# Lessons from the Financial Flows of the Great Recession*

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**Abstract**

We investigate the financial flows recorded in the United States during 2007-2009. First, we study the empirical consistency of the fire-sale hypothesis, the idea that bank lending was crowded out by the absorption of shadow-bank assets. This hypothesis is inconsistent. Data suggests that banks mostly intermediated the purchase of shadow-bank assets by the Fed, but did not use their lending capacity. Second, we study the consistency of the net-worth shock hypothesis. Again, the data reveals an inconsistency: bank book-equity losses were offset by equity issuances. Market-value losses, which in turn, provide a more precise diagonosis of a bank's health, were catastrophic. Although market leverage increased dramatically for many banks, these banks delevered very slowly. Whereas before the crisis, a bank would have tried to liquidate assets to delever, post-crisis the same bank relied on costly equity issuances. We present a model with strategic leverage accounting that can reconciles these inconsistencies.

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# 1 Introduction

The sub-prime mortgage losses that began in 2007 in the US led to a chain of events that culminated in a global economic crisis. Its consequences affected the lives of millions and it is shaping history today. The hope that a crisis of this scale can be prevented has instigated a wave of criticisms to standing macroeconomic theories. The basis of these criticisms is that standing theories lack an explicit role for financial intermediaries and thus cannot be used to analyze financial regulation.[1] Macroeconomics responded with a revival of macroeconomic models with financial intermediation over the last decade. These new theories are having a strong influence on policy makers. However, this new generation of models has preceded an examination of the financial flows recorded during the crisis. An examination of those financial flows is a priority for macroeconomics because it exposes data restrictions that models should respect and can help improve those models going forward. This paper turns in that overdue homework.

Our investigation is inspired by this recent wave of financial-macroeconomics theories. Through the paper, we report information that a modeler would want to know if she was designated to write and calibrate a model of financial intermediation, risk and optimal regulation in the United States. As a modeler, she would want to have two pieces of information. First, she would observe that any theory of financial crisis must feature a shock that interrupts financial intermediation. Hence, she would first want to know the source and magnitude of shocks that affected banks during the crisis. Second, she would also observe that any theory of financial intermediation must involve some friction in the bank's portfolio, something that prevents the perfect adjustment of bank liabilities to maintain lending constant —formally, this requires a violation to the Modigliani-Miller Theorem. Thus, she would want evidence on the types of constraints that affect banks. We investigate the flows of assets and liabilities of the Great Recession to give that modeler some answers.

Let's start with the shocks. It is clear that many simultaneous events unfolded during the crisis. For example, real-estate and stock prices declined, mortgages loans contracted, firms faced weaker sales and laid off workers, banks adopted tighter credit standards, asset-market shut downs, etc. Virtually all segments of the economy were affected. We narrow the analysis and focus to two hypothesis about shocks that impaired the supply of bank credit. We interpret the data through the most accepted narrative of the crisis —that of Gorton and Metrick (2012a), Blinder (2013), or Bernanke (2015).[2] This narrative takes the decline in home-prices as the catalyst of two critical events that affected the supply of bank credit. The first event was the fire-sale of assets held by the shadow-banking industry

[1] Read the early debate at The Economist, `http://www.economist.com/node/14165405` or the recent book by Gorton (2015).

[2] A formal model that fits in this narrative is Gertler et al. (2015) and Moreira and Savov (2014).

and its subsequent absorption by traditional banks.[3] If banks have a limited capacity to buy assets, this fire-sale hypothesis states that this outflow crowded out the flow of new credit. The second event were the direct losses suffered by banks. This net-worth loss hypothesis states that banks maintain a target for leverage. This means that their equity losses translated into a contraction in credit supply. Our paper reports two numbers. The first is an estimate of the flows of assets from shadow banks to traditional banks to be used as a test of the fire-sale hypothesis. The second is the estimate of equity losses, to be used as a test of the equity-loss hypothesis.

Regarding the fire-sale hypothesis, we document that between the first quarter of 2007 and the first quarter of 2015, the implosion of shadow banks caused an outflow of about US $3.8 trillion from the shadow sector. We provide evidence that shows that traditional banks indeed absorbed outflow. In particular, banks issued roughly this amount in deposits. In perspective, the sum of all new loans to firms going into the quarter of the Lehman Brothers bankruptcy was US $20 billion. Hence, in relation to the flow of credit to firms, this inflow of assets to banks during this period was enormous. However, the majority of those assets did not ultimately end in the balance sheet of traditional banks. Instead, they were ultimately absorbed by the Federal Reserve. The final picture is one where the Federal Reserve bought the bulk of assets liquidated by shadow banks, whereas traditional banks were intermediaries in that massive operation. That final picture reveals a banking system with a vast amount of reserves and many more deposits than pre-crisis.

When we turn to the equity-loss story, we found that although banks suffered losses —around 7.0% of their pre-crisis level, their book equity actually increased overall. This was thanks to both issuances of preferred equity —promoted by Government programs— but also through substantial common equity issuances. Essentially, book-value equity was left untouched during the crisis. On the flip-side, banks lost roughly US $710 billion in market capitalization —or 50% of the pre-crisis level. Furthermore, we also observe vast cross-sectional discrepancies between the changes in market-values and book-values —some banks showing up to 90% discrepancies. Using this cross-sectional data, we show that book equity is a poor indicator of the actual losses faced by banks: in the cross-section market-to-book ratios were predictors of bank performance going forward. This poses some challenges for the macro modeling of banks. If banks are constrained by book equity, this really did not seem to matter during the crisis. If banks are constrained by market-based measures, how can we reconcile the tremendous increase, heterogeneity and slow adjustment in market-based leverage? We argue, based on the accounting literature, that banks have a lot of flexibility in acknowledging book losses. Although book values impose regulatory constraints on banks, books couldn't have constrained bank lending substantially

[3]Through a model, this event could be interpreted as shock that caused the liquidation — fire sale — of assets held in the shadow-banking sector.

during the crisis in the usual way macroeconomic model these constraints. It is more likely that discretionary constraints such as stress-tests or market-value constraints were the true constraints.

We compute the flows of shadow-bank assets to banks and their direct equity losses because these two events were potentially responsible for the freeze in bank credit. But for either event to have mattered, the financial sector must have faced limits to maintaining a stable supply of credit. We use cross-sectional variation in market returns to estimate banks' partial equilibrium impulse-response to an innovation to market returns. We find that banks contract their balance sheets in response to negative excess-return shock, although the response is gradual. This evidence is consistent banks that have a target for market leverage, but face adjustment costs to reach that target quickly. The data also reveals a change between pre and post crisis adjustments. Pre-crisis, a bank that experienced negative excess-returns relied more on assets sales to delever. In the post-crisis period, banks with negative excess-returns banks relied more heavily in alternative measures to increase their equity: either through external equity issuances and or retained earnings, with many banks paying zero dividends. These results also favor a model where have a leverage target, but face frictions to adjust their portfolios.

The final section provides a bank-portfolio model that allows us to reconcile all of these facts. The model has two periods. There's a secondary price for loans, which in the initial period is always high, but in the final period can be high or low. A low secondary price is associated with the unwinding of the shadow banking system. Default risk and risk-averse behavior makes banks maintain desired leverage target. Banks are heterogeneous in their initial leverage, so they have different demands for loans; some want to lever up, some want to delver. The novelty of the model is a portfolio special constraint. Banks have an book-based leverage constraint, but book values are updated to market values when banks sell loans. When they buy loans, market prices are updated in proportion to the new flow.

The model can reconcile the facts in this paper in the following way. In the low loan-price regime, a large portion of banks would ideally want to delever by selling assets. However, if they delever at low prices, their book-based constraints are updated to the new low prices, making their regulatory constraints much tighter than before —it may even put them out of business. To avoid updating their books, the optimal policy for a bank is innaction. That bank will not extend new loans, but it won't loans either. It is an idea akin to evergreening. This pattern reconciles the facts reported in the paper because of market values capture information on wealth, they market-values will adjust, but book values remain fixed. The bank may partially offset the situation by retaining earnings and issuing equity, something they would normally avoid. The message is that under this alternative constraint, book-leverage may be binding although it doesn't appear to be in the data. On the flip side, market based leverage may increase, but this doesn't mean that market values don't matter.

