Safe Capital Ratios for Bank Holding Companies

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A Regulatory Capital Ratio Rule for Financial Institutions

> 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 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.

The government guarantees financial institutions' debt and bails out systemically important financial institutions if they get in trouble. The government protects banks because the failure of a systemically important financial institution creates a negative spillover that causes losses to the economy much larger than the private losses to the bank's equity and debt holders'. But the government protection is a subsidy to private financial institutions that encourages them to hold excessive debt—which makes them excessively risky. 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 Craine-Martin (CM) implied safe capital ratios are the highest averaging 22%, followed by VLab's averaging 16%, and the FED Stress tests the lowest at 11%. All of the implied safe capital ratios are two to four times greater than the FED's required "Tier1 leverage ratio" (aka capital ratio) of 5% for large bank holding companies and 6% for eight systemically important banks.[1] We attribute our (CM) higher implied safe capital ratios to our specification that allows spillovers among the bank holding companies. In a crisis accounting for spillovers among bank holding companies gives much large losses since their returns and asset values are positively correlated.

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[2] 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

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[1] FRB press release April 8, 2014.
[2] According to VLab—see Section III for details on VLab.

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[3], and the US Federal Reserve imposed a minimum leverage ratio[4] 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): 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. But 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 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 bank holding company equity value (market capitalization) in a severe downturn. 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 much different. The FED focuses on the bank holding company's balance sheet data. They project the BHC's net book income 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

[3] 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.
[4] See https://www.fdic.gov/regulations/resources/director/regcapintfinalrule.pdf for a detailed description of Tier 1 capital and the various regulatory capital ratios.

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%). All of the implied safe capital ratios are two to four times greater than the FED's required "Tier1 leverage ratio" (aka capital ratio) of 5% for large bank holding companies and 6% for eight systemically important banks.

We attribute most of the difference in the implied safe capital ratios to the importance of spillover effects among bank holding companies and the market in a crisis. The FED stress test specifies virtually no spillover effects. VLab's bivariate specification allows spillovers between the market return and bank holding company(i)'s return. But, bank holding company(i)'s return does not affect bank holding company(j)'s return or the market return in bank holding company(j)'s bivariate specification. Our (CM) specification is the multivariate extension of VLab's bivariate model. And it seems to make a big difference in a crisis. The multivariate specification allows for spillovers among the 18 bank holding companies and the market return. When things go badly for all the bank holding companies at the same time, since their returns and asset values are positively correlated, their expected losses are much larger than when viewed in isolation, see Appendix II.

After a downturn—like the Great Recession—a basic question is how long does an institution have to close the gap between their safe capital ratio and actual capital ratio and should the time be state dependent?

Section IV proposes a simple state dependent Regulatory Capital Ratio Rule (RCRR) of thumb. In normal times the regulatory capital ratio equals the safe capital ratio; in a crisis—capital is a buffer that gets run down so the regulatory capital ratio equals the actual capital ratio. After a crisis one wants the least risky institutions to make loans to support the recovery and the riskiest institutions to retrench and build up their capital. The RCRR gives bank holding companies with a smaller capital gap (Safe Capital Ratio – Actual Capital Ratio) than the expected capital gap for the average institution (less risky bank holding companies) more time to adjust and bank holding companies with a greater capital gap less time to adjust.

Section V gives the summary and conclusions.

Section II: Regulatory Capital Ratios

Basel III introduced a minimum "leverage ratio" that requires banks to have common equity that is 3% of assets[5], and the US Federal Reserve imposed a minimum Tier1 leverage ratio of 6% on eight

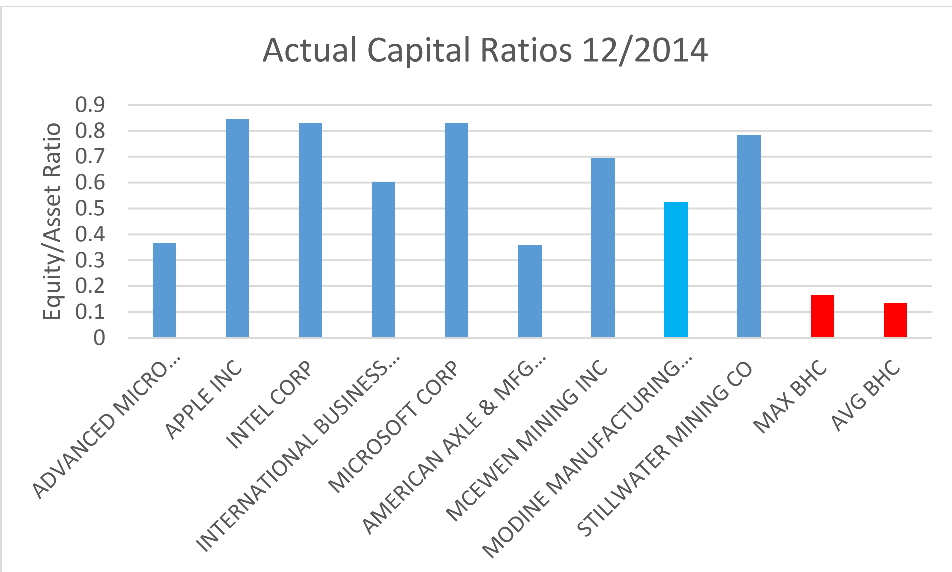
[5] The traditional definition of the leverage ratio is assets/equity so Basel III "leverage ratio" is the reciprocal of the traditional definition.

