Forthcoming, JMCB

Maintaining Adequate Bank Capital

by

Mark J. Flannery
Warrington College of Business Administration
University of Florida
flannery@ufl.edu

April 1, 2013

Prepared for the *Conference on Post-Crisis Banking*, De Nederlandsche Bank, June 28-9, 2012. I would like to thank the following individuals for helpful discussions about bank capital and capital regulation: Viral Acharya, Darrell Duffie, Walter Engert, Wilson Ervin, Ken Garbade, Paul Glasserman, Bev Hirtle, Jamie McAndrews, Hamid Mehran, George Pennacchi, Enrico Perotti, Matt Richardson, Marc Saidenberg, Til Scheurmann, Jeremy Stein, Kevin Stiroh, James Vickery, and Zhenyu Wang. Their insights and information have greatly contributed to this paper. Ben Mandel and especially Maxim Dolinsky provided excellent research assistance. Remaining errors, and all opinions, are my own. Financial support from the Europlace Institute of Finance is gratefully acknowledged.

1. INTRODUCTION

The Basel Committee on Bank Supervision (BCBS) has complex rules for defining sufficient capital at internationally active financial institutions. Pillar II of the Basel Accord requires national supervisors to assure continuous compliance with capital standards. At the end of 2007, the vast majority of U.S. banks and bank holding companies (BHCs) easily complied with minimum capital requirements. Yet even banks with very high book capital ratios encountered funding difficulties during the ensuing financial crisis, leading to unprecedented and costly government support for the financial sector.

How could a system that defined and monitored bank and BHC capital positions so carefully have permitted such catastrophic losses? Many reasons have been suggested. In this paper I document that bank supervisors have often failed to distinguish between minimum required capital and the amount of loss-absorption available to large regulated firms. To some extent, this reflects the fact that regulations and statutes focus on book equity measures. But managers can distort asset and liability values within the confines of GAAP and regulatory accounting rules. Accounting distortions become more substantial when a bank encounters difficulties, making book equity measures least informative when capital value is most relevant to a firm's viability.[1]

Nearly all banking firms are short-funded and therefore subject to potential runs. The largest (systemically important) financial institutions operate with substantial uninsured short-term liabilities. Their viability depends on market assessments of solvency, which determine whether short-term liability holders will roll over their investments. If not, the bank fails. An imminent run often provides the impetus for regulators to take aggressive action. But by this

time, regulatory choices are few: provide government support or let the firm fail. Unlike the largest BHC, which rely heavily on uninsured short-term liabilities, many other banks are funded with substantial amounts of insured deposits. These deposits are unlikely to run even if the market suspects that the issuing bank is insolvent. While deposit insurance protects these institutions from destructive bank runs, that protection is a two-edged sword. The absence of deposit runs removes market pressure for supervisors to assess the bank's solvency.

The proper role of market assessments in bank supervision is a controversial topic. Some observers assert that banks' unusual opacity makes them difficult for outsiders to value accurately. But even if market assessments are prone to errors, they still drive both equity values and depositor runs. Book capital provides no protection from loss or runs, yet supervisors remain bound to book capital measures by law and regulation. A loss of equity market value need not be reflected in book equity measures, impeding supervisors' ability to require a bank to augment its capital when it experiences a large loss. The supervisory metric for judging sufficient capital is thus seriously flawed – perhaps fatally.[2] Under these constraints, supervisors have been unable to force large banks continuously to maintain market-valued equity cushions that place their solvency beyond question. For example, adequate book capital measures prevented regulators from mandating dividend restrictions in 2008, even as the firms' market equity ratios were plunging. Another example: the FSA permitted Northern Rock to pay out "excess" capital a few weeks before its demise, based on its book capital ratios (Herring (2010), page 271).

This paper examines the extent to which large U.S. bank holding companies have held sufficient economic capital to make default unlikely. I begin by showing that the concept of "adequate" bank capital includes a time dimension. As in Pennacchi (1987), the adequacy of a

capital cushion depends on both portfolio risk and the period of time for which that initial cushion must protect liability-holders from loss. This time dimension was recognized in the initial Basel calibrations, but receives little on-going attention. Section 4 of this paper applies the concept of adequate capital to annual data from the largest twenty-five U.S. bank holding companies over the period 1987-2011. Assuming normally-distributed asset returns, the value of the presumed government guarantee for these large BHC averaged 11.4% of the BHCs' equity market value. Section 5 "re-runs history" by computing how much additional capital each BHC would have required to keep its one-year PD below Basel's intended 0.1% at each yearend date.[3] (This exercise necessarily ignores the Lucas critique.) During just the pre-crisis period (1987-2006), a policy of promptly replacing lost equity would have reduced guarantee values from 6.8% of equity value to 1.3%. Section 6 evaluates the prospects for "better" capital regulation in the future. Regrettably, I find little hope that existing supervisory procedures will perform better under Basel III. It is therefore worth considering alternative mechanisms for dealing with inadequately capitalized banks. I evaluate two such mechanisms: the "bail in" dimension of Dodd-Frank's orderly resolution process and contingent convertible bonds ("cocos"). The paper concludes by suggesting that adequate bank capital should be viewed in market value terms.

2. THE CONCEPT OF "ADEQUATE" CAPITAL

The level of a bank's capital divides risky outcomes among equity holders, debt holders, and perhaps the government. A bank's survival probability is therefore an important policy parameter. The Basel standard seemingly specifies that a bank's capital ratio should correspond to a default probability (PD) < 0.1% for a one-year horizon. According to Gordy and Howells (2006), "For large, well-diversified banks, regulatory capital under the IRB ("internal ratings based") approach should roughly approximate VaR for a one-year solvency probability of

99.9%." (p. 397). In their implementation of Basel II for the United States, federal regulators confirmed this solvency standard.[4]

< Insert Figure 1 about here >

How would adequate capital ratios look if they always provided PD $\leq$ 0.1% for a one-year horizon? Consider a portfolio of long-maturity securities with no prepayment risk, whose annualized return follows a normal diffusion process. The portfolio's equity financing is levered with fixed-maturity debt, and earnings are paid out continuously to the owners. Thus, only the initial capital protects the liability holders from default. More equity makes the debt safer because the owner has agreed to accept more of the downside risk. The "adequate" capital ratio – the minimum required to make the debt's probability of full repayment equal 99.9% -- depends on both the asset portfolio's volatility and the maturity of liabilities used to finance the portfolio.

Figure 1 plots the capital ratio required to provide 99.9% solvency over alternative liability maturities for various asset return volatilities.[5] Consider the case of asset volatility (σ) equal to 4% per year, which is slightly below the average for large U.S. bank holding companies over 1986-2011. Adequate capital is 0.78% for overnight debt finance (as in the repo market), 3.57% for one-month debt, and 27.64% for five-year debt. The required equity capital in this example would be 12.36% for Basel's one-year horizon.[6] Not surprisingly, adequate capital increases substantially with increases in portfolio return volatility. As asset volatility rises from 1% to 5.5%, the adequate initial capital ratio for a one-year default horizon rises from 2.59% to 16.50%.

The examples in Figure 1 can be extended to a conventional banking firm, which can be viewed as a leveraged investor subject to some type of margin calls. The initial capital ratios adequately protect liability holders only if the market value of equity is re-set to the minimum

required ratio at the end of each period (Pennacchi (1987)). For example, if the portfolio is financed with five sequential, one-year bond issues, the "margin calls" occur annually and the portfolio must be funded with at least 12.36% capital at each anniversary. If, after one year, equity is below 12.36% it must be restored immediately. If equity has risen above 12.36%, the excess may be withdrawn. If a capital-deficient bank at t=1 is permitted to continue operating, the ensuing PD exceeds the socially optimal level, which means that a guaranteed (TBTF) bank draws a larger conjectural subsidy from the government.

Having established a minimum solvency standard, Basel's Pillar 2 admonishes national supervisors to assure that their banks have an adequate capital planning process. If supervisors find a deficiency in this process, they

> should seek to intervene *at an early stage* to prevent capital from falling below the minimum levels required to support the risk characteristics of a particular bank and should require *rapid remedial action if capital is not maintained* or restored. (BCBS (2006), page 212, emphasis added)

Among the "range of options" supervisors should consider is "requiring banks to raise additional capital immediately" (BCBS (2006, page 212). Even if the problem lies in the bank's risk management or capital planning process, "increased capital might be used as an interim measure while permanent measures to improve the bank's position are being put in place" (BCBS (2006, page 212). Despite this Pillar 2 language, the U.S. evidence (below) indicates that large BHCs with low capital ratios have not generally taken "rapid remedial action." (This probably reflects the fact that GAAP valuation options permit large banks to avoid reporting inadequate capital.) Because the amount of "adequate" equity capital depends on the amount of time it takes to restore adequate capital following a decline, a lax enforcement of Pillar 2's recommended remediation raises the level of adequate bank capital.[7] If inadequate equity can be remedied overnight, the adequate capital ratio would be 0.78%. A one-month delay in replacing lost

equity value or reducing portfolio size requires a minimum capital ratio of at least 3.57%. And so forth. Faster restoration means that any given solvency probability can be assured with a lower level of initial capital, ceteris paribus.