**Relation to Other Studies**

The goal of the next section of the paper is to quantify the size of the asset sales by shadow-banking institutions that were absorbed by traditional banks. Our goal is to give a sense of how big were those sales in order to understand if by buying those assets, banks faced a trade-off that inclined them to provide less credit. To do so, we classify segments of the financial sector into a traditional banking sector and a shadow banking sector. This classification builds directly on the descriptions of the US financial architecture in Pozsar et al. (2012); Adrian and Shin (2010); Gorton (2010). This financial architecture emerged from the process of securitization where banks originated loans and sold them to shadow asset institutions in a process called securitization. This process involved the restructuring of assets and is described in detail in Pozsar et al. (2012). Gorton and Metrick (2010) describes how this system emerged as a result of regulatory arbitrage.

When we decompose shadow bank assets, we will separate these institutions into shadow-asset banks that would buy assets from traditional banks and fund their purchases with short term paper by a second group, shadow liability institutions. Shadow banking institutions are basically, money-market mutual funds that specialized in funding shadow-asset instutitions. In addition to Money Market Mutual Funds, we also know that shadow-assets were funded by cash pools (Pozsar, 2011).

Narratives about the crisis all have in common a story of a short-term debt roll-over crisis for shadow asset institutions. These appeared in various sources of funding. For example, Gorton and Metrick (2012b) describe this crisis in the context of REPO financing. An important paper of us is Acharya et al. (2013). That paper was able to pair issuers of asset-backed commercial paper to their sponsoring banks. That paper describe the decline in shadow-bank assets and provides evidence which shows that the direct lenders (MMMF's and cash-pools) to shadow-asset institutions suffered very few losses directly. Yet, the paper shows that sponsoring banks, did absorb the assets held by shadow-asset institutions prior to 2008.Q4, the quarter of Lehman. In turn, McCabe (2010) describes how how MMMF's themselves suffered runs. He distinguishes two faces: an initial face where sponsors supported their funds (mostly 2007) and second phase, where runs are only stopped after FED backstop. These studies shape the framework that we use in the next section, because we organize the data by merging different segments of the financial sector following that narrative.

The exercise of this section is similar to the descriptive work of He et al. (2010) and Gertler et al. (2015). The goal of He et al. (2010) is also to describe sectoral flows to gauge the scale of asset flows during the crisis. The next section of our paper shares the same spirit and reaches similar conclusions. The main distinction is that He et al. (2010) describe flows of different sectors separately. We in constrast try to match the decline of certain asset

classes in one sector with the increases of that asset class in another sector, giving a general perspective on the flow. We can account for most of the decoupling of the shadow-banking system. Of course, our paper has the advantage coming later and building on knowledge that appeared after that paper was written. Another related study is Gertler et al. (2015) which also measures the inflow of shadow-bank assets to the traditional sector. We reach a different conclusion because we conclude that most of the unwinding of the shadow industry was absorbed by the Federal Reserve.

The second main section of the paper investigates the extent of the direct equity losses faced by commercial banks during the period. We describe how book-based measures of equity losses were significant, but were entirely ofset by issuances of equity —either through preferred equity programs sponsored by the government or via the more usual common equity issuances. We also show how market-based equity measures differ substantially from market-based equity. This descrepancy is important for macroeconomic models that incorporate an intermediary sector. Authors such as Adrian and Shin (2010) argue that book leverage is a good measure of the constraints faced by banks and banks certainly face regulatory constraints. However, work by Laux and Leuz (2010), argues that books did not accurately represent bank losses. Section 4 finds that during the aftermath of the crisis, bank books lagged behind in much of the information content of market values.

Evidence of bank-credit supply shocks has been found by Ivashina and Scharfstein (2010), Campello et al. (2010) and Chodorow-Reich (2014). Those papers focus on specific sources of exogenous microeconomic variation. Ours complements these paper because we take system-wide view.

# 2 Financial Flows Between Sectors

This section reports an estimate of the outflow of assets from shadow banks that were absorbed by traditional banks. According to several narratives of the crisis that we surveyed above, the asset-fire sale from shadow banks competed with traditional bank lending for a limited amount of bank funding. If we could track asset transactions precisely we would be able to test this story directly and this task would be a straightforward. It isn't, and we have to adopt an indirect approach.

The approach of this section is to use a very simple macro-economic accounting concept. By T account analysis, a reduction in the asset position of one institution together with an equal reduction in its liabilities means one of two things: either the institution sold that asset or the both the asset and liabilities matured. If an asset is sold and the asset has not matured yet, from a macro perspective, another financial institution must have bought that asset. Otherwise, we would have seen a reduction in assets together with a reduction in equity capital, from which we can conclude there was a write down in assets. The spirit

of this section is to build on that simple accounting principle. During the crisis, we observe a massive decline in the assets and liabilities in certain segments of the financial sector, so we we will search for a proportional inflow into other sectors.

Our main challenge is the aggregate nature of the data. First, we need an accounting framework to interpret the macroeconomic flows. We present an accounting framework in the next section. Second, macroecnomic data, specially during the crisis is subject to many redefinition issues as many institutions were reclassified into different segments during the period. Third, aggregate data available in the United States does present financial losses in every segment. Furthermore, neither do we observe the fraction of maturing assets. To partially circumvent these two additional challenges, complement our study with additional micro data from many individual financial institutions. This exercise allows us to place an upper bound to the flows of assets that could have been bought by the traditional sector or the Federal Reserve. In the following section, we describe our accounting framework and the main findings.

Before we proceed, we define what we mean by traditional and shadow banks. We divide different shadow banking institutions into shadow-asset banks (SAB) and shadow-liability banks (SLB), by consolidating their balance sheet into the appropriate category. SAB comprise the following set of intermediaries: security broker-dealers (SBD)[4], government-sponsored entities (GSE), mortgage pools, REITs, finance companies, and asset-backed security issuers (ABS). Shadow liability banks (SLB) are the sum of money market mutual funds as well as repos held as assets and securities borrowed by broker dealers (See Atkeson and ...). Traditional banks are depository institutions.

## 2.1 Data

Our data comes from four different sources. (1) Each quarter, the Board of Governors of the Federal Reserve System publishes the "Financial Accounts of the United States" (Flow of Funds) that provide aggregate data of the financial sector. (2) The Federal Financial Institutions Examination Council (FFIEC) publishes quarterly data on commercial banks. Bank holding company level data is available from the Federal Reserve Bank of Chicago. (3) We hand collect security broker-dealer data from filings to the Security and Exchange Commission (SEC). (4) We obtain money market mutual funds data come from the Investment Company Institute (ICI).

The Flow of Funds report financial information by sector and instruments. With regard to the financial sector the tables distinguish between depository institutions, security

[4]For this segment, we net repos and securities borrowed within miscellaneous assets. Repos as well as securities borrowed (basically also repos) are funding tools for other financial institutions. We therefore subtract repos and securities borrowed from the asset position of broker-dealers, combined by far their largest asset position, and add it to the asset position of shadow liability banks.

broker-dealers, ABS issuers, money market funds, mutual funds, finance companies, REITSs, insurance companies, holding and funding companies. The sector specific information is mostly derived from proprietary micro-level data.