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 [6] (see Appendix II for a full list of the 18 bank holding companies).

Figure II.1



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[7]—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.[8]

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—

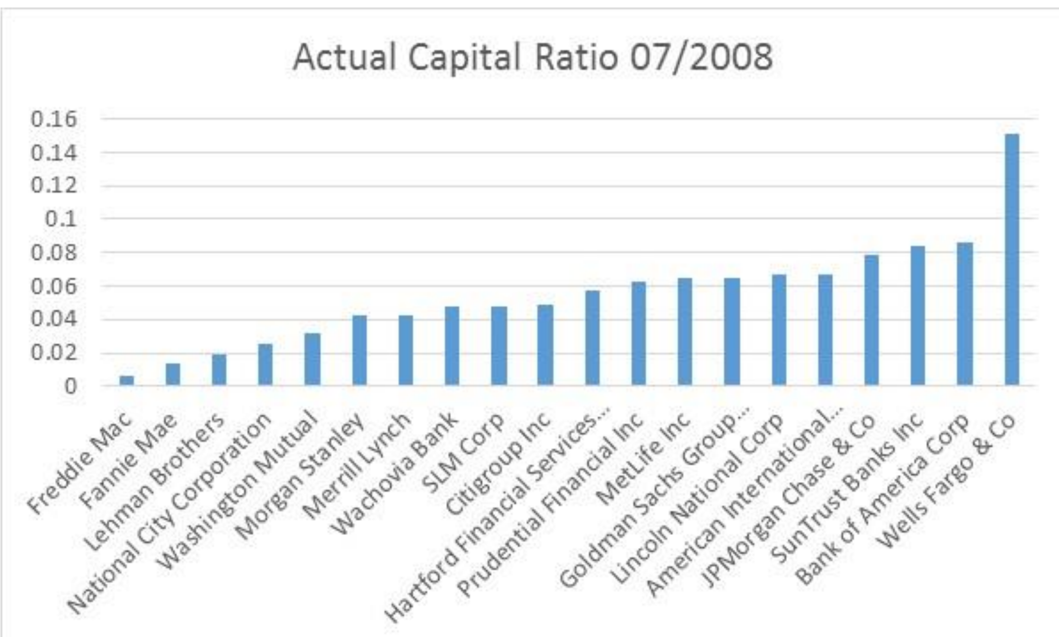
[6] See Section III for more detail.
[7] This excludes American Express and Capital One which are registered BHCs, but whose core business is credit card processing and debt.
[8] This is not the result of cherry picking the data. The exact numbers will change with time periods and comparison groups, 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[9] 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[10] one quarter before the financial meltdown in October 2008.

FIgure II.2 Capital Ratios for Financial Institutions 07/2008



[9] 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.
[10] 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—infamous 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)[11] 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[12].

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[13]. 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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[11] The Troubled Asset Relief Program—a program hastily enacted in November of 2008 to limit the financial collapse by bailing out banks.

[12] The AIG bailout represented indirect support for the banks that held the mortgage backed securities.

[13] 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 PFIederer (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[14]. Senators Brown and Vittner introduced a bill in 2013 that would require very large banks to hold 15% capital to assets[15]. 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[16]. 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.

[14] Almost all economists accept that higher regulatory capital ratios are good, the only question is how much higher—as Stan Fischer asks.
[15] VLab's average implied Safe Capital Ratio is 16%.
[16] 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[17] (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-Martin), 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 main 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

[17] The "leverage" ratio in Fed regulations is a capital ratio—in accounting value terms, i.e., tier1 equity/(book value of assets).

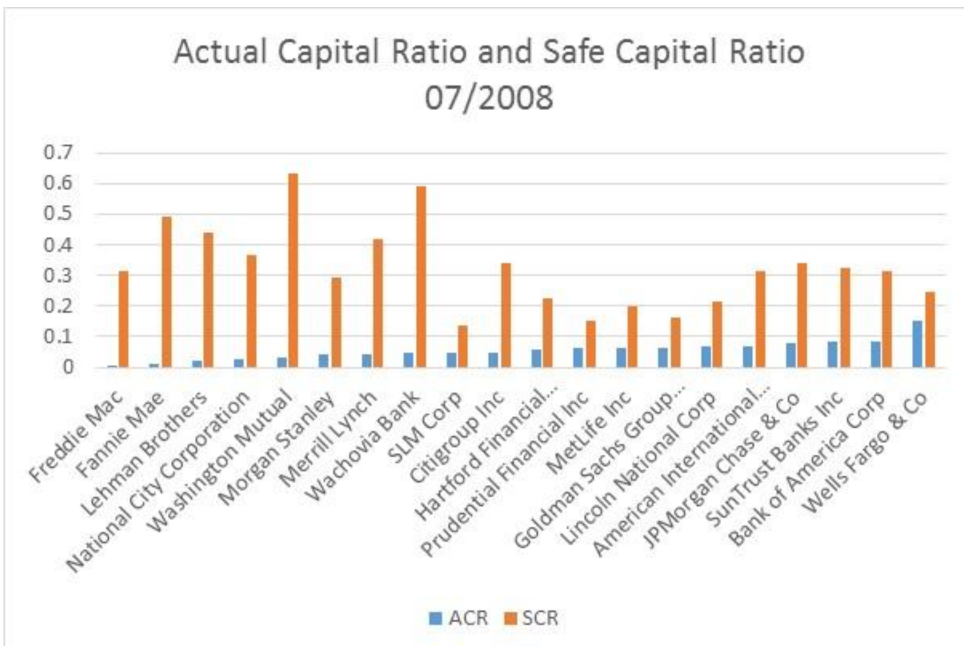
Engle and friends organized and contribute to VLab which has a treasure of data easily accessible online,

