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 low enough to encourage their intermediation and lending function as well as protect taxpayers from private financial institutions' losses. It's a delicate balance.

We compare Safe Capital Ratios for 18 Bank Holding Companies. The goal of the Federal Reserve Stress Tests, VLab's measure of systemic risk, and our estimates is to determine a safe capital buffer 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. Specifying that losses at one bank can affect other banks in a crisis turns out to be quantitatively very important. Our (CM) specification which allows for the most feedback finds the highest implied safe capital ratios averaging 22%, followed by VLab's less general specification which finds safe capital ratios averaging 16%, and the FED Stress tests which allow for no feedback find the lowest safe capital ratios averaging 11%.

The second main result is surprising and controversial. Book value capital ratios are too insensitive to an economic crisis to be a valuable macroprudential indicator. The Fed (and Basel III) stress tests calculate book value capital ratios. 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. In contrast we estimate that on average banks would have to increase their market value capital ratio by 8.4% from the current average market value ratio of 13.4% and VLab estimates a 2.4% increase is necessary. To isolate the effect of book vs market value accounting from the models and forecasting methods we looked at historical book value capital ratios and market value capital ratios—used by us and VLab—over the Gt Recession. Book capital ratios hardly move and seem to indicate that the banks are well capitalized. The market capital ratios, however, for most bank holding companies plunged after Lehman failed and screamed distress.

URL for the full paper http://eml.berkeley.edu//~craine/2009/Capital%20Ratios%2001-05-16.pdf

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

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

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 recovered very slowly—US per capita real GDP was up only 4% six years after the collapse. And Europe only recently reached its pre-recession levels.

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 which bank holding companies don't like. Section II also summarizes Admati and friends (2011, 2013) refutation of the financial industry arguments 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%. Our quantitative estimates of safe capital ratios for eighteen bank holding companies averages 22%.

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 that we use. 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 retain a sufficient capital buffer so that it can continue its intermediation function without a government bailout. A goal of Federal Reserve stress tests also is to find a sufficient capital ratio to withstand a stressful period. 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

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[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.

methodology and SIII.2 gives the safe capital ratio results for December, 2014. 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 to the model specification. Brownlees and Engle's (VLab's) bivariate modeling strategy imposes the CAPM restriction that the market return captures all of the systematic information. Disturbances to bank(i) do not directly affect bank(j)'s return. The covariance among bank returns is restricted to the product of their (dynamic) Betas. CM use a multivariate version of VLab's bivariate model. The multivariate model does not impose the CAPM restriction on the covariance among the (18) bank holding companies' returns. This 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 since the losses at one bank directly affect other banks, see Appendix II.

The safe capital ratios implied by FED stress tests are much less sensitive to a severe downturn than CM and VLab's. For the 2015 DFAST results the standard deviation of the 18 bank holding companies implied safe capital ratio is only 1.5%--all the capital ratios are close to the mean. In contrast, the standard deviation CM's implied safe capital ratio is 5.5% and VLab's is 4%. The sources of the difference between CM-VLab's implied safe capital ratios and the Fed Stress Test implied safe capital ratios are hard to pinpoint. One important difference is that the Fed Stress Tests calculate the book value of the capital ratio while CM and VLab calculate the market value of the capital ratio. To isolate the effect of book vs market value accounting from the model specification and forecasts we calculated *realized* book and market value capital ratios over the Gt Recession. To our surprise book value capital ratios show almost no variation over the Gt Recession and generally indicate that the banks are well capitalized. Market value capital ratios, on the other hand, clearly show that most bank holding companies were in deep distress after Lehman Brothers failed.

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[4], and the US Federal Reserve imposed a minimum Tier1 leverage ratio of 6% on eight 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.

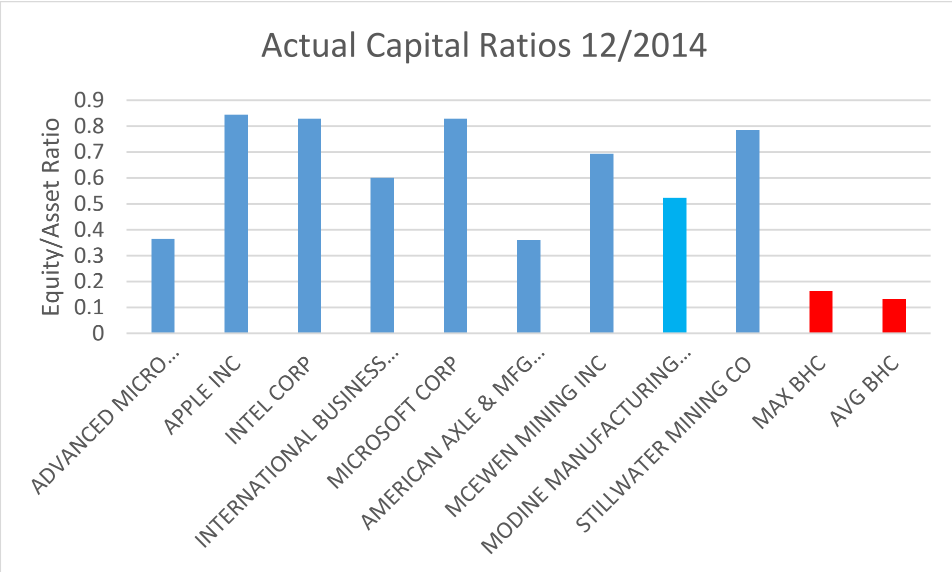
Do Depository Institutions hold less Capital?

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 of the bank holding company's actual capital ratio [5] as of December 2014 (see Table III.2 for a full list of the 18 bank holding companies).

Figure II.1

[4] The traditional definition of the leverage ratio is assets/equity so the FED and Basel III "leverage ratio" is the reciprocal of the traditional definition. Possibly they chose this awkward definition because they used the more natural label of capital ratios to describe the ratio of equity to "risk adjusted" assets, see FDIC (undated), Regulatory Capital Interim Final Rule, for a description of the terms and explanation of the various regulatory capital ratios. As a capsule of how convoluted the capital rules are the FDIC labels their pamphlet "Interim Final Rule".