For regulated banks, there exists two different types of publicly available micro-level data. Commercial banks submit quarterly reports that can be downloaded from the FFIEC. Commercial bank data[5] is used in the Flow of Funds tables on depository institutions. Bank holding companies with more than $500 million of assets must report their financial condition in the quarterly FR-9C form.[6]

We use Flow of Funds data for shadow asset and shadow liability banks and augment the data with money market mutual funds data from the ICI and hand-collected data security broker-dealers. The ICI, an industry association for investment funds, collects data on money market mutual funds financial assets among other. We use their data to break out prime money market funds from government money market funds. Registered broker-dealers have to file annual reports (10-K) as well as a report called "Financial and Operational Combined Uniform Single Report of Brokers and Dealers" (FOCUS) to the SEC. Large sections of the FOCUS report are confidential except for a statement of financial condition. The data collected from FOCUS reports[7] are used in the security broker-dealers table of the Flow of Funds.

Note that the difference between a shadow bank and a traditional bank can sometimes be elusive. Since the passage of the Gramm-Leach-Bliley Act in 1999, bank holding companies have been allowed to engage in many non-core banking activities, such as security broker-dealer activities. Thus, bank holding companies with traditional depository institution at their core may also engage in shadow bank activities. However, we focus on a view of banks as institutions that create credit by issuing deposits: we classify all bank holding companies as traditional banks if they could not be classified as a shadow bank before the crisis.[8]

## 2.2 An accounting framework

In this section we present an accounting framework that allows us to piece together different segments of the finance industry in a way that allows us to interpret the asset flows in light of many narratives of the crisis. The framework exploits double-entry bookkeeping within firm and between firms and institutional details. Knowledge of institutional details help us impose restrictions on the classes of assets and liabilities held by certain classes of

[5]Bank-level commercial banking data can be downloaded from the website of the FFIEC.

[6]Bank holding company data is available from the website of the Chicago Fed.

[7]The public available part of the FOCUS reports can be downloaded from the SEC website. An example of a Focus report for the case of J.P. Morgan Securities (formerly Bear Stearns) can be found here.

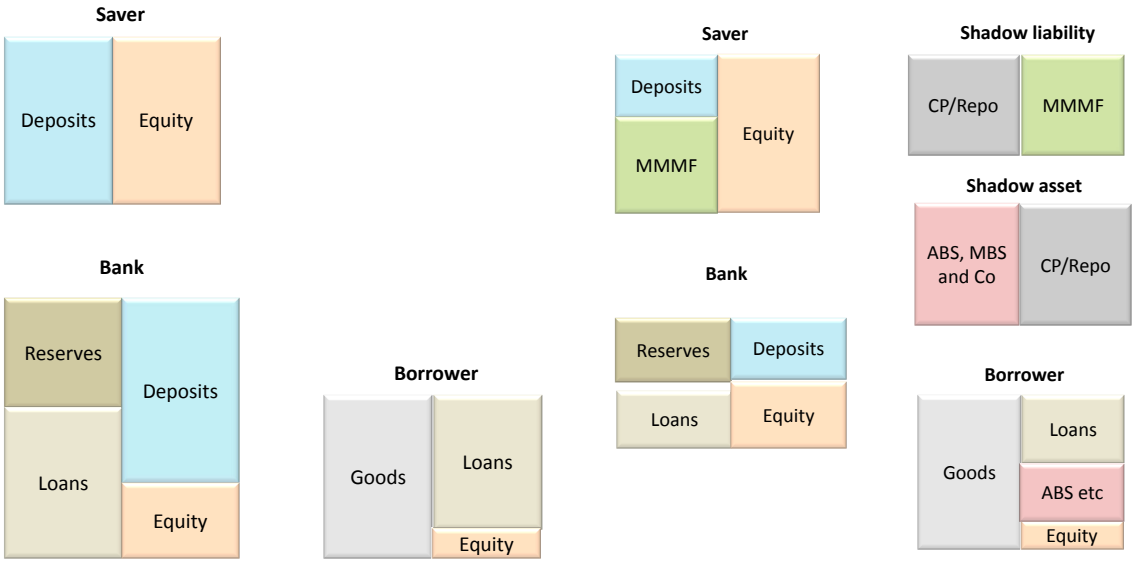
[8]For example, Goldman Sachs turned bank holding company, but is not classified as a traditional bank because it was an investment bank before the crisis. Its deposit base as a BHC is around 10% of assets, tiny compared to the average traditional banks.

institutions. An example illustrates the importance of having this accounting framework. One of the institutional details that we exploit is that only traditional banks are allowed to issue deposits whereas only money-market funds are allowed to issue money-market fund accounts, etc. We also know that money-market accounts are liquidated with a deposit transfer. Thus, if we observe a susbstantial reduction in money-market fund accounts —among active funds— we know that market funds must have sold assets to obtain deposits. If we observe an increase in issuances of deposits by traditional banks, we know that the economy adjusted by transferring assets to traditional banks. This is just an example, but next we present a systematic methodology.

We describe our methodology with the illustration of a simple accounting framework. Let's begin with the most simple exercise. A primitive system where all credit is held in banks features the following transactions registered in T-accounts like this: Banks issue deposits to borrowers that use deposits to execute payments. After deposits are transferred, banks owe deposits to savers, borrowers owe loans to banks. Figure 1a depicts the corresponding cross-system cliams.

Now, let's consider a system more akin to the United States in the last decades. In parallel to traditional banks, shadow asset and shadow liability banks also hold private credit as assets and issue money like liabilities. This is the situation depicted in Figure 1b. In the figure, a shadow liability institution offer deposit-like securities —a money-market fund shares in this example— to savers. Shadow asset banks extend credit to borrowers either directly —e.g. finance companies— or indirectly —e.g. asset-backed securities (ABS) or mortgage-backed securities.

The existence of shadow banks either extends the supply of deposit-like securities and credit in the financial sector, or leads to a reduction in size and leverage of traditional banks. Figure 1b illustrates the latter as the balance sheet of the non-financial sector is hte same as in Figure 1a. In a primitive system, the bank that originates mortgages, auto loans, etc, in keeps the claim. By contrast, in the modern system, loans are packaged into ABS, MBS, structured claims, and similar securities, and then sold to shadow-asset institutions with deposits —and this implies a reduction in both assets and liabilities of traditional banks. Shadow-asset banks obtain deposits by issuing short-term instruments —commercial paper and repo— that money-market mutual funds and other shadow liability institutions hold as assets. In turn, money-market mutual funds issue shares to savers who buy those shares with deposit accounts —which through the shadow system flow back and net out of traditional bank balance sheets. In net, the financial system's liabilities are the same, the private sectors balance sheets are the same, but deposits are now just a smaller fraction. In a nutshell, the overall leverage of the financial sector is actually the same, but the leverage of the regulated sector, traditional banks, is lower. This is called the originate-to-distribute model.




(a) Traditional Financial System (b) Modern Financial System

Figure 1: Illustrating the financial system

Let's take at face value the financial crisis narratives of Gorton (2010), Blinder (2013), or Bernanke (2015) and explain how the unwinding of the shadow banking system would look. Figure 2a illustrates the accounting flows after decline in the solvency of borrowers which affects their ability to service ABS payments. Figure 2b describes the accounts after a run on shadow liabilities that follows that situation.

Aside of the losses in the value of assets, Figure 2b shows how the financial sector is reorganized. If savers liquidate money-market mutual fund shares, they ask money-markets for a redemption in deposits. If the fund cannot obtain payments from shadow assets, we would see a loss on the money-market fund equity capital and also on the savers account. However, if the fund is successful in obtaining funds, shadow-assets must have sold their assets.[9] This means that in the aggregate, deposits should have risen, if we are fully accounting for the entire financial system because we know that savers don't hold shadow assets directly. This means that banks should have acquire shadow-bank assets. Banks can simply purchase shadow-assets issuing deposits simply by entering an entry in their T-accounts. In that case, a fraction of assets that originally were held by the shadow banking sector are reabsorbed by traditional banks. The end result is an increase in the balance sheet —and depending on equity an increase in leverage— of regulated banks and a reduction in the size of the shadow banking sector. The crisis narratives that we cite above argue that this purchase crowded out the flow of new loans. However, we've left one

[9]A third possibility is that the assets matured. However, this would lead to an equivalent observed declined in non-financial sector debt. Furthermore, non-financial sector debts like mortgages are typically long-term.

important piece out so far.

