absolute value of the gap indicates that banks are either not aggressive in managing interest sensitive assets and liabilities or are speculating on changes in market yields. The risk in this situation is that if the interest rate change is opposite to the expected direction, the bank's net interest margin will decline. Since interest rate risk increases with the size of the interest sensitive gap we expect a negative relationship between the gap and capital.

Hypothesis 3: Interest rate risk declines as the level of capital increases.

Off-balance-sheet risk is designed to capture the risk of bank commitments and other risk exposures that do not appear on a BHC's balance sheet. The size and importance of these commitments and exposures have increased dramatically as BHCs have become more involved in derivative transactions in addition to their traditional unfunded loan commitments. All of our proxies for off-balance-sheet risk are ratios defined so that a high ratio signals a high level of risk. In other words, we expect to find a negative relationship between these off-balance-sheet risk ratios and the BHCs level of capital.

Hypothesis 4: Off-balance-sheet risk is mitigated as the level of capital increases.

Market risk is designed to capture the exposure of a BHC to volatility in asset values. While a BHC cannot control market risk, they can manage the level of assets and liabilities that are susceptible to changes in value as market conditions change. One proxy for market risk is the ratio of trading account assets to total assets. Market risk increases as this ratio increases so we expect to find an inverse relationship between our market risk proxy and out instrument for capital. Therefore, the coefficient on our instrument for capital should carry a negative sign. Our second proxy for market risk is the ratio of the market value of the investment portfolio to the book value of the investment portfolio. A greater cushion between market value and book value provides greater protection for all BHC creditors. In this case, market risk decreases as the ratio increases and we expect to find a positive sign on the coefficient of our instrument for capital.

Hypothesis 5: Market risk declines as the level of capital increases.

Our first composite risk measure calculates the amount of risky assets, as measured by the Basle Capital Accords standards, as a percentage of the total assets of the BHC. The provisions of the Capital Accords include a risk-weighting of all assets and the inclusion of off-balance-sheet exposures. This combines the elements of previously described risks both on and off of the balance sheet. Therefore BHC risk increases as this ratio increases and we expect to find a negative relationship between this proxy for risk and the instrument for capital. Accordingly, we should see a negative sign on the coefficient of capital from our regression. The second ratio that we employ is the ratio of risk-free assets to total assets. In this case it is clear that risk declines as the ratio increases and we should obtain a positive sign on the coefficient of the instrument for capital.

Hypothesis 6: Composite risk declines as the level of capital increases.

Leverage risk measures the amount of debt employed by a BHC. Leverage risk is sometimes referred to as financial risk and can be distinguished from the business risks that are analyzed by the risk measures discussed above. Our first three proxies for leverage risk are defined so that leverage risk decreases as the ratio increases. An example is the ratio of risk based capital to risk-based assets. As a result we expect to find a positive relationship between leverage risk and BHC capital. As our risk proxy increases risk decreases and therefore out proxy should increase as capital increases. In other words, in this case we should find a positive coefficient on our instrument for capital. Our final risk measure is the ratio of tier 2 capital to tier 1 capital. Here risk increases as the ratio increases so we expect to find a negative sign on our instrument for capital.

Hypothesis 7: Leverage risk decreases as the level of capital increases.

6. Major empirical results

We look at seven different measures of risk: credit risk, liquidity risk, interest rate risk, off-balance-sheet risk, market risk, composite risk and leverage risk. We also use several different proxies for each type of risk. In a general sense the first six types of risk are considered business risk while the last type measures financial risk. While some of the results support the proposition that increased capital requirements reduce risk in BHCs there are also statistically significant results that suggest the opposite, that BHCs increase risk as their capital ratios increase.

6.1 Panel data results

We wish to consider BHCs' responses to higher capital levels mandated by bank regulators. As noted above (in our methodology section) we use TSLS analysis with our panel data set. The instruments for credit risk are the spread between U.S. Treasury bond rates and Aaa corporate bonds and the growth rate in GDP per capita. We use the spread between the three-month Treasury bill and three-month commercial paper and the spread between the three-month Treasury bill and the ten-year Treasury note as our instruments for liquidity risk, interest rate risk and off-balance-sheet risk. For a market risk instrument we use the standard deviation of the return on the S&P 500 index along with the spread between the three-month Treasury bill and three-month commercial paper. We calculate the instrument for leverage risk by taking the average of the ratio of total equity to total assets for all banks and all years. Finally, our instruments for composite risk are the spread between Treasury bonds and Aaa corporate bond, the growth in GDP per capita and the average ratio of cash plus government securities to total assets.

In Table 7, we present the results from our panel data estimation and show the sign and significance of our proxies for each type of risk. The ratio of the allowance for loan losses to total loans and leases is our first look at credit risk. Here a high ratio would indicate a high level of risk in the loan portfolio as determined by the BHC's management and therefore the sign on the coefficient of our instrument for capital should be negative. Our result, however, shows a highly significant positive sign. In other words, the risk of the loan portfolio increases as capital increases. Our second proxy for credit risk is the ratio of non-performing loans to total loans and leases. Here again a high ratio implies high risk in the loan portfolio so our hypothesis predicts a negative sign on the relevant coefficient. We once again find the opposite result, a positive sign on the coefficient although this result is not highly significant. Our other credit risk proxies are the ratio of loan charge-offs to total loans and leases and the ratio of the annual provision for loan losses to total loans and leases. Both of these risk measures carry the anticipated negative sign with the former carrying low significance and latter being highly significant.

[INSERT Table 7 ABOUT HERE]

We next look at measures of liquidity risk. Our first two proxies measure the amount of cash to total assets and the amount of cash to short-term purchased funds. In both of these cases a high ratio implies more liquidity so our hypotheses anticipate a positive sign on the coefficient of our instrument for capital. Instead, both ratios are negative with one highly significant result and one result significant at the 5% level. Our other proxies for liquidity show short-term purchased funds, fed funds sold and fed funds purchased, each as a percentage of total assets. Short-term purchased funds are less stable than other types of bank liabilities so a high ratio implies more risk. As a result the sign on the coefficient of our instrument for capital should be negative and it is, and at a highly significant level. Fed funds sold represent highly liquid assets so a high ratio implies lower risk and we find the anticipated positive sign on the coefficient of our capital instrument but this is at a very low level of significance. Fed funds purchased are short-term liabilities so we should find a negative sign on the capital instrument for this risk measure and we do, and at a high level of significance.

We have defined interest rate risk as the risk that BHCs are in a position to control, not simply the market risk of rising or falling interest rates. Our proxy is the absolute level of the interest sensitive gap, defined as interest-sensitive assets minus interest-sensitive liabilities. Note that a positive gap indicates more interest-sensitive assets than interest-sensitive liabilities and therefore some interest-sensitive assets are funded by fixed-rate liabilities. A negative gap indicates the opposite and the BHC has some fixed-rate assets funded by interest-sensitive liabilities. The implication of the mismatched assets and liabilities is straight forward. We use the absolute level of the gap as our measure of risk since this risk is associated with the size of the gap and not whether interest rates go up or down. Since a large gap increases risk we anticipate a negative sign on the coefficient of our instrument for capital. This is what we find and the result is highly significant.

Our next risk category is off-balance-sheet risk. We measure this risk with five different ratios. Only one ratio, the ratio of interest rate derivatives held for trading to interest rate derivatives held for other purposes, provides a counterintuitive result. We assume that any interest rate derivative not held for trading is held for hedging purposes. A high ratio indicates a larger trading position and therefore more risk. Accordingly, our hypothesis is that the sign on the coefficient of our instrument for capital should be negative. Instead, for this ratio the sign is positive although at a very low level of significance. When we look at the ratios of off-balance-sheet assets to total assets and total derivatives to total assets we see the anticipated negative sign on the coefficient of our instrument for capital and at highly significant levels. Our final two risk measures are the credit equivalent derivatives to total assets and total derivatives to total risk-based assets. In both of these cases the sign on the coefficient of our instrument for capital is negative but at lower levels of significance than the previous measures carrying negative signs.

