Safe Capital Ratios for Bank Holding Companies

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At one level, the story on capital and liquidity ratios is very simple: From the viewpoint of the stability of the financial system, more of each is better....

But at what level should capital and liquidity ratios be set?

Stanley Fischer, Vice-Chairman FRB, Martin Feldstein Lecture July 10, 2014

Abstract

This paper gives three institution specific quantitative answers to Fischer’s question “at what level should capital ratios be set?” based on (1) the FED Stress Tests 2015 (2) VLab’s Systemic Risk measures and (3) our (Craine-Martin) estimates. An appropriate regulatory capital ratio needs to be high enough to discourage excessive risk taking by financial institutions and needs to be low enough to encourage their intermediation and lending function and at the same time protect taxpayers from private financial institutions’ losses. It’s a delicate balance.

This paper compares Safe Capital Ratios for 18 Bank Holding Companies. The goal of the Federal Reserve Stress Tests, VLab’s measure of systemic risk, and Craine-Martin’s (CM’s) estimates is to determine a safe capital ratio so that a bank can absorb losses in a crisis—like the Gt Recession—and continue to lend to creditworthy customers without government assistance.

This paper has two main results. We (CM) generalized VLab’s bivariate GARCH econometric model specification to a multivariate model. It turns out that this is quantitatively very important. In a crisis accounting for the covariance among bank holding companies returns gives much larger losses since their returns and asset values are positively correlated. The CM implied safe capital ratios which allow for correlation among the bank returns are the highest averaging 22%, followed by VLab’s averaging 16%, and the FED Stress tests the lowest averaging 11%.

The second main result is surprising and controversial. Book value capital ratios are too insensitive to an economic crisis to accurately determine adequate capital. The Fed (and Basel III) stress tests calculate the book value of the capital ratio. The 2015 Stress Test results implied that on average it would only take a 1.2% increase in the current average book capital ratio of 9.3% to provide a sufficient shield to weather another economic storm like the Gt Recession. Since 1.2% seemed small to us we looked at historical book value capital ratios and market value capital ratios—used by CM and VLab—over the Gt Recession. Book capital ratios give no signal of bank distress. In contrast market capital ratios screamed distress.

Section I: Introduction

In July of 2008—three months before the Lehman Brothers’ bankruptcy led to the panic freeze of financial markets—the average capital/asset ratio for the twenty riskiest US financial institutions\(^1\) was 5.6%. Lehman held less than 2% capital. Freddie Mac and Fannie Mae, which the government took over, had 0.6% and 1.3% capital. A small decline in asset value and many financial institutions would be insolvent. Government bailouts or massive failures and the collapse of the financial system were inevitable. In October 2008 Lehman failed and financial markets froze. In November the US Congress hastily passed the three-quarter trillion dollar Troubled Asset Relief Program (TARP) to bailout the banks. Thanks to the bailout the banks survived, but the real sector is only beginning to recover—US per capita real GDP was up only 4% six years after the collapse. And Europe suffered worse than the US.

The financial sector panic and the worst recession since the Great Depression spurred financial regulatory reform—the 2000 page Dodd-Frank act in the US and Basel III (since Basel I & II didn’t work) for international banks. Basel III introduced a minimum “leverage ratio” that requires banks to have equity that is 3% of assets\(^2\), and the US Federal Reserve imposed a minimum leverage ratio\(^3\) of 6% on eight systemically important banks. These are not onerous regulatory capital ratios. But what’s most unusual is that it’s a requirement. No institutions other than financial institutions have capital requirements.

Section II reviews why bank holding companies need regulatory capital ratios (RCRs). Increasing the debt to capital ratio increases the risk of default and makes debt and equity riskier. Riskier debt normally carries a higher risk premium which gives firms an incentive limit borrowing. But, governments explicitly, or implicitly, guarantee bank holding company debt because the failure of a systemically important institution leads to widespread losses that are far greater than the losses to the institution’s equity and debt holders. The debt guarantee is a subsidy to bank holding companies that encourages them to hold excessive debt which makes them excessively risky. An appropriate regulatory capital ratio makes the bank holding companies less risky—that’s the point—and reduces the value of the subsidy. Section II also summarizes Admati and friends (2011, 2013) refutation of industry arguments—the industry doesn’t want the subsidy reduced—that higher regulatory capital ratios would undermine bank holding companies intermediation function and seriously damage the economy. But what is an appropriate safe capital ratio? Admati and friends say 20-30%.

Section III presents and compares three quantitative measures of institution specific safe capital ratios. Engle and friends (Brownlees and Engle 2012a), (Acharya, Engle, and Richardson 2012b) (Acharya, Engle, and Pierret 2014) develop the notion of a safe capital ratio. A safe capital ratio is a capital ratio so that in

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1 According to VLab—see Section III for details on VLab.

2 See, .bis.org/publ/bcbs270.pdf. The traditional definition of the leverage ratio is assets/equity so Basel III “leverage ratio” is the reciprocal of the traditional definition.

3 See https://www.fdic.gov/regulations/resources/director/regcapintfinalrule.pdf for a detailed description of Tier 1 capital and the various regulatory capital ratios.
a severe downturn—similar in magnitude to the 2008 Great Recession—the institution will not drop below a safe 8% capital buffer. We compare Engle and friends, our (CM), and the FED Stress Test implied safe capital ratios.

Engle and friends and we use an econometric model to forecast the market value of bank holding company equity value (market capitalization) in a severe downturn. The FED Stress Test methodology is much different. The FED focuses on the bank holding company’s balance sheet. They project the BHC’s book income and detailed asset losses over the downturn and add it to the current book (accounting) value of the bank holding company’s equity to obtain the book value of equity. And they project the book value of the bank holding company’s assets over the downturn. Section III.1 details the differences in methodology and SIII.2 gives the safe capital ratio results. The CM estimates imply a safe capital ratio that averages 22% (with a high of 33%), while VLab estimates imply a safe capital ratio that averages 16% (with a high of 31%). Both market value econometric model based implied safe capital ratios are much higher than the FED Stress Test results that imply an average safe capital ratio of 11% (with a high of 12%).