http://vlab.stern.nyu.edu/analysis/RISK.USFIN-MR.MESSIM

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

III.1.a VLab Estimate of Safe Capital Ratios

Engle el 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.[18] 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—spills over to affect other financial and non-financial institutions or the taxpayers. 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 reflected in equity returns, the firm's idiosyncratic risk, and its correlation with the market (roughly it's β). SRISK is computed with current publicly available data—a great advantage in terms of transparency.

They define SRISK as,

$$SRISK_{i,t} = E_{t-1}(capital\ shortfall_i \mid crisis) \qquad 3.1$$

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,

$$\begin{aligned} SRISK_{i,t} &= E_{t-1}(k(debt_{i,t} + equity_{i,t}) - equity_{i,t} \mid \text{crisis}) \\ &= k * debt_{i,t} - (1-k) * (1 - LRMES_{i,t}) * equity_{i,t} \end{aligned} \qquad 3.2$$

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 Achraya, Engle, and Richardson, section I equation 3,

[18] B&E have an empirical paper. Acharya, et al (2010) have a theoretical paper.

$$r_{m,t} = \sigma_{m,t}\varepsilon_{m,t}$$
$$r_{i,t} = \sigma_{i,t}(\rho_{i,t}\varepsilon_{m,t} + \sqrt{1-\rho^2_{i,t}}\xi_{i,t}) \quad 3.3$$
$$(\varepsilon_{m,t}\xi_{i,t}) \sim F$$

Where, r_{mt} and r_{it} denote the logarithmic market and bank(i) return respectively. And σ and ρ 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.[19] In simulating the model the shocks are obtained by bootstrapping the residuals $(\hat{\varepsilon}_{mt}, \hat{\xi}_{i,t})$ 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

$$R^s_{it:t+H-1} = \exp\left\{\sum_{\tau=1}^{H} r_{it+\tau-1}\right\} - 1 \quad 3.4$$

The long run marginal expected shortfall is,

$$LRMES_{it-1} = \frac{\sum_{s=1}^{S} R_{it:t+H-1} I(R_{mt:t+H-1} < C)}{\sum_{s=1}^{S} I(R_{mt:t+H-1} < C)}, \quad 3.5$$

Is the average cumulative 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,

$$SCR \equiv \frac{equity}{equity + debt} \text{ so that } SRISK = 0 \quad 3.6$$

[19] 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)

$$SCR = \frac{k}{1-(1-k)LRMES} \quad 3.7$$

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. Contagion only feeds through the market return to other institutions[20].

Our contribution here is to extend Brownlees and Engle's bivariate model to a multivariate model. We use the same basic setup as Brownlees and Engle's equation in 3.3,

$$\begin{aligned} r_t &= \Sigma_t^{1/2}\zeta_t \\ \zeta_t &\sim F \end{aligned} \quad 3.8$$

except *r* is a vector of returns containing the market return and 18 bank holding companies' returns and $\Sigma^{1/2}{}_t$ is the lower triangular Cholesky decomposition of the conditional covariance matrix Σ_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. ζ_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.

[20] This is a "single factor" model in the spirit of the CAPM. The market return and conditional covariance matrix is a sufficient statistic.

The parameters of the model are estimated[21] 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 bootstapped residuals $\hat{\zeta}_t$ and $\hat{\Sigma}_t$ 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 Tests

Equity Value

The Dodd-Frank Act Stress Test 2015 (DFAST 2015) and VLab-CM methodology are almost complements. VLab and CM use estimated equity market return losses during a severe downturn to construct the market value of the BHC's capitalization. DFAST constructs the book (accounting) value of the BHC's equity capitalization during a severe downturn.

DFAST projects income—net interest and noninterest income--and subtracts detailed book accounting values for the losses on bank holding company's major asset categories —accrual loan portfolio, wholesale lending (corporate and mortgage), residential, …, trading and private equity. After adjustments for taxes and distributions they get net income which equals the change in equity capital, see DFAST 2015, Analytic Framework p21-22.

DFAST calculates income and losses using two scenarios—a "Severely Adverse Scenario"—that resembles the 2008 Great Recession—and an "Adverse Scenario", see DFAST 2015 Supervisory Scenarios pp5-6. We use their results from the Severely Adverse Scenario.

DFAST projections of asset and income losses depend on (p5),

> 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.

an impressive array of macroeconomic and financial forcing variables. (While VLab and CM use only equity market returns).

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[21] 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.

Notice, however, the setup also does not allow contagion of losses among bank holding companies. The bank holding company models (see Modelling Approach p10)

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.

The channels are unidirectional. The direction goes from the trajectories in Supervisory Scenario to the individual bank holding company asset portfolio. There are no channels linking the bank holding companies, or feedback to the supervisory scenarios.