We turn our attention to market risk and look at the results for the ratio of trading assets to total assets and the ratio of the market value of investments to the book value of investments. We again find differing results. The first ratio, trading assets as a percentage of total assets, should be indirectly related to capital. A high ratio implies high risk and we hypothesize that the sign on our capital instrument should be negative. However, the sign is positive although at a low level of significance. For the second ratio, the market to book value of the investment portfolio, a high ratio indicates a cushion of safety for the BHC. Accordingly this measure should result in a positive coefficient on the instrument for capital and our results show this to be true. While the significance of this result is not high it is higher than the significance of our first ratio.

Perhaps one of the most important risk types we consider is our composite risk. The first composite risk measure is the ratio of risky assets, as measured by the Basle Capital Accords standards, compared with the total assets of the BHC. The provisions of the Capital Accords require that the calculation of risky assets must include both a risk-weighting of all assets and the inclusion of off-balance-sheet exposures. Therefore BHC risk increases as this ratio increases and we would expect to find a negative relationship between this proxy for risk and the instrument for capital. Instead we find a positive relationship at a highly significant level. Here we have important evidence that bank holding companies increase the risk in the earning asset portfolios as capital is increased. Our second measure of composite risk runs the other way. We look at the ratio of risk-free assets to total assets. Our risk-free category includes cash and government securities. Since a high ratio implies lower risk we expect to find a positive sign on our instrument for capital. Again the sign is the opposite of our hypothesis. In this case the sign is negative and highly significant. Taken together, these two results provide unambiguous evidence of the risk embodied in earning asset portfolios increasing as capital increases.

Our final risk type is leverage risk or financial risk. We test four different measures of leverage risk. The first two measures are standard leverage ratios. We look at the ratio of risk-based capital to risk-based assets. This is the primary Basle Accord capital ratio. Then we look at the accounting ratio of equity to assets. Both of these ratios produce a positive sign on the coefficient of our instrument for capital at a very significant level. However, this is true by definition. Since capital is in the numerator of these ratios as capital goes up so will the ratio. We also look at the ratio of tier 1 capital to risk assets and we get the same result, a positive sign on our instrument for capital at a highly significant ratio. Finally, we look at the ratio of tier 2 to tier 1 capital. For this ratio risk goes up as the ratio increases therefore we expect to find a negative sign on our instrument for capital and we do. Leverage risk is an appropriate risk type for analysis. But, as we have seen, increased capital lowers leverage by definition. The question we are asking is what happens to risk when mandated capital requirements are increased. Since more capital lowers leverage we must focus our attention on the other types of risk under study.

Performance measures represent another tool with which we can examine the impact of increased capital on BHC risk. We differentiate between a risk measure and a performance measure in that the level of a risk measure reflects BHC management decisions, while the performance measure is simply the result of the decisions taken. We employ the same panel data estimator to consider the impact of capital on these performance measures. We start by looking at the return on equity (ROE). It is not surprising that as capital goes up the return on equity goes down. We see this clearly in Panel B of Table 7. The coefficient of our capital instrument is negative and highly significant. This, however, is true by definition since capital is in the denominator of the ROE calculation. On the other hand, when the return on assets (ROA) is the dependent variable in our regression the sign on the coefficient of our instrument for capital is positive. In other words the ROA increases as capital increases. We argue here that BHCs are offsetting higher capital requirements and a declining ROE by increasing risk as a means to recover their ROE. We see the same phenomenon when we look at the BHCs' pre-tax ROA. This ensures that taxes are not driving the improved ROA. There are, then, only two possible was to increase the ROA. The BHC can become more efficient through cost controls or they can increase their net interest margin, the difference between what they earn on their assets and what they pay on their liabilities. When we use the ratio of non-interest expense to non-interest income as the dependent variable in our regression a positive sign is found on the coefficient of our instrument for capital. In other words, as capital increases so does this ratio and that means banks become more inefficient as capital increases. On the other hand, when the net interest margin is the dependent variable in our regression we get a positive sign on our instrument for capital but now it has an entirely different interpretation. Here we find that as capital increases the spread between earning assets and the cost of money funding the assets has widened. Since there is no reason to conclude that over the sixteen years of our study BHCs somehow found ways to raise funds more cheaply, the only explanation remaining is that BHCs have increased the risk in their earning asset portfolios.

7. Tests of robustness

In the previous section, our panel data empirical results suggest that higher capital does not necessarily mitigate the risks faced by banks. In this section, we further investigate the eight measures of risk that are inconsistent with the hypothesis that increased capital reduces risk in banks. We also present results from four measures of bank performance that further document a perverse impact from capital regulation. For tests of robustness, we analyze our data first using two-stage least squares on a year-by-year approach (in lieu of as a single panel) and then using a generalized method of moments (GMM) regression, again on a year-by-year basis. [8] We have limited our robustness tests to only those measures of risk that produced counterintuitive results. In other words, in our results section we argue that there is evidence that increasing capital

[8] The GMM result of the other variables is available upon request.

requirements does not reduce risk in banking. Here we provide robustness test only on that evidence.

7.1 Two-stage least squares in a year-by-year format

The results from employing two-stage least squares estimation on a year-by-year basis are shown in Table 8. Two of our proxies for credit risk produce a sign on the coefficient of our instrument for capital that is inconsistent with the hypothesis that higher capital reduces risk in banking. Our robustness tests provide support for our panel data results. The ratio of the allowance for loan losses as a percentage of total loans and leases carries the same inconsistent sign as our panel data in eight of the sixteen years of our study while. Our second credit risk proxy is the ratio of non-performing loans as a percentage of total loans and leases. In this case, the same inconsistent sign found in our panel results is found in five of the sixteen years. Please see Table 8.

[INSERT Table 8 ABOUT HERE]

A word of explanation is needed at this point. Our study is predicated on the belief that BHCs optimize their risk profiles across all of the various risk categories susceptible to bank management. Therefore, in any one year a BHC could be increasing credit risk and simultaneously decreasing liquidity risk. It is the net result of both actions that represents a change in the risk of the BHC. The same trade-offs could be made for the other risk categories including interest rate risk, off-balance-sheet risk, market risk, and composite risk. For this reason we do not believe our robustness tests will consistently provide the same results as our panel data for each of the sixteen years studied. Instead, we are looking for evidence that our panel data results are not clearly wrong.

Table 8 also shows two proxies for liquidity risk that provide counterintuitive results. The first measure is the ratio of cash to total assets. This ratio carries the same sign as our panel data results in 14 out of the 16 years of our study. The second liquidity measure is the ratio of cash to short-term purchased funds and it carries the same sign as our panel data in 10 of the 16 years. This is quite robust support for our argument when considering our explanatory note above.

The next risk category to be reviewed is off-balance-sheet risk and the risk proxy showing counterintuitive results is the ratio of derivatives held for trading compared with derivatives held for other purposes. We find consistent results for this measure in 10 of the 14 years for which we have data. We also have one measure of market risk that is inconsistent with our underlying hypothesis. The measure is the ratio of trading assets as a percentage of total assets and we find the same result as our panel data in four out of the fifteen years.

We have argued above that our composite risk measures capture more information than any of the other individual risk measures and it is with these composite risk measures that we find especially strong tests of robustness. One risk proxy is the ratio of risky assets as a percentage of total assets and this measure produces the same result as our panel data in 12 of the 16 years of our study. The second composite risk proxy is the ratio of risk-free assets as a percentage of total assets and in this case we find the same result as our panel data in 15 of the 16 years. We believe this also indicates our results are quite robust to the econometric technique employed.

In Table 8 we show the impact of changes in BHC capital on BHC performance measures. To summarize these results, BHCs' ROE declines as capital increases (almost by definition). But when we see an increase in ROA we need to look at the source of the improvement. We argue in our results section that the higher ROA is the result of a riskier earning asset portfolio because of the improved net interest margin while our data rule out improved expense control as the source of the higher ROA.