The difference between CM and VLab’s implied safe capital ratios is due completely to the GARCH econometric model specification. CM use a multivariate version of VLab’s bivariate model. The bivariate model allows for correlation between bank holding company(i)’s return and the market return. The multivariate model allows for correlation among the (18) bank holding companies’ returns and correlation with the market return. Allowing for correlation among bank holding company returns makes a big difference in a crisis. When things go badly for all the bank holding companies at the same time their expected losses are much larger than when viewed in isolation since their returns and asset values are positively correlated, see Appendix II.

The sources of the difference between CM-VLab’s implied safe capital ratios and the Fed Stress Test implied safe capital ratios are much harder to pinpoint. One important difference that can be isolated is difference between book and market value accounting. The Fed Stress Tests rely on book values. It turns out that book capital ratios (the Fed calls them leverage ratios) don’t respond very much, or very quickly, to economic events—even an economic event as dramatic as the Gt Recession. Citigroup’s book value capital ratio was 4% at the beginning of the recession—2007:4—and rose to 6% by the time Lehman failed in 2008:3 and stayed above 6% for the remainder of the recession. In contrast, Citigroup’s market value capital ratio began the Great Recession at 7% but plunged to less than 1% by 2009:3. Book value capital ratios are not sensitive enough to use as a macroprudential tool to evaluate the health of bank holding companies.

Section IV gives the summary and conclusions.

Section II: Regulatory Capital Ratios

Basel III introduced a minimum “leverage ratio” that requires banks to have Tier1 equity that is 3% of total assets, and the US Federal Reserve imposed a minimum Tier1 leverage ratio of 6% on eight

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4 The traditional definition of the leverage ratio is assets/equity so Basel III “leverage ratio” is the reciprocal of the traditional definition.
systemically important banks effective 2018. No institutions other than financial institutions have capital requirements. This section looks at why financial institutions have and need capital requirements.

Do Depository Institutions hold less Capital?

Figure II.1 shows actual capital ratios (ACRs)—equity/assets =((current equity market capitalization)/(current equity market capitalization + book value of debt))—for nine well known US firms and the maximum and average bank holding company’s actual capital ratio\(^5\) as of December 2014 (see Appendix II for a full list of the 18 bank holding companies).

![Figure II.1](image)

The bank holding companies’ capital ratios are very low relative to other firms. The two bars on the far right summarize the bank holding companies. The maximum\(^6\)—Wells Fargo—is 16% while the minimum for the other firms—American Axle & MFG—is 36%. And the average capital ratio for the bank holding companies is only 13% while the average is 65% for the other firms.\(^7\)

Why Do Depository Institutions hold less Capital?

The famous Modigliani-Miller theorem proves—given perfect markets—that it is the value of the firm (expected discounted future payoffs) that matters and the financing mix of equity/debt is irrelevant—

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\(^5\) See Section III for more detail.

\(^6\) This excludes American Express and Capital One which are registered BHCs, but whose core business is credit card processing and debt.

\(^7\) This is not the result of cherry picking the data. The exact numbers will change with time periods and comparison groups, but depository institutions have the lowest capital ratios.
see Appendix I. Increasing the debt/equity ratio increases the risk and the expected return to equity. It also increases the risk of debt and the default premium which makes it more expensive for firms to borrow. In equilibrium firms are indifferent to the financing mix. Of course actual markets don’t meet the assumptions of the MM theorem. But by eyeball econometrics the institutions—except for bank holding companies—in Figure II.1 don’t violate the MM theorem. Advanced Micro Devices has 36% capital and Intel has 80%—they each manufacture computer chips. There is no pattern to the other institutions’ capital ratios either except for bank holding companies’.

The government debt guarantee for financial institutions breaks the natural market equilibrating mechanism by making depository institutions’ debt default free. With the guarantee depository institutions can increase the expected return to capital (and risk) without having to pay the cost of higher default premiums on their debt. And when things go badly the government absorbs the loss while when things go well the financial institution takes the upside gain.

The debt guarantee is a subsidy to financial institutions, see Appendix I for an analytic representation of the subsidy. It encourages financial institutions to hold excessive debt and take excessive risk. Figure II.2 shows the capital ratios for the twenty riskiest financial institutions one quarter before the financial meltdown in October 2008.

**Figure II.2 Capital Ratios for Financial Institutions 07/2008**

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8 The FDIC has shown that it can and will close smaller depository institutions. In general, smaller institutions pay more for their debt, hold more equity, and are less risky, see VLab SRISK ranking for 75 financial institutions.

9 This is from VLabs’ Systemic Risk calculations—see Section III.
These capital ratios are extremely low—the institutions rode the government guarantee for the maximum benefit. Fannie Mae had 1.3% capital and Freddie Mac had only 0.6%. The government took Freddie and Fannie over and honored their debt. Of the twenty institutions only two went bankrupt so that debtholders suffered a loss—inamous Lehman Brothers who held a meager 1.9% capital and plunged world financial markets into a panic, and Washington Mutual (3% capital) who succumbed to an orderly death when the FDIC took over. But the 18 others survived or at least their debtholders didn’t suffer. Bank of America—with considerable pressure from regulators—bought Countrywide and Merrill Lynch. Wells Fargo bought Wachovia. And PNC Financial bought its rival National City Bank using Troubled Asset Relief Program (TARP)\textsuperscript{10} bailout funds. Of the remaining seven depository institutions all of them received TARP bailout funds. And, American International Group, an insurance company that wrote credit default swaps on mortgage backed securities (a default guarantee) purchased by many depository institutions received a huge bailout from the Federal Reserve\textsuperscript{11}.