Asset Value
The BHC's asset values are projected using a model that relates 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.
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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 2 for the values. We use the minimum capital ratio to calculate the implied safe capital ratio[22].

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

$$\begin{aligned} &\text{SCRFED} = \text{ACRFED - ShortfallFED} \\ &\text{where ACRFED} \equiv \text{Actual book value Capital Ratio in 09/2014} \\ &\text{ShortfallFED} \equiv \text{minTier1 Capital Ratio - 8\%} \end{aligned}$$

III.2 Results

This proportion presents and compares the implied safe capital ratios by the estimates from the three techniques. We use 18 bank holding companies where VLab, the FED Stress tests, and our estimates overlap[23]. The bank holding companies include the eight bank holding companies that the FED labels systemically important.

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[22] The FED Stress Test uses a nine quarter horizon—Vlab and CM use a two quarter horizon. Most of the losses in the Stress test

[23] 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

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,

Figure III.2.1 Safe Capital Ratios for Bank Holding Companies 12/2014

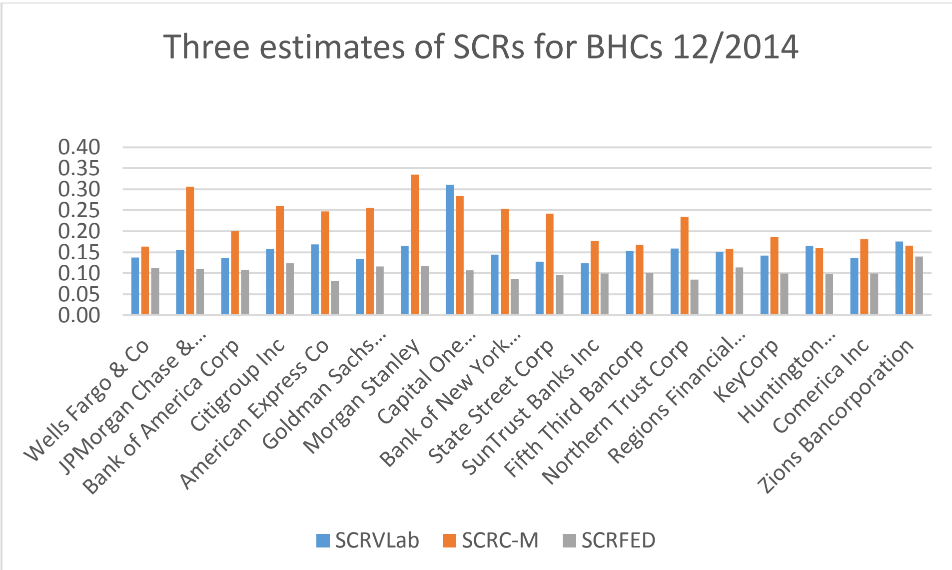

Table III.2.a below and Appendix II give the details.

We attribute most of the difference in the implied safe capital ratios to the importance of spillover effects among bank holding companies in a crisis. The FED stress test specifies virtually no spillover effects. For the eight systemically important banks a default by their largest counterparty effects their asset value.[24] But there is no feedback to other bank holding companies or the counterparty, or the Supervisory scenario. In VLab's bivariate specification current day's shock to the market return effects the current return to bank holding company(i). After the current day there is bi-directional feedback between the bank holding company(i)'s return and the market return through the time-varying covariances in the Garch specification. This is more general than the FED stress test model, but it is bivariate. The daily shocks to bank holding company(i)'s return do not effect bank holding company(j)'s return or the market return in bank holding company(j)'s bivariate specification. Our (CM) specification is the multivariate extension of VLab's bivariate model. And it seems to make a big difference in a crisis. The multivariate specification allows for direct spillovers among the 18 bank holding companies and feedback though the updates to the conditional covariance matrix. When things go badly for all the bank holding companies at the same time since their returns are positively correlated their expected losses are much larger, see Appendix II.

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return data. Enough BHCs to provide a pretty good sample and certainly enough to make multivariate Garch estimation challenging.

[24] 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.

III.2.a More Detailed Safe Capital Ratio Results

The largest differences in the safe capital ratios are for the eight bank holding companies that the FED designates systemically important. These are large banks with substantial trading, processing and custodial operations.

For the systemically important bank holding companies the FED Stress implied safe capital ratio is the lowest from the three estimates—average 11%--and less than ½ CM's average of 25%, see Table III.2a below. Our (CM) safe capital ratios are by far the highest. It figures that if spillovers are important the largest effects would show up for the systemically important banks. And that's what happens, the differences among implied safe capital ratios for the banks not designated systemically important are much smaller. See Table III.2.a below. However, although the differences are much smaller—the CM average safe capital ratio is 18%, the VLab average is 16%, and the FED average is 10%--the order remains.