[5] This is the market capital ratio used by VLab and us and commonly used in finance—not the book capital "leverage ratio" specified by Basel III. See Section III for more detail.



The bank holding companies' capital ratios are very low relative to other firms.[6] 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—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

[6] Even hedge funds have much higher capital-asset ratios than banks, see Ang, el al 2011, Figure 7. (Figure 7 shows leverage ratios—the reciprocal of capital ratios. The hedge fund leverage is measured on the left vertical axis and the financial firms on the right vertical axis since the financial firms leverage is so much greater than the hedge funds.)

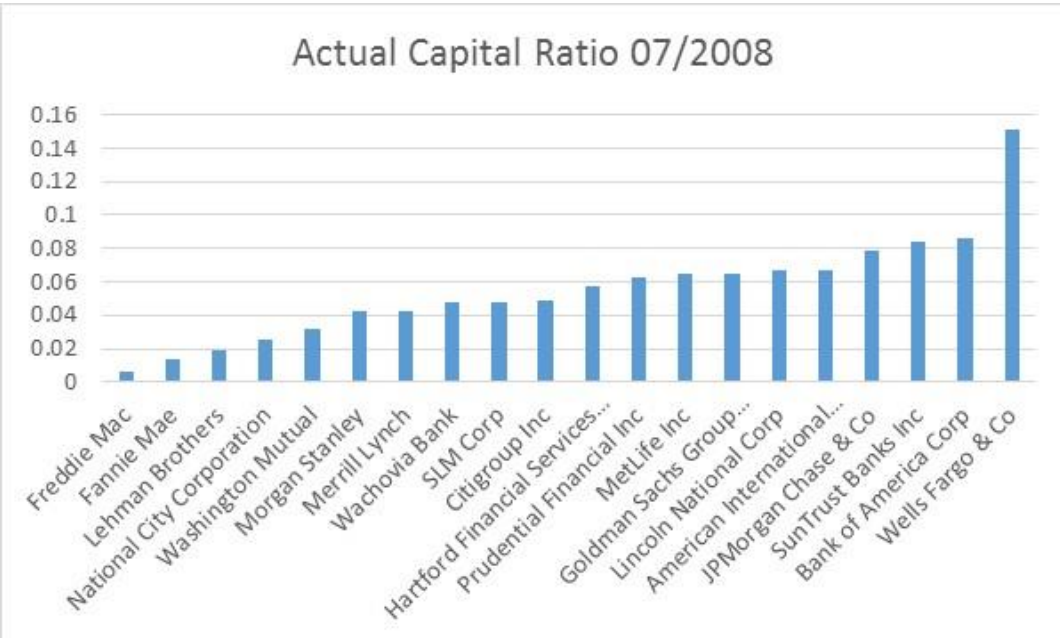
[7] This excludes American Express that had a capital ratio of 42% which is a registered BHCs, but whose core business is credit card processing and debt.

[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.

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 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



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?

[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.
[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.

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[14].

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

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[15]. 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

[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.
[14] See Chari & Kehoe (2016) for a "rigorous" derivation that regulatory capital ratios can offset the subsidy of the debt guarantee.
[15] Almost all economists accept that higher regulatory capital ratios are good, the only question is how much higher—as Stan Fischer asks.

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 banks' incentive to take excessive risk since the owners would bear more of the risk—not the taxpayers. 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 and state specific Safe Capital Ratios. Engle and friends (Brownlees and Engle 2012a), (Acharya, Engle, and Richardson 2012b), (Acharya, Engle, and Pierret 2014) develop a quantitative 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 can continue to function as a financial intermediary without government assistance. 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 major 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.

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[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.

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

Prelude

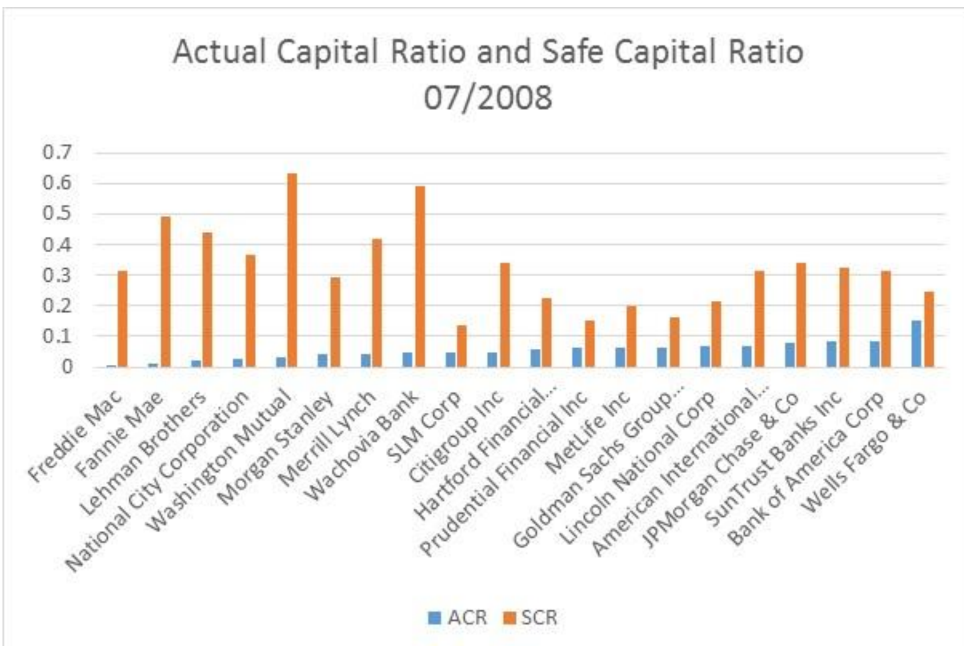
Engle and friends organized and contribute to VLab which has a treasure of data easily accessible online,

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

that is updated weekly.

Figure III shows the actual capital ratios, illustrated in Figure II.2 below and the safe capital ratios (explained in Section III.1) 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: 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 FDIC closed Washington Mutual and Wells Fargo—with considerable encouragement from the FED—bought Wachovia. The VLab measure of systemic risk indicates these twenty institutions were extremely risky in July of 2008. [18] 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—

[18] VLab uses a rolling sample and estimates only use information that was available at the time. VLab's implied safe capital ratios are based on forecasts of the expected capital shortfall.