One final step of this unraveling of shadow banks is the role of Federal Reserve (Fed). During the financial crisis, the Fed, worried about the crowding-out of lending, supported the purchase of shadow assets by traditional banks. In practical terms, it committed to purchase a portion of these assets. The Fed bought impaired MBS/CMO's and supported banks to acquire failed institutions. For example, Bank of America acquired Merrill Lynch, Wells Fargo took on Wachovia, and so forth. The balance sheet of the Fed increased by the MBS/CMO on the asset side and through reserves on the liability side. The accounts that emerge are depicted in Figure 2c. The Fed buys MBSs by issuing reserves which are in term held by banks as reserves. In the next section, we look for a data pattern that fits this accounting description and can tell us how much of the shadow bank unwinding ended up at the Fed, how much remained at banks and give a lower bound for underwritings.

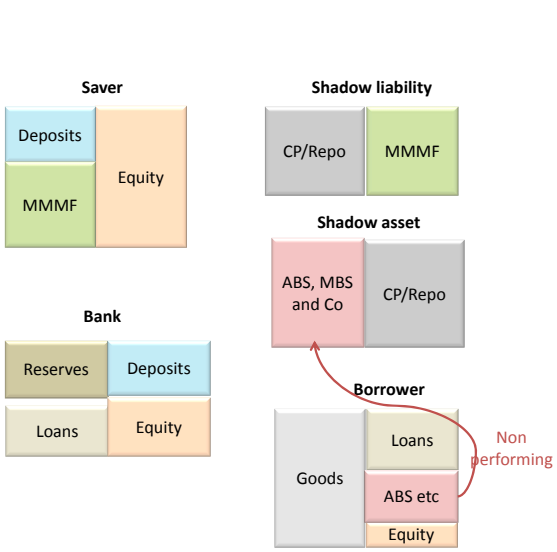
## 2.3 Aggregate Flows

We now present the data. We focus on the period between 2007 and 2015. We want to capture the entire rise and fall of the shadow-banking sector. Figure 3 depicts the time series of financial assets consolidated at the shadow asset, shadow liability, and traditional banking level since 2001 based on our definitions. Shadow banks grew larger than traditional banks until the financial crisis hit. Then, a massive outflow of assets occurred since September of 2008, the quarter after the demise of Lehman Brothers. Shadow-liabilities experienced only a moderate reduction. These positions are not entirely consistent with the description above because SAB were also funded by sources other than SLB that we considered such as foreign funds, hedge-funds, etc that we can't observe in the flow of funds. However, the data is consistent with the description of the accounts. Note that traditional banks show an eventual increase in their assets. Next, we provide a detail of the actual flows and how we overcome the challenges that the data imposes.

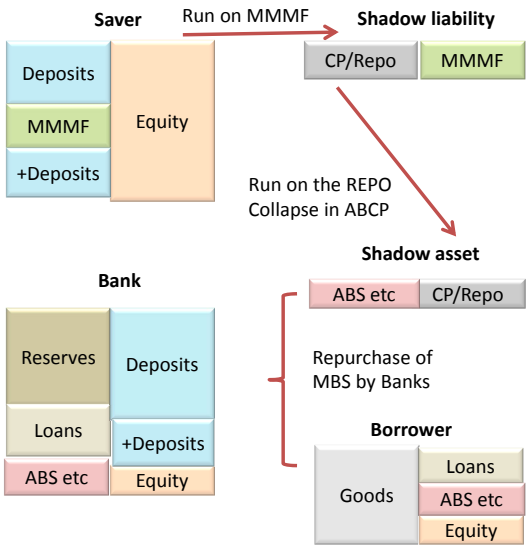
## 2.4 Calculating Flows and Losses

This section reports our calculation for the losses and asset flows between sectors during the crisis. We interpret the aggregate data from the Flow of Funds through the lense of our accounting framework. We complement the analysis with micro-data from annual reports and SEC filings where needed. Our method allows us to determine an upper bound on the amount of assets that flowed from shadow banks to traditional banks. The reason for why we find an upper bound and the actual flow is that we cannot fully determine whether the decline in SAB assets in Figure 3 corresponded to losses or asset sales.[10] We use micro-

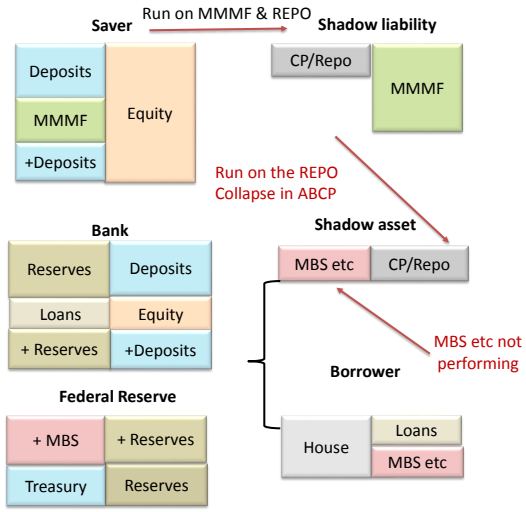
[10]The Flow of Funds accounts allow us to observe the outflow of shadow banking assets with relatively high precision. However, the Flow of Funds is less precise about the source of the decline: if it corresponds




(a) Shock




(b) Unraveling Phase 1




(c) Unraveling Phase 2

Figure 2: Unraveling of the shadow banking sector

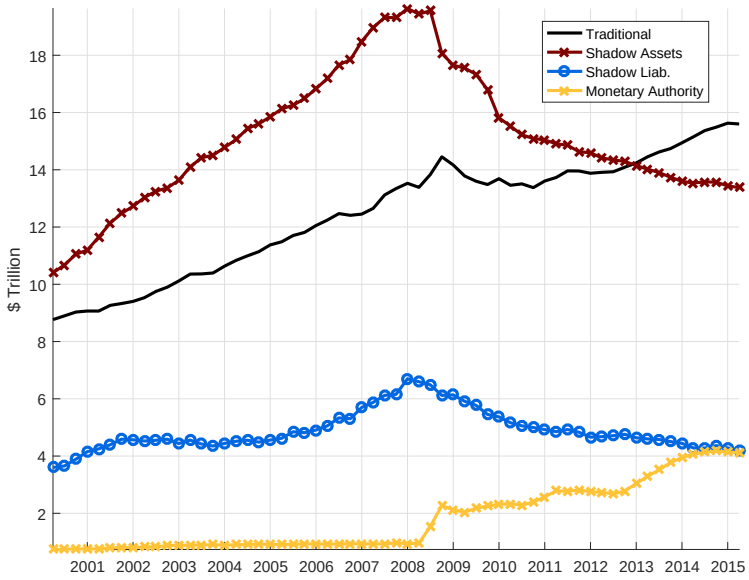



Figure 3: Assets in the Financial System

level data from security brokers-dealers to determine the amount of losses by systematically searching for words such as "write-offs" and "losses" for this reason. The micro-data doesn't give us all the scale of the losses, but yields a lower bound because it is only one segment of SAB —although its the largest portion. Unfortunately, we don't have any more detailed micro-level data on other segments of shadow banks other than on SBD's —notably, we do not have access to losses born by ABS issuers. Thus, we can only determine a lower bound on equity losses by SAB. Thus, the reduction in assets minus these losses correspond to an upper bound on the assets sold by SAB.

As argued in the previous section, after the unwinding of the shadow-banking positions, to rationalize the crowding-out of loans, we would expect traditional banks to be the buyers of shadow bank assets. Traditional banks are the natural buyers of these assets since they are capable of issuing deposits and hold that class of assets on their balance sheets. One important aspect is that banks sponsored losses born by ABS issuers, as documented by Gorton and Metrick (2010)Gorton and Metrick (2010), this losses would be accounted for by direct-security losses. This is something that we deal with in the next section and shouldn't be a concern now. Another important issue that is worth reiterating is that our consolidation of shadow-banking industry, does not include purchases by high-net worth individuals, foreign funds, etc, whose positions we can;t observe. Thus, the upper bound on the purchase of shadow bank assets equals the net outflow of shadow assets minus the losses we can account for.