In Table 8 we see ROE declined in 11 of the 13 years while ROA increased in 15 of 16 years. The net interest margin increased in 15 of 16 years and is the logical driver of the higher ROA. There is no reason to believe BHCs somehow found a cheaper source of funds with which to support their earning assets therefore an increase in risk in the earning asset portfolio is the most probable cause. Non-interest expense as a percentage of non-interest income rose with increases in capital so there is no evidence of improved efficiency. The ratio of pre-tax income to total assets increased in 6 of 16 years so it may be that taxes explain part of the higher ROA.

7.2. *GMM estimation*

The results from GMM estimation are shown in Table 9. As described above we are only providing robustness tests on the risk measures that produced evidence of BHCs increasing risk when required to raise capital. The ratio of the allowance for loan loss as a percentage of total loans and leases produced a positive sign on the coefficient of our instrument for capital in 16 of 16 years. Our second credit risk proxy is the ratio of non-performing loans to total loans and leases. In this case we find the counterintuitive results in four of the sixteen years. The first liquidity risk proxy that was inconsistent with our basic hypothesis was the ratio of cash to total assets and we found confirming results in 8 of the 16 years studied. The second liquidity risk measure of interest is the ratio of cash to short-term purchased liabilities. In this case we found confirming results in 6 of the 16 years.

[INSERT Table 9 ABOUT HERE]

Our results for off-balance-sheet risk and market risk are not well supported using GMM estimation. Off-balance-sheet risk was proxied by the ratio of interest rate derivatives held for trading as a percentage of interest rate derivatives held for other purposes and we find counterintuitive results in only 1 of 14 years. Market risk was proxied by the ratio of trading assets to total assets and we find the counterintuitive results in only 1 of 16 years.

We also find disappointing results looking at our two composite risk measures. The first measure is the ratio of risky assets to total assets and we can confirm our panel data results in only 2 of 16 years. Our second measure is the ratio of risk-free assets to total assets and we find confirming results in 1 of 16 years. Since our results for these two ratios were very strong in our panel data analysis and in our two-stage least squares analysis on a year-by-year basis we are unable to interpret the GMM results.

On the other hand the GMM results are strongly consistent with our analysis of the impact of capital on BHC performance measures. ROE results are consistent with our counterintuitive panel data results in 15 of the 16 years in our study. The ratios of ROA, pretax-income to total assets, and the net interest margin are consistent with the panel data results in 16 of 16 years.

We conclude this robustness section with the observation that the above tests, reviewed in total, provide strong support for the conclusions arising from our panel data analysis in the cases dealing with our credit risk measures, liquidity risk measures, composite risk measures, and our performance measures. Weak support is provided for the other risk measures: off-balance-sheet risk and market risk.

8. Conclusions

In this study we thoroughly analyze nearly 25,000 company-year observations of bank holding company data from 1993 to 2008 to determine the relationship between capital and bank risk-taking. Our data cover a period containing significant changes in the banking industry and varying levels of economic activity. The Riegle-Neal and Graham-Leach-Bliley acts were passed during this time period and the tech-stock and housing bubbles both burst with attendant recessions. By including a larger size range of BHCs in our analysis over a long sample period, our results are applicable to relatively small BHCs as well as to the largest 200 or so BHCs traditionally included in empirical studies.

We employ stochastic frontier analysis to create a new type of instrumental variable for capital to be used in regressions of risk and capital thereby mitigating the obvious endogeneity problem. We provide a theoretical explanation and empirical evidence to validate the use of the instrument. To take into account "risk-taking coordination" suggested by Schrand and Ünal (1998), we apply two-stage least squares regression to a panel data set. Our study also employs two-stage least squares regression on a year-by-year basis and GMM estimation as robustness tests.

Our results are consistent with the theory that BHCs respond to higher capital levels by increasing the risk in their earning asset portfolios. We find a positive relationship between the proportion of risky assets held by a bank holding company and the amount of capital they hold. Higher capital induces bank holding companies to invest in more risky assets. In addition, two of our four proxies for credit risk produce a positive sign on the coefficient of capital while our hypotheses state that the signs should be negative. Likewise, two of our four proxies for liquidity risk produce the opposite sign than that anticipated by our hypotheses.

When we consider the relationship between capital and standard performance ratios we find that ROE declines as equity increases. This, of course, is true by definition. While, however, the ROE goes down the ROA goes up. A higher ROA can be achieved by better efficiency or a higher net interest margin. We find no evidence of increased efficiency and conclude that a higher net interest margin reflects higher yields on earning assets rather than a lower cost of money. Higher yields can only be associated with higher risk.

Our analysis adds to the existing literature with three contributions. First, we employ a large panel data set to consider the capital-risk relationship for a wider range of bank holding companies than previously reviewed. Second, stochastic frontier analysis is applied to exogenously generate the effect of the use of capital in banking. Finally, our results provide what we believe are important findings with potentially major public policy implications. If the primary tool used by bank regulators to ensure a stable financial system is, instead, creating perverse results then alternative tools must be developed. Further exploring the relationship between the efficiency of capital and the risk strategy adopted by a bank would be a further contribution to this literature.

References

Bank for International Settlements Staff, 2004, International convergence of capital measurement and capital standards: A revised framework, *BIS Staff Study*.

Berger, Allen N., Richard J. Herring, and Giorgio P. Szego, 1995, The role of capital in financial institutions, *Journal of Banking and Finance* 19, 393-430.

Berger, Allen N., Robert DeYoung, Mark J. Flannery, David Lee, and Ozde Oztekin, 2008, How do large banking organizations manage their capital ratios, *Journal of Financial Services Research* 343: 123-149.

Buser, Stephen A., Andrew H. Chen, and Edward J. Kane, 1981, Federal deposit insurance, regulatory policy, and optimal bank capital, *Journal of Finance* 36: 51–60.

Calomiris, Charles W., 1999, Building an incentive-compatible safety net", *Journal of Banking and Finance*, 23: 1499-1519.

Calomiris, Charles W. and Charles M. Kahn, 1991, The role of demandable debt in structuring optimal banking arrangements, *American Economic Review* 81:497-513.

Diamond, Douglas W. and Philip H. Dybvig, 1983, Bank runs, deposit insurance, and liquidity, *Journal of Political Economy* 91: 401-419.

Diamond, Douglas W. and Raghuram Rajan, 2000, A theory of bank capital, *The Journal of Finance* 55: 2431-2465.

Duan, Jin-Chuan, Arthur F. Moreau, and C. W. Sealey, 1992, Fixed rate deposit insurance and risk-shifting behavior at commercial banks, *Journal of Banking and Finance* 16: 715-742.

Esty, Benjamin C., 1998, The impact of contingent liability on commercial bank risk taking, *Journal of Financial Economics* 47: 189-218.

Flannery, Mark J. and Kasturi P. Rangan, 2008, What caused the bank capital build-up of the 1990s?, *Review of Finance* 12: 391-430.

Gatev, Evan, Til Schuermann and Philip E. Strahan, 2009, Managing bank liquidity risk: How deposit-loan synergies vary with market conditions, *Review of Financial Studies* 22: 995-1020.

Gorton, Gary and George Pennacchi, 1992, Financial innovation and the provision of liquidity services, in James R. Barth and R. Dan Brumbaugh, eds.: *Reform of Federal Deposit Insurance*, (Harper Collins, New York).

Hamilton, James D., 1994, *Time Series Analysis* (Princeton University Press, Princeton, NJ).

Hovakimian, Armen and Edward J. Kane, 2000, Effectiveness of capital regulation at U.S. commercial banks: 1985 to 1994, *Journal of Finance* 55: 451-468.

Hughes, Joseph P., Loretta J. Mester, and Choon-Geol Moon, 2001, Are scale economies in banking elusive or illusive? Incorporating capital structure and risk into models of bank production, *Journal of Banking and Finance* 25: 2169–2208.

Hughes, Joseph P., William W. Lang, Loretta J. Mester, Choon-Geol Moon, and Michael Pagano, 2003, Do bankers sacrifice value to build empires? Managerial incentives, industry consolidation, and financial performance, *Journal of Banking and Finance* 27: 417-447.