3. ASSESSING SOLVENCY

A financial institution can continue normal operations so long as it is "solvent" – that is, so long as it can meet its financial obligations as they come due. The literature identifies two types of solvency. A firm is *balance sheet* solvent if the value of its assets exceeds the value of its liabilities. If the firm were wound up in an orderly fashion, shareholders would receive positive value (ignoring transaction costs). Alternatively, a firm may be balance sheet insolvent but *cash flow* solvent. Such a firm can postpone default if sufficient assets mature before each liability comes due. Eventually, however, maturing assets become insufficient to pay off maturing liabilities.

In the absence of deposit insurance, cash flow solvency is irrelevant for banks that use short-term liabilities to fund long-term, illiquid assets.[8] Banking theory (going back to Diamond and Dybvig (1983)) points out that maturity transformation makes a bank unstable ("fragile"). When opaque assets cannot be sold for their fair value on short notice, thinly capitalized banks may be subject to two rational expectations equilibria. If short-term depositors believe that others will roll over their claims, the bank need not liquidate and is solvent. But if short-term depositors refuse to roll over their claims, the bank must liquidate its asset portfolio, at a cost that may exhaust its equity. Even the *possibility* of insolvency creates uncertainty about how losses might be assigned in a (lengthy) bankruptcy process, and depositors might rationally run. During the recent crisis, policymakers chose to avoid disruptive bankruptcy proceedings by sheltering even financial firms' most junior creditors from loss.[9]

These market valuations are most pertinent to the largest U.S. BHC, which fund themselves substantially with uninsured short-term liabilities. Their survival depends on market investors believing that they are balance sheet solvent. Central bank lending facilities are designed to prevent liquidity-induced insolvencies (Goodhart (1990)), but bankers fear that publicly tapping such a lending facility will exacerbate, not ameliorate, depositor concerns.[10] Runs force supervisors to assess solvency.

Deposit insurance can insulate a bank from market-value-motivated runs if it has a large base of insured deposits. Such banks can continue to attract deposit funds on the strength of their federal guarantees. The supervisory challenge with these institutions is to act upon balance sheet insolvency in the absence of depositor runs. An insolvent firm's owners operate with extremely poor incentives. For example, its managers prefer to raise portfolio risk, gambling for resurrection. The U.S. savings and loan crisis illustrates that the expected return to risk-taking in such circumstances is negative.

Recent history illustrates the irrelevance of book capital measures for assuring solvency. Kuritzkes and Scott (2009) report that five large U.S. financial firms that failed or were acquired in 2008 reported Tier 1 book capital ratios between 12.3% and 16.1% in their final quarterly financial statements (Bear Stearns, Lehman Brothers, Washington Mutual, Wachovia and Merrill Lynch). Despite these high regulatory capital ratios, investors refused to roll over their short-term liabilities and the firms failed. Reported book values were viewed as over-stating the effective capital cushions. By contrast, investors impound into equity prices their contemporaneous, forward-looking expectations about the value of a bank's assets and liabilities – that is, about the firm's solvency. Figure 2 plots average equity ratios and CDS spreads for the traded SCAP institutions (GMAC is not publicly traded), between 2004 and early 2009.

Throughout the period, book equity's relationship to total assets remained steady, even as equity's market value ratio and CDS spreads began to deteriorate in the second half of 2007. Which measure of bank condition looks more accurate in hindsight?

< Insert Figure 2 about here >

Supervisors and bankers often assert that outside investors do not know the true value of a banking firm because its assets are unusually opaque.[11] Even if this were largely correct, note two facts. First, as in Figure 2, market values reflect deteriorating conditions sooner than book values.[12] Second, the short-term uninsured liability holders share equity holders' (the market's) information about bank solvency. Unless the bank appears solvent, short-term creditors will refuse to roll over their claims. Even if market investors are valuing a particular bank inappropriately, the resulting deposit runs threaten the bank's survival and require a supervisory response. Too often, this response occurs after conditions have deteriorated so much that the bank cannot raise new equity.[13]

If the future supervisory system will resemble that of the past, it is important to understand the extent to which supervisory forbearance has permitted banking firms to operate with "inadequate" capital, and what costs such policies have imposed on the public purse. I now turn to computing the default probabilities implied by equity market valuations for U.S. banks with traded shares, over the period 1987-2011.

4. HISTORICAL CAPITAL ADEQUACY

The Dodd-Frank Act of 2010 (DFA) empowers FDIC to engineer an "orderly resolution" designed to permit large financial institutions to fail with minimal effects on financial system stability. Nevertheless, a sufficiently large financial firm seems likely to be afforded TBTF support even in the absence of wider systemic problems, particularly if the firm has substantial

cross-border operations.[14] Unfortunately, the largest U.S. BHC have been operating with default probabilities far in excess of the 0.01% standard underlying the Basel formulae.

A firm's default probability depends on its asset return volatility, equity cushion, and debt maturity (Merton (1977), Crosbie and Bonn (2003)). Ronn and Verma (1986) present a method for inferring a firm's asset return volatility (σ_v) and asset portfolio market value (V) from its equity market value, equity return volatility, and nominal liabilities. They begin by observing that equity is a call option on levered assets:

$$E = VN(x) - \rho BN(x - \sigma_v\sqrt{T}) \tag{1}$$

$$x = \frac{\ln(\frac{V}{\rho B}) + \sigma_v^2 T/2}{\sigma_v T} \tag{2}$$

$$\sigma_v = \frac{\sigma_E E}{VN(x)} \tag{3}$$

where E is the market value of equity, V is the market value of assets, B is the book value of total liabilities, σ_v is the annualized standard deviation of asset returns, σ_E is the expected equity return volatility, and N(•) is a cumulative normal density function. Note that V includes the present value of all expected future cash flows, including those from its intangible assets such as goodwill, deferred tax assets, or OTC market-making. Ronn and Verma assume that the call option's strike price is ρB ($\rho \leq 1$) because supervisors tend to close banks only sometime after they have become insolvent. For any given liability maturity (or examination interval) T, equations (1) and (3) can be solved numerically for the asset portfolio's market value and asset volatility.

I collect accounting data from the Federal Reserve's FR-Y9C for all U.S. top-tier BHC with traded equity, identified from the New York Federal Reserve's web site (http://www.newyorkfed.org/research/banking_research/datasets.html). In order to concentrate

on the most important financial firms, I limit my attention to the largest 25 BHC at each yearend, measured by on-book assets. This is not a constant set of banks. Across the 1986-2011 period, a total of 68 separate banks are included in the data set.[15] Daily stock returns for these BHC were collected from CRSP. E is measured as the market value of common equity on the year's last trading day and σ_E is measured as the annualized standard deviation of the BHC's daily equity returns over the year's final quarter. Following Ronn and Verma (1986) and others, I set $T = 1$ and $\rho = 0.97$, and then compute $\hat{V}$ and $\hat{\sigma}_v$ at each year-end.[16] Some years exhibited extreme return equity volatilities, which imply implausibly large values for $\hat{\sigma}_v$. I therefore impose an arbitrary upper limit on σ_E such that

$$\sigma_E < (10\%)\frac{B+E}{E}$$

In words, this would constrain the estimated annual $\hat{\sigma}_v$ below about 10% if all BHC liabilities were riskless. This procedure reduced the equity volatility estimate for a small number (5.08%) of bank-year observations. Table 1 defines variables and presents summary statistics.

< Insert Table 1 about here >

< Insert Figure 3 about here >

Figure 3 plots each year's mean $\hat{\sigma}_v$ (left axis) and two equity ratios (E/$\hat{V}$ and BVEQ/TA)) for the largest 25 BHC. Note that the average book capital ratio roughly doubled between the late 1980s and 2011, growing along a rather smooth path. In contrast, the average market capital ratio rises only through 2000. During the crisis, we see a sharp increase (decrease) in $\hat{\sigma}_v$ (E/$\hat{V}$): volatility soared while equity values plunged. Between 1997 and 2002 both asset volatility and equity ratios plateau. This was a "golden period" for banking: the ratio of market to book equity values averaged 2.86 over these six years, exceeding the level observed for any similar-length period over the prior century (Flannery and Rangan (2008)). The mean (median) correlation

between the book and market capital ratios across years for the sample banks with at least five annual observations is 0.46 (0.49). The correlations range from -0.42 to +0.94.

4.1. Estimated BHC Default Probabilities

< Insert Figure 4 about here >

The equity ratio and estimated equity volatility together imply a one-year default probability at the end of each bank-year:

$$\text{PD} = N\left(\frac{\widehat{V}-B}{\widehat{V}\,\widehat{\sigma}_V}\right)$$

Figure 4 plots the sample's mean default probabilities for firms that were solvent at the end of each year.[17] The shaded bars in Figure 4 depict the number of firms that were insolvent at the end of each year, defined as having estimated asset values ($\widehat{V}$) below the book value of their liabilities. (Table 2 provides further information about insolvencies.) High failure probabilities for 1987-1990 and the recent crisis years dominate this figure's vertical scale. After Basel I was fully implemented in the U.S. (at yearend 1992), PDs fell sharply.