Figure 4 presents the cumulative flows in 2009 trillion $ since the first quarter of 2007.

to a change in value, a write-down or a sale. If we could observe the market value of debt and equity exactly and continuously this would be fine, but we don't observe equity issuances or retained earnings.

Table 1 reports the numbers accumulated by the end of the sample period. Inflows are positive numbers while outflows are negative. Two findings are revealed. First, we observe

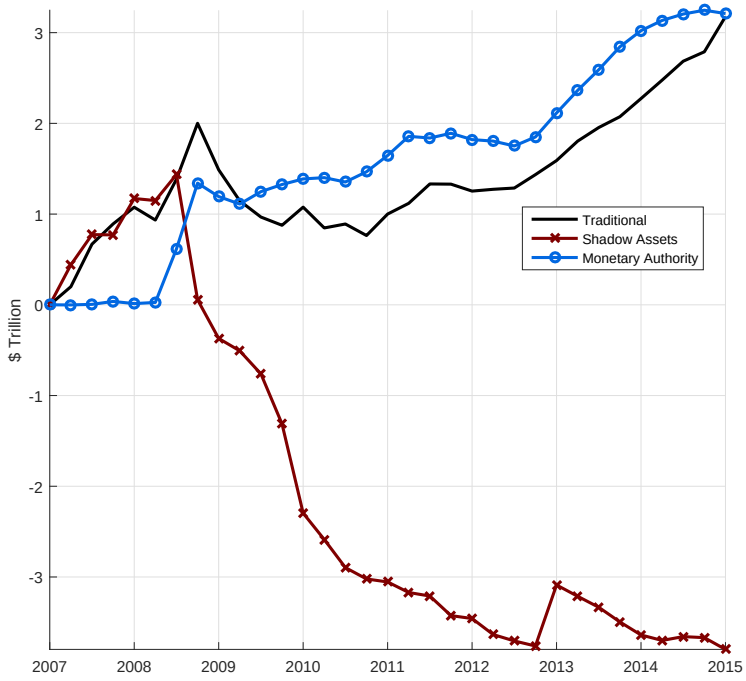



Figure 4: Cumulative Financial Flows

that, over-time, the inflow into traditional banks and the Fed is on the same scale of the outflow of the shadow banking system. The outflow is faster —because we cannot account for the losses—, at the beginning of the crisis, but starting from the quarter of Lehman, both figures track each other well. Although, we cannot fully account for these flows, we are confident that this pictures show that the bulk of the decline in shadow assets was absorbed by banks. This is a smoking gun because inflows of that magnitude are anomalous. Second, the financial assets of the Fed and traditional banks grew by the same amount. This suggests that it was the Fed, and not traditional banks, who absorbed shadow assets through its multiple programs. Furthermore, the stock of MBS held by banks doesn't increase in the period. Magnitudes match each other well.

Our calculations require substantial detailed work. Let us explain. In the raw data, from the first quarter of 2007 until the first quarter of 2015, we observe an outflow of the shadow asset sector in the amount of $\$5,059$ billion. However, the financial crisis caused several security broker-dealer firms to become bank-holding companies. For example, Goldman Sachs and Morgan Stanley became bank-holding companies in early 2009. This is a problem for our accounting exercise because the Flow of Funds tables present an outflow from shadow-asset institutions to traditional banks do to redefinitions. Futhermore, the change in financial assets due to the security brokers-dealer business of Goldman Sachs and Morgan Stanley remains within Goldman Sachs and Morgan Stanley new make-up as bank

Table 1: Flow Calculation

| $ Inflow Billion | | $ Outflow Billion | |
|---|---|---|---|
| TB | $3,177 | SBA | $5,049 |
| TB without MS & GS | $2,970 | SBA without MS & GS = | $3,855 |
| | | SLB (netted within SBA decline) | $1,416 |
| | | Losses | −$57 |
| Upper bound inflow | $2,970 | Upper bound outflow | $3,798 |

TB= traditional banking sector, SAB = shadow asset banks, SLB = shadow liability banks (prime money market mutual funds), MS = Morgan Stanley, GS = Goldman Sachs, CB = commercial bank business, MA = monetary authority (Fed), SB = shadow banking sector

holding companies is not the entire balance sheet of these institutions, but only a subset of their accounts. We deal with this by using SEC filings (FOCUS reports) on the ten largest security broker dealer to adjust our shadow asset sector time series. That is, we subtract from the aggregate shadow asset sector time series the time series of those firms that turned bank holding company. Doing that gives an asset outflow in the amount of $-\$3,855$ billion. At the same time, assets by shadow liability banks decreased by $\$1,416$ billion. Thus, only $\$1,416$ billion of the decline can be attributed to a decline in funding by prime money market mutual funds and security broker dealer repos. Hence, we are missing an important portion of the decline in funding to these institutions.

At the same time, we observe an increase in the traditional banking sector's asset in the amount of $\$3,177$ billion. This number needs to be corrected for the entry of large former shadow asset institutions such as Goldman Sachs and Morgan Stanley. Subtracting their commercial bank positions from traditional bank assets, we obtain a net inflow into the TB sector of about $\$2,970$ billion. To put the $\$2,970$B increase in traditional sector's financial assets into perspective, TARP funds to the largest institutions amounted to $\$157$B. This number is massive, but mostly captures that the Fed supported the purchase of shadow assets through the intermediation of banks.

From the evolution in financial assets we cannot necessarily back out losses. We use data from annual reports of security brokers-dealers to obtain the net-income of major investment banks in the U.S. over our sample. We also searched the annual reports for numbers on asset write-downs. At least $57 billion asset write-downs were reported by the four main investment banks during the 2008 period. This is a lower bound on asset write-downs on security brokers-dealers.

The unprecedented actions of the Federal Reserve to counteract the melt-down of the financial system are also reflected in its balance sheet. Over the time period we study,

financial assets owned by the Fed increased by $3,211B of which roughly one half amounts to an increase in mortgage-backed securities and the other half to an increase in treasuries.

Collecting all pieces, from 2007Q1-2015Q1 we document a net-outflow of $3,798B of shadow banking institutions. Meanwhile, the balance sheet of the Fed increased by $3,211B and that of the traditional banking sector by $2,970B.[11]

Next, we discuss the different phases of the Fed's program briefly to provide anecdotal evidence that supports our finding.

## 2.5 Fed Programs

In the previous section we claim that the unprecedented asset-purchases of the Federal Reserve was of the same order of magnitude as the outflows of the shadow financial sector. In this section, we briefly —a longer discussion is presented in the appendix section B— review the measures taken by the Federal Reserve Board to thwart the crisis and their timing.

The Fed crisis response can be be divided into two phases: During phase I, the Federal Reserve Board was engaged in more traditional monetary policy actions to support the financial system, meanwhile traditional banks started purchasing assets from the shadow banking sector, i.e. oftentimes assets from their off-balance sheet vehicles. During Phase II, the Federal Reserve Board carried out more unconventional policy actions, such as establishing facilities to buy shadow banking assets directly as well as through the traditional banking system. Almost all financial institutions enjoyed the benefits from government support.

The first phase started with the beginning of signs of troubles in the mortgages market, i.e. early 2007, and ended around the time Lehman collapsed. The first phase is characterized by central bank actions that are reminiscent of a lender of last resort, even though that capacity was extended to unconventional players such as primary dealers with the creation of the Primary Dealer Credit Facility. When with the collapse of Lehman the ripples of the mortgage crisis became utterly clear, the Fed began with QE 1 to actively support the mortgage market by buying up troubled mortgage backed securities.