John, Kose, Anthony Saunders, and Lemma Senbet, 2000, A theory of bank regulation and management compensation, *Review of Financial Studies* 13: 95-125.

Jondrow, James, C. A. Knox Lovell, Ivan S. Materov, and Peter Schmidt, 1982, On the estimation of technical inefficiency in the stochastic frontier production function model, *Journal of Econometrics* 19: 233-238.

Keeley, Michael, 1990, Deposit insurance, risk, and market power in banking, *American Economic Review* 80: 1183-1200.

Keeley, Michael C., 1992, Bank capital regulation in the 1980s: Effective or ineffective?, in Anthony Saunders, Gregory F. Udell and Lawrence J. White, eds.: *Bank Management and Regulation: A Book of Readings* (Mayfield Publishing Company: Mountain View, California).

Kim, Daesik, and Anthony M. Santomero, 1988, Risk in banking and capital regulation, *Journal of Finance* 42: 1219-1233.

Laeven, Luc A. and Ross Levine, 2009, Bank governance, regulation and risk taking, *Journal of Financial Economics* 93: 259-275.

Marcus, Alan J., 1984, Deregulation and bank financial policy, *Journal of Banking and Finance* 8: 557-565.

Marcus, Alan J and Israel Shaked, 1984, The valuation of FDIC deposit insurance using option-pricing estimates, *Journal of Money, Credit and Banking* 16: 446-460.

Merton, Robert C., 1977, An analytic derivation of the cost of deposit insurance and loan guarantees, *Journal of Banking and Finance* 1: 3-11.

Prescott, Edward S., 1997, The pre-commitment approach in a model of regulatory banking capital, *Economic Quarterly* 83: 23-50.

Santos, Joao A. C., 2001, Bank capital regulation in contemporary banking theory: A review of the literature, *Financial Markets, Institutions and Instruments* 10: 41-84.

Schrand, Catherine, and Ünal, Haluk, 1998, Hedging and Coordinated Risk Management: Evidence from Mutual-to-Stock Conversions, *Journal of Finance* 53: 979-1013.

Shrieves, E., Dahl D., 1992, The relationship between risk and capital in commercial banks, *Journal of Banking and Finance* 16: 439-457.

VanHoose, David, 2007, Theories of Bank Behavior under Capital Regulation. *Journal of Banking and Finance 31*, 3680-3697.

Table 1. Statistical Summary

The numbers of bank holding companies (BHCs) and statistics of their Book value of asset (BVA) over sample years are reported. The means of other descriptive statistics are listed: BE=Book value of equity; PTI=Pre-tax income; ROE=Return of equity; OHE (Over head efficiency) =Noninterest expenses/Noninterest income; OBS/A (Off-Balance Sheet Activities) =All OBS activities/Total assets; RA/A (Risk-based asset ratio)=Total Risk-based assets / Total assets; RC/RA (Total Risk-based Capital Ratio) = (Tier 1 Capital + Tier 2 Capital) / Total Risk-Based Asset; E/A=Total Equity/ Total Asset; NPA (Nonperforming assets ratio)= Nonperforming assets / Total equity capital; Gap (Interest sensitive gap) = (IS assets - IS liabilities) / Total asset. The BVA, BE, and PTI are in million US dollar.

Year	*N*	BVA (US$ Million)				BE	PTI	ROE	OHE	OBS/A	RA/A	RC/RA	Eq/A	NPA	Gap
		Mean	Max	Min	SD										
1993	1,525	2,630	216,574	22	12,260	207	43	0.135	4.10	0.120	0.438	0.161	0.085	0.069	0.160
1994	1,306	3,442	250,489	8	15,334	265	57	0.125	4.45	0.139	0.470	0.164	0.087	0.060	0.166
1995	1,355	3,526	256,853	27	16,410	283	62	0.124	4.18	0.240	0.493	0.172	0.093	0.052	0.160
1996	1,405	3,516	336,099	28	18,238	283	63	0.127	4.27	0.220	0.585	0.148	0.093	0.047	0.121
1997	1,493	3,614	365,521	30	20,027	281	65	0.127	4.04	0.222	0.607	0.146	0.094	0.043	0.086
1998	1,563	3,742	668,641	32	28,629	292	62	0.124	4.04	0.218	0.621	0.157	0.094	0.039	0.073
1999	1,658	3,845	716,937	38	29,651	292	75	0.130	4.18	0.215	0.652	0.151	0.089	0.041	0.032
2000	1,726	3,674	715,348	38	29,664	293	66	0.122	4.11	0.190	0.672	0.145	0.091	0.045	0.042
2001	1,818	3,869	693,575	38	31,651	319	56	0.117	3.77	0.224	0.682	0.145	0.091	0.055	0.026
2002	1,968	3,911	758,800	40	32,953	330	66	0.124	3.72	0.215	0.681	0.149	0.093	0.056	0.066
2003	2,129	3,960	820,103	41	34,712	334	75	0.127	3.71	0.224	0.688	0.152	0.093	0.056	0.079
2004	2,240	4,558	1,157,248	40	45,012	421	77	0.123	3.99	0.225	0.709	0.150	0.092	0.044	0.115
2005	2,252	5,407	1,494,037	40	55,416	466	91	0.130	4.15	0.242	0.725	0.147	0.090	0.041	0.115
2006	969	10,842	1,463,685	43	76,903	942	179	0.124	3.49	0.338	0.764	0.137	0.091	0.046	0.086
2007	888	10,801	1,720,688	72	88,290	1,010	152	0.110	3.82	0.322	0.778	0.133	0.092	0.085	0.076
2008	678	13,884	2,175,052	79	123,635	1,194	70	0.084	3.21	0.315	0.760	0.145	0.092	0.085	0.041

Table 2. Distribution of Instrumental Variable for Capital (δ)

Descriptive statistics of the instrumental variable for capital over sample years are presented. The instrumental variable $\delta = u - \varsigma$ is a measure of incremental bank inefficiency due to capital level, where the stochastic frontiers are $PTI = a + b_1 BVA + b_2 (BVA)^2 + e$, $e = \xi - \varsigma$, and $PTI = \alpha + \beta_1 BVA + \beta_2 (BVA)^2 + \beta_3 BVC + \varepsilon$, $\varepsilon = v - u$.

Year	Mean	SD	Skewness	Kurtosis	Max	Min
1993	-0.038	0.106	-0.167	1.936	0.470	-0.494
1994	-0.040	0.112	-0.386	3.394	0.511	-0.805
1995	-0.036	0.114	-0.196	3.791	0.551	-0.753
1996	-0.041	0.111	-0.037	1.852	0.506	-0.557
1997	-0.223	0.162	-2.848	16.357	0.302	-1.253
1998	-0.032	0.112	-0.018	3.332	0.544	-0.744
1999	-0.053	0.144	-0.266	1.274	0.502	-0.714
2000	-0.054	0.144	-0.101	1.358	0.541	-0.761
2001	-0.049	0.144	-0.146	1.286	0.558	-0.624
2002	-0.042	0.153	-0.160	1.707	0.726	-0.739
2003	-0.021	0.151	0.078	0.573	0.540	-0.559
2004	-0.021	0.121	0.070	1.425	0.531	-0.634
2005	-0.024	0.122	0.044	2.229	0.555	-0.841
2006	-0.016	0.137	-0.506	4.024	0.519	-1.006
2007	-0.015	0.190	-0.438	1.536	0.542	-0.616
2008	-0.012	0.049	-2.758	27.015	0.129	-0.581