< Insert Figure 5 about here >

While Figure 4's vertical scale is dominated by the early and late crisis periods, Figure 5 plots the same mean and median data, along with each year's maximum PD, on a larger scale for the intervening years. Even during the golden period of 1997-2002, the largest BHCs' PDs were higher than policymakers had intended: for 1998 - 2000 and 2002 the average PD exceeded 1%. In all of the other years plotted in Figure 5, the average PD far exceeded the 0.01% Basel standard except in 2006. These PD calculations indicate that the high asset volatilities in Figure 3 dominated high capital ratios over this time period.[18]

Compliance with Basel's nominal 0.01% standard has been poor. Out of 624 bank-years in the entire sample, 417 (66.8%) had default probabilities exceeding 0.1% and 341 (54.6%) had

estimated PDs > 0.5%. In all sample years except 2006, at least one of the top 25 BHC was more likely to default than the Basel standard indicates they should be. It is not very surprising that the incidence of high PDs is relatively concentrated among the larger BHC. Table 2 reports the extent of insolvency and high PDs for each sample year, for a variety of critical PD levels. In the columns headed "Asset Size Ratio" I report the ratio of the overly-risky BHCs' total assets to those of the BHC that meet the indicated solvency criterion. The Asset Size Ratios generally (but not always) exceed unity, consistent with larger BHC operating with higher default probabilities than their smaller counterparts. Table 2 further indicates that a surprisingly large number of BHC failed to comply with even a 1% PD standard in the early years (before Basel I took full effect in the U.S.) and during the recent crisis. But many firms operated with relatively high PDs even during the "calm" years of 1993-2006.

Table 3 presents information about the number of banking firms that violated the Basel solvency standard (PD $\leq$ 0.1%) more than once while they were among the largest 25 BHC. Only five of the 68 sample BHCs never violated this constraint. At the other extreme, 15 out of 68 sample BHC operated with PD > 0.1% in ten or more years – that is, for 40% of the sample period. The same general pattern applies to the higher PD standards described in the rightmost three columns of Table 3: a large majority of the sample firms violated these solvency levels more than once, and inadequate capital was permitted to linger at some important institutions.[19]

4.2. Estimated Value of Historical Guarantees

The estimated asset return distributions imply a value for each BHC's default put option – a value largely borne by taxpayers under a TBTF regime. The total value of federal guarantees for the largest 25 banks are reported in Table 4. I have not netted FDIC insurance premia against these computed values, which makes them over-estimate the social cost of risky banks.[20] On the

other hand, the calculations assume that assets can be liquidated at their fundamental values; any fire sale discount would make the put value higher, as would an asset return distribution with fatter tails (than the normal).

For now, consider only the leftmost two columns in Table 4, which report the historical mean and median values of government guarantees on the largest 25 BHC. Because the crisis period differed so greatly from the prior two decades, I report guarantee values separately for the overall period and two sub-periods: 1987-2006 and 2007-2011. Panel A indicates that the mean value of conjectural government insurance exceeded 11.4% of these sample firms' equity values over the full time period (1987-2011). Not surprisingly, this magnitude is higher during the most recent five years (29.9% of equity market value vs. 6.8%). Panel B reports the total value of all sample BHCs' guarantees in billion dollars. Prior to 2007, the value of these guarantees averaged less than $4 billion per year (= $73 bn / 20 years). The guarantee numbers are far larger during the crisis period (2007-11), averaging $173.6 billion annually.

< Insert Figure 6 about here >

Figure 6 breaks down the average information from Panel A of Table 4 across time by plotting mean and median ratios of the historical guarantee value to the BHCs' equity market value in each year.[21] In 2008, the guarantee's value substantially exceeds equity value for the mean BHC, implying that at least some firms were economically insolvent in the absence of government support. (One institution in 2008 had a guarantee worth about ten times its equity market value.) Although most extreme guarantee values occurred in the recent crisis years, a few large BHC also traded extensively on their government backing in the years surrounding the 1990-1 recession. Between the two peaks, the guarantees contributed little to the average large BHC's market value.

5. SIMULATING A "TIMELY RECAPITALIZATION" POLICY

Pillar 2 of the Basel Accord requires that supervisors control PD and insurance values by promptly forcing high-risk BHC to restore adequate capital ratios. How much added capital would have been required to implement this policy in the U.S. over the past quarter-century? Specifically, how much additional capital would have been needed to maintain all large BHCs' PDs below 0.1%? I simulate this "timely recapitalization" policy in two steps. First, I assume that any solvent BHC whose PD > 0.1% at yearend would immediately issue enough new shares to reduce its PD to 0.1%. The new equity replaces liabilities in the BHC's capital structure.[22] An insolvent BHC cannot issue equity unless the government first puts in enough capital to restore its solvency. I assume that this is done, after which the BHC sells enough equity privately to bring its PD down to the critical level. Second, if a BHC has more than adequate capital at yearend, I raise its PD back up toward 0.1% by "repurchasing shares" that had previously been issued under this policy. Repurchased shares are funded by a contemporaneous increase in liabilities. If the firm had obtained government funds, these are repaid before any privately-issued shares are retired. I never reduce the firm's equity value below its actual, historical value. The resulting Timely Recapitalization capital ratios thus combine the BHC's true history with simulated policy requirements. The Lucas Critique must be ignored in simulating this policy.

< Insert Figure 7 about here >

Obviously, raising equity's market value above its historical value reduces PDs. Figure 7 plots mean default probabilities for the largest 25 BHC, with and without the "PD $\leq$ 0.1%" simulated equity additions. Timely Recapitalization reduces PDs noticeably in the late 1980s

and early 1990s. Adding equity promptly would also have substantially reduced default probabilities during the period of turbulence centered on 2000. Just before the crisis, market values greatly under-estimated the banking system's risk. No "reasonable" amount of prior equity contribution would have prevented a dramatic increase in PDs. Even so, the Timely Recapitalization policy somewhat reduces the mean PD.

The right four columns in Panel B of Table 4 indicate that the mean annual value of government guarantees over the 1987-2011 period would have fallen by 32.7% with Timely Recapitalization to a 0.1% PD standard. Even a Timely Recapitalization to PD < 5% would have reduced guarantee values by 6.7%. In words, a policy of regularly requiring overly risky BHC to raise new equity could have reduced the value of government guarantees to large BHC by one-fourth or one-third.

< Insert Figure 8 about here >

How realistic are the simulated equity additions? Would they be sufficiently high that a bank would prefer to reduce its PD by shrinking assets? A capital policy that generates asset sales may have detrimental social effects (Brunnermeier and Pedersen (2009)). Figure 8 plots the cumulative change in equity caused by the Timely Recapitalization policy, as a proportion of the firms' historical equity value. Three periods of equity-raising are indicated. The required additional equity was quite large before 1994, with the mean sometimes exceeding 100% of its historical value. Between 1997 and 2004, the sample banks needed additional equity equal to about 25% of the historical amounts outstanding. During the crisis, maintaining the mean PD $\leq$ 0.1% would have required massive equity additions. And there was little indication at the end of 2006 that these would be needed. The first two periods illustrate a basic feature of U.S. capital regulation: the largest banks required non-trivial amounts of equity to satisfy a PD $\leq$ 0.1%

requirement, yet the group's capitalization remained deficient for at least a few consecutive years. But if the banks needed more capital, that need was temporary: following the first and second periods of added equity, the cumulative value of additional equity returns to zero. Until 2007, the problem of keeping equity in the large banks was more a problem of timing than a problem of total capital over time.

6. Can Capital Regulation Work as Intended?

Is it naïve to think that supervisors can assure "rapid remediation" when a large banking firm becomes capital deficient? Overcoming capital forbearance requires supervisors to gather convincing evidence during times of uncertainty that a bank's equity protection is inadequate. Greenspan (2008) observes that "Regulators confronting real time uncertainty have rarely, if ever, been able to achieve the level of future clarity required to act preemptively." The evidence of inadequate loss-absorbing equity must be sufficiently strong to outweigh the firm's counter-arguments, which can reasonably take the form of "let's wait and see how things develop." The regulated firms also possess legal protections against "arbitrary" supervisory decisions and these protections can be used to delay aggressive supervision. By the time supervisors obtain irrefutable evidence that a bank needs more capital – a run – the opportunity to issue new equity has passed.

The tendency to forbear reflects the Basel focus on book accounting ratios. Although Basel III proposes higher book capital requirements, supervisors will confront the same challenge at firms that have suffered big losses not yet reflected in book capital. Because book capital ratios lag economic developments, supervisors find it difficult to act aggressively when problems begin to appear. The Fed's annual stress tests and Comprehensive Capital Analysis and Review (CCAR) improve upon static capital ratios by incorporating estimated future losses

into book capital measures. Still, there exists no formal mechanism for adding risk absorption when equity market values decline.

It seems that we need fundamental changes to the regulatory environment to keep large, interconnected firms reliably away from their bankruptcy points. This section considers the extent to which two recent proposals -- the DFA's orderly resolution authority and contingent capital bonds -- might address the policy problem of maintaining adequate bank capital.

6.1. Orderly Resolution with "Bail-in"

The DFA gives FDIC the administrative power to re-organize a troubled firm's financial claims within the sort of "bridge bank" framework that has been used with selected large bank failures. FDIC has substantial power to wipe out shareholders and convert bond claims into shares. ("Bail-in" bonds were first proposed by Calello and Ervin (2010).) Unlike the experience of 2008-10, bondholders are likely to suffer losses under these revised operating procedures (Gruenberg (2012)). Long-term debt would thus provide loss absorption to protect the deposit insurance fund, as subordinated debentures were once intended to do.[23] How will these reforms affect financial stability?