**Why do Governments Guarantee Financial Institution Debt?**

The Great Depression and the Great Recession provide ample evidence that when the financial sector collapses the collapse of the real sector will follow. When a systemically important financial institution fails the damage extends far beyond its creditors and shareholders. Intermediation is a critical function in modern economies. The failure of Lehman Brothers, a medium size investment bank, froze overnight credit markets worldwide\textsuperscript{12}. Governments and Central Banks properly take measures to avoid the failure of institutions spreading to the rest of the financial market. After bank runs in the Great Depression led to the failure of many banks—small and large, some solvent some insolvent—the US enacted Federal Deposit Insurance—an explicit debt guarantee. Since then, implicit debt guarantees are more common—the TARP bailout, Freddie and Fannie, and the coerced acquisitions of Bear Stearns, Merrill Lynch, and others.

**Why Government Debt Guarantees justify Regulatory Capital Requirements**

The debt guarantee provides a subsidy to the institution that encourages them to take on excessive debt and risk—and they do, see Figure II.2. The debt guarantee interferes with the normal market mechanism that equilibrates more debt with a higher risk premium which gives firms a market incentive to limit debt. To offset the market failure introduced by the government debt guarantee the government needs regulatory capital requirements that impose a lower limit to the capital(equity)/asset ratio.

Section III presents quantitative estimates of a safe capital ratio (SCR).

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\textsuperscript{10} The Troubled Asset Relief Program—a program hastily enacted in November of 2008 to limit the financial collapse by bailing out banks.

\textsuperscript{11} The AIG bailout represented indirect support for the banks that held the mortgage backed securities.

\textsuperscript{12} Lehman froze financial markets because of the opaque web of debt connections. When Lehman declared bankruptcy it was immediately clear who they owed and how much—these creditors would have to wait and get less than they loaned. What froze the market is the fear that if Lehman’s creditors didn’t get paid, then they would default and their creditors wouldn’t get paid so they would default, and so on.
Financial Industry Arguments against higher Regulatory Capital Requirements

Debt guarantees are a subsidy to financial institutions and higher regulatory capital ratios reduce the value of the subsidy. Of course the industry vigorously opposes any effort to increase regulatory capital ratios. Admati and friends—Admati, DeMarzo, Hellwig, and Pfleiderer (2011), and Admati and Hellwig (2013)—present the best analytic and logical arguments to refute the financial sector’s claims that a higher regulatory capital ratio—higher equity—is too expensive and will damage the economy.

Admati and friends have been moderately successful in selling their position to non-economists. Senators Brown and Vittner introduced a bill in 2013 that would require very large banks to hold 15% capital to assets. And Admati testified before the Senate Committee on Banking in 2014.

This subsection summarizes the industry’s claims and Admati and friends’ refutation. See their papers and book for convincing detail.

Industry Arguments and Admati and Friends’ Response

- Increased regulatory capital ratios would force banks to hold in reserve funds that otherwise would be lent.
  - This represents an incredulous failure to understand basic accounting and economics—or cynical attempt to mislead the naïve legislators who don’t understand basic accounting and economics. Firms fund assets with liabilities—debt and equity. A large portion of bank assets are loans to the public. Increasing bank liabilities by adding equity gives the bank additional funds to lend, not less.
- Increased regulatory capital ratios would increase banks’ funding costs because equity requires a higher return than debt.
  - This is a slightly more subtle argument. Equity and debt returns normally contain a risk premium. Higher debt/equity ratios make debt and equity riskier which implies higher risk premiums. The M-M theorem shows that with perfect markets firms are indifferent between debt and equity financing, see Appendix I. The government debt guarantee for financial institutions transfers the debt risk to the government (public) so that banks get to pay the default free interest rate on their debt. So yes, equity financing for banks is more expensive than subsidized debt financing. But a higher regulatory capital ratio would make banks less risky—that’s the point—and it would reduce bank’s incentive to take excessive risk since the owners would bear more of the risk—not the taxpayers.

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13 Almost all economists accept that higher regulatory capital ratios are good, the only question is how much higher—as Stan Fischer asks.
14 VLab’s average implied Safe Capital Ratio is 16%.
15 Bank loans are liabilities to the public, but loans are assets to the bank. The public owes the value of the loan to the bank.
Less risky banks reduce the value of the debt guarantee subsidy. So the banking industry vigorously lobbies against higher regulatory capital ratios.

- Increased regulatory capital ratios would increase banks’ funding costs because debt has favorable tax shields.
  - This is true. The US tax codes favor debt over equity financing because companies can deduct interest payments as an expense while dividend payments are not tax deductible. However, the tax code applies to all industries. The government guarantee of bank debt—not the tax code—drives depository institutions to use excessive debt financing, see Figure II.1.

III. What is the Appropriate Regulatory Capital Ratio?

Section II and Appendix 1 show that government and/or central bank debt guarantees provide a subsidy to financial institutions that encourages them to hold excessive debt. And the data confirm that bank holding companies have much more debt relative to equity than other institutions. More debt means more risk. Appropriate regulatory capital ratios are a way to balance the perverse incentive created by the debt guarantee. But as Stanley Fischer asked what is the appropriate capital ratio? The Federal Reserve declared that large depository institutions would have to meet a “leverage” ratio\(^\text{16}\) (a capital ratio) of 5% and systemically important bank holding companies—eight at present—would have to meet a 6% “leverage” ratio—by 2018. Adamiti and Hellwig, the most vocal and successful academic advocates of higher regulatory capital ratios, want much higher regulatory capital ratios—20% to 30%—for all banks (CM’s average implied safe capital ratio is 22%).

In this Section we present and compare three quantitative measures of institution specific Safe Capital Ratios. Engle and friends (Brownlees and Engle 2012a), (Acharya, Engle, and Richardson 2012b) (Acharya, Engle, and Pierret 2014) develop the notion of a safe capital ratio. A safe capital ratio is a capital ratio so that in a severe downturn—similar in magnitude to the 2008 Great Recession—the institution will not drop below a safe 8% capital buffer. We compare Engle and friends (VLab), our (Craine-Martín), and the FED Stress Test implied safe capital ratios.

