

# Bank Capital Requirements\*

Luisa Lambertini<sup>†</sup>

Pinar Uysal<sup>‡</sup>

EPFL

EPFL

October 2, 2013

*Preliminary and Incomplete*

## Abstract

This paper analyzes the macroeconomic effects of bank capital requirements. Using data for U.S. bank holding companies over the period 1993Q1 to 2012Q1 we document that: a) bank capital requirements bind especially for the largest banks (top 5%), which represent more than 90% of the assets of the financial system; b) bank assets and deposits are procyclical while equity is acyclical; c) an increase in loan loss provisions reduces output, raises the corporate bond spread and the bank capital ratio. We develop a macroeconomic model where financial intermediaries are subject to an equity constraint along the lines of Basel II and III. Our model, calibrated over the pre-crisis period, generates moments in line with the empirical evidence. A decline in bank assets generates a fall in asset prices and bank loans that reduces output and consumption. The presence of a minimum capital requirement mitigates the impact of capital quality shocks on output and reduces the frequency of bankruptcy of the banking system.

Keywords: Banking; Capital Adequacy; Financial Regulation

JEL Codes: E32, E44, G01, R31

Address of corresponding author: Luisa Lambertini, EPFL SFI-LL, Station 5, CH-1015 Lausanne, Switzerland. E-mail: [luisa.lambertini@epfl.ch](mailto:luisa.lambertini@epfl.ch)

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\*We thank SNF

<sup>†</sup>École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [luisa.lambertini@epfl.ch](mailto:luisa.lambertini@epfl.ch).

<sup>‡</sup>École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [pinar.uysal@epfl.ch](mailto:pinar.uysal@epfl.ch).

# 1 Introduction

We examine how financial intermediaries, mainly large Bank Holding Companies (BHCs) in the US behave over the business cycle. First, we empirically analyze the cyclical properties of balance sheet variables such as total assets, loans, deposits and equity, and also the equity-to-asset ratio which is subject to supervisory capital regulation.

Covas and Den Haan (2011) document that using firm-level data is important to analyze the cyclical behavior of firm financing i.e. debt vs. equity financing. Hence, in this paper we closely follow their method. We use bank-level data and group banks into quartiles according to their asset size. Then, we construct time series for the balance sheet variables at the group level, and examine the correlation between the cyclical component of these variables and the cyclical component of real per capital GDP, where we use HP-filter to calculate the cyclical component. We show that cyclical properties of the banking sector is driven by the behavior of the banks that are in the top 25% quartile. Total assets, loans and deposits are procyclical whereas equity is acyclical and equity-to-asset ratio is countercyclical.

According to Basel II bank capital requirements BHCs must have Tier 1 capital of 4% risk-weighted assets (RWAs).<sup>1</sup> BHCs also must have at least 8% of their RWAs as Tier 1 plus Tier 2 capital. We present evidence that there is heterogeneity in banks' behavior in terms of how much regulatory capital they hold and moreover majority of the banks hold at least the minimum capital ratio required. This behavior is also documented by Berger, DeYoung, Flannery, Lee and Oztekin (2008). They find that BHCs that have access to inexpensive external capital can afford to hold less capital which they interpret as BHCs actively managing their capital ratios. We also show that among the well-capitalized banks the smallest banks are prevalent, and among the significantly-undercapitalized banks the largest banks are prevalent.

Next, we present vector autoregression (VAR) evidence to capture the importance of bank capital and how it responds to losses in the banking sector. Particularly we focus on the shocks to loan loss provisions (LLPs) and net charge-offs (NCOs) and how they affect the balance sheet of the banks and the rest of the economy. For this purpose we only focus on the set of 15 largest BHCs which constitute about 76% of the total bank assets in our data sample, and almost about 2% of total banks. We acknowledge that knowing the differences between

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<sup>1</sup>Basel regulation and the variables will be explained in the following sections.

small and large banks and how they manage their capital ratios is crucial especially for the regulators. However as a starting point we focus only on the largest BHCs as they summarize the behavior of the banking sector as a whole. Our VAR analysis shows that an increase in the LLPs or NCOs leads to a decrease in output and an increase in bank capital, which in line with counter-cyclical bank capital ratios.

In the theoretical part, we develop a model with financial intermediaries that face equity constraints as in Basel II. The model consists of households, who can save in risk-free deposits or risky equity; firms that rent capital (from capital producers) and labor to produce goods; and banks that take deposits, issue equity, and make loans to firms. The financial friction consists in a bank equity constraint such that equity should be 8% of total assets. The constraint is modeled as a penalty in terms of the bank's net worth. For example, low bank equity relative to assets could result in limitations to distribute dividends and/or the requirement to recapitalize or simply higher funding rates.

We use the model to analyze the effects of a crisis, which we model as a reduction in banks' assets – a decline in capital quality. The model with capital constraints de-amplifies the initial shock and leads to a smaller output reductions and avoids equity from reaching extremely low levels. In fact, we can use the model to compute the frequency of bankruptcy in the financial system. We show that reducing the minimum capital requirement increases the frequency of bankruptcy.

## 2 Literature

A number of papers have introduced financial intermediation in general equilibrium macroeconomic models in recent years. Gertler and Karadi (2011) and Gertler and Kiyotaki (2010) develop a quantitative monetary DSGE model with financial intermediaries that face endogenously determined balance sheet constraints. They introduce a simple agency problem between intermediaries and their respective depositors: bankers can divert funds from the project and instead transfer them back to the household if the value of remaining a banker is too low. In these models, deposits and loans must be limited and efficient equilibrium cannot be achieved. Most notably, these models do not have bank capital. Gertler, Kiyotaki and Queralto (2012) introduce bank capital in this setup. To raise external funds, banks can raise deposits and

issue equity. These models are used to evaluate government credit policy along the lines of the unconventional monetary policy carried out during the financial crisis. In our model banks can issue outside equity as well as deposits and households face a portfolio choice between risky equity and safe deposits along the lines of Gertler et al. (2012). However, the liability composition of the balance sheet of the banks is pinned down by a minimum equity requirement that we model as a penalty.

He and Krishnamurthy (2012) present a model with financial intermediaries where bank reputation limits the amount of equity funding. The model produces systemic states where aggregate bank reputation is low and the banking system faces a binding constraint on equity. Unlike He and Krishnamurthy (2012), our bank capital constraint is written explicitly as a fraction of assets, as specified in the Basel accords. Moreover, we emphasize matching the behavior of bank-level variables at the business cycle level.

### 3 Historical Background on Bank Capital Regulation

The Basel Committee on Banking Supervision issued a set of minimum capital requirements for banks (Basel I) and it was implemented by G-10 countries by the end of 1992. Basel I accord introduced:

1. Tier 1 Capital, also called core capital, which includes common shareholders' equity, disclosed reserves or retained earnings, and may also include non-redeemable non-cumulative preferred stock;
2. Tier 2 Capital, also called supplementary capital, which includes undisclosed reserves, revaluation reserves, general provisions and general loan-loss reserves, hybrid debt capital instruments, and subordinated term debt;
3. Risk Weighted Assets (*RWA*), which is a weighted sum of different categories of asset or off-balance-sheet exposure of a bank, where weights are assigned according to broad categories of relative riskiness.

Basel I required banks to hold a core capital ratio (*Tier 1 Capital-to-RWA*) of at least 4%, and a total capital ratio (*(Tier 1 + Tier 2) Capital-to-RWA*) of at least 8%. The supplementary

capital was also limited to 100% of core capital. In 1989, in the United States, the Federal Reserve, FDIC, and OCC issued plans implementing Basel I requirements, and set deadline of December 1992 for the full implementation of these rules.

The second Basel accord, Basel II, was initially introduced in 2004 and should have become effective in 2008. Basel II redesigned the weighting scheme of RWA assets by allowing for more risk differentiation. In the U.S. a minimum of 4% leverage ratio, which is Tier 1 capital divided by average total assets, was also introduced. Table 1 summarizes the Basel II accord.

**Table 1: Basel II**

Bank Capital Regulation	
Components	Minimum Requirement
Core capital (Tier 1)	$\geq 4\%$ of RWA
Supplementary capital (Tier 2)	$\leq$ of 100% of Tier 1
Total capital (Tier 1 + Tier 2)	$\geq 8\%$ of RWA
U.S.: Leverage ratio	$\geq 4\%$

With the financial crisis of 2007-2009, Basel II became difficult to implement, and the regulators also noticed the need to revise their requirements. With Basel III banks have to hold a core capital ratio of at least 6%, and the common equity should be at least 4.5% of RWA. Total capital ratio is left unchanged and it still has to be at least 8%. Basel III introduced two new buffers:

1. Capital conservation buffer, which requires banks to hold an additional 2.5% of RWAs during calm times that they can draw down when losses are incurred;
2. Counter cyclical buffer, which requires banks to hold an additional 2.5% of RWAs when authorities judge credit growth is resulting in an unacceptable build up of systematic risk.

Table 2 summarizes the proposed Basel III regulation.

## 4 Empirical Evidence

In our analysis we use quarterly data for U.S. bank holding companies between 1993Q1 and 2012Q1. Because the implementation deadline for Basel I rules was December 1992, our data set starts with the first quarter of 1993. Our data sample includes the latest financial crisis

Table 2: **Basel III**

Bank Capital Regulation	
Components	Minimum Requirement
Core capital (Tier 1)	$\geq 6\%$ of RWA
of which common equity Tier 1	$\geq 4.5\%$ of RWA
Total capital (Tier 1 + Tier 2)	$\geq 8\%$ of RWA
Capital Conservation Buffer	
Common equity Tier 1	additional 2.5% of RWA
Counter-cyclical Buffer	
Common equity Tier 1	additional 2.5% of RWA

period, but for our analysis we sometimes exclude the time period after 2007q4, to eliminate the effects of this extraordinary time period. Also, banks started reporting Tier 1 capital and RWAs in 1996Q1, and Tier 2 capital in 1998Q1 therefore we have missing observations for these variables for the beginning of our sample. And since our theoretical model does not differentiate among different types of assets for risk weighting purposes, we mainly focus on equity-to-asset ratio in our empirical analysis.

The balance sheet data are from the Federal Reserve’s Y-9C consolidated financial statements for BHCs, and data definitions are listed in Appendix A. We include banks that existed for at least 50 quarters during the period the 1993Q1-2012Q1 period. We would like to isolate the effect of the banks that enter and exit the system from our analysis to achieve stable results. We also match this balance sheet information with the stock price information from Center for Research on Stock Prices (CRSP) database using the mapping available from Federal Reserve Bank of New York.<sup>2</sup> As a result of this merge, we lose some observations which are mainly small and non-publicly traded banks. To avoid this decrease in observations in a non-random manner, we use the merged data set only when we need information on stock prices.

First, we examine how the regulatory capital,  $TotCap/RWA$  (*Tier 1 plus Tier 2 capital divided by RWAs*), is distributed across different size groups. We divide the banks into quartiles for each time period by assigning the bank to a size group according to its asset size. Then, we classify the BHCs according to their capital position relative to the regulatory thresholds following Berger et al. (2008). The “well-capitalized” threshold is 10%, and the “adequate capital” threshold is 8%.

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<sup>2</sup>The mapping is available at [http://www.newyorkfed.org/research/banking\\_research/datasets.html](http://www.newyorkfed.org/research/banking_research/datasets.html). The merging is done using the PERMCO from CRSP and the RSSD9001 identifier from FR Y-9C reports.

- Wellcap\_over800 if the BHC's capital ratio exceeds the regulatory standard for "well capitalized" by more than 800 bps,
- Wellcap\_600to800 if the BHC's capital ratio is 600-800 bps above the "well capitalized" threshold,
- Wellcap\_400to600 if the BHC's capital ratio is 400-600 bps above the "well capitalized" threshold,
- Wellcap\_200to400 if the BHC's capital ratio is 200-400 bps above the "well capitalized" threshold,
- Wellcap\_0to200 if the BHC's capital ratio is up to 200 bps above the "well capitalized" threshold,
- Adeqcap if the BHC's capital ratio lies between the adequate and well-capitalized thresholds,
- Undercap if the BHC's capital ratio lies less than 100 bps below the adequately capitalized level,
- Sig-Undercap if the BHC's capital ratio lies more than 100 bps below the adequately capitalized level.