Orderly resolution procedures are intended to apply when a financial institution reaches the point of non-viability. Under traditional regulatory rules, non-viability was identified at large institutions by uninsured liability runs that forced a regulatory response. At this point, the bank's assets are nearly sufficient to repay liability holders, and even a relatively small amount of bail-in debt would permit re-organization without a net contribution of new funds. However, the existence of orderly resolution and bail-in bonds may delay runs until asset values are substantially smaller than total liabilities. For example, suppose that the firm has equity worth 8% of total assets and bail-in bonds worth 10%, and that short-term liability holders feel confident that FDIC will use bail-in to protect them. Then depositors will not run when asset

value falls by nearly 8% because they are credibly protected by the junior bonds. Short-term claimants will run only when the value of assets falls another 10%, to approximately the value of the bank's "protected" claims. At this point, of course, issuing new shares is impossible and the bail-in bonds cannot be converted to much equity. Supervisors thus confront the same unpalatable choices associated with any bank run: let the firm fail or provide taxpayer support. Note that a credible bail-in policy prevents runs by even the uninsured liability-holders when the bank first approaches insolvency. In this sense, bail-in raises the burden on supervisors to monitor large banks' solvency continuously. There is no market-based run to force aggressive action. So the question recurs whether supervisors will act to re-organize a bank that is not confronting destabilizing depositor runs. To the extent that they delay, the bank's shareholders continue to control the firm and operate under very poor incentives.

Orderly resolution with bail-in will make supervisors jobs easier in one important way: a credible bail-in process will cause junior bond yields to rise as the firm's condition deteriorates. As noted by Kwast et al. (1999) in the context of subordinated debentures, supervisors will therefore have good market signals upon which to base their actions – provided that bondholders believe they will be subject to losses. (Even then, many supervisors are suspicious of market prices.) A central question about orderly resolution is thus whether supervisors will re-organize a firm that they believe is insolvent even if it can continue funding its daily operations. This is the main point at which capital supervision has failed in the past. It will be particularly difficult to implement such a policy when the firm has multi-national operations.

6.2. *Contingent Capital Bonds*

Contingent capital bonds (CCB) represent an automatic, "going concern" mechanism for re-capitalizing banks that become capital deficient.[24] A troubled bank with sufficient CCB in its capital structure can avoid a bankruptcy or resolution process. Although converting debt to

equity claims provides no liquidity, it does restore the bank's solvency and thus presumably restores its ability to borrow from private lenders. From the perspective of "adequate" capital, contingent capital bonds provide a rapid de-levering when banks suffer large losses. Returning to the logic underlying Figure 1, this rapid response permits issuing banks to operate with lower initial capital ratios while continuing to offer a high (PD $\leq$ 0.1%) level of safety. Unlike regular equity – which also protects liability-holders – CCB afford shareholders the benefits of leverage when asset returns are high. In other words, CCB provide downside protection to bondholders without burdening shareholders with high capital levels when things turn out well. This feature will diminish (but not eliminate) the tendency of higher bank capital requirements to drive financing into the shadow banking system, where supervisors may find risks more difficult to monitor.

The most important design features of CCB specify the trigger that serves to convert them into equity shares, the effect of conversion on managerial control, and the conversion ratio between bonds and new shares at conversion.

Trigger. Existing CCB, issued in large amounts by Lloyds, Rabobank, Credit Suisse, and (most recently) Barclays specify a book-valued trigger. If the issuer's book capital ratio falls below a specific level, the bonds convert. The obvious shortcoming of such a conversion rule is that the accounting lags behind market value changes when a bank is suffering losses. These bonds are unlikely to convert before the market begins to worry about the issuers' solvency, and hence will not necessarily prevent disorderly funding conditions. Conditioning CCB conversion on a book ratio thus perpetuates a historical system that has provided inadequate protection to anyone besides bank equity holders. A market trigger (the ratio of equity market value to some scale variable such as total assets) would generally be more timely (Flannery (2009), Haldane

(2011)), and would provide firms with strong incentives to avoid conversion by issuing new shares when its equity approaches a trigger point (Chen et al. (2012), Himmelberg and Tsyplakov (2012)). This sort of pressure does not exist under present institutional and supervisory arrangements.

Managerial Discipline. Some observers object to the automatic de-leveraging provided by CCB because it seems to protect incumbent management. As part of its orderly resolution, FDIC intends to dismiss at least some managers (Gruenberg (2012)). CCB can also specify whether their conversion must be accompanied by a change in management or board composition. For example, CCB might require that top management resign and the board schedule new elections for all board members within 30 days of conversion.

Dilution at Conversion. A CCB must specify a share price at which bonds are converted into shares.[25] A higher price leaves the initial shareholders with a larger proportion of post-conversion firm ownership. If the conversion price deviates from the shares' recent market price, value will be transferred at conversion between initial shareholders and the CCB investors. In a discrete time model, Sundaresan and Wang (2012) show that this transfer can multiple equilibrium prices for CCB and shares. Pennacchi et al. (2012) propose to address this problem by setting the conversion price very low and giving the initial shareholders an option to purchase the new shares. Duffie (2009) proposes a rights offering with similar effect. Glasserman and Nouri (2012) argue that the multiple equilibrium problem reflects the discrete time nature of Sunderasan and Wang's analysis. If securities can be continuously traded, equity and CCB prices will adjust continuously so that there is no value transfer at conversion. Finally, the value transfers (if any) associated with conversion are inversely related to the market-valued

capital ratio at which conversion occurs. Setting a high trigger therefore reduces the possible disruptions caused by a market-value trigger.

Despite their implementation challenges, CCB offer an innovative mechanism for assuring bank stability by reversing deterioration in loss-absorbing equity. They have some attractive incentive features. CCB with tax deductible interest payments may also reduce political opposition to policies that maintain bank solvency, as well as reducing the incentive for risks to migrate out of the regulated banking sector.

7. SUMMARY AND CONCLUSIONS

The notion of "adequate" capital is essential to the Basel Committee's system of capital regulation. Yet capital regulation has failed to provide safe banks. The system suffers from two inherent flaws. First, book capital does not define a firm's solvency, and hence cannot assure that short-term liability holders will renew their investments. In an industry that lives on an asset-liability mismatch, this distinction is crucial. Second, the second Basel Pillar has not lead supervisors to insist that large banks restore their market capital ratios promptly following losses. This almost certainly reflects the book-based definition of adequate capital. But whatever the cause, supervisors cannot control the safety of regulated banking firms without a reliable mechanism for assuring that adequate loss-absorbing capital is maintained,

Adequate capital reflects not only a firm's leverage and its asset risk, but also the length of time for which a given capital cushion is expected to protect liability-holders from default. By this criterion, the largest 25 U.S. BHC had socially excessive mean (median) default probabilities nearly two-thirds of the time between 1987 and 2011. The resulting cost of (conjecturally) guaranteeing these 25 U.S. firms' liabilities amounted to $941 billion over the sample period,

including $868 billion for the crisis-related sub-period (2007-2011). The mean sample firm enjoyed guarantees worth approximately 11.4% of its equity market value over the entire period; during the 2007-2011 period, this proportion averaged nearly 30% of firm capitalization. These guarantees are concentrated among the largest U.S. BHC and generate the capital market distortions associated with TBTF firms. A simulated policy of strict capital maintenance reduces the value of these government guarantees substantially before the crisis, but only slightly during the 2007-11 period.

Our bank regulatory apparatus requires a fundamental change to the present, fatally flawed, system of capital regulation. The Dodd-Frank Act's orderly resolution authority for FDIC will not directly reduce defaults because it applies only to firms that become non-viable. If the orderly resolution process is credible, short-term depositors will not run until assets fall close to the value of the protected deposits. In other words, the event that most reliably has precipitated government intervention will do so less promptly. A credible "bail in" regime would lead banks' junior debtholders to provide market signals of deteriorating credit quality. But ultimately orderly resolution requires the same sort of aggressive supervisory action that has been in scarce supply in the past.

An alternative approach to maintaining adequate bank capital would replace supervisory discretion with a rules-based recapitalization via contingent capital bonds. The pros and cons of such a substitution are reminiscent of the historical debate over monetary policy rules vs. discretion. In the final analysis, contingent capital bonds with market triggers may represent the worst possible mechanism for maintaining adequate capital. Except perhaps for all the attainable alternatives.

REFERENCES

Admati, A, PM DeMarzo, MF Hellwig, and P Pfleiderer, 2011. "Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive," Stanford University Working Paper (March 23, 2011).

Brunnermeier MK, Pedersen LH. 2009. Market Liquidity and Funding Liquidity. *Review of Financial Studies*, 22(6), 2201--38.

Basel Committee on Banking Supervision, 2006. Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework - Comprehensive Version (June).

Calello, Paul and Wilson Ervin, Economics focus: From bail-out to bail-in, *The Economist* (Jan 28th 2010).

Chen, Nan, Paul Glasserman and Behzad Nouri 2012, CoCos, Bail-in and Tail Risk, working paper.

Crosbie, Peter and Jeff Bonn (2003), "Modeling Default Risk", Moody's/KMV working paper.

da Costa, P, 2013. Bernanke on Sen. Warren and too big to fail banks: 'I agree with her 100 percent', Reuters MacroScope, March 22, 2013 http://blogs.reuters.com/macroscope/2013/03/22/bernanke-on-sen-warren-and-too-big-to-fail-banks-i-agree-with-her-100-percent/

Diamond, D, P Dybvig, Banks Runs, Deposit Insurance and Liquidity, *Journal of Political Economy*, 1983; 91: 401-19.