Table 3. Variables

Symbol	Definition
Leverage	
Eq/A	Total Equity/ Total Asset
RC/RA	Capital Requirement Ratio (Total Risk-based capital / Total Risk-based Assets)
Tier 1/RA	Tier 1 capital/ Total Risk-based Assets
Tier 2/Tier 1	Tier 2 Capital/ Tier 1 Capital
Credit Risk	
NPL/LL	Nonperforming Assets / Total Loans and Leases
Charge-offs/L	Net Loan Charge-offs / Total Loans and Leases
Provision/L	Annual Provision for Loan Losses / Total Loans and Leases
Allowance/L	Allowance for Loan Losses / Total Loans and Leases
Liquidity Risk	
STPF/A	Short-term Purchased Funds (Eurodollars, federal funds, security RPs, large CDs and commercial paper) / Total Assets
Cash/A	Cash and Due from Other Banks / Total Assets
FFS/A	(Federal Funds Sold + Reverse RPs - Sum of Federal Funds Purchased - RPs) / Total Assets
FFP/A	(Federal Funds Purchased + RPs) / Total Assets
Cash/STPF	Cash and Due from Other Banks / Short-term Purchased funds (Eurodollars, Federal Funds, Security RPs, Large CDs and Commercial Papers)
Interest Rate Risk	
Gap	Interest Sensitive Gap (IS assets - IS liabilities) /Total Assets
Off-balance-sheet Risk	
OBS/A	Off-Balance-Sheet Assets / Total Assets
Der/A	Credit Equivalent Amount of Off-Balance-Sheet Derivative Contracts /Total Assets
Der/RA	Credit Equivalent Amount of Off-Balance-Sheet Derivative Contracts / Total Risk-based Assets
IR Der	Notional Amount of Interest Rate Derivatives held for Trading / Notional Amount of Interest rate Derivatives held for Other Purposes
FX Der	Notional Amount of Foreign Exchange Derivatives held for Trading/Notional Amount of Foreign Exchange Derivatives held for Other Purposes
Eq Der	Notional Amount of Equity Derivatives held for Trading /Notional Amount of Equity Derivatives held for other Purposes
Cmd Der	Notional Amount of Commodity Derivatives held for Trading / Notional Amount of Commodity Derivatives held for other Purposes
Der/A	Total Derivatives/Total Assets
Market Risk	
Trading assets	Trading Account Assets /Total Assets
Trading A/L	Trading Account Assets / Trading Account Liabilities
Investment	Market Value of Investment Portfolio / Book Value of Investment Portfolio
Composite Risk	
RA/A	Total Risk-based Assets /Total assets
HLA/A	Cash Assets and Government Securities / Total Assets
Performance	
PTI/A	Pre-Tax Income/Asset
ROE	Return on Equity
ROA	Return on Asset
ATR	Average Tax Rate (Taxes/Pre-Tax Income)
Spread	Earning Spread (Interest income/(Loan + Investment)-(Interest expenses/Deposits))
OHE	Overhead efficiency (Noninterest expenses/Noninterest income)

Table 3. Variables (continued)

Instrumental Variables Used in Panel Analysis	
CRP	Credit Risk Premium. The difference between 10 year Moody's AAA yield and 10 year Treasury Security yield.
GDPg	GDP growth. The change in GDP in the year.
LRP	Liquidity Risk Premiums. The difference between 3-Month Commercial Paper rate and Treasury Bill Secondary market rate.
LRP1	Liquidity Risk Premiums 1. The difference between 10-Year Treasury Security yield and 3-
SPSD	Market Volatility. The standard deviation of the daily return of the S&P 500 index in the year.
Average Equity Ratio	The average of Equity ratio in the year.
Average HLA/A Ratio	The average of Highly Liquid Assets to Total Assets ratio in the year.

Table 4. Spearman's Rank Correlation Coefficient

Spearman's rank correlation coefficients between bank size, each risk measure variable, and performance with δ, the instrument for capital, for each year are reported.

Panel A. Bank Size (Book Value of Asset, Book Value of Equity, Pre-Tax Income)

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
BVA	0.27	0.02	-0.01	-0.01	0.01	-0.07	-0.01	-0.03	-0.03	0.01	0.03	0.25	0.07	0.07	0.00	-0.01
p-value	0.001	0.409	0.422	0.429	0.412	0.101	0.413	0.323	0.327	0.450	0.337	0.000	0.145	0.136	0.495	0.467
BE	0.51	0.27	0.23	0.32	0.34	0.26	0.32	0.31	0.30	0.33	0.34	0.51	0.34	0.33	0.26	0.20
p-value	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PTI	0.38	0.09	0.04	0.13	0.13	0.04	0.13	0.16	0.20	0.20	0.17	0.35	0.23	0.23	0.16	0.17
p-value	0.000	0.123	0.304	0.005	0.006	0.247	0.007	0.002	0.000	0.000	0.003	0.000	0.000	0.000	0.008	0.002

Panel B. Leverage Risk

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Eq/A	0.71	0.82	0.83	0.90	0.89	0.83	0.89	0.89	0.93	0.91	0.92	0.72	0.90	0.90	0.91	0.92
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RC/RA	0.41	0.42	0.46	0.43	0.44	0.44	0.44	0.44	0.39	0.42	0.42	0.41	0.42	0.42	0.36	0.40
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tier 1/RA	0.38	0.45	0.50	0.44	0.42	0.46	0.44	0.44	0.45	0.44	0.44	0.44	0.44	0.44	0.44	0.44
p-value	0.000	0.000	0.000	0.000	0.009	0.003	0.004	0.005	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.004
Tier 2/Tier 1	-0.23	-0.37	-0.38	-0.33	-0.36	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35	-0.35
p-value	0.006	0.000	0.000	0.002	0.001	0.001	0.006	0.002	0.003	0.004	0.003	0.003	0.003	0.003	0.003	0.003

Panel C. Credit Risk

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
NPL/LL	-0.02	-0.03	0.02	-0.02	-0.03	-0.02	0.01	-0.03	-0.05	-0.05	-0.02	0.01	-0.04	-0.08	-0.05	-0.07
p-value	0.412	0.340	0.418	0.346	0.285	0.290	0.407	0.291	0.209	0.189	0.381	0.453	0.246	0.118	0.215	0.123
Charge-offs/L	0.01	0.02	0.05	0.03	0.02	0.02	0.06	0.03	0.02	0.00	0.00	0.10	-0.01	-0.04	-0.07	-0.08
p-value	0.452	0.415	0.270	0.328	0.341	0.360	0.142	0.290	0.396	0.489	0.498	0.048	0.410	0.282	0.148	0.106
Provision/L	0.01	-0.13	-0.18	-0.11	-0.14	-0.14	-0.08	-0.14	-0.13	-0.15	-0.15	-0.06	-0.15	-0.17	-0.13	-0.07
p-value	0.442	0.052	0.010	0.083	0.052	0.052	0.065	0.005	0.010	0.005	0.006	0.160	0.008	0.004	0.022	0.142
Allowance/L	0.18	0.08	0.08	0.13	0.12	0.13	0.17	0.13	0.15	0.14	0.14	0.17	0.11	0.06	0.05	0.02
p-value	0.021	0.144	0.135	0.045	0.069	0.068	0.001	0.012	0.005	0.009	0.011	0.003	0.038	0.168	0.204	0.350

Panel D. Liquidity Risk

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
STPF/A	-0.05	-0.10	-0.11	-0.30	-0.34	-0.38	-0.38	-0.38	-0.36	-0.34	-0.41	-0.16	-0.31	-0.40	-0.39	-0.45
p-value	0.287	0.104	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000
Cash/A	-0.01	0.01	0.04	0.03	0.04	0.06	0.00	0.04	0.00	-0.01	-0.02	-0.06	-0.09	-0.13	-0.01	-0.07
p-value	0.440	0.474	0.290	0.252	0.209	0.133	0.487	0.260	0.490	0.446	0.379	0.176	0.073	0.025	0.430	0.142
FFS/A	-0.16	-0.04	0.01	0.05	0.05	0.17	0.06	0.08	0.08	0.08	0.03	-0.10	-0.01	-0.04	0.09	0.00
p-value	0.037	0.294	0.471	0.177	0.148	0.000	0.127	0.081	0.070	0.077	0.287	0.048	0.461	0.279	0.091	0.485
FFP/A	0.04	-0.04	-0.15	-0.32	-0.33	-0.43	-0.39	-0.35	-0.32	-0.29	-0.34	-0.12	-0.65	-1.00	-0.99	-1.00
p-value	0.346	0.289	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.023	0.000	0.000	0.000	0.000
Cash/STPF	-0.04	-0.03	-0.04	-0.10	-0.10	-0.10	-0.13	-0.11	-0.10	-0.09	-0.13	-0.08	-0.20	-0.31	-0.24	-0.31
p-value	0.431	0.434	0.374	0.266	0.241	0.196	0.315	0.240	0.275	0.261	0.288	0.250	0.277	0.266	0.259	0.295