We have a total of 44,049 bank-quarter observations for the period 1998Q1-2012Q1. Tables 3 and 4 indicate that the majority of the banks were well-capitalized, and they hold more than the regulatory requirement. Table 3 shows the size distribution of banks for a given capital group. Among the significantly undercapitalized banks, the big banks have the largest share. Big banks also have the largest share for banks that hold up to 400 bps above the 10% well capitalized threshold. However, it is the small banks that have the largest share that hold more than 400 bps above the 10% well capitalized threshold.

Table 4 shows that most of the small banks which are at the bottom 25% of the size distribution are very well capitalized. Almost 35% of the smallest banks hold at least 16% equity. As we move to the larger banks this number goes down gradually, and only 16% of the largest banks

Table 3: **Regulatory Capital and Size - Row Percentage**

	[0,25]	[25,50]	[50,75]	[75,100]	Total
Sig-Undercap	30.75	15.70	18.49	<b>35.05</b>	100
Undercap	<b>32.99</b>	24.37	<b>32.99</b>	9.64	100
Adeqcap	26.77	<b>31.83</b>	29.30	12.09	100
Wellcap_0to200	18.05	23.47	28.89	<b>29.60</b>	100
Wellcap_200to400	20.90	25.38	25.71	<b>28.02</b>	100
Wellcap_400to600	<b>26.07</b>	25.82	23.15	24.96	100
Wellcap_600to800	<b>29.70</b>	27.32	20.58	22.39	100
Wellcap_over800	<b>40.29</b>	24.82	22.38	12.51	100
Total	25.14	25.21	25.22	24.43	100

Time period: 1998Q1-2012Q1, for banks that exist for at least 50 quarters. The numbers in bold reflect the highest percentage in a given row.

which are at the top 25% of the size distribution hold at least 16% equity. Medium and large sized banks are hold most around 10-14% equity.

Next, Table 5 has various mean capital ratios for different size groups. In column (1), Tier 1 capital to risk-weighted-asset ratio gradually declines from smaller banks to larger banks. However in column (2) Tier 2 capital to risk-weighted-asset ratio gradually increases from smaller banks to larger banks. Overall, the regulated  $(Tier\ 1+Tier\ 2)/RWA$  ratio follows the pattern of  $Tier1/RWA$ , i.e. as the size group of the bank increases, the capital ratio gets smaller. In column (4), *Leverage* is the leverage ratio  $(Tier\ 1/Average\ Total\ Assets)$  that is regulated under Basel rules, and the largest 2% of the banks have the lowest leverage ratio. In the last three columns we present different equity ratios which could also be potential bank capital ratios that are empirically measured and could be counterparts for the equity-to-asset ratio in our theoretical model, as our model does not differentiate different types of asset in terms of riskiness and equity in terms of quality. In column (5) there is  $Equity/RWA$  ratio. As the bank size gets larger this ratio gets smaller similar to the  $Tier\ 1+Tier\ 2$  regulatory ratio. For  $Equity/Asset$  ratio there is not a monotonous decreasing relation between the bank size and capital ratio however, the largest 2% of the banks hold the lowest equity to asset ratio. In the last column, there is  $Equity/Loan$  ratio, which could also be a potential empirical variable as a counterpart to the equity-to-asset ratio in our theoretical model, since we only have loans on the asset side of the bank's balance sheet. And the largest 2% of the banks have the highest equity-to-loan ratio.

We examine the cyclicity of bank balance sheet variables in Table 6. We measure real economic activity with HP-filtered log of real GDP per capita. We also deflate the bank level



Table 4: **Regulatory Capital and Size - Column Percentage**

	[0,25]	[25,50]	[50,75]	[75,100]	Total
Sig-Undercap	1.29	0.66	0.77	1.52	1.06
Undercap	0.59	0.43	0.59	0.18	0.45
Adeqcap	4.30	5.10	4.69	2.00	4.04
Wellcap_0to200	18.59	24.11	<b>29.66</b>	<b>31.38</b>	25.9
Wellcap_200to400	22.63	<b>27.41</b>	27.75	31.23	<b>27.23</b>
Wellcap_400to600	17.96	17.74	15.89	17.70	17.32
Wellcap_600to800	10.82	9.92	7.47	8.39	9.16
Wellcap_over800	<b>23.82</b>	14.63	13.19	7.61	14.86
Total	100	100	100	100	100

Time period: 1993Q1-2012Q1, for banks that exist for at least 50 quarters.

Table 5: **Size Classes and Mean Capital Ratios**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	$\frac{Tier1}{RWA}$	$\frac{Tier2}{RWA}$	$\frac{Tier1+2}{RWA}$	<i>Leverage</i>	$\frac{Equity}{RWA}$	$\frac{Equity}{Asset}$	$\frac{Equity}{Loan}$
[0, 25]	<b>14.35</b>	1.36	<b>15.54</b>	<b>9.50</b>	<b>14.48</b>	<b>9.37</b>	15.74
[25, 50]	13.28	1.33	14.41	9.10	13.39	8.93	14.77
[50, 75]	13.01	1.42	14.20	9.18	13.28	9.12	14.98
[75, 90]	12.48	1.48	13.71	8.78	13.02	8.90	14.62
[90, 95]	11.64	1.99	13.55	8.30	13.06	8.86	14.89
[95, 98]	10.05	2.93	12.98	8.10	12.34	9.12	15.91
[98, 100]	8.30	<b>3.34</b>	11.67	6.59	11.62	8.26	<b>18.46</b>
Total	13.10	1.50	14.40	9.06	13.50	9.07	15.15
Start Year	1996q1	1998q1	1998q1	1996q1	1996q1	1993q1	1993q1

Time period: 1998Q1-2012Q1, for banks that exist for at least 50 quarters.

variables using GDP deflator and create per capita measures. Then we use HP-filter of the log of this variable to get the cyclical component. For the equity-to-asset ratio, we use the ratio itself.<sup>3</sup> We examine the correlations of the bank variables with GDP lagged one period, current GDP, and one-period-ahead GDP. The first three columns in Table 6 report the correlations for the period 1993Q1-2007Q4, and the last three columns report the correlations for the period 1993Q1-2012Q1. *Panel A* reports the variables that come from the FR Y-9C reports. Most of the balance sheet variables are procyclical, such as assets, loans, liabilities, deposits, stocks (preferred stock plus common stock) and retained earnings,<sup>4</sup> as expected. Loan loss provisions (*LLP*) and net charge offs (*NCO*) are countercyclical. Except for equity all these correlations are statistically significant at the 10% level. The reason why equity is not significantly correlated with output is because equity is negatively correlated with output for the bottom 75% of the banks, whereas it is positively correlated with top 25% of the banks. Even though these numbers are not statistically significant, they point out that the sign of the correlation is different for different size groups, and the overall positive correlation is driven by the largest banks.

*Panel B* reports variables that come from FR Y-9C reports merged with CRSP database which has information about share prices. Since not all the banks are publicly traded, the merged data set includes only 18,258 bank-quarter observations from 1993Q1 till 2011Q4. Value of total shares outstanding, which is the number of shares times price, is procyclical, and share prices are positively correlated only with future GDP. Equity premium and return on bank stocks are countercyclical. Again, these correlations are statistically significant at the 10% level.

Next, in Table 7 we report the cross correlations of aggregate variables: output, consumption, investment and aggregated bank level variables. In this Table we also include various return measures: return on average equity ( $ROAE = \text{Net Income} / \text{Average Equity}$ ), return on liabilities ( $ROL = \text{Net Income} / \text{Liabilities}$ ), return on average assets ( $ROAA = \text{Net Income} / \text{Average Assets}$ ), net interest margin ( $NIMA = \text{Net Interest Margin} / \text{Average Assets}$ ). As expected, assets, loans, liabilities, deposits, retained earnings, and stocks are positively correlated with output, consumption, and investment. Equity is only positively correlated with consumption

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<sup>3</sup>We also investigate the cyclicity for different size groups. We aggregate the level variables for each group and each quarter, deflate using GDP deflator, calculate the per capita measure, and then take the HP filter of the log of the variable. For the equity-to-asset ratio, we use the group mean. The results for different size groups can be found in Appendix A in Tables B.3-B.6.

<sup>4</sup>Retained Earnings<sub>t</sub>=Retained Earnings<sub>t-1</sub>+Net Income<sub>t</sub> -Dividends<sub>t</sub>

Table 6: Cyclicalty in the Aggregate Data

	1993Q1-2007Q4			1993Q1-2012Q1		
	$Y_{t-1}$	$Y_t$	$Y_{t+1}$	$Y_{t-1}$	$Y_t$	$Y_{t+1}$
<b>Panel A: FR Y9-C</b>						
Asset	<b>0.305</b>	<b>0.308</b>	<b>0.266</b>	<b>0.237</b>	<b>0.221</b>	0.172
	(0.019)	(0.017)	(0.040)	(0.039)	(0.054)	(0.137)
Loan	<b>0.370</b>	<b>0.361</b>	<b>0.312</b>	<b>0.310</b>	<b>0.248</b>	0.155
	(0.004)	(0.005)	(0.015)	(0.006)	(0.030)	(0.182)
Liability	<b>0.342</b>	<b>0.349</b>	<b>0.306</b>	<b>0.280</b>	<b>0.262</b>	<b>0.204</b>
	(0.008)	(0.006)	(0.017)	(0.014)	(0.021)	(0.077)
Deposit	<b>0.222</b>	<b>0.257</b>	<b>0.277</b>	0.046	0.127	<b>0.199</b>
	(0.092)	(0.047)	(0.032)	(0.694)	(0.271)	(0.085)
Ret. Earn.	<b>0.486</b>	<b>0.510</b>	<b>0.489</b>	<b>0.560</b>	<b>0.644</b>	<b>0.660</b>
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Equity	0.074	0.050	0.031	-0.131	-0.105	-0.030
	(0.578)	(0.707)	(0.817)	(0.261)	(0.365)	(0.796)
Stocks	<b>0.230</b>	<b>0.227</b>	<b>0.220</b>	-0.052	0.080	<b>0.193</b>
	(0.079)	(0.081)	(0.092)	(0.654)	(0.489)	(0.095)
LLP	<b>-0.378</b>	<b>-0.413</b>	<b>-0.504</b>	<b>-0.388</b>	<b>-0.511</b>	<b>-0.627</b>
	(0.003)	(0.001)	0.000	(0.001)	(0.000)	(0.000)
NCO	<b>-0.474</b>	<b>-0.493</b>	<b>-0.573</b>	<b>-0.563</b>	<b>-0.617</b>	<b>-0.672</b>
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
E/A	<b>-0.387</b>	<b>-0.329</b>	-0.214	-0.075	-0.003	0.102
	(0.002)	(0.010)	(0.101)	(0.521)	(0.976)	(0.379)
<b>Panel B: FR Y9-C merged with CRSP</b>						
No. of Shares $\times$ Stock Price	<b>0.444</b>	<b>0.521</b>	<b>0.586</b>	<b>0.278</b>	<b>0.477</b>	<b>0.588</b>
	(0.000)	(0.000)	(0.000)	(0.016)	(0.000)	(0.000)
Stock Price	0.082	0.182	<b>0.279</b>	<b>0.244</b>	<b>0.271</b>	<b>0.311</b>
	(0.535)	(0.163)	(0.031)	(0.035)	(0.018)	(0.007)
Equity Premium	<b>-0.469</b>	<b>-0.452</b>	<b>-0.484</b>	<b>-0.238</b>	-0.154	<b>-0.208</b>
	(0.000)	(0.000)	(0.000)	(0.039)	(0.184)	(0.073)
Return on Stocks	<b>-0.440</b>	<b>-0.427</b>	<b>-0.463</b>	<b>-0.212</b>	-0.129	-0.183
	(0.000)	(0.001)	(0.000)	(0.068)	(0.267)	(0.116)

Time period: 1993Q1-2012Q1, for banks that exist at least 50 quarters. The correlations that are significant at the 10% are reported in bold, and the values reported in parenthesis are the p-values.

and investment. Loan loss provision and net charge-offs however are negatively correlated with output, consumption, and investment. Equity-to-asset ratio and return on average equity are negatively correlated with output and consumption. The rest of the return variables, ROL, ROAA, and NIMA are all negatively correlated with output, consumption, and investment.