Duffie, Darrell, 2009. "A Contractual Approach to Restructuring Financial Institutions," Chapter 6 of *Ending Government Bailouts as We Know Them*, edited by Kenneth Scott, George P. Schultz, and John B. Taylor, pp. 109-124, Hoover Press.

Flannery, MJ, 2009. Stabilizing Large Financial Institutions with Contingent Capital Certificates. Available at SSRN: http://ssrn.com/abstract=1485689.

Flannery MJ, Rangan, KP. 2008. What caused the bank capital build-up of the 1990s? *Review of Finance*, 12(2): 391--429.

Flannery, MJ, SH. Kwan, and M Nimalendran 2013, The 2007–2009 financial crisis and bank opaqueness, Journal of Financial Intermediation, 22(1), 55-84.

Glasserman, Paul and Behzad Nouri (2012), "Market-Triggered Changes in Capital Structure: Equilibrium Price Dynamics", Columbia University working paper.

Goodhart C. 1990. *The Evolution of Central Banks* ((Cambridge, MA: The MIT Press, 1990).

Gordy, Michael B, and Bradley Howells, 2006, Procyclicality in Basel II: Can we treat the disease without killing the patient? *Journal of Financial Intermediation* 15(3), 395-417.

Greenspan, A. (2008). The fed is blameless on the property bubble. Financial Times, April 7.

Gruenberg, Martin, 2012. Remarks to the Federal Reserve Bank of Chicago Bank Structure Conference; Chicago, IL (May 10).

Haldane, Andrew G., 2011. Control rights (and wrongs). Wincott Annual Memorial Lecture, 24 October 2011, Westminster, London.

Herring, Richard J. 2010, How Financial Oversight Failed & What it May Portend for the Future of Regulation, *Atlantic Economic Journal*, 38, 265–282.

Himmelberg, Charles and Sergey Tsyplakov 2012, Pricing Contingent Capital Bonds: Incentives Matter, mimeo.

Hovakimian, Armen, Edward J. Kane and Luc Laeven 2012, "Variation in Systemic Risk at US Banks During 1974-2010," Boston College working paper.

James, Christopher M., "The Losses Realized in Bank Failures," *The Journal of Finance,* Vol. 46, No. 4 (Sep., 1991), pp. 1223-1242.

Kuritzkes A, Scott H. 2009. Markets are the best judge of bank capital, *Financial Times* (September 23, 2009).

Kwast, M. et al. (1999) Using subordinated debt as an instrument of market discipline, Study Group on Subordinated Notes and Debentures, Federal Reserve Board of Governors.

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

Miles, David, Jing Yang, Gilberto Marcheggiano, 2011, "Optimal bank capital," External MPC Unit Discussion Paper No. 31: revised and expanded version (April).

Pennacchi GG. 1987. A reexamination of the over-(or under) pricing of deposit insurance. *Journal of Money, Credit and Banking*. 19(3): 340--60.

Pennacchi, George G., Theo Vermaelen, Christian C. P. Wolff, 2013. "Contingent Capital: The Case for COERCs," INSEAD working paper.

Pyle DH. 1986. Capital regulation and deposit insurance. *Journal of Banking and Finance*. 10(2): 189-20l.

Ronn EI, Verma A. 1986. Pricing-risk-adjusted deposit insurance: an option-based model. *Journal of Finance*. 41(4): 871-95.

Sundaresan S., Z Wang, 2011: On the Design of Contingent Capital with Market Trigger. Federal Reserve Bank of New York Staff Reports, no. 448.

Table 1: Summary Statistics for the 25 largest (by total on-book assets) BHC at each year-end

Panel A: Variable Definitions

TA ($mm)	BHCK2170 (total on-book assets)
$\hat{V}$ ($mm)	Estimated market value of assets
B	Book value of BHC liabilities (BHCK2170 – BHCK3210)
BVEQ	Book value of equity (BHCK3210)
MVEQ	Market value of BHC equity: (Price per share)*(shares outstanding)
S_e Raw (annual %)	Standard deviation of return on equity, last quarter of each year
S_e trimmed (annual %)	S_e capped at <0.1*(B + MVEQ)/MVEQ
S_v trimmed (annual %)	S_v calculated using trimmed S_e

BHCKxxxx variables are from the Federal Reserve's quarterly Y-9C reports.

Panel B: Summary Statistics for the 25 largest BHC (by on-book assets) at each year-end

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
TA ($mm)	649	198,522	72,448	368,319	17,465	2,268,347
$\hat{V}$ ($mm)	649	199,535	76,181	357,320	17,424	2,158,342
B ($mm)	649	182,254	67,304	337,680	16,329	2,082,219
$\hat{V}$/TA (%)	649	103	101	10	70	189
BVEQ / TA (%)	649	8.0	7.7	2.6	1.6	21.7
MVEQ / BVEQ (%)	649	170.8	150.0	105.5	23.7	928.2
MVEQ / TA (%)	649	14.0	11.7	10.6	1.0	102.9
MVEQ / $\hat{V}$ (%)	649	12.9	11.8	7.8	1.1	54.4
S_e Raw (annual %)	649	36.7	29.6	28.1	2.0	361.7
Se trimmed (annual %)	649	35.6	28.8	24.8	2.0	190.5
Sv trimmed (annual %)	649	4.2	3.1	3.6	0.2	34.0

Table 2: Troubled BHC among the largest 25 firms, 1987-2011

I compute the default probability (PD) of each sample BHC at the end of each calendar year. The number of BHCs exceeding the indicated PD is reported here, and includes firms that were already insolvent at yearend. "Asset Size Ratio" is the ratio of mean book assets for BHC over vs. under the indicated PD. A ratio above unity indicates that larger BHC tend to have higher default probabilities. Missing values for the Asset Size Ratio occur when either the high-PD or the low-PD groups is empty.

		BHC with PD > 0.1%		BHC with PD > 0.5%		BHC with PD > 1%		BHC with PD > 5%	
Year	# Insol-vent [a]	# (out of 25)	Asset Size Ratio	# (out of 25)	Asset Size Ratio	# (out of 25)	Asset Size Ratio	# (out of 25)	Asset Size Ratio
1986	3	17	176%	14	213%	14	213%	10	216%
1987	8	25		25		25		25	
1988	5	16	165%	14	186%	14	186%	12	163%
1989	3	25		22	148%	18	148%	15	157%
1990	9	25		25		25		21	133%
1991	5	22	169%	18	142%	16	148%	13	180%
1992	1	10	172%	7	157%	5	144%	3	201%
1993	0	13	95%	6	150%	3	167%	0	0%
1994	0	12	200%	9	229%	5	172%	1	114%
1995	0	9	199%	4	129%	2	84%	1	60%
1996	0	4	80%	0		0		0	
1997	0	17	116%	9	189%	5	203%	0	
1998	0	24	404%	20	336%	10	435%	4	212%
1999	0	21	62%	18	103%	15	152%	0	
2000	0	18	272%	16	230%	14	264%	2	332%
2001	0	8	97%	4	126%	2	249%	0	
2002	0	23	103%	17	174%	16	196%	4	146%
2003	0	3	47%	2	63%	2	63%	0	
2004	0	1	136%	1	136%	0		0	
2005	0	1	59%	1	59%	0		0	

Year	# Insol-vent	BHC with PD > 0.1%		BHC with PD > 0.5%		BHC with PD > 1%		BHC with PD > 5%	
		# (out of 25)	Asset Size Ratio	# (out of 25)	Asset Size Ratio	# (out of 25)	Asset Size Ratio	# (out of 25)	Asset Size Ratio
2006	0	0		0		0		0	
2007	0	23	280%	21	310%	18	421%	5	153%
2008	10	24	600%	24	600%	24	600%	24	600%
2009 [b]	0	24		20	464%	18	210%	12	117%
2010	0	16	256%	14	319%	10	132%	3	181%
2011	1	25		24	343%	24	343%	16	227%

[a] Insolvency defined as $\hat{V}$ < total liabilities (B).

[b] This year's sample includes only 24 BHC due to missing data.

Table 3: Incidence of BHC with Multiple Years of High Default Probabilities (PDs)

An "offense" is a year-end at which a BHC has a default probability higher than the values indicated at the top of each column.

# offenses	Number of Offending Firms			
	PD > 0.1%	**PD > 0.5%**	**PD > 1%**	**PD > 5%**
10 or more	15	10	5	3
9	3	2	2	0
8	3	5	5	1
7	4	2	5	2
6	4	3	1	1
5	9	9	12	3
4	7	9	3	10
3	4	6	8	10
2	6	4	6	8
1	8	9	8	10
0	5	9	13	20

Table 4: The value of government guarantees for 25 largest U.S. BHC, 1987-2011

The mean and median values of the TBTF guarantee are presented as a proportion of each BHC's market-valued equity (in Panel A) and in billion dollars (in Panel B). The first two columns describe history. The other columns report guarantee values if BHC are re-capitalized at the end of each year to reduce their default probability (PD) below 0.1%, 0.5%, etc.