Engle and friends and we use an econometric model to forecast bank holding company equity value (market capitalization). The only methodological difference between Engle et al and us is that Engle et al use a bivariate specification and we use a multivariate specification. The FED Stress Test methodology is very different. The FED focuses on the bank holding company’s balance sheet data. They project the book value of the bank holding company’s net income and assets over the stress test horizon. Section III.1 details the differences in methodology and Section III.2 gives the safe capital ratio results.

Prelude

\(^{16}\) The “leverage” ratio in Fed regulations is a capital ratio—in accounting value terms, i.e., tier1 equity/(book value of assets).
Engle and friends organized and contribute to VLab which has a treasure of data easily accessible online, [http://vlab.stern.nyu.edu/analysis/RISK.USFIN-MR.MESSIM](http://vlab.stern.nyu.edu/analysis/RISK.USFIN-MR.MESSIM) which is updated weekly.

Figure III.1.1 shows the actual capital ratios, as shown in Figure II.2, and the safe capital ratios (explained below) for the twenty systemically riskiest US Financial institutions (according to VLab’s estimates) as of July, 2008—the eve of the financial meltdown.

**Figure III.1.1: Actual and Safe Capital Ratios 07/2008**

The safe capital ratios—the large orange bars—are enormous relative to the actual capital ratios (the small blue bars)—the two largest safe capital ratio spikes, Washington Mutual and Wachovia, are at 60%. The VLab measure of systemic risk indicates these twenty institutions were extremely risky in July of 2008. And subsequent events proved they were. All of the depository institutions—except Washington Mutual which the FDIC closed—got Troubled Asset Relief Program bailout funds—or were bought by another bank. As a consequence of the bailouts and the Great Recession, financial oversight got stronger—Dodd, Frank in the US and Basel III internationally. Now depository institutions hold substantially more capital. But do they hold enough?

**Section III.1 Safe Capital Ratio Estimates**
Section III.1 Safe Capital Ratio Estimates

III.1.a VLab

Engle et al’s development of a safe capital ratio begins with Brownlees and Engles’ (BE 2012a) measure of the “systemic risk” that a financial institution contributes to the economy. The institution contributes to systemic risk if it cannot meet its debt obligations and its resolution—bankruptcy (think Lehman Brothers), sale (think Bear Sterns) or government bailout (think TARP)—spills over to affect other financial and non-financial institutions or it requires taxpayer bailout. In normal times banks that experience an idiosyncratic loss can sell assets to regain their balance or they get bought by another institution. But in bad times when all institutions experience a market loss and they need to contract they cannot sell assets without severely depressing prices because there are few willing buyers and many sellers. Mega banks affect prices more in a fire sale since they have more to sell.

Brownlees and Engle’s quantitative measure of systemic risk, SRISK, depends on the firm’s size, actual capital ratio = (current equity market capitalization/(current equity market capitalization + book value debt)), the state of the economy as reflected in equity returns, the firm’s idiosyncratic risk, and its correlation with the market (roughly it’s \( \beta \)). SRISK is computed with current publicly available data—a great advantage in terms of transparency.

They define SRISK as,

\[
SRISK_{i,t} = E_{t-1}(\text{capital shortfall}_i \mid \text{crisis})
\]

the expected capital shortfall for firm \( i \) given a crisis. The shortfall is when the market capitalization falls below a capital buffer of \( k\% \) of assets. The institution’s market capitalization is expected to decline by the long run marginal expected shortfall (LRMES) times the current equity (market capitalization) value, \( LRMES_{it} * equity_{it} \). And assuming the book value of their debt is held constant,

\[
SRISK_{i,t} = E_{t-1}(k(\text{debt}_{i,t} + \text{equity}_{i,t}) - \text{equity}_{i,t} \mid \text{crisis})
\]

\[
= k * \text{debt}_{i,t} - (1-k) * (1-LRMES_{i,t}) * \text{equity}_{i,t}
\]

Then SRISK can be calculated from the current market capitalization and book value of debt of the bank and an estimate of the long run expected marginal shortfall.

To quantify the shortfall Brownlees and Engle estimate a bivariate model of equity returns for bank \( i \) and the market return, see Brownlees and Engle, equation 1, or Acharya, Engle, and Richardson, section I equation 3,

\[\]

\(^{17}\) B&E have an empirical paper. Acharya, et al (2010) have a theoretical paper.
Where, $r_{mt}$ and $r_{it}$ denote the logarithmic market and bank(i) return respectively. And $\sigma$ and $\rho$ denotes the conditional standard deviations and correlation of the returns. In this system, the volatilities are asymmetric GARCH processes and the correlation is estimated by DCC. The joint distribution, $F$, ensures that the random variables are independent over time, but not of each other. On the VLab web site, recursive estimates are presented so that systemic risk inferences are made at each point using only the information that was available.

VLab calculates the long run (6-month) marginal expected shortfall (LRMES) in a crisis by dynamically simulating the model many times and averaging the returns of institution $i$ when the market return falls by more than 40% over a six month horizon—a crisis. In simulating the model the shocks are obtained by bootstrapping the residuals $(\hat{\epsilon}_{mt}, \hat{\epsilon}_{i,t})$ and updating the conditional covariance matrix in (3.3). The 6-month simulated return on each bank holding company is computed as the cumulated sum of the of the daily returns over the period

$$R_{it+H-1}^r = \exp \left\{ \sum_{t=1}^{H} r_{it+1} \right\} - 1$$

The long run marginal expected shortfall is,

$$LRMES_{it-1} = \frac{\sum_{s=1}^{S} R_{it+H-1} I(R_{mt+H-1} < C)}{\sum_{s=1}^{S} I(R_{mt+H-1} < C)},$$

the average cumulative loss given a cumulative drop in the market return of at least 40%, ie, where $C = -40\%$.