Our evidence suggests that these transactions were carried out with the help of depository institutions. By creating reserves, the Fed has an unparalleled capacity to fund purchases. But reserves can only (with very few exceptions) be held by depositories institutions. Thus, any major involvement of the Fed has to go through traditional banks. The next section presents evidence that support that view.

[11] Our approach uses the Flow of Funds definition of sectors. The sector numbers also include residual numbers to match the flow of instruments in the Flow of Funds. We thank Andrea Prestipino for suggesting this robustness check.

## 2.6 Positions by Instrument

Figure 5 presents the cumulative flows in 2009 trillion $ since the first quarter of 2007 of shadow banking assets (mirrored), the purchases by the Federal reserve, and deposits plus currency less bank credit. We subtract bank credit flow in order to account for the fact that the balance sheet of banks typically grows with its loans. That is, we are interested in the growth in deposits over and above what a bank would do to fund its loans, e.g. for example to fund an increase in bank reserves. Inflows are positive numbers while outflows are negative numbers. It is striking how similar the flows of additional deposits (not credit

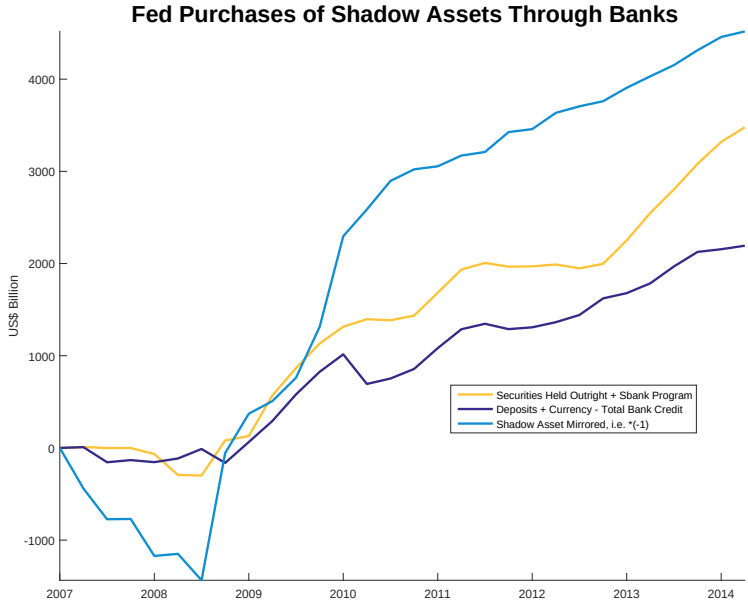



Figure 5: Assets in the Financial System

growth induced), shadow banking assets, and central bank actions are. Figure 6 presents the

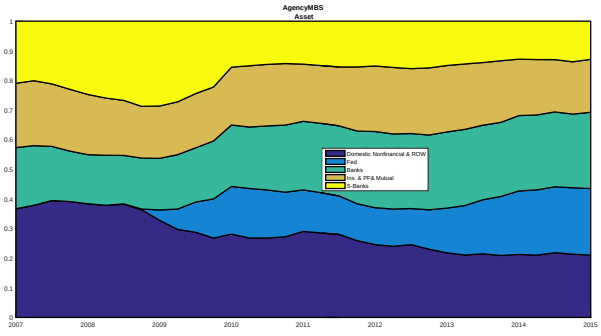



Figure 6: Agency MBS

holding share of different sectors in agency mortgage backed securities. S-banks represent the share of shadow banks' agency mortgage backed security holdings. The most remarkable

change that occurred in the ownership of agency MBS is a switch in the ownership from shadow banks to the Federal reserve.

## 2.7 Losses recorded in other sectors

We have already described that the lion's share of shadow banks' assets were absorbed by the Fed, acting through traditional banks' reserve and deposits. Table 1 leaves an unexplained gap of $800B. We investigate if other sectors suffered equity losses of a similar magnitude.

Using the Flow of Funds data on pension funds, we compute the difference between pension funds' financial assets and their liabilities (see figure7). Pension funds have been running a funding shortfall since the beginning of the 2000s, but when we normalize the figure (2007 to zero) to make the comparison with figure 4 we find that the actual crisis

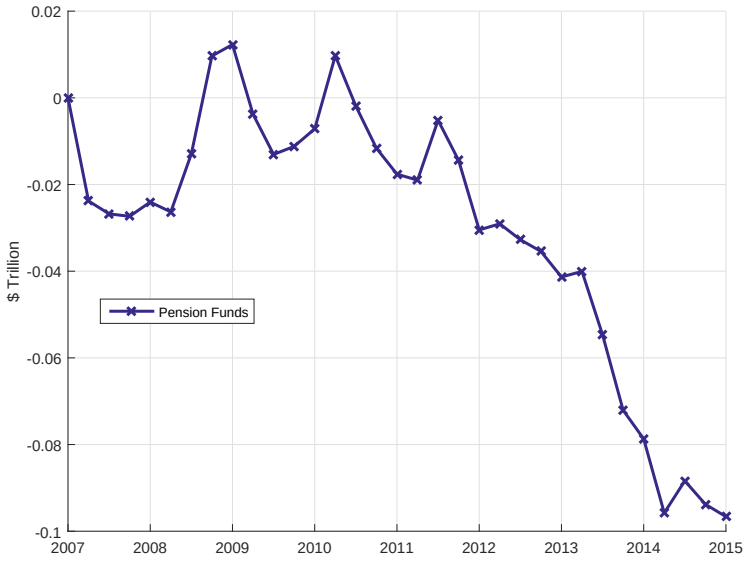



Figure 7: Assets in the Financial System

period (2007-2009) did not significantly contribute to the funding shortfall of pension funds. In contrast, they seem to have at least in the short term benefited from the recession.

In order to get an idea how hedge funds fared during the crisis, we used the Morningstar Hedge Fund database. We only considered hedge funds domiciled in the US and computed their assets under management (taken as a snapshot at the end of each quarter), as well as the average quarterly return of an investor that had an asset weighted portfolio of the hedge fund industry. Figure 8 shows the cumulative change in assets under management of U.S. domiciled funds since the first quarter in 2007. The figure clearly shows that hedge funds did not come away unscathed, but the magnitudes of the outflows do not support the view that hedge funds were a large residual claimant of the shadow banking sector. We also found that quarterly losses 2007q1-2015q1 only amounted to $53B. One missing sector

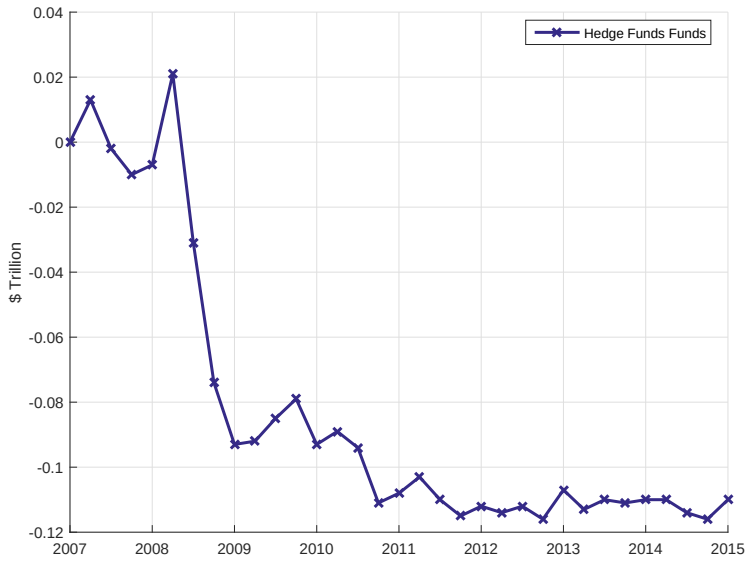



Figure 8: Assets in the Financial System

that we have not accounted for the declines in reserves in private and public and private retirement funds. We currently working on computing flows out of this segment.