We also run a vector autoregression (VAR) model with a sample of banks consisting only of the largest BHCs. Following Covas, Rump and Zakrajsek (2012) our sample includes 15 BHCs over the 1989Q1-2012Q1 period and they are listed on Table 8.<sup>5</sup>

We estimate a VAR model similar to Lown and Morgan (2006) and Berrospide and Edge (2010). These studies examine the effect of bank capital ratio shock to output growth through its effect on loan growth. They find modest effects of bank capital on lending. In order to be more in line with our theoretical model, we use shocks to loan loss provisions as a shock to the asset side of the bank.<sup>6</sup> These shocks will be equivalent to quality of capital shocks in our model.

Our core VAR consists of six variables: loan loss provisions, real per capita GDP growth, GDP price inflation, bank equity to asset ratio, corporate bond spread, and fed funds rate. The three aggregate variables (real per capita GDP growth, GDP price inflation, fed funds rate) are standard components of a monetary policy VAR. We use two variables (loan loss provisions and bank equity to asset ratio) to model the banking sector, and the corporate bond spread is used to take into account expected future economic activity. We also do robustness analysis using the net charge-offs instead of loan loss provision to see whether using a different proxy would change our empirical results. The identifying assumption implicit in the recursive ordering of the VAR implies that loan loss provision shocks have an immediate impact on the other variables. We also experiment with changing the order of loan loss provisions by placing them after inflation and our results do not change qualitatively.

We estimate the model over the 1989Q1-2012Q1 period with two lags of endogenous variables. The plots of the variables are shown in Figure 1 and the summary statistics are reported on Table 9.

Figure 2 shows the response of the variables to a positive shock to loan loss provisions. The solid line is for the estimation that includes the whole time period, and the dashed line includes the time period until 2007Q4. For both of the time periods

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<sup>5</sup>We use the merger files that contain information to identify all bank and BHC acquisitions and mergers from [http://www.chicagofed.org/webpages/publications/financial\\_institution\\_reports/merger\\_data.cfm](http://www.chicagofed.org/webpages/publications/financial_institution_reports/merger_data.cfm). We use this information to take into account previous mergers and acquisitions and adjust the data by aggregating bank level variables.

<sup>6</sup>We also use net charge offs as a robustness check and our results are similar.

Table 7: Correlations - 1993Q1-2007Q4

	GDP	Cons.	Inv.	Assets	Loan	Liab.	Deposits	R.E.	Equity	Stocks	LLP	NCO	E/A	ROAE	ROL	ROA	NIN
GDP	1																
Cons.	<b>0.859</b>	1															
Inv.	<i>0.000</i>	<b>0.921</b>	1														
Assets	<b>0.244</b>	<b>0.305</b>	0.192	1													
Loan	<i>0.060</i>	<b>0.421</b>	<b>0.401</b>	<b>0.442</b>	1												
Liability	<i>0.001</i>	<i>0.002</i>	<i>0.000</i>	<i>0.000</i>	<i>0.857</i>	1											
Deposits	<i>0.033</i>	<b>0.322</b>	<b>0.223</b>	<b>0.995</b>	<b>0.857</b>	<b>0.768</b>	1										
Ret. Earn.	<i>0.010</i>	<i>0.001</i>	<i>0.007</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<b>0.586</b>	1								
Equity	<b>0.447</b>	<b>0.514</b>	<b>0.514</b>	<b>0.430</b>	<b>0.578</b>	<b>0.425</b>	<b>0.586</b>	<b>0.818</b>	<b>0.548</b>	1							
Stocks	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.001</i>	<i>0.000</i>	<i>0.001</i>	<i>0.000</i>	<i>0.000</i>	<i>0.166</i>	<b>0.701</b>	1						
LLP	<i>0.059</i>	<i>0.005</i>	<i>0.302</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.000</i>	<i>0.205</i>	<i>0.000</i>	<b>0.257</b>	<b>0.903</b>	1					
NCO	<b>-0.490</b>	<b>-0.357</b>	<b>-0.696</b>	<b>-0.065</b>	<b>-0.309</b>	<b>-0.078</b>	<b>-0.241</b>	<b>-0.534</b>	<b>-0.257</b>	<i>0.001</i>	<i>0.997</i>	<i>0.025</i>	1				
E/A	<i>0.000</i>	<i>0.005</i>	<i>0.000</i>	<i>0.623</i>	<i>0.016</i>	<i>0.554</i>	<i>0.063</i>	<i>0.000</i>	<i>0.048</i>	<i>0.848</i>	<i>0.000</i>	<i>0.050</i>	<i>0.050</i>	1			
ROAE	<i>0.016</i>	<i>0.002</i>	<i>0.157</i>	<i>0.047</i>	<i>0.681</i>	<i>0.034</i>	<i>0.210</i>	<i>0.636</i>	<i>0.821</i>	<i>0.003</i>	<i>0.733</i>	<i>0.702</i>	<i>0.702</i>	<i>0.004</i>	1		
ROL	<i>0.078</i>	<i>0.013</i>	<i>0.128</i>	<i>0.741</i>	<i>0.603</i>	<i>0.751</i>	<i>0.543</i>	<i>0.009</i>	<i>0.944</i>	<i>0.657</i>	<i>0.725</i>	<i>0.978</i>	<i>0.064</i>	<b>0.839</b>	<b>0.926</b>	1	
ROAA	<i>0.005</i>	<i>0.001</i>	<i>0.020</i>	<i>0.454</i>	<i>0.249</i>	<i>0.374</i>	<i>0.354</i>	<i>0.009</i>	<i>0.877</i>	<i>0.801</i>	<i>0.623</i>	<i>0.912</i>	<i>0.280</i>	<i>0.000</i>	<i>0.113</i>	<b>0.939</b>	1
NIMA	<i>0.005</i>	<i>0.000</i>	<i>0.031</i>	<i>0.623</i>	<i>0.395</i>	<i>0.580</i>	<i>0.327</i>	<i>0.005</i>	<i>0.855</i>	<i>0.533</i>	<i>0.600</i>	<i>0.960</i>	<i>0.391</i>	<i>0.000</i>	<i>0.000</i>	<b>0.364</b>	<b>0.501</b>
	<i>0.086</i>	<i>0.009</i>	<i>0.036</i>	<i>0.685</i>	<i>0.290</i>	<i>0.729</i>	<i>0.068</i>	<i>0.000</i>	<i>0.254</i>	<i>0.668</i>	<i>0.017</i>	<i>0.011</i>	<i>0.133</i>	<i>0.000</i>	<i>0.004</i>	<i>0.000</i>	<i>0.000</i>

Time period: 1993Q1-2007Q4, for banks that exist at least 50 quarters. The numbers in italics are p-values.

Table 8: **List of Bank Holding Companies**

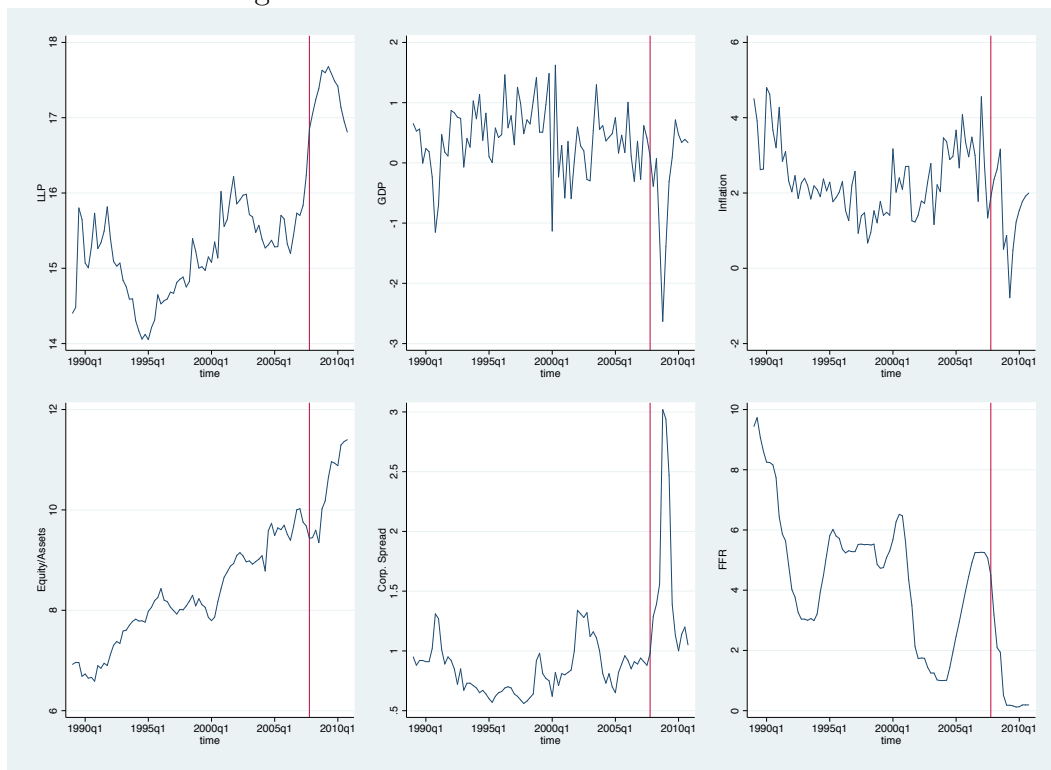
Bank Holding Company	Ticker
Bank of America	BAC
BB&T Corporation	BBT
Citigroup Inc.	C
Citizens Financial	RBS
Comerica Inc.	CMA
Fifth Third Bancorp	FITB
JPMorgan Chase & Co.	JPM
KeyCorp	KEY
M&T Bank Corp.	MTB
PNC Financial Services Group	PNC
Regions Financial Corporation	RF
SunTrust Banks Inc.	STI
U.S. Bancorp	USB
Wells Fargo & Company	WFC
Zions Bancorporation	ZION

Table 9: **Summary statistics**

Variable	Mean	Std. Dev.
Output Growth	0.311	0.653
Inflation	2.248	1.007
Fed Funds Rate	3.893	2.497
Corp. Spread	0.958	0.412
Equity/Asset	0.087	0.014
LLP/Asset	0.001	0.001
NCO/Asset	0.001	0.001
Deposit/Asset	44.096	5.256
Loan/Asset	53.346	5.011
Ret. Earn./Asset	4.604	0.768

Time period: 1993Q1-2012Q1

Figure 1: Variables used in VAR estimation



the results are qualitatively similar. An increase in loan loss provisions leads to a decline in output and an increase in corporate spreads. The monetary authority responds by decreasing the interest rate to stimulate the economy and the banks respond to the shock by increasing their equity to asset ratios. Table 10 shows the forecast variance decomposition for output growth at various horizons. We see that after four quarters, 78% of the the variation in output is explained by output shocks, 7% by variation in loan loss provisions, and 6% by variation in corporate spreads. And after five years, 68% of the variation in output is explained by its own shocks, and loan loss provisions still explain 7%. Inflation and corporate spreads explain about 6% of the variation in output, and equity to asset ratio explain about 3% of the output fluctuations.