Panel A: Government guarantee value as a percentage of equity market value

	Historical Capitalizations		**Timely Recapitalization**							
			PD $\leq$ 0.1%		PD $\leq$ 0.5%		PD $\leq$ 1%		PD $\leq$ 5%	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median
1987-2011	11.4%	0.0%	5.0%	0.0%	6.0%	0.0%	6.5%	0.0%	7.9%	0.0%
1987-2006	6.8%	0.0%	1.3%	0.0%	1.6%	0.0%	1.9%	0.0%	2.7%	0.0%
2007-2011	29.9%	0.6%	20.1%	0.1%	23.5%	0.1%	25.2%	0.1%	28.7%	0.2%

Panel B: Dollar value of government guarantees ($bn)

1987-2011	941	633	733	787	878
1987-2006	73	18	24	28	40
2007-2011	868	615	709	759	838

Number of observations = 624, 500 and 124 for periods 1987 – 2011, 1987 – 2006 and 2007 – 2011 respectively.

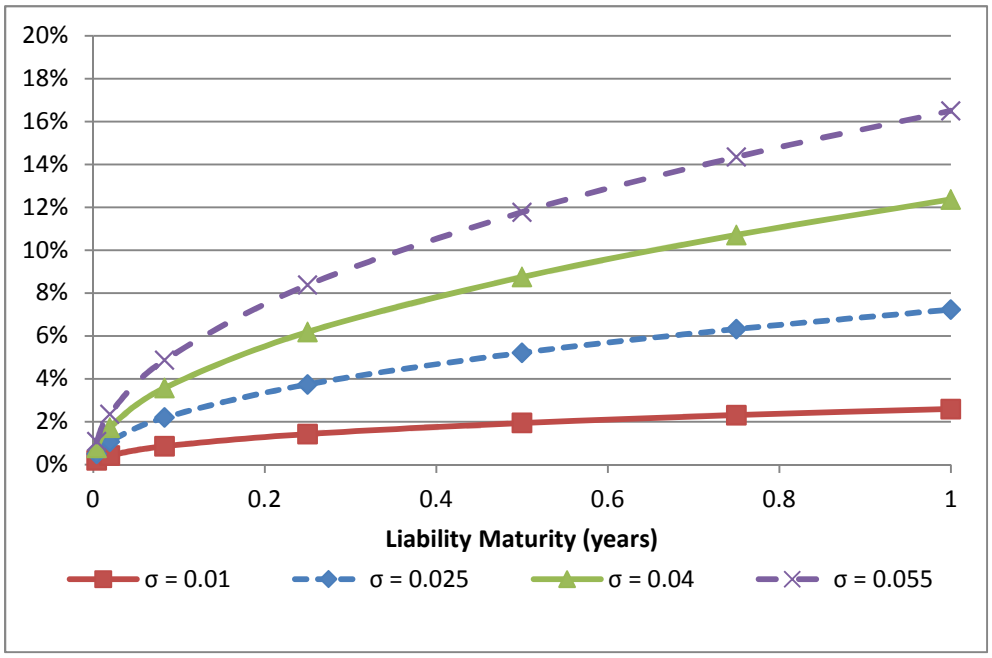

Figure 1: "Adequate" bank capital ratios (various asset return volatilities, σ)

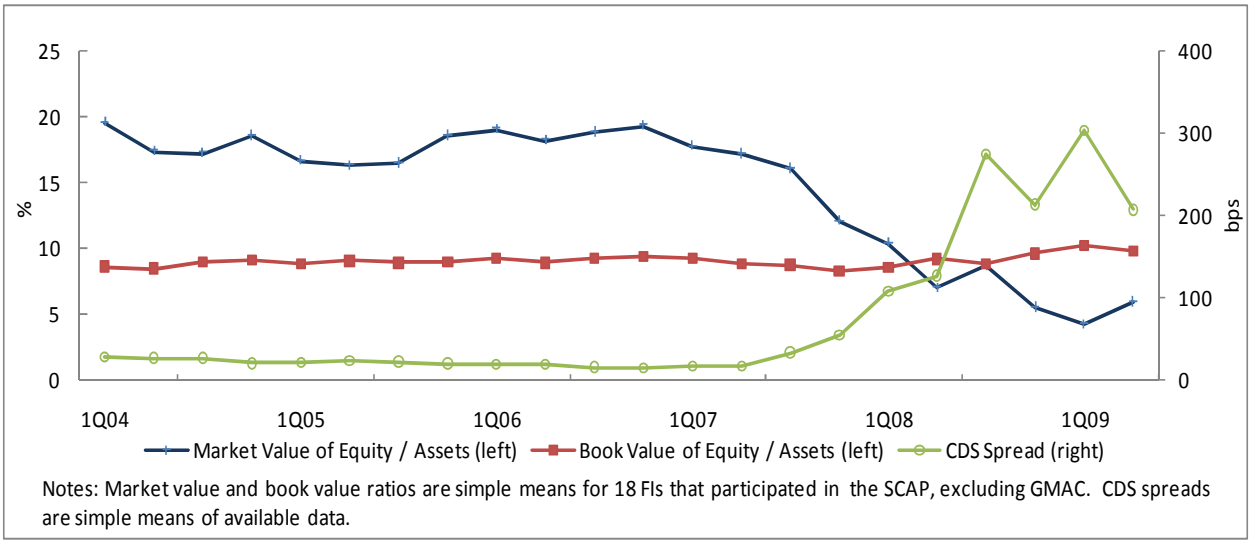

Figure 2: Book capital ratios vs. market solvency indicators (Source: Kevin Stiroh)

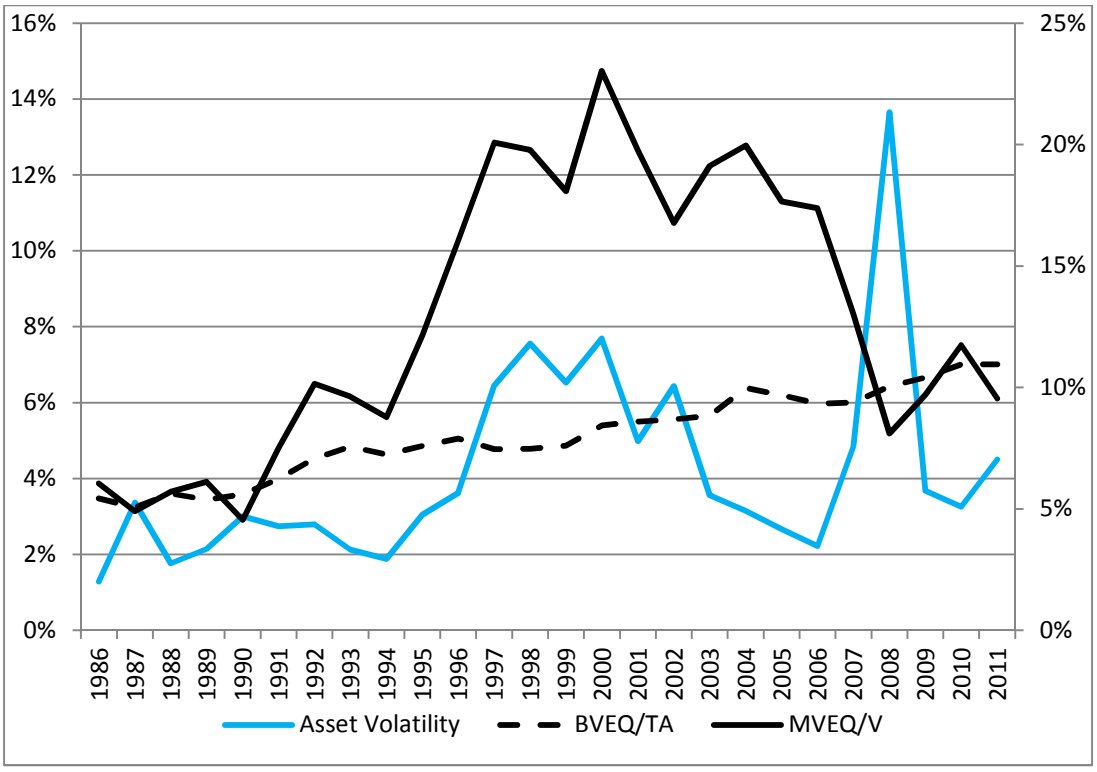

Figure 3: Mean estimated equity ratios (right axis) and estimated asset volatilities (left axis)