### 2.8 Taking Stock

Calculations from indicate that the Fed purchased about 75% of the assets outflow from SBAs. Traditional banks intermediated that operation, issueing deposits and holding reserves. Reserves help bank lending, so this operation hardly impaired the banking system's lending ability. In the following section, we argue that book-value constraints were not likely to have limited the ability to provide loans: book values did not fall.[12] This leads us to conclude that if the unwinding of assets by shadow assets had an effect on bank lending, it was through indirect effect on prices, but not via a direct crowding out effect. The common fire-sale simply does not show up in the aggregate flows.

## 3 Banking Sector Losses

The previous section described the financial flows between shadow banks and traditional banks. This section investigates the evolution of bank balance sheets, income statements, and market values. We document that during the crisis, traditional banks increased loan write downs and suffered losses in security investments. In their book, those losses were small and fully offset by equity issuances. Market capitalization paints a completely different picture: market-value losses were catastrophic. Cross-sectional evidence suggests that book-values failed to acknowledge sizable losses while market values contained information of

[12]Perhaps by because it was difficult to securitize loans going forward.

future book returns.

## 3.1 Data

We study individual bank-level data to reconstruct aggregate time series and exploit the cross-section. Among the universe of banks, we focus on top-tier Bank Holding Companies (BHCs) rather than on other levels of aggregation, e.g. the commercial bank level.[13] BHCs provide a complete picture of the activities of a financial organization and not just the narrow accounts of their commercial bank subsidiaries (e.g. Citigroup vs. Citibank) and only BHCs can be matched to market data. Book data is obtained from the FR Y-9C regulatory reports that BHCs file with the Federal Reserve, and merged with market data from the Center for Research in Security Prices (CRSP). Our data extends from 2000 Q1 to 2015 Q4. The FR Y-9C is only filed by BHCs with total assets above $500 million.[14] However, since the industry is highly concentrated, our sample likely represents the majority of the industry. We use the microdata to reconstruct aggregate time series, dropping new entrants to correct for the entry of many major financial institutions into the sample during the crisis. Without this correction, we see a spurious increase in the assets of the traditional industry due to the reclassification of large actors such as Morgan Stanley and Goldman Sachs into bank holding companies. We also summarize some of our readings from the Annual Shareholders' Reports of the "Big Four" banks (Bank of America, Citigroup, JPMorgan Chase, and Wells Fargo). We believe that those reports provide informative detail about the banking industry, and among these four banks, which account for 50% of the industry's activities, we find notable heterogeneity in performance.

## 3.2 Sources of Losses

The data reveals that most losses during the crisis were associated, directly or indirectly, with the real-estate market. In the FR Y-9C, bank profits are decomposed into interest and non-interest revenues and expenses. During the crisis, interest expenses fall almost about the same amount as interest revenues, thus profits from spreads were not strongly affected. Non-interest expenses (e.g. salaries, and other fixed operating costs) also remained constant. Non-interest income, however, suffered larger losses. Within non-interest income, the largest source of losses originated from trading revenue on cash instruments and derivatives. An important share was also accounted for by provisions for loan losses (PLL) and net gains from securities. The FR Y-9C treats these two categories as separate from the previously

[13] A bank holding company is an umbrella company which holds banks, and may hold many banks, while a commercial banks is a single bank which provides traditional banking services like deposits and loans. For example, Citibank is a commercial bank, which is held by Citigroup, which is a BHC which holds Citibank and other banks, including non-commercial banks.

[14] Prior to 2006 Q1, this threshold was $100 million, and the threshold became $1 billion in March 2015.

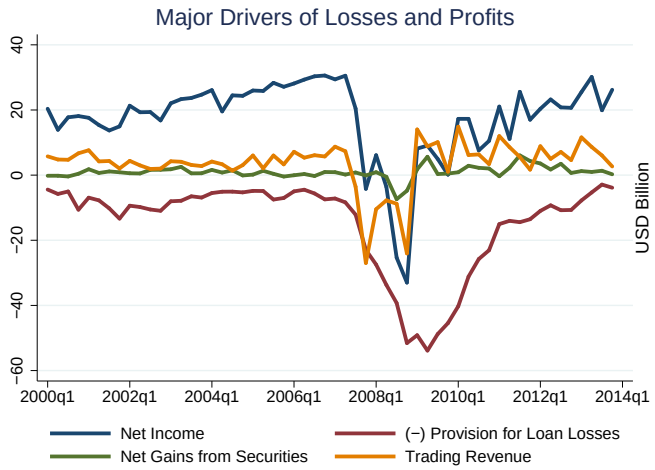



Figure 9: Main Drivers of Losses

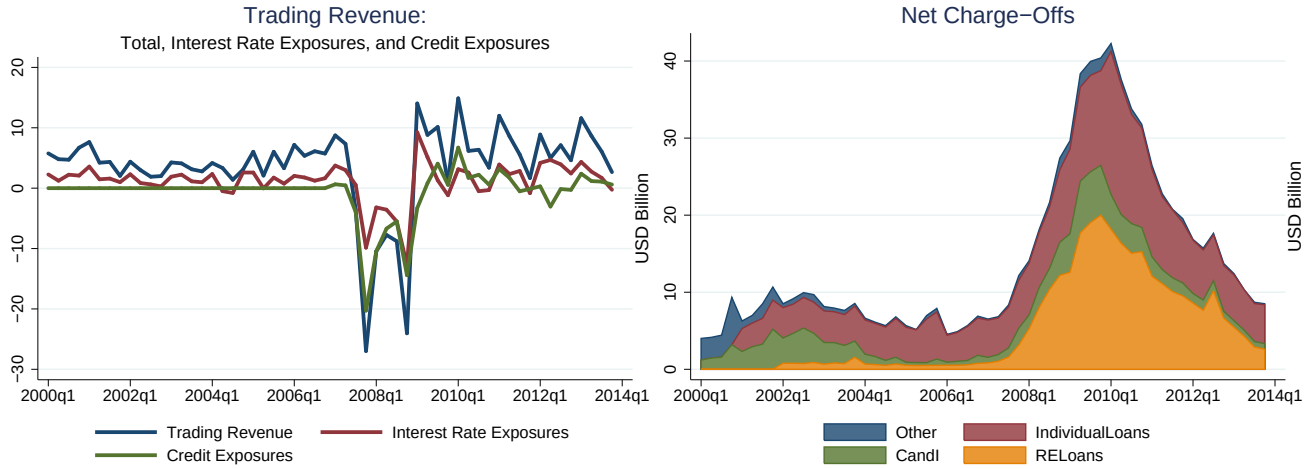



Figure 10: Decomposition of Trading Revenue and Charge-offs

mentioned components of income. These major drivers of losses are summarized in Figure 9.

The two largest sources of losses, trading revenue and PLL, can be decomposed further. Within trading revenue, the drop is primarily driven by losses on credit-derivatives (e.g. CDS), with some portion also stemming from interest-rate derivatives, as seen in Figure 10. PLL cannot be decomposed directly, but do we get a sense of what credit categories were the main sources of loan losses by decomposing net charge-offs[15], shown in Figure 10. The rise in net charge-offs is driven predominantly by a spectacular rise in real-estate loan charge-offs. While there is a modest rise in net charge-offs on individual loans (direct consumer loans and credit cards), there is only a small spike in commercial and industrial loans charge-offs. Note

[15]In the course of a loan loss, a bank first provisions for the loan loss when the loss is "estimable and probable", then charges the loan off when the bank is confident that it will not be collected, although it can recover the loan if this charge-off turns out to be a mistake. PLL is thus a precursor to net charge-offs, which is simply charge-offs minus recoveries.

that the rise in real-estate charge-offs cannot be entirely attributed to households (Mian and Sufi (QJE, 2102)) because an important portion (28%) resulted from construction-related loans and 10% resulted from commercial real estate —61% was residential real estate.[16] Overall, real-estate related losses were indisputably the main drivers of book losses, whether through credit derivatives, provisions for loan losses, or losses on other securities.[17] From the first losing quarter (2007 Q4) to the last losing quarter (2008 Q4), banks lost $60 billion on the books, or 7.3% of their original book equity. In the next subsection, we address the question of magnitudes in greater detail, and present other measures of the size of bank losses.