Figure 3 shows the response of the variables to a positive shock to net charge-offs. An increase in net charge-offs leads to a decline in output, an increase in corporate spreads, and an increase in the banks' equity to asset ratio like in a loan loss provision shock. The rest of the variables in the VAR respond to the net charge-off shock similar



Figure 2: Response to a Shock in Loan Loss Provisions

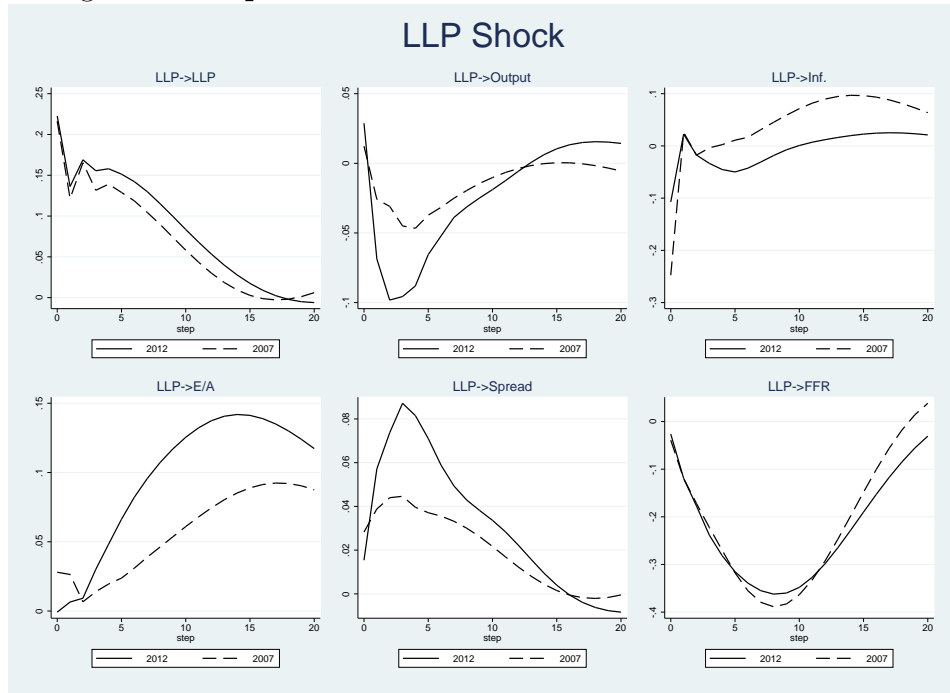
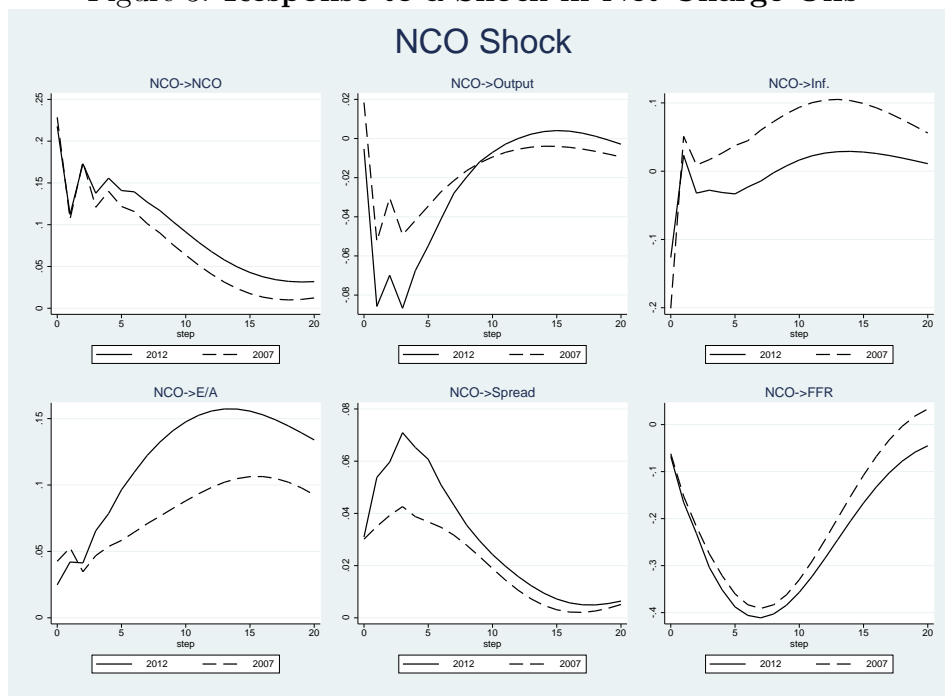


Table 10: Forecast Error Variance Decomposition for Output Growth - LLP

Horizon	LLP	Output	Inf	E/A	Corp Spread	FFR
1	0.000	1.000	0.000	0.000	0.000	0.000
2	0.043	0.872	0.000	0.006	0.059	0.021
3	0.058	0.812	0.039	0.007	0.058	0.026
4	0.070	0.783	0.049	0.009	0.058	0.032
8	0.077	0.728	0.065	0.018	0.056	0.055
12	0.075	0.695	0.066	0.021	0.063	0.081
16	0.074	0.680	0.066	0.026	0.063	0.091
20	0.073	0.676	0.066	0.029	0.062	0.093

Time period: 1989Q1-2012Q1

Figure 3: **Response to a Shock in Net Charge-Offs**



to the loan loss provision shock. Table 11 shows the forecast variance decomposition for output growth at various horizons. We see that after four quarters, 82% of the the variation in output is explained by output shocks, 4% by variation in net charge-offs, and 9% by variation in corporate spreads. And after five years, 73% of the variation in output is explained by its own shocks, and net charge-offs explain about 5%. Inflation and equity to asset ratio explain 4% of the variation in output, and corporate spreads explain almost 9%.

Table 11: **Forecast Error Variance Decomposition for Output Growth - NCO**

Horizon	NCO	Output	Inf	E/A	Corp Spread	FFR
1	0.002	0.998	0.000	0.000	0.000	0.000
2	0.018	0.886	0.001	0.011	0.076	0.009
3	0.027	0.843	0.022	0.015	0.083	0.011
4	0.037	0.821	0.027	0.015	0.087	0.014
8	0.051	0.772	0.035	0.024	0.083	0.035
12	0.051	0.745	0.035	0.028	0.087	0.054
16	0.051	0.734	0.036	0.033	0.086	0.059
20	0.051	0.730	0.036	0.038	0.086	0.060

Time period: 1993Q1-2012Q1

## 5 The Model

### 5.1 Households

We consider an infinite horizon model with households, firms and banks. The basic structure of our model follows Gertler et al. (2012). The representative household consists of members distributed over the unity interval; the fraction  $f$  of members are bankers and the fraction  $1 - f$  are workers. The bankers operate the financial intermediaries, which are described in detail later. In every period there is a constant, exogenous probability  $\epsilon$  that a banker becomes a worker and that a worker becomes a new banker. The workers choose how much labor to supply and consume non-durable goods. In our model households are the ultimate capital providers. In particular, workers provide funds to the financial intermediaries, which in turn make loans to firms. Financial intermediaries, which we will refer to as banks, offer two one-period financial instruments to workers: deposit and equity. Deposit is a risk-free asset that pays a non-state contingent, predetermined rate of return; equity, on the other hand, is risky because it pays a state-contingent rate of return. Hence, workers can choose among two different assets with which to save.

Formally, households maximize expected discounted utility

$$\max_{C_t, D_t, E_t, L_t} \sum_{t=0}^{\infty} \beta^t E_0 \left\{ \frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \nu \frac{L_t^{1+\varphi}}{1+\varphi} \right\}, \quad 0 < \beta < 1, \quad (1)$$

where  $C_t$  is current consumption,  $L_t$  is labor supply,  $\beta$  is the discount factor,  $\sigma$  is the coefficient of relative risk aversion,  $\varphi$  is the inverse Frisch elasticity of labor supply,  $\nu$  is the weight of labor in the utility function and  $h$  is the parameter capturing habit persistence. Households maximize (1) subject to the budget constraint

$$C_t + D_t + X_t q_t = L_t w_t + R_{D,t-1} D_{t-1} + R_{X,t} X_{t-1} q_{t-1} + \Pi_t - T_t, \quad (2)$$

where  $X_t$  is bank equity purchased at  $t$  at price  $q_t$ ,  $D_t$  are deposits and  $R_{D,t-1}$  is the gross non-state-contingent rate of return determined at  $t - 1$  and paid on

deposits taken at  $t - 1$ ,  $R_{X,t}$  is the gross state-contingent rate of return paid on equity purchased at time  $t - 1$  and  $w_t$  is the wage.  $\Pi_t$  is net distributions from ownership of bank equity and capital producing firms and transfers from old bankers and to new bankers;  $T_t$  are lump-sum taxes levied by the government to finance government expenditure. Households choose consumption, labor supply, deposits and equity and the first-order conditions are, respectively,

$$\lambda_t = (C_t - hC_{t-1})^{-\sigma} - \beta h(C_{t+1} - hC_t)^{-\sigma}, \quad (3)$$

$$\nu L_t^\varphi = \lambda_t w_t, \quad (4)$$

$$\lambda_t = \beta R_{D,t} E_t \lambda_{t+1}, \quad (5)$$

$$\lambda_t = \beta E_t [R_{X,t+1} \lambda_{t+1}]. \quad (6)$$

Let  $\Lambda_{t,t+1}$  denote the household's stochastic discount factor between  $t$  and  $t + 1$ . Then equations (5) and (6) can be rewritten respectively as

$$R_{D,t} E_t \Lambda_{t,t+1} = 1, \quad (7)$$

$$E_t [R_{X,t+1} \Lambda_{t,t+1}] = 1. \quad (8)$$

Household choices of labor and consumption are fairly standard. Conditional on time  $t$ , the rate of return on deposits is predetermined and riskless. On the other hand, the rate of return on equity is state-contingent and varies with economic conditions. Households take prices, rate of returns and wages as given.

In our model households face a portfolio choice problem. They can save by investing either in deposits or in equity. In the deterministic steady state, these two assets must offer the same rate of return and portfolio allocation is indeterminate from the point of view of consumers. When we consider the second-order approximation of the model and the risky steady state, the two assets will offer different rate of returns that reflect their hedging properties. As a result, households will prefer a specific portfolio allocation. On the supply side, deposits and equity are offered by banks.

In a model where banks are unconstrained in the composition of their liabilities, the equilibrium is the solution of a two-sided optimal portfolio allocation by banks and households. In our model banks face a constraint which effectively puts a lower limit on the amount of equity relative to assets. This implies that banks may not be free to choose their liability composition and that the supply of equity and deposits by banks may well be determined by regulation. In this case, the portfolio choice of households will play a role in determining the equilibrium rate of returns of deposits and assets.

## 5.2 Capital Producers

Capital producers are firms that produce new capital using final output subject to adjustment costs. More precisely, capital producers choose investment to maximize present and future expected profits, which can be written as

$$\max_{I_t} E_0 \sum_{t=0}^{\infty} \Lambda_{t,t+1} \left\{ Q_t I_t - \left[ 1 + f \left( \frac{I_t}{I_{t-1}} \right) \right] I_t \right\}, \quad (9)$$

where  $Q_t$  is the price of capital in terms of the consumption good at time  $t$ ,  $f(I_t/I_{t-1})I_t$  are investment adjustment costs with  $f' > 0$ ,  $f'' > 0$ . Capital producers produce new capital at unitary cost  $1 + f$ , which is then sold to output-producing firms at the price  $Q_t$ . The first-order condition of capital producers is

$$Q_t = 1 + f \left( \frac{I_t}{I_{t-1}} \right) + f' \left( \frac{I_t}{I_{t-1}} \right) \frac{I_t}{I_{t-1}} - E_t \left[ f' \left( \frac{I_t}{I_{t-1}} \right) \left( \frac{I_t}{I_{t-1}} \right)^2 \right], \quad (10)$$

which is the standard equation that defines Tobin's  $Q$ . The profits of capital producers are distributed in lump-sum fashion to households.

## 5.3 Firms

Output producing firms are perfectly competitive. They produce using a standard technology characterized by constant returns to scale in capital and labor. At the beginning of each period firms hire labor at the wage rate  $w_t$ , which they take as

given, and purchase capital from capital producers. Firms take loans from banks to purchase capital, which needs to be paid before production takes place. More precisely, in period  $t$  firms take total loans  $Q_t S_t$  from banks, which are then used to purchase installed and new capital. Firms receive funding by issuing state-contingent claims on future return from capital; banks purchase these claims and therefore are the owners of capital. Loans  $S_t$  can therefore be interpreted as the security backed by capital; this security has price  $Q_t$  and it pays the state-contingent rate of return to capital  $R_{K,t+1}$ . Formally firms choose labor and new capital to maximize profits

$$\max_{I_t, L_t} A_t K_t^\alpha L_t^{1-\alpha} - w_t L_t - R_{K,t} Q_{t-1} S_{t-1} + Q_t S_t - Q_t I_t, \quad (11)$$

subject to

$$S_t = (1 - \delta) K_t + I_t, \quad (12)$$

$$K_{t+1} = \Psi_{t+1} S_t, \quad (13)$$

where we define the gross rate of return to loans as follows

$A_t$  is a standard technology shock to production and  $\Psi_t$  is a shock to capital quality. As in Merton (1973), Gertler and Kiyotaki (2010) and Gertler et al. (2012), we assume an exogenous source of variation for the quality of capital. A shock to the quality of capital affects the economy directly through its effect on capital and therefore output production and indirectly through its effect on the balance sheet of banks of changes in claim prices and returns. Firms maximize profits subject to two constraints. (12) defines the securities issued at  $t$  to purchase installed capital and investment;  $\delta$  is the rate of depreciation of capital. (13) defines quality-adjusted capital held by the firm, which differs from loans by the quality shock.  $R_{K,t}$  is the rate of return paid to total loans taken at time  $t - 1$ .