Dodd, Frank in the US and Basel III internationally. Now regulated financial institutions hold substantially more capital. But do they hold enough?

Section III.1 Safe Capital Ratio Estimates

III.1.a VLab

VLab's development of Safe Capital Ratios begins with Acharya, Pedersen, Philippon, and Richardson's (2010) behavioral structural model that links systemic risk[19] to bank capital shortages. A capital shortfall is when the market capitalization of bank *i* falls below a capital buffer of *k%* of assets. A bank's capital shortfall contributes to systemic risk when most banks are in trouble. They define bank *i*'s contribution to systemic risk, SRISK,

$$SRISK_i = E(k * \text{assets}_i - \text{equity}_i \mid \sum_i^N equity_i \leq k * \sum_i^N assets_i) \qquad 3.1$$

as bank *i*'s expected capital shortfall *given a crisis when the aggregate banking sector also suffers a capital shortfall*. Notice this is a lower tail definition of systemic risk. A bank that falls below the safe capital buffer in normal times does not contribute to systemic risk because in normal times it can sell assets and continue to borrow, or gets bought by a competitor, or even if it fails doesn't cause a risk to the system. It's only when most banks are in difficulty that each bank's shortfall contributes to systemic risk.

Brownlees and Engle's (2012a) make Acharya, el al's (2010) static measure of systemic risk a dynamic operational tool by 1. generalizing the aggregate banking sector capital shortfall in a crisis to an equity market crisis and 2. quantifying it by estimating a dynamic reduced form model for bank capital shortages.

They define an equity market crisis as when **the cumulative market return falls by more than 40% over a six month horizon,**[20]Since bank returns on average are positively correlated with the market return with a β greater than one Brownlees and Engle's definition of an equity market crisis encompasses Acharya, et al's (2010) notion of an aggregate banking sector shortfall.

Bank *i*'s equity (market capitalization) in a crisis declines by the fall in its cumulative equity return, see equation 3.4 below, times current equity value. Brownlees and Engle define the *expected* cumulative fall in bank *i's* return as the long run marginal expected shortfall, $LRMES_{it}$. Using Brownlees and Engle's definitions, and assuming the book value of debt doesn't change during the crisis[21], bank *i's* contribution to *SRISK* becomes,

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

a simple function of the long run marginal expected shortfall (*LRMES)* and observable debt and equity.

[19] Hansen (2012) has a clear paper on "The Challenges in Identifying and Measuring Systemic Risk". In Hansen's taxonomy the approach in this paper equates systemic risk with lower tail risk.
[20] The S&P500 return fell by 40% over the 6-month period at the worst of the financial meltdown from September 2008-February 2009.
[21] The bank's obligation is the book value of debt.

Quantifying *SRISK* only requires an estimate of the long run expected marginal shortfall.

Brownlees and Engle estimate a bivariate model of equity returns for bank *i* and the market return, see equation 1, or Achraya, Engle, and Richardson (2012), section I equation 3,

$$
\begin{aligned}
r_{m,t} &= \sigma_{m,t}\varepsilon_{m,t} \\
r_{i,t} &= \sigma_{i,t}(\rho_{i,t}\varepsilon_{m,t} + \sqrt{1-\rho^{2}{}_{i,t}}\xi_{i,t}) \\
(\varepsilon_{\mathrm{m},t}\xi_{i,t}) &\sim F
\end{aligned}
\qquad 3.3
$$

Where, r_{mt} and r_{it} denote the logarithmic market and bank(i) daily 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, see Appendix II for more detail.

VLab calculates the long run (6-month) marginal expected shortfall (LRMES) by dynamically simulating the model many times and averaging the returns of institution *i* in a crisis. 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

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

The long run marginal expected shortfall is,

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

the average cumulative loss *given* a cumulative drop in the market return of at least 40%, i.e., where *C* = -40%.

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

VLab's Safe Capital Ratio

Achraya, Engle, and Richardson (2012) propose the safe capital ratio (SCR) that sets the systemic risk (SRISK) to zero for each bank,

$$SCR_{i,t} \equiv \frac{equity_{i,t}}{equity_{i,t} + debt_{i,t}} \text{ so that } SRISK_{i,t} = 0 \qquad 3.6$$

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)

$$SCR_{i,t} = \frac{k}{1-(1-k)LRMES_{i,t}} \quad 3.7$$

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)

Our econometric contribution here is simple. We extend Brownlees and Engle's bivariate model to a multivariate model. It turns out that the extension is quantitatively important for the long run marginal expected shortfall. The Brownlees and Engle bivariate modeling strategy adopts the popular CAPM tradition that the market return contains all the systematic information. The CAPM model imposes restriction that the covariance among bank returns equals the product of their (dynamic) Betas.

$$E(r_{it}, r_{jt}) = \sigma_{it}\rho_{it}\sigma_{jt}\rho_{jt} = \beta_{it}\beta_{jt}Er_{mt}^{\ 2} = \beta_{it}\beta_{jt}\sigma_{mt}^{\ 2}$$

$$\beta_{l,t} = \text{cov}_t(\text{r}_{l,t}, r_{m,t}) / \sigma^2_{\ mt} = \frac{\rho_{lt}\sigma_{mt}}{\sigma_{lt}}$$

Our multivariate model does not restrict the covariance among bank returns. In a crisis, when all the banks suffer losses the cumulative impact is greater than looking at the banks in a bivariate setting because losses at one bank directly affect other banks.

Otherwise we use the exactly same basic setup as Brownlees and Engle's in equation 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 DDCC (diagonal dynamic correlation matrix) specification, see Appendix II for details and a comparison to Brownlees and Engle.

The parameters of the model are estimated[22] using a two-step maximum likelihood estimator with the asymmetric GARCH parameters estimated in the first step and the DDCC 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 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) and the total number of simulations is set at *S* = 1,000,000.

[22] 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.

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

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

The goal of the FED Stress tests, Vlab's systemic risk measure and our estimates 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."[23]

But methodologies are very different. VLab and CM only use estimated BHC's equity market return losses conditional on a severe downturn in the market return[24]. 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 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.