Achraya, Engle, and Richardson propose the safe capital ratio (SCR) that sets the systemic risk (SRISK) to zero,

$$SCR \equiv \frac{equity}{equity + debt} \quad \text{so that} \quad SRISK = 0$$

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18 The S&P500 return fell by 40% over the 6-month period at the worst of the financial meltdown from September 2008-February 2009.
**VLab Safe Capital Ratio:** Manipulating equation (3.2) gives the safe capital ratio (SCR) as a simple function of the long run marginal expected shortfall (LRMES), (eq 8 in Achraya, Engle, and Richardson)

\[
SCR = \frac{k}{1 - (1 - k)LRMES}
\]

where \(k\) is the safe capital buffer. Engle and Friends choose a buffer of 8%. The VLab safe capital ratio is easily computed from the data reported in VLab.

**III.1.b Craine-Martin (CM)**

VLab is an enormous undertaking and an incredibly valuable resource to academics, policymakers, and business. VLab generates estimates of SRISK for 75 US financial institutions and for financial institutions in twenty countries weekly—and posts them on their website.

The scope of the VLab project is enormous in terms of the number of institutions and countries. They make the estimation of SRISK and calculation of the long run marginal expected shortfall for each institution more manageable by assuming the bivariate specification in equation 3.2. In principle, institutions contribute to systemic risk when their shortfall spills over and affects other institutions. In the bivariate specification the only channel for spillovers is through the market return. Shocks to other financial institutions do not directly affect institution \(i\) and shocks to institution \(i\) cannot directly affect other firms.

Our contribution here is analytically simple—we extend Brownlees and Engle’s bivariate model to a multivariate model. Our extension is not so simple computationally. We use the same basic setup as Brownlees and Engle’s equation in 3.3,

\[
\begin{align*}
    r_t &= \Sigma_t^{1/2} \zeta_t \\
    \zeta_t &\sim F
\end{align*}
\]

except \(r\) is a vector of returns containing the market return and 18 bank holding companies’ returns and \(\Sigma_t^{1/2}\) is the lower triangular Cholesky decomposition of the conditional covariance matrix \(\Sigma_t\) (the multivariate extension of the BE’s bivariate model) where the ordering is the market return followed by the 18 bank holding companies ranked by their market capitalization from highest to lowest. \(\zeta_t\) is a corresponding vector of disturbances, with distribution \(F\), that are independent over time but not of each other. As in the bivariate specification of BE, the conditional variances are estimated as univariate asymmetric GARCH processes. The corresponding conditional correlation matrix is estimated with a DCC specification.
The parameters of the model are estimated\textsuperscript{19} using a two-step maximum likelihood estimator with the asymmetric GARCH parameters estimated in the first step and the DCC correlation parameters in the second step. Maximization of the full joint log-likelihood gives the standard errors.

The cumulative returns and the LRMES for the 18 bank holding companies are computed by simulating the system (3.8) with bootstrapped residuals $\hat{z}_t$, and updating the conditional covariance matrix $\hat{\Sigma}_t$ over a time horizon corresponding to 6 months using the same equations as VLab, (3.4) and (3.5) where we take $H = 125$ to be days and the total number of simulations is set at $S = 1,000,000$.

**CM Safe Capital Ratio:** The CM safe capital ratios (SCRs) are computed using the same equation as VLab 3.7 with our estimates of the LRMES.

### III.1.c FED Stress Test Estimates of Safe Capital Ratios

The goal of the FED Stress tests and Vlab’s systemic risk measure is the same,

“Capital is central to a BHC’s ability to absorb losses and continue to lend to creditworthy businesses and consumers…..For this reason, the Federal Reserve has made assessments of capital planning and analysis of capital adequacy on a post stress basis a cornerstone of its supervision of the largest and most complex financial institutions.”\textsuperscript{20}

but methodologies are very different.

**Equity Value**

VLab and CM only use estimated BHC’s equity market return losses conditional on a severe downturn in the market return to construct the loss in the market value of the BHC’s capitalization. In contrast, the Dodd-Frank Act Stress Test 2015 builds up the book value of BHC (DFAST 2015 p 10) from detailed micro models to project the book accounting values for the losses on bank holding company’s major asset categories and the its net income,

The models are intended to capture how the balance sheet, RWAs, and net income of each BHC are affected by the macroeconomic and financial conditions described in the supervisory scenarios, given the characteristics of the BHCs’ loans and securities portfolios; trading, private equity, and counterparty exposures from derivatives and SFTs; business activities; and other relevant factors.

DFAST calculates book income and losses using two scenarios—a “Severely Adverse Scenario” and an “Adverse Scenario”, see DFAST 2015 Supervisory Scenarios pp5-6,

Supervisory scenarios include trajectories for 28 variables. These include 16 variables that capture economic activity, asset prices, and interest rates in the U.S. economy and financial markets and three variables (real gross domestic product (GDP) growth, inflation, and the U.S./foreign currency exchange rate) in each of the four countries/country blocs.

\textsuperscript{19} We use the same data as VLab. All the data come from the CRSP daily security files. The market return is the return on the value weighted index with distributions. Our sample runs from 12/14/2001 through 12/31/2014.

We use the results from the Severely Adverse Scenario which resembles the Gt Recession—the simulation period lasts 9 quarters (the Gt Recession officially lasted 8 quarters), equity values fall by 60% in the first year, house prices decline by 25%, the unemployment rate increases by 4% and GDP falls by 4.5%—see DFAST 2015 for more detail.

**Asset Value**

The BHC's asset values are projected from different models that relate industrywide loan and non-loan growth to broader economic variables, see DFAST 15, Balance Sheet Items and Risk-Weighted Assets, pp 62-63. The industry loan and asset growth rates projections over the stress test horizon use the macroeconomic variables in the supervisory scenario. Over this horizon, each BHC is assumed to maintain a constant share of the industry's total assets.

**Tier1 Leverage Ratio**

The Tier1 Leverage Ratio, aka Capital Ratio, is the ratio of the BHC's (projected Equity)/(projected Assets) over the Stress Test horizon.

The FED STRESS TEST results report the actual book capital ratio at the beginning of the test, the minimum projected capital ratio and the project terminal capital ratio (the final value at the end of the 9-quarter stress test), see Appendix II for the values. We use the minimum capital ratio to calculate the implied safe capital ratio²¹.