Firms choose labor  $L_t$  and  $I_t$  and demand loans  $Q_t S_t$ . The first-order condition relative to labor is

$$w_t = (1 - \alpha) \frac{Y_t}{L_t}, \quad (14)$$

and the first-order condition relative to  $I_t$  is

$$\frac{\Psi_{t+1} [Z_{t+1} + (1 - \delta)Q_{t+1}]}{Q_t} = R_{K,t+1}, \quad (15)$$

where  $Z_{t+1}$  is the marginal productivity of capital:

$$Z_{t+1} \equiv \alpha A_{t+1} \left( \frac{L_{t+1}}{K_{t+1}} \right)^{1-\alpha} = \alpha \frac{Y_{t+1}}{K_{t+1}}. \quad (16)$$

## 5.4 Banks

Every period banks make loans to good-producing firms by raising funds both externally and internally. External funds come from households, who can purchase deposits or equity in the bank. These two assets differ in terms of their riskiness: deposits pay a pre-determined rate of interest while equity pays a state-contingent one. In other words, equity is risky in the sense that its rate of return varies with the state of the economy. Deposits, on the other hand, offer a rate of return that may still vary over time but is determined in advance. Deposits and equity are assets for households and liabilities for banks. Financial intermediaries also raise funds internally by using their net worth, i.e. retained earnings.

The balance sheet of the bank implies that the values of the loans made to firms in a given period,  $Q_t S_t$ , is equal to the sum of deposits  $D_t$  and equity  $q_t X_t$  raised from households and the bank's net worth  $N_t$ :

$$Q_t S_t = N_t + q_t X_t + D_t. \quad (17)$$

The bank's net worth at  $t$  is the gross payoff from loans made at  $t - 1$  net of gross returns paid to equity and deposits also raised at  $t - 1$  and other costs. Hence, the net worth can be interpreted as retained earnings.

It is typically assumed in the banking literature that equity is more expensive than deposits – see Myers and Majluf (1984) and Berger, Herring and Szego (1995), citing different tax treatment of interest payments and dividends, transaction costs, asymmetric information and deposit insurance. For simplicity, we assume that the

total cost in period  $t$  borne by the bank for one unit (value) of equity raised in period  $t - 1$  is  $R_{X,t} + \tau, \tau > 0$ . The functional form of these funding and adjustment costs are specified in section 6. Formally, the net worth is given by

$$N_t = R_{k,t}Q_{t-1}S_{t-1} - [R_{X,t} + \tau]X_{t-1}q_{t-1} - R_{D,t-1}D_{t-1} + \mathcal{P}_t, \quad (18)$$

where  $\mathcal{P}$  will be described in detail later. To sum up, the bank can raise funds via deposits, equity and net worth, which have different costs. Since equity pays a state-contingent rate of return, it allows better hedging against fluctuations than deposits; the equity cost  $\tau > 0$  makes deposits more attractive than equity from the bank's perspective so that the capital requirement is binding. Since net worth does not entail funding costs, at least at the steady state, and it is a substitute to external funds, the bank would naturally accumulate enough retained earnings to fund all loans internally. To ensure that our equilibrium entails financial intermediation and in line with existing literature, we assume that the bank exits with constant probability  $1 - \epsilon$  in every period and continues with probability  $\epsilon$ . When the bank exits, its net worth is transferred to the household in a lump-sum fashion. Low continuation probabilities align the goals of the banks with those of households; high continuation probabilities make banks care more about their value.

Banks are typically regulated in several dimensions. The recent financial crisis and its effects on the financial system has brought bank regulation back to the top of the policy agenda. Here we focus on bank capital adequacy regulation and, in particular, on requirements on bank capital such as Basel II and III. These rules typically require a bank to hold a certain fraction of assets, or risk-weighted assets, as capital (namely, equity). More precisely, Basel II requires that the bank's capital to risk-weighted asset ratio must be at or above 8 percent, where risk-weighted assets are the bank's assets evaluated taking into consideration the risk of different asset classes and consequently assigning them different weights. Basel III requires banks to hold 4.5 percent of common equity and 6 percent of Tier 1 capital of risk-weighted assets. The Federal Reserve Board requires bank holding companies to hold total



capital of at least 8 percent of risk-weighted assets, in line with Basel II.

The evidence presented in section 4 shows that most U.S. banks are indeed above the minimum capital requirements dictated by Basel II. Nevertheless, this ratio displays significant variation, both across banks and over time for the same bank. We interpret this evidence as suggesting that mandated capital requirements overall bind for financial institutions but not strictly and not at all times. We capture these features by modeling capital requirements for the bank as a penalty

$$\mathcal{P}_t = \phi \left[ \log \left( \frac{X_t q_t + N_t}{\gamma Q_t S_t} \right) - \zeta \left( \frac{X_t q_t + N_t - Xq - N}{Xq + N} \right) \right], \quad \phi, \zeta \geq 0, \quad (19)$$

which contributes to net worth.  $\gamma$  is the required minimum capital ratio, for example 0.08 for Basel II;  $Xq$  is the steady-state value of bank equity. Due to the log term, the bank is penalized when its capital goes below the required 8 percent of total assets and the parameter  $\phi \geq 0$  measures the intensity of the penalty in terms of net worth. The second component of the penalty function penalizes capita-to-asset ratios above the steady state. Modeling capital requirements with a penalty function has two advantages. First, it allows for variations in the capital-to-asset ratio that a fixed constraint would instead rule out. Second, it allows us to apply standard perturbation methods.<sup>7</sup>

As suggested earlier, banks exit with constant probability  $1 - \epsilon$ . Let  $V_{t-1}$  be the value of the bank at time  $t - 1$ . This value satisfies the Bellman equation

$$V_{t-1}(S_{t-1}, X_{t-1}, N_{t-1}) = E_{t-1} \Lambda_{t-1,t} \left\{ (1 - \epsilon) N_t + \epsilon \max_{S_t, X_t} [V_t(S_t, X_t, N_t)] \right\}. \quad (20)$$

In every period  $t$  the variables  $S_t$  and  $X_t$  are chosen so as to maximize the value of the bank subject to the flow budget constraint (17) and the law of motion of net worth (18). Using (17) to eliminate deposits from (18) we obtain the following recursive formulation for net worth

$$N_t = [R_{K,t} - R_{D,t-1}] Q_{t-1} S_{t-1} - [R_{X,t} + \tau - R_{D,t-1}] X_{t-1} q_{t-1} + R_{D,t-1} N_{t-1} + \mathcal{P}_t. \quad (21)$$

---

<sup>7</sup>See Preston and Roca (2007) and Kim, Kollmann and Kim (2010) for applications of the barrier method.

We guess that the value of the bank at time  $t$  has the simple linear form

$$V_t(S_t, X_t, N_t) = \mu_{s,t}Q_tS_t - \mu_{x,t}q_tX_t + \mu_{n,t}N_t,$$

where  $\mu_{s,t}, \mu_{x,t}, \mu_{n,t}$  are undetermined coefficients that we will find later. The first-order conditions relative to  $S_t$  and  $X_t$  are, respectively,

$$\mu_{s,t}Q_tS_t = \phi\kappa_t, \quad (22)$$

$$\mu_{x,t} = \phi\kappa_t \left[ \frac{1}{X_tq_t + N_t} - \frac{\zeta}{Xq + N} \right], \quad (23)$$

and the envelope condition relative to  $N_{t-1}$  is

$$V_{N,t-1} = E_{t-1}\Lambda_{t-1,t}\Omega_tR_{D,t-1}, \quad (24)$$

where

$$\Omega_t \equiv \frac{1 - \epsilon + \epsilon\mu_{n,t}}{1 - \mathcal{P}_{N,t}} \quad \text{and} \quad \kappa_t \equiv \frac{\mu_{n,t}}{1 - \mathcal{P}_{N,t}},$$

where  $\mathcal{P}_{N,t} \equiv \partial\mathcal{P}_t/\partial N_t$ . Substituting (21) into the Bellman equation at time  $t$  we can solve for the undetermined coefficients to find

$$\mu_{s,t} = E_t\Lambda_{t,t+1}\Omega_{t+1}(R_{K,t+1} - R_{D,t}), \quad (25)$$

$$\mu_{x,t} = E_t\Lambda_{t,t+1}\Omega_{t+1}(R_{X,t+1} + \tau - R_{D,t}), \quad (26)$$

$$\mu_{n,t} = E_t\Lambda_{t,t+1}\Omega_{t+1}R_{D,t}. \quad (27)$$

New banks at  $t$  receive a transfer from households equal to a fraction  $\omega$  of the returns to loans of existing bankers:

$$\omega R_{k,t}Q_{t-1}S_{t-1}, \quad (28)$$

so that the evolution of aggregate net worth can be written as follows

$$N_t = (1 - \epsilon) \{ [R_{K,t} - R_{D,t-1}] Q_{t-1} S_{t-1} - [R_{X,t} + \tau - R_{D,t-1}] q_{t-1} X_{t-1} + R_{D,t-1} N_{t-1} + \mathcal{P}_t \} + \epsilon \omega R_{K,t} Q_{t-1} S_{t-1}. \quad (29)$$

## 5.5 Government

The government purchases the amount  $G_t$  of goods produced in the economy and these purchases are financed by lump-sum taxes  $T_t$ . Government expenditure are exogenous and stochastic

$$\log G_t = \rho_g \log G_{t-1} + (1 - \rho_g) \log G + \varepsilon_g, \quad (30)$$

where  $G$  is government purchases at the steady state,  $\rho_g \geq 0$  is the coefficient of autocorrelation and  $\varepsilon_g$  is a government spending shock, which we assume to be distributed normally with zero mean and standard deviation  $\sigma_g$ .

## 5.6 Equilibrium

Equilibrium requires clearing in the market for goods, assets, loans and labor. For goods, we require that

$$Y_t = C_t + G_t + \left[ 1 + f \left( \frac{I_t}{I_{t-1}} \right) \right] I_t + \tau X_t q_t, \quad (31)$$

and for labor we require that supply by households, from (4), equals demand by firms, as defined in (14). Regarding loans, the supply of securities  $S_t$ , as specified in (12), must equal demand by banks. The supply of deposits  $D_t$  and equity  $X_t$  by banks must equal the demand by households.

There are three sources of exogenous fluctuations in our model. The first is a shock to government expenditure, which we have described above. The second is a shock

to productivity, which follows the exogenous AR(1) process

$$\log A_t = \rho_a \log A_{t-1} + \varepsilon_a, \quad (32)$$

where  $\rho_a \geq 0$  and  $\varepsilon_a$  has distribution  $N(0, \sigma_a^2)$ . The third is a capital quality shock, which we assume to also follow an AR(1) process

$$\log \Psi_t = \rho_\Psi \log \Psi_{t-1} + \varepsilon_\Psi, \quad (33)$$

with  $\rho_\Psi \geq 0$  and  $\varepsilon_\Psi$  being the normally distributed disturbance with zero mean and variance  $\sigma_\Psi^2$ .<sup>8</sup>

## 6 Calibration

For investment, we assume standard adjustment costs

$$f\left(\frac{I_t}{I_{t-1}}\right) \equiv 0.5\chi\left(\frac{I_t}{I_{t-1}} - 1\right)^2.$$

Table 12 summarizes the calibration of our economy. The time unit is meant to be a quarter. We set the coefficient of relative risk aversion  $\sigma$  equal to 2 and the habit parameter  $h$  equal to 0.85. The discount factor  $\beta$  implies an annual real interest rate just above 3 percentage points. The inverse elasticity of labor supply  $\varphi$  is set equal to 1/3, as standard in the macro literature and the disutility from work  $\nu$  is equal to 4. For firms, we set the capital share  $\alpha$  equal to 0.3 and capital depreciation  $\delta$  equal to 2.5 percentage points. The parameter  $\chi$  measuring investment adjustment costs is set to 0.8.

Regarding banks, we choose the parameters to come as close as possible to the aggregate summary statistics for banks reported in section 4. We set  $\gamma$ , the bank capital-to-asset minimum required ratio, equal to 8 percentage points. This figure is in line with Basel II and Basel III regulation, although this regulation is in terms

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<sup>8</sup>Gertler et al. (2012) model the capital quality shock as the product of two processes, one holding in normal times and the other arising occasionally during disasters.