Panel E. Interest Rate Risk

Gap	0.07	-0.07	-0.08	-0.05	-0.08	-0.03	-0.11	-0.05	-0.06	-0.02	-0.07	-0.03	-0.05	-0.06	-0.09	-0.10
p-value	0.207	0.019	0.015	0.014	0.016	0.255	0.021	0.163	0.141	0.352	0.117	0.326	0.203	0.185	0.092	0.054

Panel F. Off-balance-sheet Risk

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
OBS/A	-0.10	-0.16	-0.19	-0.29	-0.28	-0.26	-0.29	-0.26	-0.28	-0.29	-0.28	-0.18	-0.29	-0.28	-0.30	-0.30
p-value	0.328	0.247	0.128	0.070	0.064	0.113	0.084	0.101	0.104	0.153	0.101	0.150	0.120	0.113	0.117	0.116
Der/A	-0.93	-0.99	-0.96	-0.96	-0.94	-0.92	-1.00	-0.92	-0.92	-0.90	-0.89	-0.96	-1.02	-1.00	-1.00	-1.00
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Der/RA	-0.21	-0.20	-0.29	-0.28	-0.26	-0.29	-0.26	-0.28	-0.22	-0.27	-0.27	-0.27	-0.26	-0.26	-0.26	-0.24
p-value	0.319	0.227	0.195	0.140	0.129	0.225	0.168	0.201	0.208	0.306	0.202	0.288	0.240	0.225	0.176	0.175
IR Der	-0.14	-0.16	-0.20	-0.25	-0.27	-0.27	-0.28	-0.27	-0.26	-0.26	-0.27	-0.25	-0.25	-0.27	n.a	n.a
p-value	0.256	0.276	0.179	0.119	0.087	0.103	0.115	0.111	0.121	0.149	0.152	0.149	0.158	0.143	n.a	n.a
FX Der	-0.16	-0.48	-0.56	-0.59	-0.60	-0.60	-0.61	-0.62	-0.60	-0.59	-0.58	-0.59	-0.62	-0.63	n.a	n.a
p-value	0.085	0.103	0.093	0.065	0.045	0.039	0.043	0.045	0.046	0.053	0.059	0.060	0.061	0.060	n.a	n.a
Eq Der	-0.71	-0.35	-0.38	-0.42	-0.43	-0.44	-0.44	-0.44	-0.43	-0.42	-0.43	-0.43	n.a	n.a	n.a	n.a
p-value	0.000	0.122	0.123	0.103	0.080	0.086	0.094	0.092	0.099	0.119	0.123	0.122	n.a	n.a	n.a	n.a
Cmd Der	-0.89	-0.45	-0.31	-0.31	-0.34	-0.35	-0.36	-0.36	-0.35	-0.35	-0.35	-0.35	n.a	n.a	n.a	n.a
p-value	0.000	0.109	0.135	0.110	0.083	0.073	0.079	0.082	0.084	0.095	0.106	0.109	n.a	n.a	n.a	n.a
Der/A	-0.39	-0.54	-0.44	-0.44	-0.45	-0.45	-0.45	-0.46	-0.46	-0.44	-0.42	-0.38	-0.26	-0.12	-0.07	-0.06
p-value	0.132	0.167	0.145	0.107	0.085	0.105	0.100	0.106	0.111	0.144	0.129	0.146	0.123	0.126	0.130	0.257

Panel G. Market Risk

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Trading assets	-0.75	-0.92	-0.96	-1.00	-0.99	-0.97	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98	-0.98
p-value	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trading A/L	-0.57	-0.13	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.11	-0.10	-0.09	n.a
p-value	0.044	0.153	0.207	0.204	0.176	0.163	0.164	0.165	0.170	0.190	0.206	0.214	0.214	0.206	0.206	n.a
Investment M/B	0.20	0.21	0.16	0.15	0.16	0.14	0.14	0.17	0.13	0.16	0.14	0.13	0.16	0.13	0.13	n.a
p-value	0.059	0.070	0.118	0.070	0.059	0.052	0.050	0.050	0.051	0.041	0.057	0.063	0.041	0.038	0.059	n.a

Panel H. Composite Risk

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
RA/A	-0.10	-0.18	-0.15	-0.21	-0.22	-0.15	-0.20	-0.20	-0.17	-0.12	-0.16	-0.10	-0.11	-0.16	-0.15	-0.20
p-value	0.144	0.012	0.022	0.000	0.000	0.001	0.000	0.000	0.002	0.020	0.004	0.047	0.047	0.008	0.012	0.000
HLA/A	-0.01	0.01	0.02	0.05	0.07	0.09	0.03	0.07	0.08	0.10	0.09	0.04	0.07	0.04	0.12	-0.07
p-value	0.476	0.443	0.382	0.168	0.089	0.041	0.274	0.096	0.088	0.042	0.059	0.250	0.130	0.291	0.032	0.142

Panel I. Performance

	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
PTI/A	0.12	0.06	0.06	0.22	0.16	0.32	0.26	0.34	0.42	0.39	0.32	0.19	0.39	0.35	0.36	0.44
p-value	0.100	0.215	0.235	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
ROE	0.20	-0.37	-0.43	-0.40	-0.43	-0.28	-0.32	-0.24	-0.18	-0.28	-0.31	-0.35	-0.26	-0.26	-0.26	-0.19
p-value	0.138	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001
ROA	0.10	0.07	0.06	0.20	0.17	0.31	0.29	0.36	0.43	0.40	0.36	0.24	0.45	0.42	0.41	0.48
p-value	0.136	0.175	0.214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATR	0.19	0.03	0.00	0.02	-0.03	-0.06	-0.08	-0.06	-0.06	-0.04	-0.10	-0.11	-0.14	-0.13	-0.06	-0.09
p-value	0.018	0.353	0.488	0.312	0.245	0.120	0.079	0.148	0.163	0.236	0.056	0.043	0.012	0.024	0.164	0.064
Spread	0.05	0.19	0.20	0.16	0.17	0.14	0.23	0.21	0.22	0.10	0.17	0.05	0.10	0.10	0.08	0.17
p-value	0.287	0.009	0.005	0.057	0.019	0.058	0.000	0.000	0.000	0.041	0.002	0.226	0.050	0.060	0.124	0.003
OHE	-0.15	-0.04	-0.05	-0.08	-0.05	-0.05	0.00	-0.01	-0.02	0.23	0.04	-0.10	-0.01	0.00	-0.01	0.00
p-value	0.049	0.295	0.244	0.053	0.167	0.154	0.490	0.439	0.366	0.113	0.264	0.054	0.454	0.477	0.453	0.489

Table 5. Endogeneity Test

The table shows the correlation of the error term of the second-stage regression as shown in Equation (7) with the instrumental variable for capital. The various measures of risk shown in the table are the dependent variables on the left-hand side of Equation (7) in our regressions. Note again that the correlations shown in the table are for the error term with the instrument.