The FED stress tests provide valuable *microprudential* information on the bank loan portfolio. The tests breakdown loan losses into seven detailed categories—first lien mortgages, junior liens and HELOFs (home owner lines of credit), commercial and industrial, commercial real estate, credit cards, other consumer, other. The FED invests great effort to ensure that its loan loss forecasts are accurate, e.g. see Hale, et al (2015).

The BHC's asset values projections are much less detailed. Assets 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.

FED Stress Test Scenarios

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.

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. The Severely Adverse Scenario depicts a truly severe recession.

-

Tier1 Leverage Ratio

The Tier1 Leverage Ratio, aka Capital Ratio, is the ratio of the BHC's Equity to Assets.

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[23] Comprehensive Capital Analysis and Review 2015, Board of Governors of the Federal Reserve System, p 1.

[24] Notice that the safe capital ratio in equation 3.7 does not require of bank debt or equity. It only is a function of the long run expected marginal shortfall.

The FED STRESS TEST results report the actual book capital ratio at the beginning of the test, the minimum projected capital ratio and the projected terminal capital ratio (the final value at the end of the 9-quarter stress test). We use the minimum capital ratio to calculate the implied safe capital ratio[25].

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

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

III.2 Results

This proportion presents and compares the implied safe capital ratios from the three techniques. We use 18 bank holding companies where the VLab data and our data overlap with the FED Stress tests (2015).[26] The bank holding companies include the eight banks that the FED designates systemically important.

Figure III.2 summarizes the results.

Figure III.2

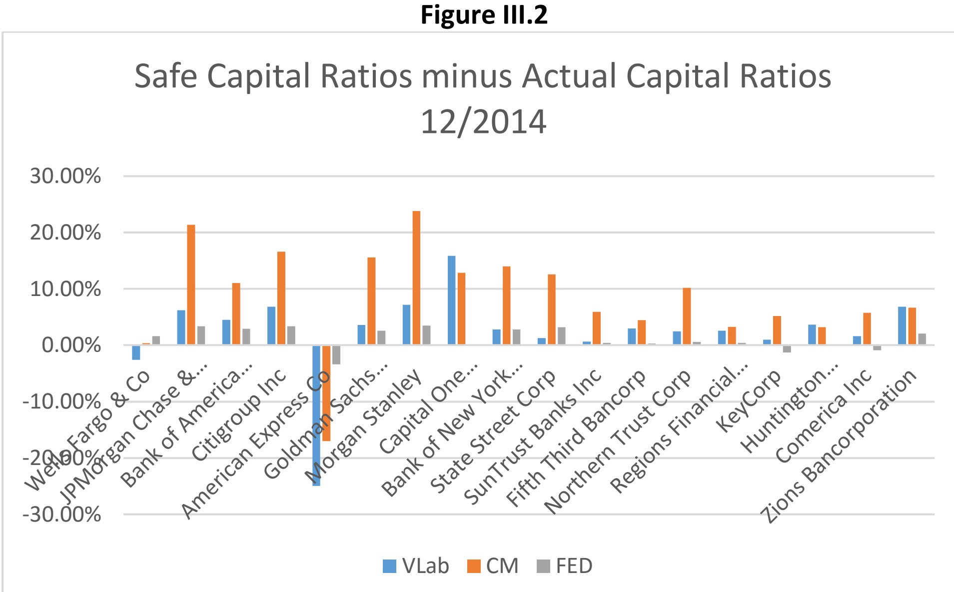

Figure III.2 shows the difference between the estimated bank holding company safe capital ratios and the actual capital ratios as of December 2014.[27]We (CM) call for the largest increases to reach a safe capital ratio—on average 8.7%. And some of our increases for investment banks to reach the safe capital threshold are dramatic. We estimate that JPMorgan (middle orange bars and Table III.2 below) should increase their actual capital/asset ratio by more than 21% from 9% to 31% and Morgan Stanley by 24% from 9% to 33%. VLab calls for smaller increases averaging 2.4%. But they also call for larger, but

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

[26] 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.

The most recent data when we did the estimation.

not as dramatic, increases on the investment banks—6% from 9% to 15% for JPMorgan and 7% from 9% to 16% for Morgan Stanley. The FED stress tests call for the smallest increases averaging 1.2%. The FED also targets the investment banks for the largest increases (although not that large)—3% for JPMorgan from 8% to 11% and 4% for Morgan Stanley from 8% to 12%.

Table II.2 gives the detailed results. The first two columns on the left show the actual capital ratios as of December 2014[28], the next three show the estimated safe capital ratios, and the last three the difference between the safe and actual capital ratios as illustrated in Figure III.2.

Table III.2

	Actual Capital Ratios		Safe Capital Ratios			Safe - Actual Capital Ratios		
Institution	Vlab-CM	FEDTier1 Lvg	VLab	CM-DDCC	FED	VLab	CM	FED
Wells Fargo & Co	16.37%	9.60%	13.77%	16.74%	11.20%	-2.60%	0.37%	1.60%
JPMorgan Chase & Co	9.25%	7.60%	15.47%	30.61%	11.00%	6.22%	21.36%	3.40%
Bank of America Corp	9.07%	7.90%	13.60%	20.14%	10.80%	4.52%	11.07%	2.90%
Citigroup Inc	8.94%	9.00%	15.76%	25.55%	12.40%	6.83%	16.61%	3.40%
American Express Co	41.84%	11.60%	16.86%	24.85%	8.20%	-24.98%	-16.99%	-3.40%
Goldman Sachs Group Inc/The	9.75%	9.00%	13.34%	25.32%	11.60%	3.60%	15.57%	2.60%
Morgan Stanley	9.29%	8.20%	16.48%	33.11%	11.70%	7.19%	23.82%	3.50%
Capital One Financial Corp	15.20%	10.60%	31.07%	28.04%	10.70%	15.87%	12.84%	0.10%
Bank of New York Mellon Corp/The	11.60%	5.80%	14.44%	25.60%	8.60%	2.84%	14.00%	2.80%
State Street Corp	11.45%	6.40%	12.74%	24.04%	9.60%	1.29%	12.59%	3.20%
SunTrust Banks Inc	11.72%	9.50%	12.35%	17.63%	9.90%	0.63%	5.91%	0.40%
Fifth Third Bancorp	12.38%	9.80%	15.36%	16.83%	10.10%	2.99%	4.46%	0.30%
Northern Trust Corp	13.40%	7.90%	15.87%	23.58%	8.50%	2.46%	10.18%	0.60%
Regions Financial Corp	12.47%	11.00%	15.06%	15.71%	11.40%	2.59%	3.24%	0.40%
KeyCorp	13.18%	11.20%	14.17%	18.39%	9.90%	0.99%	5.21%	-1.30%
Huntington Bancshares Inc/OH	12.87%	9.80%	16.53%	16.11%	9.80%	3.66%	3.24%	0.00%
Comerica Inc	12.05%	10.80%	13.66%	17.79%	9.90%	1.62%	5.74%	-0.90%
Zions Bancorporation	10.73%	11.90%	17.56%	17.40%	14.00%	6.83%	6.67%	2.10%
Median	11.89%	9.55%	15.21%	21.68%	10.40%	2.91%	8.42%	1.10%
average	13.42%	9.31%	15.78%	22.08%	10.52%	2.36%	8.66%	1.21%
std	7.39%	1.75%	4.09%	5.36%	1.45%	7.85%	9.10%	1.94%
max	41.84%	11.90%	31.07%	33.11%	14.00%	15.87%	23.82%	3.50%
min	8.94%	5.80%	12.35%	15.71%	8.20%	-24.98%	-16.99%	-3.40%