Table III.2a Safe Capital Ratios for BHCs

		SCRs for BHCs that the FED designates systemically important			SCRs for BHCs that the FED doesn't designate systemically important		
Bank Holding Co		CM	VLab	FED	C-M	VLab	FED
Wells Fargo & Co	x	0.16	0.14	0.112			
JPMorgan Chase & Co	x	0.31	0.15	0.11			
Bank of America Corp	x	0.20	0.14	0.108			
Citigroup Inc	x	0.26	0.16	0.124			
American Express Co					0.25	0.17	0.082
Goldman Sachs Group Inc/The	x	0.26	0.13	0.116			
Morgan Stanley	x	0.33	0.16	0.117			
Capital One Financial Corp					0.28	0.31	0.107
Bank of New York Mellon Corp/The	x	0.25	0.14	0.086			
State Street Corp	x	0.24	0.13	0.096			
SunTrust Banks Inc					0.18	0.12	0.099
Fifth Third Bancorp					0.17	0.15	0.101
Northern Trust Corp					0.23	0.16	0.085
Regions Financial Corp					0.16	0.15	0.114
KeyCorp					0.19	0.14	0.099
Huntington Bancshares Inc/OH					0.16	0.17	0.098
Comerica Inc					0.18	0.14	0.099
Zions Bancorporation					0.17	0.18	0.14
	median	0.25	0.14	0.11	0.18	0.16	0.10

mean	0.25	0.14	0.11	0.20	0.17	0.10
Std	0.05	0.01	0.01	0.04	0.05	0.02

The results in Table III.2.a seem to indicate that measuring spillovers (systemic risk) are crucial in setting a safe capital ratio.

III.2.b Analysis by Models

Overview

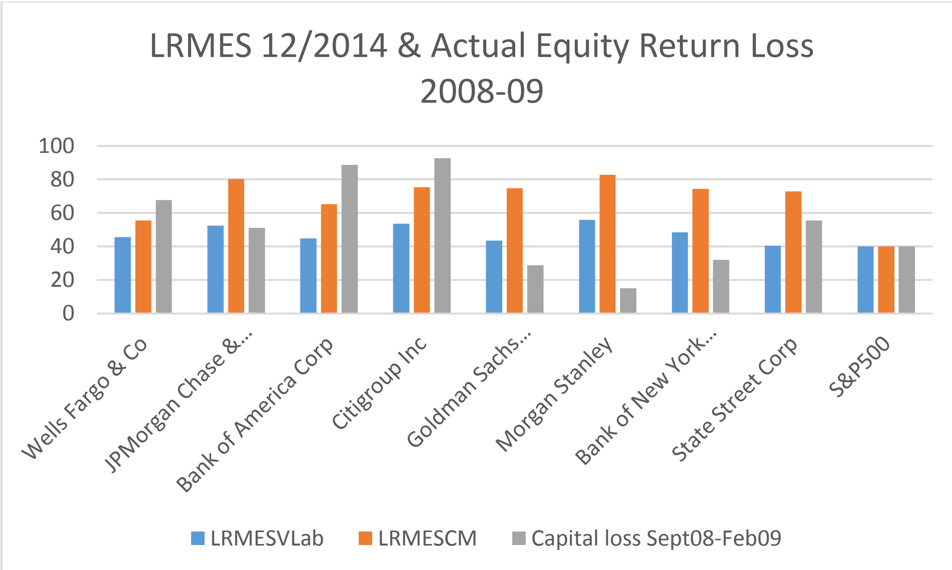
We examine the differences between (1) actual capital ratios—for which VLab and CM use market value of equity and the book value of debt while the FED uses book values. On average the FED values are 4% less than VLab's and CM's. And (2) the sensitivity of calculated safe capital ratios to a severe recession. On average the FED's (implied Safe Capital Ratio/Actual Capital Ratio) are much less sensitive to a severe downturn.

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. And all of the action is in the estimate of the LRMES. 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 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



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 BofNY[25]—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. They also project the book value of assets.

The difference between the market and book value of equity accounts for about 4%. The FED's measure of actual capital ratios (ACRs) is on average about 4% less than VLab-CM's[26], 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 accounting

[25] The investment banks suffered heavy losses prior to September 2008.
[26] 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.

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 is only 16%. In contrast, the increase in the implied average safe capital ratio for VLab is 31%, and for CM 89%. See columns 7-9.

Table III.2.b ACRs, SCRs, and % Difference 12/2014

	Actual Capital Ratios		Safe Capital Ratios			%change SCR-ACR		
Institution	Vlab-CM	FED Tier1 Lvg=ACR	SCRVLab	SCRFED	SCRCM	Vlab	FED	CM
Wells Fargo & Co	0.16	0.10	0.14	0.11	0.16	-0.16	0.17	0.00
JPMorgan Chase & Co	0.09	0.08	0.15	0.11	0.31	0.67	0.45	2.30
Bank of America Corp	0.09	0.08	0.14	0.11	0.20	0.50	0.37	1.20
Citigroup Inc	0.09	0.09	0.16	0.12	0.26	0.76	0.38	1.91
American Express Co	0.42	0.12	0.17	0.08	0.25	-0.60	-0.29	-0.41
Goldman Sachs Group Inc/The	0.10	0.09	0.13	0.12	0.26	0.37	0.29	1.62
Morgan Stanley	0.09	0.08	0.16	0.12	0.33	0.77	0.43	2.60
Capital One Financial Corp	0.15	0.11	0.31	0.11	0.28	1.04	0.01	0.87
Bank of New York Mellon Corp/The	0.12	0.06	0.14	0.09	0.25	0.24	0.48	1.18
State Street Corp	0.11	0.06	0.13	0.10	0.24	0.11	0.50	1.11
SunTrust Banks Inc	0.12	0.10	0.12	0.10	0.18	0.05	0.04	0.51
Fifth Third Bancorp	0.12	0.10	0.15	0.10	0.17	0.24	0.03	0.36
Northern Trust Corp	0.13	0.08	0.16	0.09	0.23	0.18	0.08	0.75
Regions Financial Corp	0.12	0.11	0.15	0.11	0.16	0.21	0.04	0.27
KeyCorp	0.13	0.11	0.14	0.10	0.19	0.08	-0.12	0.41
Huntington Bancshares Inc/OH	0.13	0.10	0.17	0.10	0.16	0.28	0.00	0.24
Comerica Inc	0.12	0.11	0.14	0.10	0.18	0.13	-0.08	0.50
Zions Bancorporation	0.11	0.12	0.18	0.14	0.17	0.64	0.18	0.55
average	0.13	0.09	0.16	0.11	0.22	0.31	0.16	0.89