Panel A. Leverage Risk

Dependent Variable	Correlation
Eq/A	0.00
p-value	0.000
RC/RA	0.00
p-value	0.000
Tier 1/RA	0.00
p-value	0.000
Tier 2/Tier 1	0.00
p-value	0.006

Panel B. Credit Risk

Dependent Variable	Correlation
NPL/LL	0.00
p-value	0.000
Charge-offs/L	0.00
p-value	0.000
Provision/L	0.00
p-value	0.000
Allowance/L	0.00
p-value	0.021

Panel C. Liquidity Risk

Dependent Variable	Correlation
STPF/A	0.00
p-value	0.000
Cash/A	0.00
p-value	0.000
FFS/A	0.00
p-value	0.000
FFP/A	0.00
p-value	0.000
Cash/STPF	0.00
p-value	0.000

Panel D. Interest Rate Risk

Dependent Variable	Correlation
Gap	0.00
p-value	0.000

Panel E. Off-Balance-Sheet Risk

Dependent Variable	Correlation
OBS/A	0.00
p-value	0.000
Der/A	0.00
p-value	0.000
Der/RA	0.00
p-value	0.000
IR Der	0.00
p-value	0.000
FX Der	0.00
p-value	0.000
Eq Der	0.00
p-value	0.000
Cmd Der	0.00
p-value	0.000
Der/A	0.00
p-value	0.000

Panel F. Market Risk

Dependent Variable	Correlation
Trading assets	0.00
p-value	0.000
Trading A/L	0.00
p-value	0.044
Investment M/B	0.00
p-value	0.006

Panel G. Composite Risk

Dependent Variable	Correlation
RA/A	0.00
p-value	0.000
HLA/A	0.00
p-value	0.005

Table 6. Validation of Instrumental Variable

To validate the instrument variable, we run two regression models. Model 1: $BVE = b_o + b_1 BVA + b_2 BVA^2$ and Model 2: $BVE = b_o + b_1 BVA + b_2 BVA^2 + b_3 \delta$

Year	Model	*BVA*	*t*	*BVA*^{2}	*t*	δ	*t*
1993	1	1.249	21.340	-0.009	-4.192		
	2	1.266	50.202	-0.009	-10.386	2.362	81.680
1994	1	1.025	12.612	-0.001	-0.491		
	2	1.036	24.837	-0.002	-1.257	2.219	60.378
1995	1	1.126	14.086	-0.005	-1.826		
	2	1.006	25.573	-0.001	-0.891	2.160	65.159
1996	1	1.013	12.943	-0.001	-0.454		
	2	0.871	23.143	0.003	2.537	2.173	68.393
1997	1	0.961	12.862	0.000	0.058		
	2	0.948	15.414	0.000	-0.169	0.990	26.621
1998	1	0.899	11.647	0.002	0.881		
	2	0.823	23.536	0.005	4.064	2.344	77.823
1999	1	0.835	10.470	0.005	1.707		
	2	0.789	19.882	0.006	4.515	1.897	70.971
2000	1	0.859	11.000	0.004	1.516		
	2	0.795	22.172	0.007	5.265	1.891	80.371
2001	1	0.852	11.147	0.004	1.710		
	2	0.815	18.406	0.006	3.980	1.788	59.970
2002	1	0.862	11.532	0.004	1.639		
	2	0.771	17.126	0.007	4.814	1.661	58.773
2003	1	0.846	11.826	0.005	1.985		
	2	0.853	17.800	0.005	3.077	1.583	51.080
2004	1	0.825	12.563	0.006	2.636		
	2	0.754	20.221	0.008	6.403	2.149	68.534
2005	1	0.873	13.533	0.004	1.909		
	2	0.778	22.595	0.007	6.331	2.239	75.261
2006	1	1.225	11.831	-0.007	-2.146		
	2	1.095	15.297	-0.003	-1.225	1.711	32.563
2007	1	0.963	9.450	0.002	0.608		
	2	0.896	12.442	0.004	1.701	1.098	29.807
2008	1	0.928	4.242	0.002	0.268		
	2	0.696	4.278	0.007	1.401	8.050	23.426

Table 7. Panel Data Two-stage Least Squares Regressions

The regression coefficients, b_k, on the instrumental variable for capital are reported. We use the forecasted values from the first-stage regression to control the relation among variables. Specifically, $y_k = c_i + b_k \delta_i + \gamma_k \ln(BVA_i) + \sum_{\substack{j=1 \\ j \neq k}}^{J} h_j \hat{y}_j + \zeta_k$, where

y_k is one of the measures of risk or performance (e.g. Credit Risk or Return on Equity) for bank i; c_i is a constant; b_k is the coefficient of the instrumental variable of capital, δ_i, γ_k is the coefficient of natural logarithm of bank's book value; h_j is the coefficient of the fitted values of our endogenous risk measures, $\hat{y}_j$, and ζ_k is the error term. All variables are defined in Table 3.

Proxy	Instrument	Coefficient	*p*-value	Spearman ρ	*p*-value
Credit Risk					
NPL/LL	CRP, GDPG	0.001	0.20	-0.050	0.31
Charge-offs/L		-0.001	0.20	-0.030	0.34
Provision/L		-0.003	0.00	-0.030	0.36
Allowance/L		0.003	0.00	0.100	0.19
Liquidity Risk					
STPF/A	LRP, LRP1	-0.023	0.00	-0.300	0.00
Cash/A		-0.006	0.00	-0.040	0.01
FFP/A		-0.020	0.00	-0.520	0.00
Cash/STPF		-215.9	0.05	-0.050	0.27
Interest Rate Risk					
|GAP|	LRP, LRP1	-0.030	0.00	-0.050	0.00
Off-balance-sheet Risk					
OBS/A	LRP, LRP1	-0.001	0.00	-0.970	0.00
Der/A		-0.157	0.00	-0.910	0.00
Der/RA		-0.664	0.11	-0.920	0.00
IR Der		1.396	0.95	0.140	0.13
CD Der/A		-0.352	0.15	-0.860	0.00
Market Risk					
Trading Assets	SPSD, LRP	0.001	0.84	0.098	0.32
Investment		0.003	0.07	0.170	0.06
Leverage Risk					
Eq/A	Eq/A avg, HLA/A	0.148	0.00	0.810	0.00
RC/RA		0.163	0.00	0.410	0.00
Tier 1/RA		0.199	0.00	0.370	0.00
Tier 2/Tier 1		-0.227	0.00	-0.230	0.02
Composite Risk					
RA/A	HLA/A	0.028	0.00	0.440	0.00
HLA/A	LRP, LRP1	-0.009	0.00	-0.040	0.02
Performance					
ROE	Asset, RC/RA	-0.072	0.00	-0.290	0.00
ROA		0.009	0.00	0.260	0.00
PTI/A		0.010	0.00	0.230	0.00
ATR		0.197	0.22	0.080	0.35
Spread		0.007	0.55	0.100	0.11
OHE		0.550	0.01	0.060	0.32

Table 8. Results of Year-by-Year Two-Stage Least Squares Regressions

The table reports the coefficient on our instrument for capital when regressed with the following risk measures as the dependent variable and the respective p-value for the year-by-year two-stage least squares regressions. We select one risk measure from each group as the proxy for the same class of risk and identify instrumental variables that can be used as regressors to estimate the risk proxies at the first-stage regressions. The predicted values $\hat{y}_k$ that are derived in the first stage are then used as regressors to test the relation between banking capital and the risk category represented by the risk proxy being tested. The second stage regression is: $y_{k,t} = c_{t,t} + d_{k,t,t}\delta_{i,t,t} + f_{k,t,t}\ln(BVA) + \sum_{\substack{j=1 \\ j\neq k}}^{J} h_{j,t}\hat{y}_{j,t} + \zeta_{k,t}$.