We (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%. The range of the FED stress test implied safe capital ratios is noticeably much less, only 6% from a max of 14% to a min of 8%--than our and VLab's range of almost 18% and maxs over 30%.

III.2.b Analysis by Models

[28] We (CM) use the same data as VLab so, of course, the actual capital ratios are the same. The FED uses book value accounting which differs from the market value numbers.

Overview

The two main results in this paper follow from the model specifications and the choice of book vs market accounting.

(1) Explicitly allowing losses at any bank holding company to directly affect other banks turns out to be quantitatively very important for measuring the long run marginal expected shortfall and the safe capital ratios. Our model finds the highest average safe capital ratios for all 18 bank holding companies. The VLab specification that allows for feedback between bank holding company(i)'s return and the market return, but not directly among banks, finds the second highest average implied safe capital ratios. Finally the FED stress tests where the causality runs from the driving variables in the adverse scenario to bank(i) and there is no feedback from bank(i) to the variables in the adverse scenario or among banks[29]finds the lowest safe capital ratios.
(2) Surprisingly the accounting convention—book or market equity capitalization—also turns out to be quantitatively 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 a macroprudential indicator of bank distress.

III.2.b.1 VLab and Craine-Martin

Brownlees and Engle (2012) specify a bivariate CAPM type model. In Sections 5 & 6—BE(2012)—they do extensive tests on their model. They compare the forecasts of the marginal expected shortfall and SRISK with other bivariate and univariate specifications and their model performs very well. The closest competitor is a model that they label "Dynamic Conditional Beta" which is essentially a univariate version of their bivariate specification. They also show that their measure of SRISK was a good predictor of the upcoming crisis in the Great Recession. For example see Figure III.1 at the beginning of this Section which shows VLab's safe capital ratios at the eve of the financial crisis far exceeded actual capital ratios.

We follow their method except we use a multivariate GARCH model. Their bivariate specification (3.3) implicitly restricts the covariance among bank returns to the product of their (dynamic conditional) Betas,

$$\begin{aligned} Er_{it}r_{jt} &= E[(\sigma_{it}\rho_{it}\xi_{mt} + \sigma_{it}\sqrt{1-\rho_{it}}\xi_{it})(\sigma_{it}\rho_{it}\xi_{mt} + \sigma_{it}\sqrt{1-\rho_{it}}\xi_{it})] \\ &= \sigma_{it}\rho_{it}\sigma_{jt}\rho_{jt}\sigma^{2}_{mt} \\ &= \beta_{it}\beta_{jt} \\ \text{since } \beta_{kt} &\equiv \rho_{kt}\frac{\sigma_{kt}}{\sigma_{mt}} \end{aligned} \qquad 3.9$$

The bivariate specification restricts any direct affect from the return of bank holding company(i) on bank holding company(j)'s return—everything must go through the market—as in the CAPM.

Our multivariate specification allows bank holding company(i)'s return to directly affect bank holding company(j)'s return which results in substantially higher safe capital ratios estimates. Correlation among bank returns is particularly important in the tails of the distribution since bank returns are positively correlated. When all banks suffer losses the losses at any bank directly affects other banks—which is why we estimate higher safe capital ratios than VLab.

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[29] 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.b.2 FED STRESS TEST

A straight forward comparison of the differences between the econometric approach of CM and VLab and the Fed Stress Tests is not possible although both focus on the equity values of bank holding companies during a severe downturn. The modelling and forecasting strategies are very different.

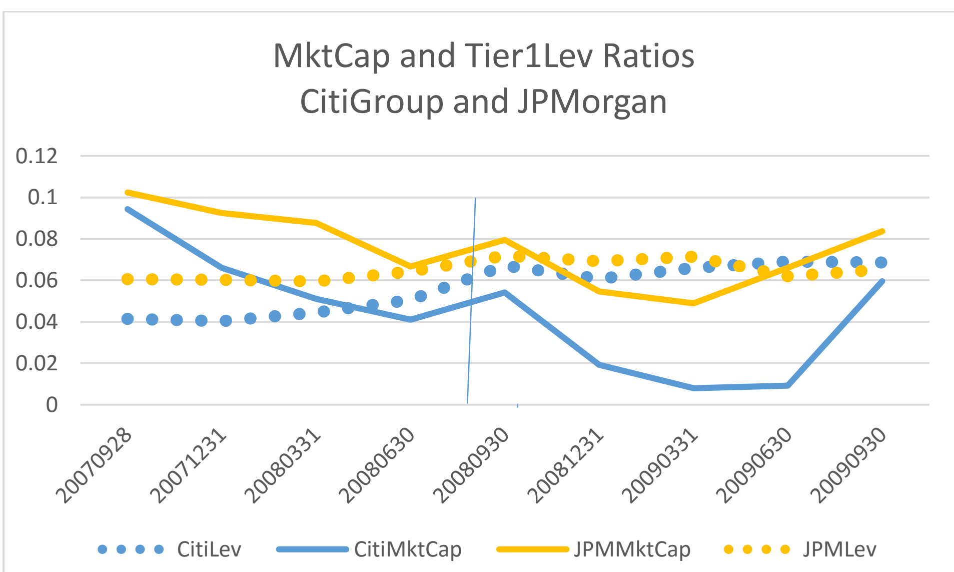
The FED uses a bottom up approach to forecast detailed balance sheet items and then aggregates. They use regression models to forecast the book value of loan losses and income driven by the macro variables in the “scenarios”. The losses and income are aggregated which gives a forecast of book equity value in a severe downturn. In contrast, we (CM) and VLab use equity market return data to directly estimate returns and calculated the expected loss in a severe downturn by averaging draws from the lower tail of the distribution.