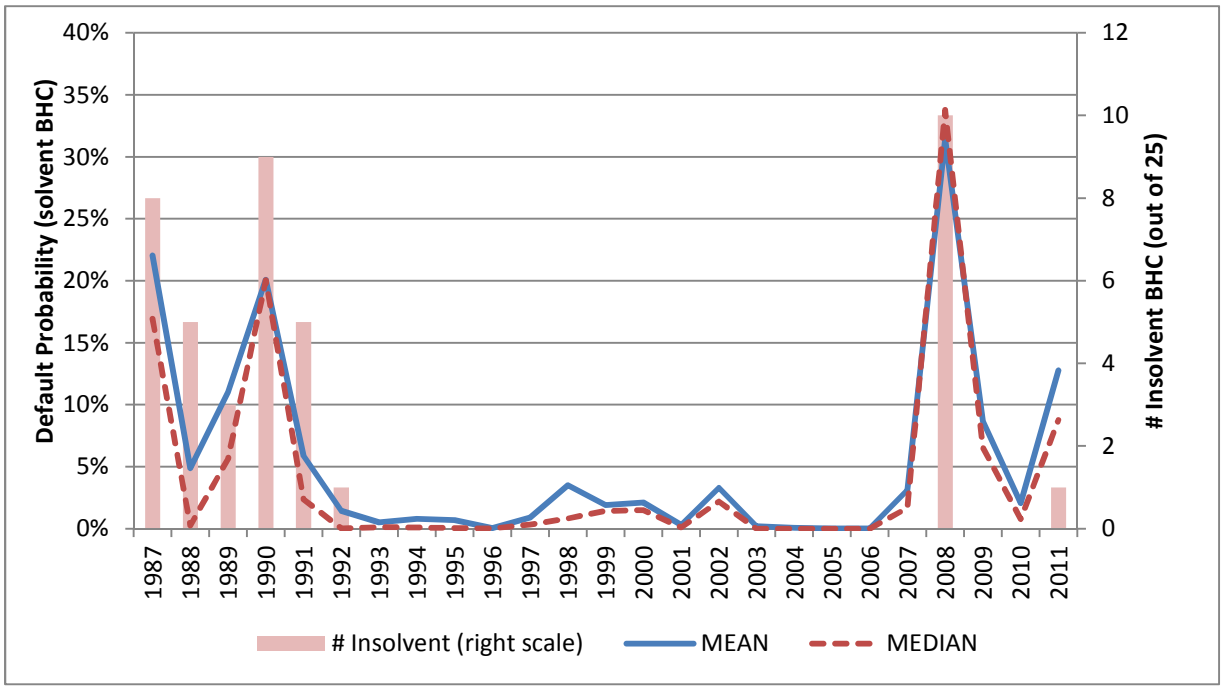

Figure 4: Mean and median default probabilities for solvent firms (left axis), and number of insolvent firms

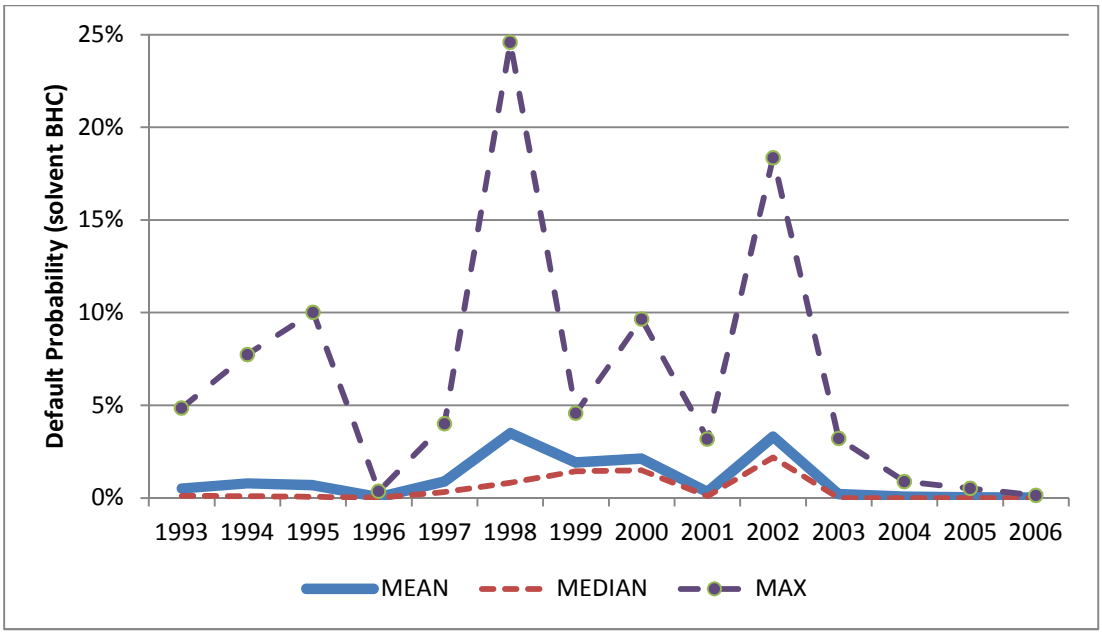

Figure 5: Default probabilities from Figure 4, shorter time-series and larger scale

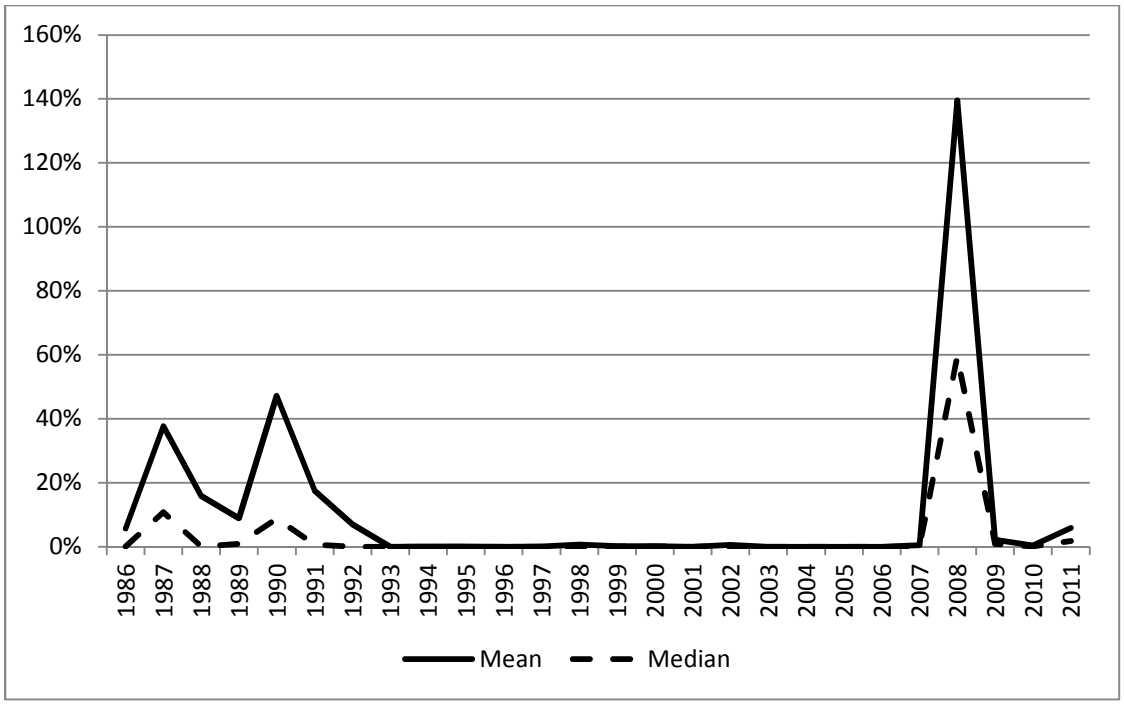

Figure 6: Guarantee values as a proportion of equity market value

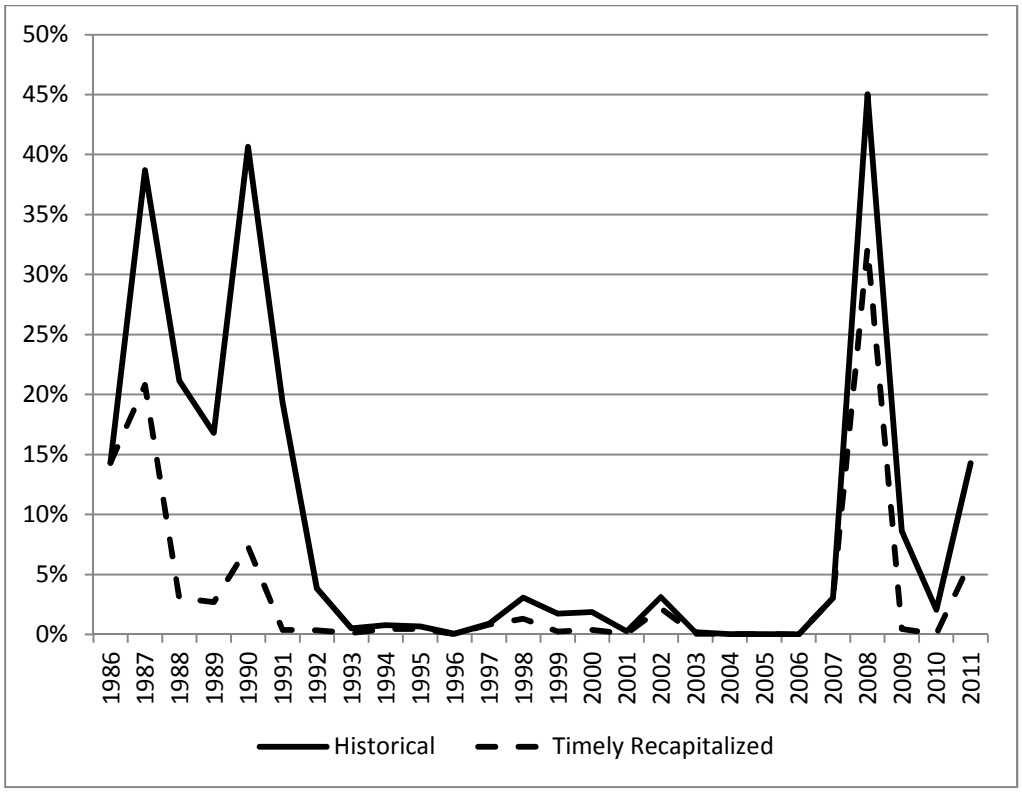

Figure 7: Mean PD estimates with historical and Timely Recapitalized capital ratios