Variables	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Credit Risk																
NPL/L	-0.070	-0.004	0.000	0.000	0.005	0.309	-0.002	0.015	-0.002	-0.033	-0.033	0.015	-0.079	0.034	-0.660	-0.004
p-value	0.000	0.569	0.980	0.980	0.186	0.365	0.782	0.282	0.916	0.002	0.002	0.229	0.019	0.720	0.001	0.192
Allowance/L	-0.017	0.000	0.001	-0.067	-0.002	0.297	0.001	0.002	0.018	-0.136	0.006	0.006	-0.076	0.043	-2.091	0.025
p-value	0.095	0.891	0.662	0.219	0.520	0.217	0.847	0.683	0.226	0.565	0.651	0.785	0.046	0.548	0.000	0.057
Liquidity Risk																
Cash/A	-0.126	-0.114	-0.236	-0.399	-0.296	-2.058	-0.361	-0.290	-0.090	0.364	-0.264	-0.033	-0.401	-0.719	-0.779	0.004
p-value	0.006	0.000	0.000	0.228	0.000	0.018	0.000	0.000	0.096	0.579	0.000	0.583	0.059	0.026	0.096	0.668
Cash/STPF	-667.0	-174.1	-7096.3	-6490.1	-718.3	-7251.5	-304.9	-35.3	1273.5	165.2	34.5	-110.3	306.6	4069.5	1269.5	-1942.3
p-value	0.585	0.858	0.092	0.781	0.729	0.753	0.552	0.565	0.785	0.788	0.197	0.584	0.780	0.755	0.913	0.338
HLA/A	-0.130	-0.106	-0.293	-0.387	-0.366	-0.321	-0.457	-0.360	-0.217	-0.241	-0.287	-0.197	-0.208	-0.167	-0.164	0.002
p-value	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.833
Off-balance-sheet Risk																
IR Der	-0.991	19.1	58.5	-533.1	33.7	-1.464	6.963	259.0	4424.9	321783.6	220.7	6936.8	9268.7	-18058.3	na	na
p-value	0.541	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-
Market Risk																
Trading Assets	-0.023	0.021	-0.008	-0.008	-0.011	-0.023	-0.014	0.135	-0.026	-0.001	-0.001	-0.005	-0.011	0.003	0.021	-0.001
p-value	0.174	0.001	0.039	0.039	0.000	0.530	0.000	0.000	0.005	0.918	0.918	0.370	0.213	0.000	0.483	0.8727
Leverage Risk																
RA/A	0.295	-1.024	0.323	18.778	-0.025	0.718	0.457	0.459	1.378	8.541	4.855	0.762	2.498	-7.376	15.89	-0.056
p-value	0.087	0.000	0.000	0.000	0.835	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.002	0.596
Performance																
ROE	-0.105	-0.237	-0.204	1.805	-0.192	-11.679	-0.135	0.010	0.201	-0.482	0.257	-0.190	0.090	-0.363	-6.255	-0.098
p-value	0.090	0.000	0.000	0.060	0.000	0.000	0.011	0.891	0.282	0.834	0.015	0.030	0.630	0.395	0.014	0.000
ROA	0.024	0.025	0.019	0.069	0.027	0.981	0.012	0.001	0.015	0.011	0.034	0.011	0.005	-0.020	0.050	0.0164
p-value	0.001	0.000	0.000	0.432	0.000	0.000	0.002	0.923	0.306	0.947	0.000	0.131	0.728	0.578	0.000	0.000
PTI/A	-0.028	-0.038	-0.018	0.082	-0.033	-1.310	-0.022	0.001	0.007	-0.084	0.047	-0.014	0.092	-0. 0001	-0.634	0.022
p-value	0.001	0.000	0.007	0.456	0.000	0.003	0.030	0.883	0.740	0.753	0.000	0.434	0.019	0.998	0.000	0.000
Spread	0.038	0.021	0.054	0.072	0.021	11.226	0.005	0.010	0.020	0.040	0.016	0.011	-0.025	0.019	9.708	0.016
p-value	0.030	0.000	0.000	0.733	0.000	0.000	0.000	0.619	0.000	0.000	0.000	0.000	0.000	0.878	0.000	0.000

Table 9. Results of Robustness Test Using Generalized Method of Moments Year-by-Year

We report the GMM regression coefficients of $b_{k,t}$ for each dependent variable k in each year t are reported. Specifically, $y_{k,t} = c_t + b_{k,t}\delta_{i,t} + \gamma_{k,t}\ln(BVA) + \eta_{k,t}$, where $y_{k,t}$ is one of the measures of risk or performance (e.g. Total Equity/ Total Asset) for bank i in year t; c is a constant; $b_{k,t}$ is the coefficient of instrumental variable of capital, $\delta_{i,k}$, for k's regression in year t; $\gamma_{k,t}$ is the coefficient of natural logarithm of bank's book value; and $\eta_{k,t}$ is the error term.

Variables	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993
Credit Risk																
NPL/L	-0.074	-0.006	-0.002	0.002	0.007	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	-0.004	-0.004	-0.009	-0.001	-0.003
p-value	0.022	0.017	0.219	0.134	0.007	0.000	0.258	0.402	0.373	0.246	0.415	0.012	0.028	0.003	0.437	0.204
Allowance/L	0.009	0.002	0.002	0.006	0.006	0.005	0.004	0.006	0.004	0.005	0.006	0.001	0.004	0.001	0.008	0.026
p-value	0.013	0.049	0.015	0.000	0.000	0.000	0.000	0.005	0.003	0.000	0.000	0.332	0.043	0.306	0.086	0.145
Liquidity Risk																
Cash/A	0.001	-0.001	-0.012	-0.004	0.005	0.007	0.005	0.006	0.002	-0.004	0.005	-0.018	-0.023	-0.031	-0.004	0.002
p-value	0.487	0.397	0.046	0.409	0.224	0.131	0.272	0.121	0.405	0.218	0.252	0.015	0.001	0.000	0.300	0.441
Cash/STPF	172.87	-21.99	-904.47	276.21	193.34	72.96	58.75	88.84	-4.764	39.15	195.89	-0.744	-5434.9	356.92	2.226	-1990.9
p-value	0.112	0.347	0.180	0.007	0.137	0.143	0.035	0.248	0.470	0.197	0.235	0.489	0.157	0.063	0.493	0.088
HLA/A	0.011	0.000	-0.020	0.014	0.029	0.024	0.020	0.026	0.035	0.039	0.060	0.027	0.069	0.043	0.127	0.002
p-value	0.346	0.484	0.013	0.234	0.002	0.003	0.021	0.001	0.006	0.000	0.000	0.024	0.002	0.031	0.000	0.441
Off-balance-sheet Risk																
IR Der	-0.002	-0.304	-0.173	-0.104	-0.291	-0.157	-0.121	-0.019	-4.707	-1.127	-3.398	-1.459	1.383	-2.868	na	na
p-value	0.397	0.146	0.070	0.006	0.071	0.065	0.084	0.440	0.097	0.228	0.080	0.210	0.334	0.010	-	-
Market Risk																
Trading Assets	-0.028	0.001	-0.023	-0.007	-0.007	-0.002	-0.005	-0.003	-0.009	-0.006	-0.009	-0.004	-0.014	-0.010	-0.009	-0.003
p-value	0.062	0.399	0.049	0.003	0.020	0.173	0.056	0.104	0.040	0.075	0.067	0.047	0.077	0.077	0.074	0.252
Overall Risk																
RA/A	-0.035	-0.105	-0.045	-0.199	-0.242	-0.152	-0.155	-0.152	-0.154	-0.114	-0.165	-0.049	-0.066	0.021	0.070	-0.118
p-value	0.375	0.000	0.150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.106	0.116	0.372	0.172	0.225
Performance																
ROE	0.024	-0.061	-0.124	-0.146	-0.136	-0.108	-0.058	-0.037	-0.055	-0.065	-0.098	-0.010	-0.058	-0.063	-0.015	-0.083
p-value	0.317	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.000
ROA	0.022	0.004	0.005	0.009	0.008	0.008	0.011	0.013	0.012	0.013	0.013	0.011	0.017	-0.160	0.016	0.018
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
PTI/A	0.027	0.006	0.009	0.013	0.011	0.010	0.015	0.017	0.017	0.019	0.017	0.015	0.023	0.020	0.020	0.024
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Spread	0.042	0.009	0.030	0.019	0.017	0.021	0.019	0.021	0.019	0.011	0.020	0.006	0.032	0.016	0.117	0.042
p-value	0.059	0.000	0.010	0.000	0.000	0.049	0.000	0.000	0.000	0.000	0.000	0.033	0.019	0.000	0.179	0.001