Section IV: A Proposal for a simple Regulatory Capital Ratio Rule (RCRR)

Section II and Appendix 1 showed that safe capital ratios are needed to counter the incentive to take on excessive debt and risk created by a government debt guarantee for financial institutions. This section augments Acharya, Engle and Richardson's safe capital ratio with a regulatory capital ratio rule. Our rule is basically a smoothed procyclical version of the safe capital ratios.

A safe capital ratio serves two purposes:

1. Safe capital ratios make private financial institutions less risky and much less likely to impose private losses on the public. And as Admati and friends show, the economic cost is not high for the banks. And the benefit to society can be very large.
2. A higher capital/asset ratio provides the institution with a buffer to absorb losses without a government bailout.

The capital buffer is why a safe capital ratios rule needs smoothing to become a regulatory capital ratio rule. Financial institutions should accumulate capital in good times—the safe capital ratios insures that they accumulate enough—and use the capital in bad times to weather the economic storm. A sufficient equity buffer assures the institution's creditors—much like a government debt guarantee—that in a crisis the value of the institution's debt is safe. So the bank can roll over debt as it expires.

The complicated and controversial component of a regulatory capital ratio rule is: after a period of stress how quickly should the institution be required to rebuild its capital?

A Simple Regulatory Capital Ratio Rule

This section presents a regulatory capital ratio rule using the data from VLab. It is straight forward to apply the concept in CM, but it requires numerical simulations to calculate the expected shortfall for the average bank. We don't know how to apply the rule to the Stress Test results.

Normal

When the state of the economy is good and has been for a while (defined more precisely below)—measured as the equity market return is positive—then, the regulatory capital ratio for the next quarter (for institution *i)* ,

$$RCR_{i,t+1} = SCR_{i,t} \qquad 4.1$$

equals the safe capital ratio calculated at the end of the current quarter.

Stress

When the state of the economy is bad—the equity market return is negative—then, the institution uses its capital buffer. So that,

$$RCR_{i,t+1} = ACR_{i,t} \tag{4.2}$$

the regulatory capital ratio next quarter equals the current actual capital ratio. If the equity market return is negative for consecutive quarters, then the regulatory capital ratio next quarter again equals the actual capital ratio this quarter.

In the last 25 years consecutive quarters of negative returns on the S&P500 including distributions only occurred three times: (1) when the DotCom bubble burst in 2000 returns were negative for 4 consecutive quarters and the cumulative loss was 22%[27], (2) in the recession of 2002 returns were negative for 2 quarters in a row and the cumulative market loss was 28%, and (3) in the Great Recession returns were negative for 6 consecutive quarters in 2007-09 and the cumulative market loss was *45%*.

Adjustment Path to a Safe Capital Ratio

After a downturn there is a tension between a financial institution acquiring more assets (making loans) which enables the recovery and the need to rebuild its capital. The policy goal is for less risky institutions to make loans and riskier ones to retrench.

We present a simple rule for the time to rebuild capital that (1) depends on the cumulative equity market return loss (CMRL) (2) the average institution's safe capital ratio (ASCR) and (3) the institution's actual capital ratio. It rewards safer institutions with more time to reach the safe capital ratio—so that they can lend more—and forces riskier institutions to reach the safe capital ratio more quickly—so they must contract.

Define the expected capital gap as,

$$ECG = ASCR * CMRL * \text{average } \beta \tag{4.3}$$

the average institution's safe capital ratio times the cumulative market return loss times the average financial institution's [28] β . So for example, if the cumulative market return declined by 10% and average institution's safe capital ratio and actual capital ratio was 20%, then one might expect it to lose 2% of its actual capital ratio. But since average financial institutions' β is 1.09—it is slightly risker than the market—the average institution would be expected to lose slightly more, 2.18%.

[27] The DotCom bubble hit smaller high tech firms and affected the S&P much less.
[28] See http://vlab.stern.nyu.edu/analysis/RISK.USFIN-MR.MESSIM

Table IV.1 shows the expected capital gap for the average financial institution with a safe capital ratio of 13% and a beta of 1.09[29]for cumulative market return losses from 0.10 to 0.40.