The implied safe capital ratios from the two approaches are quantitatively very different. In 2014 the increase in the implied average safe capital ratio for the FED is only 1.2% from 9.3% to 10.5%. The increase in the average implied average safe capital ratio for us is 8.7% and for VLab 2.4%.

Book vs. Market Values

The difference between the FED stress test and our and VLab’s results depends on the modelling approaches and book vs market value accounting. We can’t separate the effect of the FED bottom up modelling approach from our and VLab’s aggregate modelling on the implied safe capital ratios. But we can isolate the effect of book vs. market value accounting from the modelling approaches by looking at *actual* capital ratios over the Great Recession, September 2007—September 2009. Figure III.2.b.2 illustrates the book and market capital ratios for CitiGroup and JPMorgan. The blue lines represent CitiGroup and the yellow lines JPMorgan.

Figure III.2.b.2 Capital Ratios CitiGroup and JPMorgan 2007/09—2009/09



CitiGroup and JPMorgan represent extremes. JPMorgan was hailed as a well-managed bank with appropriate risk controls—CitiGroup, on the other hand, was roundly criticized for loose supervision and out of control traders. Yet their Tier 1 Leverage Ratios (book value capital ratios) look very similar---the dotted lines in Figure III.2.b.2—and don't signal distress. The Federal Reserve, the FDIC, and the Comptroller of the Currency—2014 press release—announced strengthened capital requirements that as of 2018 systemically important banks (JPMorgan and Citi are systemically important) must have a leverage ratio of at least 6% to be considered well-capitalized. JPMorgan had a leverage ratio greater than 6% over the entire period. CitiGroup enters the Gt Recession with a leverage ratio of only 4%, but reaches 6% by September 2008 and stays above 6% for the remainder of the recession. According to the strengthen capital requirements for 2018 both banks were well capitalized for the worst part of the recession after Lehman failed in October 2008.[30]

In sharp contrast both banks market capital ratios (the solid lines) fell through most of the recession. After Lehman failed CitiGroup's market capital ratio fell precipitously from 5.5% to less than 1% by March 2009 which clearly signaled a bank in distress. JPMorgan's market capital ratio also fell from 8% to 5% indicating trouble, but not distress.[31]

These result are robust. Appendix II has the additional data on the book value of assets—risk weighted and total assets—and the leverage ratio and risk weighted capital ratio from the Federal Reserve Y9C reports and the market value of assets and equity from Compustat and CRSP. All of the eighteen bank holding companies in our sample got Troubled Asset Relief from TARP, a sign that they were in trouble. But none of the banks book capital (leverage) ratios fall below 6% after 2008. (A sign that TARP worked?) But many of their market capital ratios fell well below 6%. (A sign that the market—which knew about the TARP bailouts—still believed the banks were in distress.)

IV Summary and Conclusions

An appropriate regulatory capital ratio needs to be high enough to discourage excessive risk taking by financial institutions and low enough to encourage their intermediation and lending function as well as protect taxpayers from private financial institutions' losses. It's a delicate balance. This study presents three quantitative institution specific safe capital ratios—a sufficient capital buffer to withstand a crisis like the Gt Recession can continue to lend to credit worthy borrowers without government assistance—for eighteen large bank holding companies. The safe capital ratios are derived from the Federal Reserve Stress tests—DFAST 2015—from VLab's website—December 2014—and from Craine and Martin's econometric model estimates.

The two main results are:

1. The specification of how losses at one bank effect other banks during a crisis is quantitatively very important in determining the safe capital ratio. VLab and CM use the same model except VLab's bivariate model uses the CAPM specification that the market return transmits all of the systematic information so that the covariance among bank returns is the product of their Betas. CM's multivariate model does not restrict the covariance among bank returns—losses at one bank can directly affect other banks. CM finds the highest implied safe capital ratios—averaging 22%--VLab finds the next highest—averaging 16%--and FED setup that has no feedback finds the lowest—averaging 11%.
2. It turns out, surprisingly, that the choice of the accounting metric also is very important. The FED and Basel use book value accounting to calculate the capital ratio. VLab and CM use market value accounting. Book value capital ratios are relatively insensitive to macroeconomic events, even a downturn as severe as the Gt Recession. Book value capital ratios didn't fall below 6%--a level at which the FED considers systemically important banks well capitalized—after Lehman failed in October 2008 through the remainder of the Gt Recession. Market value capital ratios for many banks, in contrast, cried distress. CitiCorp's market capital ratio fell under 1%.

[30] Both banks received TARP bailout funds in November 2008—as all of the 18 bank holding companies in our sample did—which immediately boosted their book equity.

[31] The market knew that the banks received TARP funds and nevertheless depreciated their equity value.

The main lessons from this study are safe capital ratios derived from econometric models of equity returns provide a valuable alternative or complement to FED and Basel stress tests. They are computed using publically available data, can be updated quarterly to provide more timely signals than annual stress tests. And they are much more sensitive to economic events. In fact, book value stress test results while they give detailed loan loss projections valuable for micro-prudential regulation are not sensitive enough to deliver useful macro-prudential signals about capital ratios.

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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*,

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

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*,

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

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.