Parameter	Value	Description
$\beta$	0.9925	Discount factor of households
$\sigma$	2	Coefficient of relative risk aversion
$\nu$	4	Disutility from work
$h$	0.85	Habit parameter
$\varphi$	1/3	Inverse of elasticity of labor supply
$\chi$	0.8	Firm adjustment costs
$\alpha$	0.3	Share of capital in production
$\delta$	0.025	Capital depreciation
$\gamma$	0.08	Bank capital constraint
$\tau$	0.01	Bank (proportional) cost of equity
$\epsilon$	0.83	Survival rate of bankers
$\omega$	0.01	Transfer to new bankers
$\phi$	0.0025	Penalty parameter
$\zeta$	0.85	Penalty parameter for deviation from steady state
$\rho_g$	0.87	Serial correlation of government spending shocks
$\rho_a$	0.8556	Serial correlation of productivity shocks
$\rho_\Psi$	0.88	Serial correlation of capital quality shocks
$\sigma_g$	0.00768	Standard deviation of government spending shocks
$\sigma_a$	0.0064	Standard deviation of productivity shocks
$\sigma_\Psi$	0.0025	Standard deviation of capital quality shocks

Table 12: Benchmark Calibration

of risk weighted assets, and with the empirical evidence reported in Table 5. The survival rate of bankers  $\epsilon$  is set equal to 0.83 and the transfer to new bankers  $\omega$  is set equal to 0.01. The survival rate brings a wedge between bankers and consumers. When the survival rate tends to zero, bankers will almost surely become consumers at the end of the period and they put a large weight on maximizing current retained earnings rather than , which are then transferred to households and consumed. In this case,  $\Omega$  is constant and equal to one, so that the banker and the household discount factors are identical. With a positive probability of survival banks care more about their future value and less about retained earnings, which become more volatile.  $\Omega$  becomes counter-cyclical, which in turn makes the banker augmented discount factor  $\Lambda\Omega$  more counter-cyclical than that of households. The penalty parameters  $\phi$  and  $\zeta$  are set equal to 0.0025 and 0.85, respectively.  $\zeta < 1$  rewards banks for capital ratios above the required value (except at the steady state) while  $\zeta = 0$  penalizes banks for capital ratios above its required value. We set the cost of equity  $\tau$  equal to 0.01.

For the parameters of the exogenous disturbance processes, we set the standard deviation and autoregressive parameters for the technological progress and government spending using values typically used in the literature. More precisely, we set  $\sigma_a = 0.0064$  and  $\rho_a = 0.8556$ ;  $\sigma_g = 0.00768$  and  $\rho_g = 0.87$ . There is little empirical evidence and literature on the values to assign to the standard deviation  $\sigma_\Psi$  and autoregressive parameter  $\rho_\Psi$ . We choose these values to match the standard deviation of bank assets as reported in table 9.

## 7 The response to a capital quality shock

Figure 4 reports the impulse responses of our model to a decline in the quality of capital by 4% of the existing stock. All variables are reported in percentage point deviation from steady state and for twenty periods after the shock.

We interpret a capital quality shock as the occurrence of losses on loans made by banks to firms. Capital and its price fall on impact and drive bank assets down. The rate of return on loans is also reduced, thereby driving down net interest income

by banks. Because the price of capital remains depressed for a number of periods, investment also remains below its steady state for a while so that capital and loans continue to fall. On the other hand, the rate of return on deposits displays a contained response to the shock. On the bank side, the sharp fall in assets and loan interest income generates losses that reduce net worth. Bank stock prices  $q$  fall and contribute to downward pressure on bank equity. To keep the equity-to-asset ratio from falling below its required level, banks balance the fall in net worth (retained earnings) by issuing new stocks. Since equity decreases less than assets, the equity-to-asset ratio slightly increases. The dynamic response of the capital ratio is consistent with the VAR evidence reported in section 4, which showed that a shock in loan loss provisions (or net charge offs) generates an inverse-U shaped response in the equity-to-asset ratio.

Consumers are affected by the capital quality shock in two ways. First, they experience a negative wealth effect due to the loss in value of their portfolio and the sharp fall in returns. Second, their labor income is reduced to reduced labor demand and lower wages. As a result, household consumption falls following the shock. Interestingly, the drop in consumption is deeper and more persistent than that in output. This is because investment must restore capital to its pre-shock level, thereby crowding out consumption.

Figure 5 compares the responses to a capital quality shock in the model with and without bank capital constraints. More precisely, the solid blue line is the response in the model with capital constraint, already shown in figure 4; the dashed red line is the response of the model without bank capital constraints. We approximate the model without capital constraints by assigning a very low value to the penalty parameter  $\phi = 0.0001$ ; notice that the model with and without capital constraint share the same deterministic steady state. Without the capital requirement both net worth and stocks drop sharply in response to a capital quality shock, thereby driving down equity and the equity-to-asset ratio. Banks substitute stocks with deposits as their liabilities. The capital requirement presses banks to recapitalize at a time when stock prices are low. In the absence of such requirements, banks would reduce their stocks

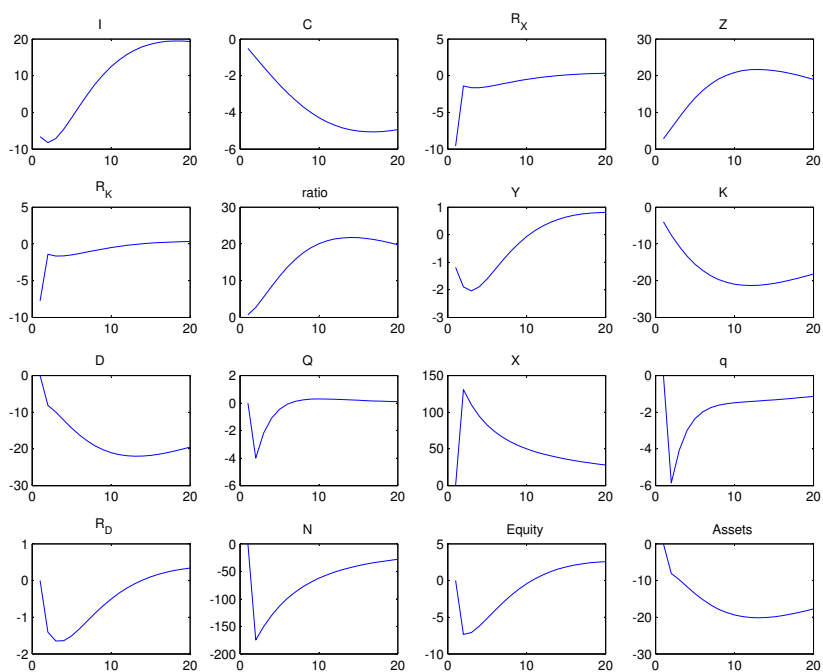


Figure 4: Impulse responses to a capital quality shock

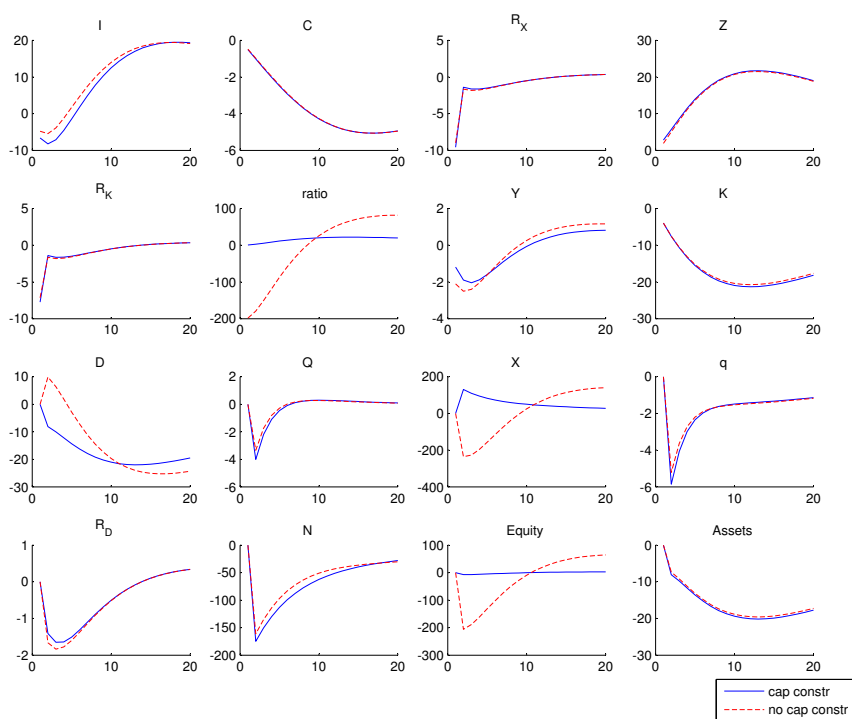


Figure 5: Impulse responses to a capital quality shock with and without bank capital constraints



and let equity fall. Notice that bank equity falls by more than 20% in response to a two standard deviation capital quality shock. It is clear that the presence of capital constraints greatly reduces the volatility of bank equity by requiring recapitalization when the balance sheet of banks is under stress. In terms of the effects on the real economy, bank capital requirements lead to a smaller fall in output right after the shock. Asset prices experience a sharper drop that depresses investment and loans more in the model with bank capital constraints. As a result, labor demand does not fall and the decline in output is less severe.

## 8 Second Moments

First we generate the second moments of our model under the benchmark calibration but in the absence of capital quality shocks ( $\sigma_\Psi = 0$ ). The model replicates well the empirical standard deviation of output, consumption and investment (not reported) but the standard deviation of bank variables is about half its empirical counterpart. We raise the standard deviation of the capital quality shock to 0.2% to match the standard deviation of bank assets in the data. Table 13 reports the second moments of the data (left-hand side) and the model (right-hand side).

Table 13: Second moments: empirical and theoretical

Empirical				Model			
Variable	Std	Corr $Y$	Corr $C$	Variable	Std	Corr $Y$	Corr $C$
GDP	1.2	1	0.85	$Y$	1.2	1	0.18
Cons	0.9	0.85	1	$C$	0.9	0.18	1
Investment	5.2	0.92	0.69	$I$	6	0.85	-0.17
Assets	3.6	0.56	0.63	$Q \times K$	3.4	0.22	0.94
Deposits	2.7	0.49	0.58	$D$	3.6	0.23	0.94
Ret. Earnings	3.8	0.34	0.37	$N$	29	0.80	0.40
Equity	4.1	0.13	0.25	$q \times X + N$	1.16	-0.31	-0.28
Equity/Asset	2.0	-0.31	-0.4	<i>ratio</i>	3.8	-0.28	-0.89
Stock Return <sup>†</sup>	270	-0.23	-0.31	$R_X$	154	0.04	-0.08

Standard deviation expressed in percentage points

The empirical second moments are calculated over the period 1993Q1 to 2007Q4; all variables are real and per capita. To calculate the standard deviation first we take

the log of the variable, then we apply the HP filter it, and then calculate the standard deviation using the cyclical component, which is what we report in table 13. For the variables marked with † we take the HP filter without taking the log and calculate the standard deviation from the HP trend. All empirical correlations are statistically significant, with the exception of the correlation of equity with GDP. In computing the theoretical second moments, the parameters of the model take the values shown in table 12. Second moments are calculated using Monte Carlo simulations with second-order accurate path of the variables. We perform 1000 simulations of 100 quarters each. For each simulation, we compute second moments and then average these figures over the 1000 simulations.

The model-generated standard deviations are in line with the empirical counterparts for output, consumption, investment, assets, deposits. Equity is less volatile while the equity-to-asset ratio is more volatile in the model than in the data. The model also underestimates the standard deviation of bank stock returns and overestimates that of retained earnings. Notice that the volatility of bank stock returns remains high even if we eliminate capital quality shocks.

The model predicts a strong negative correlation between stocks  $X$  and retained earnings  $N$ , as seen in figure 4. When the assets of the bank are hit by a negative shock, net worth inevitably falls but the bank maintains the capital ratio in line with requirements by issuing stocks. As a result equity, which is the sum of net worth and the value of stocks, displays little volatility. This in turn makes the equity-to-asset ratio more volatile because equity responds little at the numerator of the ratio while assets move a lot at the denominator.