**FED STRESS test Safe Capital Ratio:** We calculate the Safe Capital Ratio implied by the STRESS TEST as,

$$
	ext{SCRFED} = \text{ACRFED} - \text{ShortfallFED}
$$

where  

\( \text{ACRFED} \equiv \text{Actual book value Capital Ratio in 09/2014} \)

\( \text{ShortfallFED} \equiv \text{minTier1 Capital Ratio - 8%} \)

**III.2 Results**

This proportion presents and compares the implied safe capital ratios from the three techniques. We use 18 bank holding companies where VLab, the FED Stress tests, and our estimates overlap²². The bank holding companies include the eight bank holding companies that the FED labels systemically important.

The broad summary is: CM have the largest implied Safe Capital Ratios averaging 22%, VLab has the second highest averaging 16%, and the FED Stress tests the smallest at 11%.

Figure III.2.1 illustrates the results,

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²¹ The FED Stress Test uses a nine quarter horizon—Vlab and CM use a two quarter horizon.

²² The FED STRESS Tests report results for 31 BHCs. 21 of those overlap with VLab's data. Three of these BHCs are headquartered in Europe so that CRSP does not report their return data. That leaves 18 BHCs with overlapping return data. Enough BHCs to provide a pretty good sample and certainly enough to make multivariate Garch estimation challenging.
III.2.a More Detailed Safe Capital Ratio Results

Table III.2.a below gives detailed results by the bank holding companies separated into the eight banks that the FED designates as systemically important and others. Systemically important banks are large banks with substantial trading, processing and custodial operations.

**Table III.2a Safe Capital Ratios for BHCs**

<table>
<thead>
<tr>
<th>Bank Holding Co</th>
<th>Systemically Important CM</th>
<th>Important VLab</th>
<th>FED</th>
<th>Other CM</th>
<th>VLab</th>
<th>FED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Fargo &amp; Co</td>
<td></td>
<td></td>
<td></td>
<td>0.163</td>
<td>0.138</td>
<td>0.112</td>
</tr>
<tr>
<td>JPMorgan Chase &amp; Co</td>
<td></td>
<td></td>
<td></td>
<td>0.306</td>
<td>0.155</td>
<td>0.110</td>
</tr>
<tr>
<td>Bank of America Corp</td>
<td></td>
<td></td>
<td></td>
<td>0.200</td>
<td>0.136</td>
<td>0.108</td>
</tr>
<tr>
<td>Citigroup Inc</td>
<td></td>
<td></td>
<td></td>
<td>0.260</td>
<td>0.158</td>
<td>0.124</td>
</tr>
<tr>
<td>American Express Co</td>
<td></td>
<td></td>
<td></td>
<td>0.256</td>
<td>0.133</td>
<td>0.116</td>
</tr>
<tr>
<td>Goldman Sachs</td>
<td></td>
<td></td>
<td>0.247</td>
<td>0.169</td>
<td>0.082</td>
<td></td>
</tr>
</tbody>
</table>
III.2.b Analysis by Models

Overview

The two main results in this paper follow directly from the model specifications.

(1) Explicitly allowing losses at any bank holding company to directly affect other banks turns out to be quantitatively very important for measuring systemic risk. The CM model jointly estimates the correlation among bank returns and the market return and finds the largest implied safe capital ratios. The losses during a crisis are larger because bank returns and asset values are positively correlated. When all banks suffer their collective distress is even greater. In addition, the greatest implied losses occur at the banks the FED designates as systemically important see Table III.2.a above. The VLab specification that allows for feedback between bank holding company(i)'s return and the market return. But it doesn’t allow returns at bank holding company(i) to directly affect bank holding company(j)'s return. VLab finds the second highest
implied safe capital ratios. Finally the FED stress tests where the causality runs from the driving variables in the adverse scenario to bank(i). There is no feedback from bank(i) to the variables in the adverse scenario or among banks\textsuperscript{23}. The FED stress tests find the lowest implied safe capital ratios.

(2) Surprisingly the accounting convention—book or market equity capitalization—also turns out to be quantitatively very important for measuring systemic risk. Book equity capitalization responds so slightly and slowly to economic distress—even a crisis as severe as the Gt Recession—that it is useless as an indicator of bank distress.

**VLab and Craine-Martin (CM)**

Vlab and CM are easy to compare. They use the same data, the same basic GARCH econometric specification. And they use the same equation (3.5) to compute the Safe Capital Ratio. The only substantive difference is the VLab bivariate specification vs the CM multivariate specification.

The safe capital ratios in Table III.2.a for VLab and CM are completely determined by their estimates of the LRMES (Long Run Marginal Expected Shortfall) which are estimates of the loss in the bank holding company’s cumulative return in a severe recession. Here we examine the estimates of the LRMES as of December 2014 and compare them to the actual capital losses for the financial meltdown period from September 2008 to February 2009 for the 8 bank holding companies the FED considers systemically important.

**Figure III.2.b.1 LRMES as of Dec 2014 and Actual Equity Return Losses 2008-09**

\textsuperscript{23} The losses from counterparty risk and the global shock on the eight systemically important BHCs accounts for more than 20% of the total Stress test losses for the 31 BHCs subject to stress tests in the FED results, see Table 4 in DFAST 2015. Interdependence is obviously important and hard to account for.
On average VLab predicts that current losses will be 3.5% less than the losses in 2008-09 and CM predicts they will be 23% higher. For the three big losers in 2008—Wells, BofA, Citi—CM and VLab predict smaller losses now. For the investment banks—Goldman, Morgan Stanley, and BofNY24—they project much larger losses. For JPMorgan it’s a wash VLab predicts the same CM predicts more. State Street Bank is the only qualitative disagreement—CM predicts a higher loss than the historical loss and VLab less.

Allowing direct spillovers (CM multivariate specification) matters, and it matters a lot—on average CM predicts a 26% greater loss than VLab.