Appendix II: Brownlees and Engle's (BE) and Craine and Martin's (CM) Econometric Model

The basic model for returns is a fairly standard model in finance and economics,

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

Where *r* is a vector of demeaned logarithmic daily returns whose first element is the market return followed the eighteen bank holding company (bank) returns, ranked by their market capitalization from highest to lowest, and $\Sigma^{1/2}{}_t$ is the lower triangular Cholesky decomposition of the conditional covariance matrix Σ_t. ζ_t is a corresponding vector of mean zero uncorrelated disturbances, with distribution *F* , that are independent over time but not of each other.

The problem with estimating the returns model directly is that the conditional covariance contains a lot of parameters and the estimates of the covariance matrix must be positive definite for statistical and numerical reasons.

BE

BE estimate 18 separate CAPM type bivariate models[32] of returns. In their specification,

$$r^{BE}_{kt} \equiv \begin{bmatrix} r_{mt} \\ r_{it} \end{bmatrix} \text{ k = 1,...,18} \tag{0.1}$$

To make the estimation simple and robust they estimate the conditional covariance matrix with DCC (dynamic conditional correlation).

DCC for BE

1. Estimate the diagonal elements univariate asymmetric GARCH processes,

$$\begin{gathered} V_{ii,t} \equiv \sigma^2_{\text{i},t} = a_{i0} + a_{i1}v^2_{t,t-1} + a_{i2}dv^2_{i,t-1} + b_i\sigma^2_{\text{i},t-1} \quad \text{i = 1, ...,19} \\ \text{where d is a dummy variable of 0 if } v_{i,t-1} > 0, \text{ or 1 otherwise} \end{gathered} \tag{0.2}$$

2. Define the conditional covariance matrix as,

$$V_{kt} = S_{kt}R_{kt}S_{kt} \text{ k =1,,,18} \tag{0.3}$$

where V_{kt} is a (2x2) matrix and *S* is a diagonal matrix whose elements are the square root of the univariate GARCH processes, $S_{kt} = \begin{bmatrix} \sigma_{mt} & 0 \\ 0 & \sigma_{kt} \end{bmatrix}$,

and R_{kt} is the conditional correlation matrix.

3. Now restrict the estimates of the conditional correlation matrix

$$\begin{aligned} R_{kt} &= diag(Q^{-1/2}{}_{kt})Q_{kt}diag(Q^{-1/2}{}_{kt}) \\ Q_{kt} &= (1-\alpha_k-\beta_k)\bar{Q}_k + \alpha_k z_{kt-1}z'_{kt-1} + \beta Q_{kt-1} \quad \text{k = 1,...,18} \\ z_{i,t} &= {}^{v_{it}}\!/_{\sigma_{it}} \end{aligned} \tag{0.4}$$

[32] In fact they (VLab) estimate the returns model for 75 US financial institutions as well as financial institutions in 20 countries.

to *a matrix* GARCH(1,1) updating process where Q *only depends on two scalar parameters*, α and β . $\bar{Q}$ is the unconditional mean—sample average—of the normalized innovations $\frac{1}{T}\sum_t z_t z'_t$

BE summary

1. The BE bivariate modeling strategy imposes the CAPM restriction that the market return captures all of the systematic information. Disturbances to bank(i) do not directly affect bank(j)'s return. The covariance among bank returns is restricted to the product of their (dynamic) Betas.

$$E(r_{it}, r_{jt}) = \sigma_{it}\rho_{it}\sigma_{jt}\rho_{jt} = \beta_{it}\beta_{jt}Er_{mt}^{\ 2} = \beta_{it}\beta_{jt}\sigma_{mt}^{\ 2}$$
$$\beta_{l,t} = \text{cov}_t(\text{r}_{l,t}, r_{m,t}) / \sigma^2_{\ mt} = \frac{\rho_{lt}\sigma_{mt}}{\sigma_{lt}} \qquad (0.5)$$

2. The eighteen BE bivariate models with DCC takes 112 parameters to estimate,

76 parameters—19 asymmetric GARCH(1,1) equations for the conditional variances with 4 parameters in each equation

36 parameters—18 DDC GARCH(1,1) updating equations with 2 parameters for each of the conditional correlation matrices

Craine-Martin

CM estimate a single multivariate model for the 19 returns.

DCC

1. Estimate the diagonal elements univariate asymmetric GARCH processes,

$$V_{ii,t} \equiv \sigma^2_{\ \text{i},t} = a_{i0} + a_{i1}v^2_{\ t,t-1} + a_{i2}dv^2_{\ i,t-1} + b_i\sigma^2_{\ \text{i},t-1} \quad \text{i} = 1, ..., 19$$
$$\text{where d is a dummy variable of 0 if } v_{i,t-1} > 0, \text{ or 1 otherwise} \qquad (0.6)$$

CM and BE estimate the same univariate GARCH processes for conditional variance of the 19 returns.

2. Define the conditional covariance matrix as,

$$V_t = S_t R_t S_t \qquad (0.7)$$

Where S is a diagonal matrix whose elements are the square root of the univariate GARCH processes, $S_{ii,t} = \sigma_{i,t}$, and R_t is a (19x19) conditional correlation matrix.

3. Now restrict the conditional correlation matrix,

$$
\begin{aligned}
R_t &= diag(Q^{-1/2}{}_t)Q_t diag(Q^{-1/2}{}_t) \\
Q_t &= (1-\alpha-\beta)\bar{Q} + \alpha z_{t-1}z'_{t-1} + \beta Q_{t-1} \\
z_{i,t} &= {}^{v_{it}}\!/_{\sigma_{it}}
\end{aligned}
\tag{0.8}
$$

to *a matrix* GARCH(1,1) updating process where *Q only depends on two scalar parameters*, α and β .

Differences between BE and CM DCC

1. The CM multivariate model imposes no restrictions on covariances among bank returns.
2. The CM model with DCC only requires estimating 78 parameters,

   76 parameters—19 GARCH(1,1) equations for the conditional variances with 4 parameters in each equation—same as BE

   2 parameters—1 GARCH(1,1) equation with 2 parameters for the conditional correlation matrix updating equation—34 fewer parameter estimates than BE

CM Diagonal Dynamic Conditional Correlation

Martin modified the DCC conditional correlation matrix updating equation from an equation that only requires 2 estimated parameters to a GARCH(1,1) equation that requires 2 estimated diagonal matrices. Replace the scalars α and β in equation (1.8) with the diagonal matrices, $D_\alpha = \begin{pmatrix} \alpha_{11} & 0 & 0 \\ 0 & \alpha_{..} & 0 \\ 0 & 0 & \alpha_{nn} \end{pmatrix}$ and $D_\beta = \begin{pmatrix} \beta_{11} & 0 & 0 \\ 0 & \beta_{..} & 0 \\ 0 & 0 & \beta_{nn} \end{pmatrix}$

$$
Q_t = (I - D_\alpha - D_\beta)\bar{Q}(I - D_\alpha - D_\beta) + D_\alpha z_{t-1}z'_{t-1} D_\alpha + D_\beta Q_{t-1} D_\beta \tag{0.9}
$$

Where the matrices are squared to preserve positivity.