Table IV.1: Expected Capital Gap (for the average institution) for a Cumulative Market Return Loss

CML	0.10	0.20	0.30	0.40
ECG	0.0142	0.0283	0.0425	0.0567

An Adjustment Rule

The rule rewards institutions whose actual capital loss is less than the average expected capital loss—gives less risky institution's more time to attain their safe capital ratio—and penalizes institutions whose actual loss is greater than the average expected capital loss. The adjustment rule is,

$$\frac{T}{CMRL*100} = a*\exp(b(ECG - ACG_i)) \qquad 4.4$$

where *T* is the time in quarters to reach the safe capital ratio. *a and b* are parameters. *a* is a scale parameter that sets *T* relative to the cumulative market return loss. So for example, if *a=0.5,* and the market return fell by 10% and institution *i's* gap relative to the average expected gap is zero, *ECG-ACG = 0*[30]*,* then the institution has 5 quarters, or 1 1/4 years—same as the average institution—to reach its safe capital ratio. *b* sets the curvature of the reward/penalty ratio for institutions that have a smaller or larger than expected capital gap.

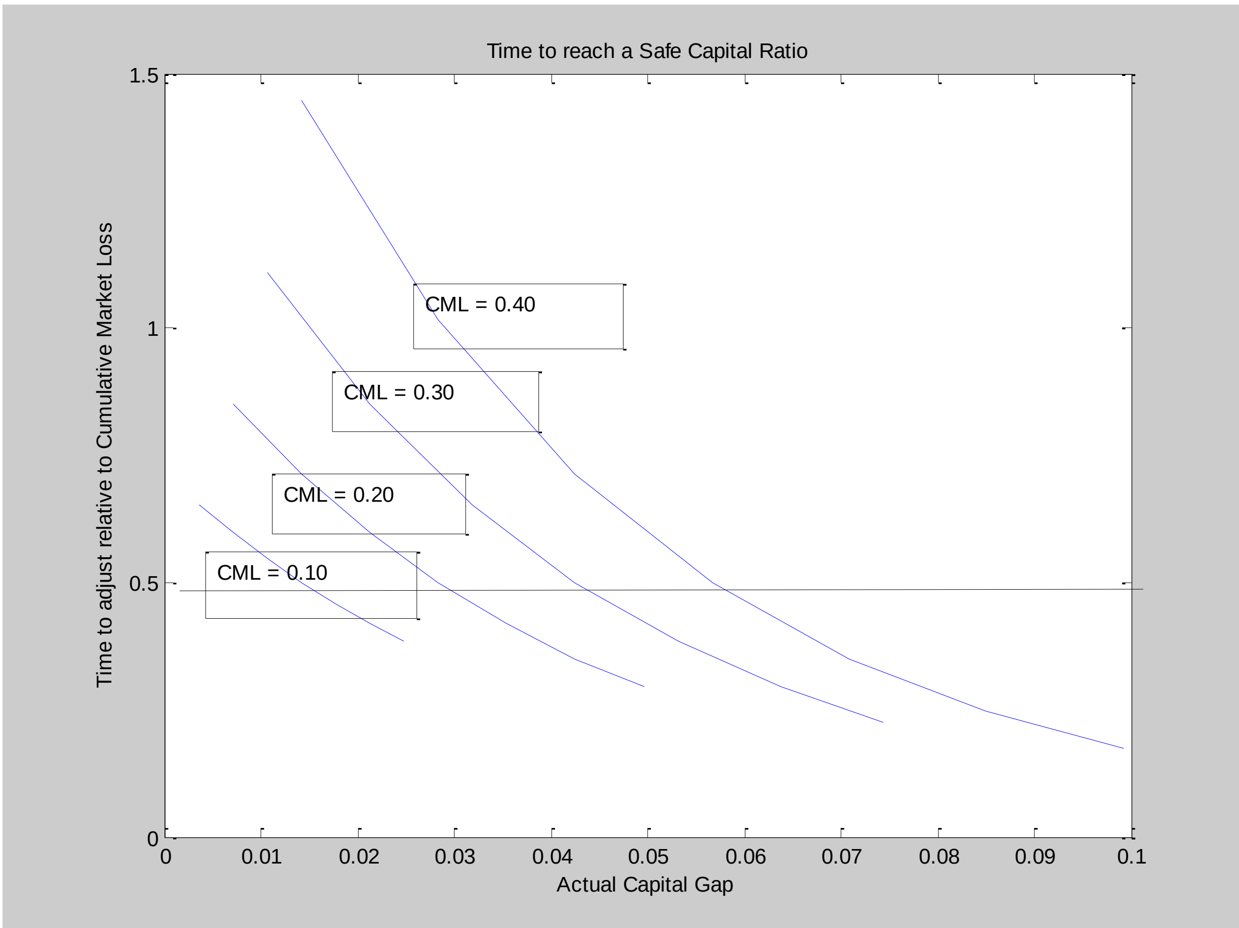
Figure IV.1 illustrates the rule, equation (4.4), for *a=0.5, b = 25.* Where the horizontal line at 0.5 crosses the curves, e.g. CMRL = 0.40 shows the average institution's expected capital gap—0.0567—on the x axis. The vertical axis shows the normalized time to allowed reach the safe capital ratio. So an institution with a 5.67% capital gap after a 40% decline in the equity market return—which is roughly the cumulative return loss on the S&P500 in the Great Recession—has 5 yrs (= .5*40/4) to attain the safe capital ratio. Riskier institutions—to the right on the graph have less time to reach their safe capital ratio, e.g., the riskiest with institutions (with a β *= 1.75*the average Beta)* whose capital/asset ratio falls by 10% have less than 2 years to attain a safe capital ratio and the safest institutions to the left on the graph with a β = 0.25*average *Beta* whose capital/asset ratio falls by only 1 ½% would have 14 years to reach their attain a safe capital ratio[31]. The goal is to constrain risky institutions forcing them to build up capital and pay down their debt, while not constraining less risky institutions so that they make loans to support the recovery.