**FED STRESS TEST**

A simple direct comparison between the econometric approach of CM and VLab and the Fed Stress Tests is not possible although both focus on the equity value of the bank holding company during a severe downturn. CM and VLab estimate the market value of bank holding company equity using equity market return data. Fed stress tests compute the book value of bank holding company equity by projecting book income and losses.

The difference between the market and book value accounts for about 4% on average. The FED’s measure of actual capital ratios (ACRs) is on average about 4% less than VLab-CM’s25, see Table III.2.b columns 2-3. But if one simply adds 4% to the implied average FED safe capital ratios (to adjust for the

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24 The investment banks suffered heavy losses prior to September 2008.
25 The FED STRESS TEST data on ACRs are for the end of the 3rd quarter of 2014 and VLab CM are the end of the 4th quarter. But that doesn’t explain the large difference.
accounting differences) they are still short of the implied average safe capital ratios for VLab by 1% and CM by 7%, columns 4-5-6.

We also looked at a simple measure of the sensitivity of the implied safe capital ratios to a severe downturn. VLab and CM specify a severe downturn as a 40% loss in the equity market. The FED’s severely adverse scenario is much more comprehensive and seemingly harsher. Equity prices fall by 60%, housing prices fall by 25%, GDP by 4.5%, and unemployment rises by 4%; see the Severely Adverse Scenario for the full list. But the increase in the implied average safe capital ratio for the FED is only 1.2% from 9.3% to 10.5%. In contrast, the increase in the average implied average safe capital ratio for VLab is 2.4% and for CM 8.7%.

### Table III.2.b ACRs, SCRs 12/2014

<table>
<thead>
<tr>
<th>Institution</th>
<th>Actual Capital Ratios</th>
<th>Safe Capital Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vlab-CM</td>
<td>FED Tier1 Lvg=ACR</td>
</tr>
<tr>
<td>Wells Fargo &amp; Co</td>
<td>16.37%</td>
<td>9.60%</td>
</tr>
<tr>
<td>JPMorgan</td>
<td>9.25%</td>
<td>7.60%</td>
</tr>
<tr>
<td>Chase &amp; Co</td>
<td>9.07%</td>
<td>7.90%</td>
</tr>
<tr>
<td>Bank of America Corp</td>
<td>8.94%</td>
<td>9.00%</td>
</tr>
<tr>
<td>Citigroup Inc American Express Co</td>
<td>41.84%</td>
<td>11.60%</td>
</tr>
<tr>
<td>Goldman Sachs Group Inc/The Morgan Stanley Capital One Financial Corp Bank of New York Mellon Corp/The State Street Corp SunTrust Banks Inc Fifth Third Bancorp Northern Trust Corp Regions Financial Corp KeyCorp Huntington Bancshares Inc/OH Comerica Inc Zions Bancorporation</td>
<td>9.75%</td>
<td>9.00%</td>
</tr>
<tr>
<td>15.20%</td>
<td>10.60%</td>
<td>31.07%</td>
</tr>
<tr>
<td>11.60%</td>
<td>5.80%</td>
<td>14.44%</td>
</tr>
<tr>
<td>11.45%</td>
<td>6.40%</td>
<td>12.74%</td>
</tr>
<tr>
<td>11.72%</td>
<td>9.50%</td>
<td>12.35%</td>
</tr>
<tr>
<td>12.38%</td>
<td>9.80%</td>
<td>15.36%</td>
</tr>
<tr>
<td>13.40%</td>
<td>7.90%</td>
<td>15.87%</td>
</tr>
<tr>
<td>12.47%</td>
<td>11.00%</td>
<td>15.06%</td>
</tr>
<tr>
<td>13.18%</td>
<td>11.20%</td>
<td>14.17%</td>
</tr>
<tr>
<td>12.87%</td>
<td>9.80%</td>
<td>16.53%</td>
</tr>
<tr>
<td>12.05%</td>
<td>10.80%</td>
<td>13.66%</td>
</tr>
<tr>
<td>10.73%</td>
<td>11.90%</td>
<td>17.56%</td>
</tr>
<tr>
<td>Median</td>
<td>11.89%</td>
<td>9.55%</td>
</tr>
<tr>
<td>average</td>
<td>13.42%</td>
<td>9.31%</td>
</tr>
</tbody>
</table>
III.2.c  Book vrs Market Values

To separate the effect of book vrs market value accounting from the models we looked at actual capital ratios and equity values over the Gt Recession for the eight banks that the FED deems systemically important. Figure III.2.c illustrates the book and market capital ratios for one of the most dramatic cases—CitiGroup.

**Figure III.2.c CITIGROUP Capital Ratios 2007:09 2009:09**

Lehman Brothers failed in October 2008 and financial markets froze and the equity market crashed. In November 2008 a panicked Congress passed the Troubled Asset Relief Program to bail out the banks. The top line in the graph to the right of the box indicating Lehman’s failure is CitiGroup’s Tier1 Leverage ratio—the book value of tier1 equity divided by average book assets. Citi’s Tier1 leverage ratio never falls below 6% for the remainder of the recession. To put this in perspective, in April 2014 the Federal Reserve Board announced that they had adopted a final rule to strengthen capital standards and beginning in 2018 the eight largest banking institutions must maintain a 6% leverage ratio to be considered well capitalized.26 So according to the new strengthened capital standards CitiGroup was well capitalized during the Gt Recession. A look at the lower line which plots the market capitalization ratio paints a totally different picture of CitiGroup’s capitalization. After Lehman failed it fell from 5.5% to 2% to 1%. The market capitalization ratio screams that CitiGroup is a bank in deep distress.

Appendix III has book and market equity and asset data for all eight banks. CitiGroup is the most dramatic, but none of the book value leverage (capital) ratios signal that the bank is in distress during the Gt Recession.

References


Dodd-Frank Act Stress Test 2015: Supervisory Stress Test Methodology and Results, March 2015, Board of Governors of the Federal Reserve System.


revised 2015


http://vlab.stern.nyu.edu/
Appendix I: Analytical basis for Financial Institution Regulatory Capital Ratios

This appendix is the foundation of the intuitive discussion in Section II. It proves the Modigliani-Miller theorem and shows that the government debt guarantee for financial institutions is a subsidy. And it shows that the value of the subsidy is increasing in the debt to equity ratio.