All empirical variables reported in table 13 are positively correlated with GDP, with the exception of the equity-to-asset ratio and the stock return. Our model also predicts positive correlations with output for all variables except the equity-to-asset ratio, stock return and equity. In particular, since retained earnings are positively correlated with output both in the data and in the model, it is clear that the negative co-movement between output and equity is due to the behavior of stocks. The correlation of consumption with output and investment predicted by

the model are lower than in the data. Our model dictates a tight link between loans and deposits due to the equity constraint faced by banks.

## 9 Deterministic and Risk-adjusted Steady State

The deterministic steady state does not account the difference in risk between deposits, which pay a pre-determined rate of return, and bank stocks, which pay a state-contingent one. At the deterministic steady state deposits and equity pay the same rate of return

$$R_D = R_X = \frac{1}{\beta}$$

and, up to a first-order approximation, households are indifferent between these two instruments. This is not the case for banks. Since  $\tau > 0$  banks prefer to fund themselves via deposits at the deterministic steady state and the bank capital requirement is binding. To capture risk perception and its implications on the portfolio choice of households and financial intermediaries we work with the second-order approximation of our model and construct the risk-adjusted steady state, namely the steady state of the economy that takes into account risk – see ?. Risk perceptions play an important role in portfolio choices. Equity is risky relative to deposits because its return is state-contingent and more volatile than that of deposits. Moreover the rate of return of deposits is more negatively correlated with consumption than the rate of return on equity. Hence, equity is a worse hedge to consumption volatility than deposits for households and it must therefore pay a premium for consumers to be willing to hold it. Since the bank capital requirement is binding, the liability side of the bank balance sheet and household portfolio are pinned down. In turn, this determines a unique equilibrium equity premium necessary for households to be willing to invest on bank equity in the amount offered by financial institutions.

Our model generates an equity premium for bank stocks at the risk-adjusted steady state that depends on the underlying stochastic processes. The left-hand side of table 14 reports the empirical mean of a number of bank variables over the period 1993Q1

Table 14: Steady State

Empirical		Model			
Variable	Mean	Model Variable	Det. SS	Risk-adjusted SS	
				$\sigma_a = 0.0064$	$\sigma_a = 0.0064$
				$\sigma_g = 0.00768$	$\sigma_g = 0.00768$
				$\sigma_\Psi = 0.0025$	$\sigma_\Psi = 0.0175$
Stock return	14	$R_X$	3	3.3	12.7
Equity Premium	10.2	$R_X - R_D$	0	0.3	10.2
Ret. Earnings / Assets	0.045	$N/(Q \times K)$	0.034	0.045	0.048

Rate of returns in percent and annualized

to 2007Q4: the rate of return on bank stocks,<sup>9</sup> the equity premium relative to bonds and retained earnings to assets ratio. The right-hand side of the same table reports the deterministic and risk-adjusted steady-state values of the corresponding variables in our model. When risk is taken into consideration, the model generates an equity premium. Under the benchmark calibration the equity premium on bank stocks is well below its empirical counterpart. The premium goes up with  $\sigma_\Psi$ , the volatility of the capital quality shock.

## 10 Bank capital and bankruptcy

We can use our model to evaluate the importance of minimum capital requirements for bankruptcy in the financial system. We say that the financial system is bankrupt when bank equity hits the zero bound. At this point, retained earnings (i.e. net worth) and stocks are wiped out and the bank does not have any funding sources with the exception of deposits. A realistic model of bankruptcy should have costs associated with bankruptcy that we ignore here. We should therefore interpret our findings in this light.

Table 15 reports the frequency with which the model reaches the zero bank equity in a Monte Carlo simulation. As before, our simulation is based on second-order accurate path of the variables. We perform 1000 simulations of 100 quarters each. For each simulation, we compute second moments and then average these figures

<sup>9</sup>This is calculated as the return of holding stocks.

Table 15: Frequency of bankruptcy of the banking system

Variable	Frequency
$\gamma = 0.08$	0%
$\gamma = 0.03$	7.4%
$\gamma = 0.02$	27.4

over the 1000 simulations. The standard deviation of the exogenous disturbances as well as the parameter values are those reported in our benchmark specification. As the minimum capital requirement falls from 8 to 3 percentage points, the frequency of bankruptcy increases from zero to 7.4 percentage points; for a minimum capital requirement  $\gamma = 0.02$ , the financial system is bankrupt one quarter every four.

## 11 Conclusions

## References

- Berger, Allen, Richard Herring, and Giorgio Szego**, “The Role of Capital in Financial Institutions,” *Journal of Banking and Finance*, 1995, 19 (3-4), 393–430.
- , **Robert DeYoung, Mark Flannery, David Lee, and Ozde Oztekin**, “How Do Large Banking Organizations Manage Their Capital Ratios?,” *Journal of Financial Services Research*, 2008, 34 (2), 123–149.
- Berrospide, Jose M. and Rochelle M. Edge**, “The Effects of Bank Capital on Lending: What Do We Know, and What Does It Mean?,” *International Journal of Central Banking*, 2010, 6 (4), 5–54.
- Covas, Francisco and Wouter J. Den Haan**, “The Cyclical Behavior of Debt and Equity Finance,” *American Economic Review*, 2011, 101 (2), 877–99.
- , **Ben Rump, and Egon Zakrajsek**, “Stress-Testing U.S. Bank Holding Companies: A Dynamic Panel Quantile Regression Approach?,” *Preliminary Paper*, 2012, 33 (3), 389–404.
- Gertler, Mark and Nobuhiro Kiyotaki**, “Financial Intermediation and Credit Policy in Business Cycle Analysis,” in Benjamin M. Friedman and Michael Woodford, eds., *Benjamin M. Friedman and Michael Woodford, eds.*, Vol. 3 of Handbook of Monetary Economics, Elsevier, 2010, pp. 547 – 599.
- **and Peter Karadi**, “A Model of Unconventional Monetary Policy,” *Journal of Monetary Economics*, 2011, 58 (1), 17–34.
- , **Nobuhiro Kiyotaki, and Albert Queralto**, “Financial Crises, Bank Risk Exposure and Government Financial Policy,” Technical Report 2012.
- He, Zhiguo and Arvind Krishnamurthy**, “A Macroeconomic Framework for Quantifying Systemic Risk,” *Working Paper*, 2012.

- Kim, Sunghyun Henry, Robert Kollmann, and Jinill Kim**, “Solving the Incomplete Market Model with Aggregate Uncertainty Using a Perturbation Method,” *Journal of Economic Dynamics and Control*, 2010, *34* (1), 50–58.
- Lown, Cara and Donald P. Morgan**, “The Credit Cycle and the Business Cycle: New Findings Using the Loan Officer Opinion Survey,” *Journal of Money, Credit and Banking*, 2006, *38* (6), 1575–1597.
- Merton, Robert C**, “An Intertemporal Capital Asset Pricing Model,” *Econometrica*, 1973, *41* (5), 867–87.
- Myers, Stewart and Nicholas Majluf**, “Corporate Financing and Investment Decisions When Firms Have Information that Investors Do Not Have,” *Journal of Financial Economics*, 1984, *13* (2), 187–221.
- Preston, Bruce and Mauro Roca**, “Incomplete Markets, Heterogeneity and Macroeconomic Dynamics,” NBER Working Papers 13260, National Bureau of Economic Research, Inc 2007.

## A Appendix A: Variable Names and Construction

Table A.1: Variable Names and Construction

Variable	FR Y-9C Data Item	Explanation
Asset	BHCK2170	Total assets
Loan	BHCK2122 + BHCK2123	Total loans and leases
Liability	BHCK2948	Total liabilities and minority interest
Deposit	BHCK3517 + BHCK3404	Quarterly averages of interest-bearing deposits + Quarterly average of interest-bearing deposits in foreign offices, edge and agreement subsidiaries, and IBFs
Retained Earning	BHCK3247	Retained earnings
Equity	BHCK3210	Total equity capital
Stocks	BHCK3230 + BHCK3240	Common stock (par value) + Surplus (exclude all surplus related to preferred stock)
Net Interest Income	BHCK4074	Net interest income (Interest income - Interest expense)
Net Income	BHCK4340	Net Income
Average Asset	BHCK3368	Quarterly average of total assets
Average Equity	BHCK3519	Quarterly average of equity capital
Return on Average Asset	BHCK4340 / BHCK3368	
Return on Average Equity	BHCK4340 / BHCK3519	
Net Interest Margin	BHCK4074 / BHCK2170	
Loan Loss Provision	BHCK4230	Provision for loan and lease losses
Net Charge Off	BHCK4635 - BHCK4605	Charge-offs on allowance for loan and lease losses - Recoveries on allowance for loan and lease losses
Tier 1	BHCK8274	Tier 1 capital allowable under the risk-based capital guidelines
Tier 2	BHCK8275	Tier 2 capital allowable under the risk-based capital guidelines
RWA	BHCKA223	Risk-weighted assets (net of allowances and other deductions)
Regulatory Avg. Total Asset	BHCKA224	Average total assets (net of deductions)
Tier 1 / RWA	BHCK8274 / BHCKA223	
Tier 2 / RWA	BHCK8275 / BHCKA223	
Leverage Ratio	BHCK8274 / BHCKA224	

## B Appendix B: Additional Tables



Table B.1: Regulatory Capital and Size

	[0,25]	[25,50]	[50,75]	[75,100]	Total
Sig-Undercap	143	73	86	163	465
Undercap	65	48	65	19	197
Adeqcap	476	566	521	215	1778
Wellcap_0to200	2,059	2,677	3,295	3,376	11,407
Wellcap_200to400	2,506	3,044	3,083	3,360	11,993
Wellcap_400to600	1,989	1,970	1,766	1,904	7,629
Wellcap_600to800	1,198	1,102	830	903	4,033
Wellcap_over800	2,638	1,625	1,465	819	6,547
Total	11,074	11,105	11,111	10,759	44,049

Time period: 1998Q1-2012Q1, for banks that exist for at least 50 quarters.

Table B.2: Regulatory Capital and Mean Capital Ratios

	$\frac{Tier1}{RWA}$	$\frac{Tier2}{RWA}$	$\frac{Tier1+2}{RWA}$	$\frac{Tier1}{Asset}$	$\frac{Equity}{RWA}$	$\frac{Equity}{Asset}$	$\frac{Equity}{Loan}$
Sig-Undercap	1.18	1.07	2.25	1.25	3.84	2.51	5.22
Undercap	6.05	1.52	7.57	4.63	6.49	4.78	6.94
Adeqcap	7.82	1.44	9.26	6.13	8.00	6.11	8.50
Wellcap_0to200	9.57	1.56	11.13	7.62	9.91	7.64	10.81
Wellcap_200to400	11.42	1.52	12.94	8.55	11.66	8.52	12.78
Wellcap_400to600	13.41	1.49	14.90	9.46	13.71	9.44	15.11
Wellcap_600to800	15.40	1.50	16.90	10.22	15.89	10.34	17.79
Wellcap_over800	18.39	1.41	23.11	11.04	19.00	10.26	19.34
Total	13.10	1.50	14.40	9.06	13.50	9.07	15.15
Start Year	1996q1	1998q1	1998q1	1996q1	1996q1	1993q1	1993q1

Time period: 1993Q1-2012Q1, for banks that exist for at least 50 quarters.

Table B.3: Cyclicity and Size Class [0,25]

	1993Q1-2007Q4			1993Q1-2012Q1		
	$Y_{t-1}$	$Y_t$	$Y_{t+1}$	$Y_{t-1}$	$Y_t$	$Y_{t+1}$
Asset	<b>0.263</b> (0.044)	<b>0.291</b> (0.024)	<b>0.227</b> (0.081)	-0.158 (0.173)	-0.185 (0.107)	-0.184 (0.111)
Loan	<b>0.351</b> (0.006)	<b>0.344</b> (0.007)	<b>0.295</b> (0.022)	-0.029 (0.807)	-0.122 (0.292)	-0.18 (0.120)
Liability	<b>0.346</b> (0.007)	<b>0.380</b> (0.003)	<b>0.308</b> (0.017)	-0.119 (0.306)	-0.142 (0.217)	-0.146 (0.208)
Deposit	-0.085 (0.520)	-0.031 (0.814)	0.041 (0.756)	<b>-0.295</b> (0.010)	<b>-0.212</b> (0.064)	-0.097 (0.403)
Ret. Earn.	<b>0.267</b> (0.041)	<b>0.226</b> (0.083)	<b>0.222</b> (0.088)	0.164 (0.156)	0.048 (0.681)	-0.041 (0.723)
Equity	-0.122 (0.357)	-0.136 (0.302)	-0.118 (0.369)	-0.071 (0.543)	-0.114 (0.323)	-0.092 (0.428)
Stocks	<b>0.505</b> (0.000)	<b>0.521</b> (0.000)	<b>0.474</b> (0.000)	<b>0.510</b> (0.000)	<b>0.521</b> (0.000)	<b>0.492</b> (0.000)
LLP	<b>-0.353</b> (0.006)	<b>-0.333</b> (0.009)	<b>-0.507</b> (0.000)	<b>-0.481</b> (0.000)	<b>-0.529</b> (0.000)	<b>-0.639</b> (0.000)
NCO	<b>-0.303</b> (0.020)	<b>-0.238</b> (0.067)	<b>-0.401</b> (0.001)	<b>-0.446</b> (0.000)	<b>-0.440</b> (0.000)	<b>-0.537</b> (0.000)
E/A	<b>-0.286</b> (0.028)	<b>-0.272</b> (0.035)	-0.212 (0.104)	0.07 (0.546)	0.043 (0.713)	0.066 (0.573)

Time period: 1993Q1-2012Q1, for banks that exist at least 50 quarters.