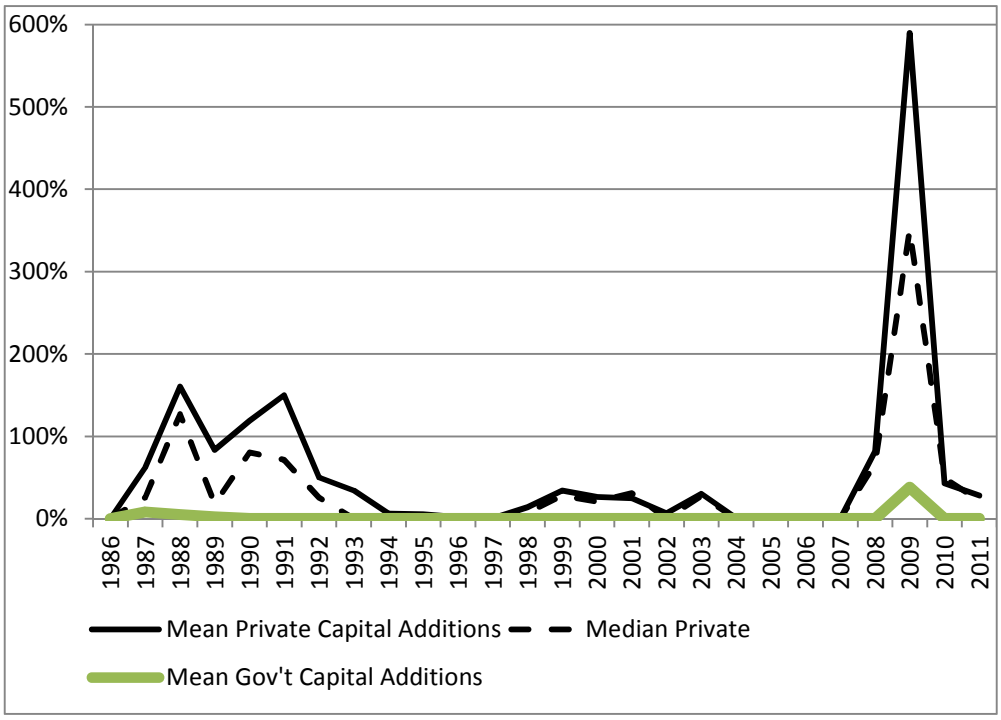

Figure 8: Capital additions under Prompt Recapitalization (PD $\leq$ 0.1%) policy, as a % of historical equity market value

1. One indication of the extent to which book equity measures are distorted comes from the FDIC's cost of resolving failed banks. During 2008-2011Q1, 361 banks (mostly quite small) failed in the U.S. At their failure dates, the FDIC's estimated resolution cost averaged 26% of failure-date total assets, suggesting that the failed banks' measured capital substantially over-stated their economic values. (Actual resolution costs were subsequently higher.) James (1991) reports similar resolution costs for the 1980s.

2. Herring (2010) concludes that "capital does not appear to be a very effective regulatory weapon." (page 272)

3. The same problem can alternatively be solved for the amount of assets a BHC would need to sell to attain universal PD < 0.1%. Large implied asset sales raise the specter of fire sale spirals, which have received much recent attention (e.g. Brunnermeier and Pedersen (2009)).

4. When federal bank regulators proposed rules for implementing Basel II in 2006, they made two references to this implicit solvency standard: "the IRB framework for assessing credit risk capital requirements is based on a 99.9 percent nominal confidence level, a one-year horizon …" (Federal Register September 25, 2006, page 55833). Capital requirements for operational risks should "meet[s] a 1-year, 99.9th percentile soundness standard." (Federal Register September 25, 2006, page 55835).

5. This example takes the asset properties as exogenous, even though the required capital ratio would probably influence a firm's preferred portfolio risk.

6. Calculations throughout this paper assume normally or log-normally distributed asset returns. Fatter-tailed distributions would imply higher default probabilities for any level of equity capital and more valuable government guarantees. Results based on a t-distribution with 10 df are qualitatively quite similar to the ones presented here.

7. Admati et al. (2011), Miles et al. (2011), and others contend that much higher minimum capital ratios provide the best means of protecting taxpayers and the financial system from future disruptions. Although this approach probably makes regulated banks safer, the effect of higher bank capital requirements on financial system stability is difficult to discern. The tax deductibility of corporate interest payments will give nonbanks a comparative funding advantage for some risks, which will migrate from the regulated banking system into the "shadow" banking system.

8. For simplicity, I refer to all short-term liabilities as "deposits." Note that some BHC finance themselves with substantial amounts of insured, retail deposits, which are less likely to run even if the bank appears to be solvent. These firms are less fragile than those relying on short-term, uninsured liabilities.

9. Section 6.1 discusses the Dodd-Frank Act's "orderly resolution" procedure, which is intended to avoid disruptive re-organizations in the future.

10. Creditors' increased anxiety about a bank that taps the discount window is probably quite rational. Central bank takes high-quality assets as collateral, leaving assets that are worth less and are probably more difficult to value.

11. For example, fears about market manipulation and uncertain asset values lead some governments to forbid short-selling of financial institutions' stock in 2008. Flannery et al. (2013) evaluate the trading properties of U.S. BHCs' shares and find no evidence of unusual opacity during normal times. However, the BHCs' asset opacity rose sharply during the financial crisis, compared to a matched sample of nonfinancial firms.

12. Future research might usefully categorize the market's Type I and Type II errors in assessing large financial firms' solvencies.

13. The idea that supervisors should track market-valued equity is not new. Pyle (1986), for example, argues that

> If bank regulators are serious about using capital regulation as a major regulatory tool, *it is time for them to take seriously the idea of monitoring capital on a market value basis*. (p. 197, emphasis added)

14. Despite the reforms contained in the Dodd-Frank Act of 2010 (DFA), a sufficiently large financial firm seems likely to be afforded TBTF support even in the absence of wider systemic problems. Chairman Bernanke acknowledged the challenge presented by TBTF at a March 22, 2013 press conference: "I hope that we'll make progress against too big to fail, because I agree with [Sen. Elizabeth Warren] 100 percent that it's a real problem and needs to be addressed if at all possible." (da Costa).

15. One large BHC was excluded from the dataset because it had missing returns for part of the fourth quarter in 2009. The 2009 results therefore include only 24 of the largest 25 BHC.

16. Setting $\rho = 0.97$ when estimating historical parameters assumes that investors were anticipating a "late" closure policy, which seems appropriate. Repeating the calculations with an assumed "prompt" closure policy ($\rho = 1$) raises the mean estimated asset value by 2.72% and reduces the estimated asset return volatilities by 2.78%. The implied failure probabilities and guarantee values are somewhat lower than those presented in the paper, but the qualitative results presented here remain unchanged.

17. In computing PDs, I assume that $\rho = 1.0$ – banks should be closed when their liability value exceeds the market value of their assets on an annual examination date.

18. Although their primary focus is on systemic risk, Hovakimian et al. (2012) calculate individual banks' default probabilities using a method similar to mine for all traded BHC from 1974-2010. Their Figures 2 and 3 show estimated leverage and asset volatilities broadly similar to those in Figure 3 here. Their estimated guarantee values (expressed as a proportion of total bank debt) also broad resemble mine in Table 4, where they are expressed as a proportion of bank equity.

19. Many banks had high PDs after 2006, but some of the largest institutions operated with PD > 1% (note: this is *ten times* the reputed Basel standard) for at least several years during the quiet banking period, including BankAmerica (1997-99, 2000, 2002), Citicorp (1997-98, 2000, 2002), JPMorgan (1998-2002), First Union (1998-2000, 2002 (as "Wachovia")), KeyCorp (1998-2000, 2002), and State Street (1997, 1999-2000, 2002).

20. The offsetting value of net FDIC premia for sample banks was a portion the $90.9 billion net assessments charged to all banks from 1987 to 2011 (FDIC 2011 Annual Report, pp. 133-4). Given that the nation's largest banks' deposits were generally less than half of total deposits Table 4 indicates that the largest BHC enjoyed a net subsidy of at least $895 billion (= 941 – 90.9/2) over this time period. Recall that most banks paid zero premia in the decade between 1996 and early 2006.

21. The mean PDs in Figure 6 Sometimes exceed those in Figure 4 because the mean values include the relatively high probability that an insolvent firm today will remain insolvent through the end the coming year. By contrast, the PDs in Figure 4 describe only the solvent BHC.

22. Presumably, shareholders would protest and delay when ordered to issue more equity. The shareholders' gain from delay is a direct cost to the government: if a large bank continues operating with "too high" a PD, the government is bearing an unacceptably high share of the bank's expected losses.

23. Subordinated debt ultimately failed to provide much loss absorption because the losses could be imposed only in bankruptcy. During the crisis, supervisors feared that bankruptcies would encourage de-stabilizing deposit runs.

24. The tax regime in some countries (including the U.S.) might not permit CCB interest payments to be deducted from the issuers' taxable income.

25. Some recent European CCBs do not convert to shares, but are simply cancelled if the issuer's capital ratio falls too low. For some issuers, this is the only possibility – Rabobank has no equity shares. For other issuers (Barclay's in November 2012) this is an explicit choice. Cancelling debt seems to provide shareholders with a gain following bad outcomes, which may encourage higher risk-taking ex ante.