Modigliani-Miller Theorem

The M-M Theorem shows that it is the value of the firm, \( V \), that matters. The financing mix—\( E \), equity, and \( D \), debt—is irrelevant.

Modigliani and Miller published their Theorem and ingenious proof in 1958. The proof is as complicated as it is ingenious. Arrow and Debreu published their path breaking work on the existence and welfare properties of a competitive equilibrium in 1954. But financial economists and others did not realize the power, beauty, and simplicity of the A-D setup until years later. This Appendix proves M-M using A-D the contingent claims setup. I present a simplified two period version of the proof in Merton (1992) and Ljungqvist and Sargent (2004).

Assumptions: standard assumption for the existence of a competitive equilibrium.

Define:

\[ p(s) = \text{the Arrow-Debreu price of a contingent commodity in state } s \text{ next period. The states, } s, \text{ are stochastic and defined by a probability distribution. The price, } p(s), \text{ incorporates time discounting and uncertainty.} \]

\[ x(s) = \text{the net asset value of the firm next period in state } s \]

\[ n = \text{the promised payoff to debtholders in all states. If the firm cannot meet the promised debt obligation, then debtholders get the firm, worth } x(s), \text{ and equity holders get nothing.} \]

Then,
The current value of the firm
\[ V = \sum_s p(s) x(s) \]
the current equity value (market cap) of the firm
\[ E = \sum_s p(s) \max(x(s)-n,0) \]
the current value of debt of the firm
\[ D = \sum_s p(s) \min(n, x(s)) \]

The Modigliani-Miller Theorem
\[ V = E + D \]

\[ \sum_s p(s)x(s) = \left[ \sum_s p(s) \max((x(s)-n),0) + \sum_s p(s) \min(n, x(s)) \right] \]

The financing mix, \( D/E \), is irrelevant. The proof is so deceptively simple it masks generality of the result.

**Why Debt Guarantees for Financial Institutions Require Regulatory Capital Ratios**

Governments guarantee financial institutions debt because the failure of a significant financial institution spreads well beyond losses to the firm’s equity and debt holders—a negative externality. But the debt guarantee is a subsidy to the financial institution, and the subsidy is increasing in value with the debt to equity ratio. So institutions with a guarantee have an incentive to hold excessive debt.

The guarantee makes the institution’s debt default free. The value of the default free debt is,
\[ D^d = n \sum_s p(s) \]
And as Merton (1977) shows the value of the firm’s risky debt with a government guarantee equals the value firm’s risky debt plus a put option with a strike price of the firm’s promised debt payment, \( n \),
\[ D^d = D(x(s), n) + \text{Put}(x(s), n) = \sum_s p(s) \left[ \min(x(s), n) + \max(n-x(s), 0) \right] \]

The guarantee violates the M-M perfect markets assumption. The equity value plus the value of the guaranteed debt of the financial institution is greater than the value of the firm,
\[ V = E + D \leq E + D + \text{Put}(x(s), n) \]

The debt guarantee is a subsidy to the institution. Merton proposed that the fairly priced deposit insurance premium equal the value of the put option, i.e., the value of the subsidy.

The value of the Put,
\[ \text{Put}(n, x(s)) = \sum_s p(s) \max(n-x(s),0) \]
Is increasing in the promised debt payment, \( n \), (the institution’s debt).
An appropriate regulatory capital ratio reduces debt and the risk—which is the point. It also reduces the value of the subsidy. A safe capital ratio, SCR, (see Section III) can make the likelihood of default so small that the value of the put option, the subsidy, is essentially zero.

Appendix II

<table>
<thead>
<tr>
<th>Bank Holding Co</th>
<th>Market Cap</th>
<th>Actual Capital Ratios</th>
<th>LRMEs</th>
<th>Tier1Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wells Fargo &amp; Co</td>
<td>284385548.00</td>
<td>0.1636661 0.096 45.55 55.45 6.4</td>
<td>FED</td>
<td>Vlab&amp;CM Lvg=ACR</td>
</tr>
<tr>
<td>JPMorgan Chase &amp; Co</td>
<td>233935868.00</td>
<td>0.0925069 0.076 52.5 80.25 4.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank of America Corp</td>
<td>188139291.00</td>
<td>0.0907441 0.079 44.75 65.14 5.1</td>
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<tr>
<td>Citigroup Inc American Express Co</td>
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<td>0.0893655 0.09 53.53 75.25 4.6</td>
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</tr>
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<td>Goldman Sachs Group Inc/The Morgan Stanley Capital One Financial Corp</td>
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<td>0.41841 0.116 57.12 73.5 11.4</td>
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<td></td>
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<td>32773358.00</td>
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<td>SunTrust Banks Inc</td>
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<td>Fifth Third Bancorp</td>
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<td>Regions Financial Corp</td>
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<td>0.1246883 0.11 50.97 53.68 7.6</td>
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</tr>
<tr>
<td>KeyCorp Huntington Bancshares Inc/OH</td>
<td>12041918.00</td>
<td>0.1317523 0.112 47.33 61.97 9.3</td>
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</tr>
<tr>
<td>Comerica Inc</td>
<td>8568056.00</td>
<td>0.1287001 0.098 56.09 54.19 8</td>
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<td>Zions Bancorporation</td>
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<td>0.1204819 0.108 45.06 60.61 8.9</td>
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<tr>
<td>Avg</td>
<td>0.1341995</td>
<td>0.0931111 51.413889 67.046667 6.8176471</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FED ACR==actual capital ratio==book equity/book assets
ACR(Vlab) = ACR(CM) == mkt equity/(mkt equity + book debt)
FED Tier1 ACR==actual capital ratio==book equity/book assets
LRMES == % loss in market capitalization in severe downturn
Tier1Min == FED stress tests results for min capital ratio in the severe downturn scenario

Appendix III