[29] These are the averages of 75 financial institutions at the end of 2014 listed in VLab.

[30] The exponential term in equation 4.4 equals one.

[31] The lowest β of the 75 financial institutions listed in VLab is 0.8. An institution with a β of 0.75 capital/asset ratio would fall by 4 ¼% and it would have 7 years to reach its safe capital ratio.

FIgure 4.1



Section V: Summary and Conclusions

This paper addresses an important monetary policy question: at what level should Regulatory Capital Ratios be set? We compared actual capital ratios to implied safe capital ratios for 18 bank holding companies using three quantitative techniques: the FED STRESS tests, VLab's systemic risk measure, and Craine-Martin's multivariate extension of VLab's bivariate econometric model.

The quantitative results indicate that spillovers among bank holding companies in a crisis are very important. This makes perfect sense because bank holding company returns and asset values are positively correlated. The CM specification which allows spillovers among all the bank holding companies implies safe capital ratios (average 22%) twice as high as the safe capital ratios implied by the FED Stress test results (average 11%) which allow for very limited spillovers. In any event, all of the estimates imply much higher safe capital ratios than the required capital ratios of 5% for large institutions and 6% for the eight systemically important institutions recently imposed (but not effective until 2018) by the FED.

Higher regulatory capital ratios are politically feasible. The Federal Reserve Board sets regulatory capital ratios for depository institutions and Dodd-Frank gave the Financial Stability Oversight Council the authority to regulate any financial institution if they contributed to systemic risk. So the increased regulatory capital ratios could be implemented without Congressional action. And as Admati and friends—supported by economic theory—forcefully argued higher regulatory capital ratios would not be costly to the economy and only costly to the financial institutions because they would lose the value of the debt guarantee subsidy.

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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) == the Arrow-Debreu price of a contingent commodity in state s next period. The states, s, are stochastic and defined by a probability distribution. The price, p(s), incorporates time discounting and uncertainty.*
>
> *x(s) == the net asset value of the firm next period in state s*
>
> *n == 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), and equity holders get nothing.*

Then,

$V = \sum p(s)x(s)$ the current value of the firm

$E = \sum p(s)\max(\mathrm{x(s)} - \mathrm{n}, 0)$ the current equity value (market cap) of the firm

$D = \sum p(s)\min(n, x(s))$ the current value of debt of the firm

The Modigliani-Miller Theorem

$$V = E + D$$

$$\sum_s p(s)x(s) = \left[\sum \mathrm{p(s)}\max((x(s) - n), 0) + \sum \mathrm{p(s)}\min(n, x(s))\right]$$

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,

$$D^{df} = n\sum p(s)$$

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*,

$$\begin{aligned} D^{df} &= D(x(s), n) + Put(x(s), n) \\ &= \sum p(s)\left[\min(\mathrm{x(s), n}) + \max(\mathrm{n} - \mathrm{x(s)}, 0)\right] \end{aligned}$$

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,

$$V = E + D \le E + D + Put(x(s), n)$$

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*,

$$Put(n, x(s)) = \sum p(s)\max(\mathrm{n} - \mathrm{x(s)}, 0)$$

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

	Data 12/31/2014						
	Market Cap		Actual Capital Ratios		LRMES		Tier1Min
Bank Holding Co			Vlab&CM	FED Tier1 Lvg=ACR	Vlab	CM	FED
Wells Fargo & Co	284385548.00		0.1636661	0.096	45.55	55.45	6.4
JPMorgan Chase & Co	233935868.00		0.0925069	0.076	52.5	80.25	4.6
Bank of America Corp	188139291.00		0.0907441	0.079	44.75	65.14	5.1
Citigroup Inc	163925596.00		0.0893655	0.09	53.53	75.25	4.6
American Express Co	96266348.00		0.41841	0.116	57.12	73.5	11.4
Goldman Sachs Group Inc/The	84421881.00		0.0974659	0.09	43.52	74.69	5.4
Morgan Stanley	75947236.00		0.0929368	0.082	55.94	82.72	4.5
Capital One Financial Corp	45895407.00		0.1519757	0.106	80.71	78.09	7.9
Bank of New York Mellon Corp/The	45670055.00		0.1160093	0.058	48.46	74.35	5.2
State Street Corp	32773358.00		0.1145475	0.064	40.45	72.74	4.8
SunTrust Banks Inc	21849006.00		0.1172333	0.095	38.3	59.54	7.6
Fifth Third Bancorp	16789143.00		0.1237624	0.098	52.1	56.85	7.7
Northern Trust Corp	15873037.00		0.1340483	0.079	53.9	71.53	7.4
Regions Financial Corp	14535576.00		0.1246883	0.11	50.97	53.68	7.6
KeyCorp	12041918.00		0.1317523	0.112	47.33	61.97	9.3
Huntington Bancshares Inc/OH	8568056.00		0.1287001	0.098	56.09	54.19	8
Comerica Inc	8416539.00		0.1204819	0.108	45.06	60.61	8.9
Zions Bancorporation	5785591.00		0.1072961	0.119	59.17	56.29	5.9
		Avg	0.1341995	0.0931111	51.413889	67.046667	6.8176471

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