Table B.4: Cyclicalty and Size Class [25,50]

	1993Q1-2007Q4			1993Q1-2012Q1		
	$Y_{t-1}$	$Y_t$	$Y_{t+1}$	$Y_{t-1}$	$Y_t$	$Y_{t+1}$
Asset	<b>0.336</b> (0.009)	<b>0.332</b> (0.010)	<b>0.271</b> (0.036)	-0.104 (0.372)	-0.078 (0.497)	-0.043 (0.711)
Loan	<b>0.627</b> (0.000)	<b>0.596</b> (0.000)	<b>0.49</b> (0.000)	<b>0.191</b> (0.098)	0.082 (0.477)	-0.018 (0.877)
Liability	<b>0.427</b> (0.001)	<b>0.419</b> (0.001)	<b>0.337</b> (0.008)	-0.04 (0.731)	-0.028 (0.812)	-0.021 (0.860)
Deposit	-0.041 (0.757)	-0.008 (0.950)	0.038 (0.772)	<b>-0.413</b> (0.000)	<b>-0.292</b> (0.010)	<b>-0.110</b> (0.342)
Ret. Earn.	<b>0.331</b> (0.011)	<b>0.326</b> (0.011)	<b>0.441</b> (0.000)	<b>0.438</b> (0.000)	<b>0.487</b> (0.000)	<b>0.588</b> (0.000)
Equity	-0.078 (0.557)	-0.058 (0.661)	0.067 (0.610)	-0.162 (0.161)	-0.05 (0.669)	0.165 (0.153)
Stocks	<b>0.454</b> (0.000)	<b>0.528</b> (0.000)	<b>0.521</b> (0.000)	0.186 (0.108)	<b>0.269</b> (0.018)	<b>0.287</b> (0.012)
LLP	<b>-0.358</b> (0.005)	<b>-0.343</b> (0.007)	<b>-0.458</b> (0.000)	<b>-0.475</b> (0.000)	<b>-0.551</b> (0.000)	<b>-0.661</b> (0.000)
NCO	<b>-0.301</b> (0.021)	<b>-0.236</b> (0.070)	<b>-0.331</b> (0.010)	<b>-0.438</b> (0.000)	<b>-0.434</b> (0.000)	<b>-0.499</b> (0.000)
E/A	<b>-0.375</b> (0.003)	<b>-0.329</b> (0.010)	<b>-0.198</b> (0.130)	-0.059 (0.612)	0.018 (0.875)	0.166 (0.152)

Time period: 1993Q1-2012Q1, for banks that exist at least 50 quarters.

Table B.5: Cyclicalty and Size Class [50,75]

	1993Q1-2007Q4			1993Q1-2012Q1		
	$Y_{t-1}$	$Y_t$	$Y_{t+1}$	$Y_{t-1}$	$Y_t$	$Y_{t+1}$
Asset	<b>0.543</b> (0.000)	<b>0.581</b> (0.000)	<b>0.540</b> (0.000)	0.119 (0.304)	0.112 (0.333)	0.119 (0.307)
Loan	<b>0.745</b> (0.000)	<b>0.758</b> (0.000)	<b>0.638</b> (0.000)	<b>0.215</b> (0.062)	0.106 (0.360)	-0.013 (0.911)
Liability	<b>0.625</b> (0.000)	<b>0.649</b> (0.000)	<b>0.595</b> (0.000)	0.161 (0.165)	0.148 (0.199)	0.147 (0.205)
Deposit	0.003 (0.984)	0.166 (0.204)	<b>0.284</b> (0.028)	<b>-0.347</b> (0.002)	<b>-0.213</b> (0.063)	-0.021 (0.857)
Ret. Earn.	0.185 (0.161)	<b>0.376</b> (0.003)	<b>0.461</b> (0.000)	<b>0.519</b> (0.000)	<b>0.508</b> (0.000)	<b>0.409</b> (0.000)
Equity	<b>-0.247</b> (0.059)	-0.135 (0.303)	-0.053 (0.689)	0.009 (0.939)	0.078 (0.503)	0.135 (0.247)
Stocks	<b>0.301</b> (0.021)	0.185 (0.157)	0.063 (0.630)	0.135 (0.246)	0.128 (0.268)	0.133 (0.254)
LLP	<b>-0.331</b> (0.010)	<b>-0.373</b> (0.003)	<b>-0.503</b> (0.000)	<b>-0.442</b> (0.000)	<b>-0.541</b> (0.000)	<b>-0.660</b> (0.000)
NCO	<b>-0.318</b> (0.014)	<b>-0.336</b> (0.009)	<b>-0.443</b> (0.000)	<b>-0.436</b> (0.000)	<b>-0.492</b> (0.000)	<b>-0.578</b> (0.000)
E/A	<b>-0.556</b> (0.000)	<b>-0.507</b> (0.000)	<b>-0.437</b> (0.000)	-0.121 (0.297)	-0.044 (0.706)	0.005 (0.966)

Time period: 1993Q1-2012Q1, for banks that exist at least 50 quarters.

Table B.6: Cyclicity and Size Class [75,100]

	1993Q1-2007Q4			1993Q1-2012Q1		
	$Y_{t-1}$	$Y_t$	$Y_{t+1}$	$Y_{t-1}$	$Y_t$	$Y_{t+1}$
Asset	<b>0.303</b> (0.020)	<b>0.305</b> (0.018)	<b>0.264</b> (0.041)	<b>0.239</b> (0.038)	<b>0.223</b> (0.051)	0.174 (0.133)
Loan	<b>0.358</b> (0.005)	<b>0.349</b> (0.006)	<b>0.302</b> (0.019)	<b>0.308</b> (0.007)	<b>0.249</b> (0.029)	0.158 (0.174)
Liability	<b>0.338</b> (0.009)	<b>0.345</b> (0.007)	<b>0.303</b> (0.019)	<b>0.281</b> (0.014)	<b>0.264</b> (0.020)	<b>0.206</b> (0.075)
Deposit	<b>0.225</b> (0.087)	<b>0.257</b> (0.048)	<b>0.273</b> (0.035)	0.062 (0.594)	0.139 (0.229)	<b>0.203</b> (0.079)
Ret. Earn.	<b>0.484</b> (0.000)	<b>0.505</b> (0.000)	<b>0.481</b> (0.000)	<b>0.553</b> (0.000)	<b>0.639</b> (0.000)	<b>0.656</b> (0.000)
Equity	0.083 (0.533)	0.057 (0.663)	0.036 (0.787)	-0.123 (0.288)	-0.099 (0.391)	-0.028 (0.808)
Stocks	<b>0.227</b> (0.084)	<b>0.224</b> (0.085)	<b>0.217</b> (0.095)	-0.052 (0.654)	0.079 (0.495)	<b>0.191</b> (0.099)
LLP	<b>-0.376</b> (0.003)	<b>-0.411</b> (0.001)	<b>-0.500</b> (0.000)	<b>-0.385</b> (0.001)	<b>-0.508</b> (0.000)	<b>-0.623</b> (0.000)
NCO	<b>-0.475</b> (0.000)	<b>-0.495</b> (0.000)	<b>-0.572</b> (0.000)	<b>-0.562</b> (0.000)	<b>-0.617</b> (0.000)	<b>-0.670</b> (0.000)
E/A	0.004 (0.976)	0.045 (0.733)	0.145 (0.270)	-0.088 (0.449)	-0.026 (0.825)	0.045 (0.698)

Time period: 1993Q1-2012Q1, for banks that exist at least 50 quarters.

Table B.7: Cyclicity in the Aggregate Data using CRSP

	1993Q1-2007Q4			1993Q1-2012Q1		
	$Y_{t-1}$	$Y_t$	$Y_{t+1}$	$Y_{t-1}$	$Y_t$	$Y_{t+1}$
Asset	<b>0.417</b> (0.001)	<b>0.475</b> (0.000)	<b>0.442</b> (0.000)	<b>0.326</b> (0.004)	<b>0.323</b> (0.004)	<b>0.270</b> (0.019)
Loan	<b>0.528</b> (0.000)	<b>0.575</b> (0.000)	<b>0.539</b> (0.000)	<b>0.461</b> (0.000)	<b>0.415</b> (0.000)	<b>0.313</b> (0.006)
Liability	<b>0.447</b> (0.000)	<b>0.510</b> (0.000)	<b>0.475</b> (0.000)	<b>0.365</b> (0.001)	<b>0.360</b> (0.001)	<b>0.297</b> (0.010)
Deposit	<b>0.422</b> (0.001)	<b>0.494</b> (0.000)	<b>0.508</b> (0.000)	<b>0.257</b> (0.026)	<b>0.348</b> (0.002)	<b>0.401</b> 0.000
Ret. Earn.	<b>0.547</b> (0.000)	<b>0.599</b> (0.000)	<b>0.571</b> (0.000)	<b>0.594</b> (0.000)	<b>0.699</b> (0.000)	<b>0.701</b> (0.000)
Equity	<b>0.262</b> (0.045)	<b>0.283</b> (0.028)	<b>0.274</b> (0.034)	0.014 (0.907)	0.048 (0.681)	0.12 (0.304)
Stocks	<b>0.419</b> (0.001)	<b>0.457</b> (0.000)	<b>0.473</b> (0.000)	0.151 (0.197)	<b>0.287</b> (0.012)	<b>0.393</b> (0.000)
$X \times q$	<b>0.444</b> (0.000)	<b>0.521</b> (0.000)	<b>0.586</b> (0.000)	<b>0.278</b> (0.016)	<b>0.477</b> (0.000)	<b>0.588</b> (0.000)
q	0.082 (0.535)	0.182 (0.163)	<b>0.279</b> (0.031)	<b>0.244</b> (0.035)	<b>0.271</b> (0.018)	<b>0.311</b> (0.007)
Equity Premium	<b>-0.469</b> (0.000)	<b>-0.452</b> (0.000)	<b>-0.484</b> (0.000)	<b>-0.238</b> (0.039)	-0.154 (0.184)	<b>-0.208</b> (0.073)
Return on Stocks	<b>-0.440</b> (0.000)	<b>-0.427</b> (0.001)	<b>-0.463</b> (0.000)	<b>-0.212</b> (0.068)	-0.129 (0.267)	-0.183 (0.116)
ROAE	<b>-0.271</b> (0.038)	<b>-0.302</b> (0.019)	<b>-0.246</b> (0.058)	<b>0.195</b> (0.094)	<b>0.225</b> (0.050)	<b>0.285</b> (0.013)
LLP	<b>-0.315</b> (0.015)	<b>-0.349</b> (0.006)	<b>-0.430</b> (0.001)	<b>-0.320</b> (0.005)	<b>-0.461</b> (0.000)	<b>-0.578</b> (0.000)
NCO	<b>-0.421</b> (0.001)	<b>-0.433</b> (0.001)	<b>-0.515</b> (0.000)	<b>-0.506</b> (0.000)	<b>-0.575</b> (0.000)	<b>-0.634</b> (0.000)
E/A	-0.188 (0.153)	-0.153 (0.244)	-0.046 (0.729)	-0.159 (0.174)	-0.067 (0.566)	0.028 (0.811)

Time period: 1993Q1-2012Q1, for banks that exist at least 50 quarters.