CM DDCC summary

CM DDCC requires estimating 114 parameters

76 parameters—19 univariate asymmetric GARCH(1,1) updating equations with 4 parameters in each equation

38 parameters---1 conditional correlation matrix with 2 diagonal (19x19) diagonal matrices to be estimated—2 more parameter estimates than BE

Appendix III

Bank Holding Company data reported to Federal Reserve

Y9C Data

Source FRB.CH https://www.chicagofed.org/banking/financial-institution-reports/index

Date	Bank	Tier1 Capital	Risk Weighted Assets	Total Average Assets	Tier1 Risk-Based Capital Ratio	Tier1 Leverage Ratio
20070930	JPMorgan	$86,096	$1,028,551	$1,423,171	8.37%	6.05%
20071231	JPMorgan	$88,746	$1,051,879	$1,473,541	8.44%	6.02%
20080331	JPMorgan	$89,646	$1,075,697	$1,507,724	8.33%	5.95%
20080630	JPMorgan	$98,775	$1,218,431	$1,611,762	9.15%	6.43%
20080930	JPMorgan	$111,630	$1,377,060	$1,707,112	8.85%	7.18%
20081231	JPMorgan	$136,104	$1,337,480	$2,088,347	10.94%	6.92%
20090331	JPMorgan	$137,144	$1,277,106	$2,014,275	11.36%	7.13%
20090630	JPMorgan	$122,174	$1,260,237	$1,969,339	9.69%	6.20%
20090930	JPMorgan	$126,541	$1,237,760	$1,940,689	10.22%	6.52%
20070928	CitiGroup Inc	$92,370	$2,234,744	$1,261,790	7.32%	4.13%
20071231	CitiGroup Inc	$89,226	$2,216,505	$1,253,321	7.12%	4.03%
20080331	CitiGroup Inc	$99,088	$2,226,675	$1,285,580	7.71%	4.45%
20080630	CitiGroup Inc	$106,915	$2,119,295	$1,223,313	8.74%	5.04%
20080930	CitiGroup Inc	$137,362	$2,049,008	$1,175,706	11.68%	6.70%
20081231	CitiGroup Inc	$118,758	$1,954,846	$996,247	11.92%	6.08%
20090331	CitiGroup Inc	$121,925	$1,848,635	$1,023,038	11.92%	6.60%
20090630	CitiGroup Inc	$126,778	$1,836,432	$995,414	12.74%	6.90%
20090930	CitiGroup Inc	$126,285	$1,842,336	$989,711	12.76%	6.85%
					Tier1 Capital/ Risk-Weighted Assets	Tier1 Captial/ Tot Avg Assets

Publicly available Market Capitalization and Market Asset Data

Market Capitalization = Share Price*number shares/1000 (to match scale of COMPUSTAT data)

Source	CRSP	permno
	CitiGroup	70519
	JPMorgan	47896

Book Value of Debt = Book Value of Total Assets (AQT) - Book Value Common/Ordinary Equity (CEQQ)

Source	CompuStat	gvkey
	CitiGroup	3243
	JPMorgan	2968

"Market" Value of Assets = Market Capitalization + Book Value of Debt

Date	BANK	Market Cap	Book Eqiity	Book Assets	Book Debt	"Mkt" Assets	Mkt Cap Ratio
20070928	JPMORGAN CHASE & CO	155,050	119,978	1,479,575	1,359,597	1,514,647	10.24%
20071231	JPMORGAN CHASE & CO	146,622	123,221	1,562,147	1,438,926	1,585,548	9.25%

20080331	JPMORGAN CHASE & CO	145,881	125,627	1,642,862	1,517,235	1,663,116	8.77%
20080630	JPMORGAN CHASE & CO	117,568	127,176	1,775,670	1,648,494	1,766,062	6.66%
20080930	JPMORGAN CHASE & CO	182,345	137,691	2,251,469	2,113,778	2,296,123	7.94%
20081231	JPMORGAN CHASE & CO	117,681	134,945	2,175,052	2,040,107	2,157,788	5.45%
20090331	JPMORGAN CHASE & CO	99,886	138,201	2,079,188	1,940,987	2,040,873	4.89%
20090630	JPMORGAN CHASE & CO	133,063	146,614	2,026,642	1,880,028	2,013,091	6.61%
20090930	JPMORGAN CHASE & CO	172,325	154,101	2,041,009	1,886,908	2,059,233	8.37%

Date	Bank	Market Cap	Book Equity	Book Assets	Book Debt	"Mkt" Assets	Mkt Cap Ratio
20070928	CITIGROUP INC	232,162	126,913	2,358,266	2,231,353	2,463,515	9.42%
20071231	CITIGROUP INC	146,645	113,598	2,187,631	2,074,033	2,220,678	6.60%
20080331	CITIGROUP INC	112,350	108,835	2,199,848	2,091,013	2,203,363	5.10%
20080630	CITIGROUP INC	85,241	108,981	2,100,385	1,991,404	2,076,645	4.10%
20080930	CITIGROUP INC	111,685	98,638	2,050,131	1,951,493	2,063,178	5.41%
20081231	CITIGROUP INC	36,566	70,966	1,938,470	1,867,504	1,904,070	1.92%
20090331	CITIGROUP INC	13,948	69,688	1,822,578	1,752,890	1,766,838	0.79%
20090630	CITIGROUP INC	16,315	78,001	1,848,533	1,770,532	1,786,847	0.91%
20090930	CITIGROUP INC	110,741	140,530	1,888,599	1,748,069	1,858,810	5.96%