## 3.3 Scale of Changes in Equity

We now turn to compute the magnitude of the cyclical changes in BHC balance sheet components and other variables included for comparison. The goal is to get a sense of the scale of the shifts. For that, it is important to separate the cycle from the trend. Thus, we provide estimates of residuals from three detrending methodologies. We use the seasonally-adjusted GDP deflator to adjust for inflation, and report all values in 2012 Q1 dollars. We apply a Hodrick-Prescott filter to the logged real series to obtain our first set of detrended estimates. We obtain a second set of estimates by fitting a linear trend to the logged real series, estimating the trend using the data through 2007 Q1. We report the residuals of the HP-filtered series and the residuals of the linear trend fit. Finally, we report the real change in the series since 2007 Q3 as our third estimate. These values are reported in Table 2, with values reported for the fourth quarter of 2008, 2009, and 2010. We treat market returns slightly differently: we take $\log(1 + r)$ instead of $\log(r)$, we fit a constant to the data through 2007 Q1 rather than a linear trend, and for each set of estimates we report the cumulative cyclical deviation since the end of 2007 Q3 (add up each quarter's residual).

The different methods of detrending yield different estimates. The HP-filtered residuals typically being of substantially smaller magnitude then the residuals estimated with a log-linear trend. This point is illustrated in Figure 11, which shows logged real market capitalization as well as common equity on the books (book equity minus preferred equity), along with their HP and log-linear trends (all of our figures in this subsection will take this form). Based on this figure, we may be concerned that the HP filter is overfitting the data and treating as trend what is really just a persistent cyclical component; we also may be concerned that the log-linear trend is based on an unsustainable boom, yielding an over-

[16] These figures were computed by taking the change in real estate net charge-offs between 2009 Q1 (when such chargeoffs peaked) and 2006 Q1 (which we use often as a pre-crisis reference quarter), and computing the change in each component as a share of the total change.

[17] Although the data does not allow us to decompose losses on securities into its subcategories, it seems likely that losses on mortgage-backed securities were a major component of securities losses.


Figure 11: Shocks to BHC Common Equity

estimate of the size of the cyclical deviation. Simply looking at raw changes in this series sidesteps these concerns, but only by not dealing with the trend altogether. We report all three estimates for completeness, but we acknowledge that each of these estimates is imperfect.

Market data suggests that banks suffered large losses during the crisis, although book data shows small changes. Figure 11 shows that market capitalization fell markedly during the crisis, but common equity on books suffered a much smaller loss. Between the 2007 Q3 and 2008 Q4, market cap dropped $710 billion; by the fourth quarter of 2010 the gap was still $380 billion, with much of this rebound coming from new equity issuances. In contrast, real book equity did not fall during the crisis. This suggests that book losses were made up for by equity issuances. We look into the cause of this disparity in the book and market data in the next subsection.

Figure 12 plots the path of loans net of the allowance for loan losses (this subtracts out "probable and estimable" future losses on the current stock of loans), as well as total liabilities. These plots show the early crisis rise followed by a mild decline. The decline is steeper in percentage terms for loans net of ALL, which is consistent with losses on loans being recognized by banks slowly.[18]

For comparison, we provide estimates of the cyclical deviation of the S&P 500 and the Case-Shiller index, deflating by the GDP deflator. This is shown in Figure 13. There was a sizable negative cyclical deviation of prices during the crisis in both the securities and housing markets.[19] The percentage drop in the stock and housing markets are substantially smaller (they had fallen by 28.83% and 20.42% respectively by 2009 Q4) than the cumulative drop in market returns (a 55.07% drop over the same time period).

[18] ALL continued to rise through 2010 Q1, as seen by comparing loans to loans net of ALL in Table 2

[19] The fall in prices in certain housing markets was even larger than the one shown here for the national market.

| | HP Filtered | | | Log-Linear | | | Real Change Since 2007 Q3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2008 | 2009 | 2010 | 2008 | 2009 | 2010 |
| Market Cap. | -33.11% | -4.761% | 13.27% | -61.23% | -50.07% | -42.93% | -53.99% | -39.28% | -28.86% |
| | (-$300B) | (-$40B) | ($110B) | (-$956B) | (-$801B) | (-$704B) | (-$710B) | (-$517B) | (-$380B) |
| Book Equity | -1.433% | 2.129% | .3512% | -4.242% | -1.15% | -3.63% | 7.428% | 17.01% | 20.36% |
| | (-$14B) | ($22B) | ($3.7B) | (-$42B) | (-$12B) | (-$40B) | ($66B) | ($151B) | ($180B) |
| Public Equity | -.2109% | 2.634% | 1.03% | -3.508% | -1.493% | -4.361% | 11.79% | 21.69% | 25.99% |
| | (-$1.9B) | ($25B) | ($10B) | (-$32B) | (-$15B) | (-$46B) | ($94B) | ($173B) | ($208B) |
| Common Equity | -18.96% | 1.627% | 3.255% | -27.91% | -10.51% | -9.25% | -18.57% | 6.79% | 14.4% |
| | (-$167B) | ($15B) | ($32B) | (-$277B) | (-$110B) | (-$102B) | (-$163B) | ($60B) | ($126B) |
| Assets | 1.834% | -.306% | -1.237% | 1.947% | -3.299% | -8.196% | 1.999% | 1.18% | .4552% |
| | ($206B) | (-$35B) | (-$141B) | ($219B) | (-$388B) | (-$1,008B) | ($225B) | ($133B) | ($51B) |
| Liabilities | 2.163% | -.5091% | -1.361% | 2.504% | -3.562% | -8.71% | 1.534% | -.1725% | -1.246% |
| | ($223B) | (-$53B) | (-$141B) | ($257B) | (-$382B) | (-$976B) | ($159B) | (-$18B) | (-$129B) |
| Loans | 5.794% | -2.521% | -1.81% | 6.629% | -5.115% | -8.548% | 3.13% | -5.29% | -5.792% |
| | ($316B) | (-$137B) | (-$97B) | ($359B) | (-$286B) | (-$493B) | ($175B) | (-$296B) | (-$324B) |
| Loans Net of ALL | 6.292% | -2.419% | -1.015% | 3.34% | -9.624% | -13.37% | 1.794% | -7.609% | -8.086% |
| | ($333B) | (-$126B) | (-$52B) | ($182B) | (-$543B) | (-$783B) | ($99B) | (-$420B) | (-$447B) |
| Real Estate Loans | 6.147% | 3.018% | -1.567% | -4.021% | -14.36% | -26.17% | 4.373% | -.4398% | -8.244% |
| | ($186B) | ($90B) | (-$45B) | (-$135B) | (-$514B) | (-$1,002B) | ($135B) | (-$14B) | (-$254B) |
| S&P 500 | -23.39% | -4.806% | 2.418% | -25.55% | -7.011% | 4.634% | -42.08% | -28.83% | -21.2% |
| | (-289) | (-59) | (30) | (-325) | (-88) | (57) | (-688) | (-472) | (-347) |
| Case-Shiller Index | -6.449% | -4.08% | -5.593% | -34.75% | -41.17% | -48.33% | -17.63% | -20.42% | -25.08% |
| | (-11) | (-6.4) | (-8.4) | (-83) | (-106) | (-133) | (-34) | (-39) | (-48) |
| Market Returns | -43.62% | -36.68% | -24.88% | -57.79% | -61.28% | -60.02% | -54.16% | -55.07% | -50.45% |
| | (-$574B) | (-$483B) | (-$327B) | (-$760B) | (-$806B) | (-$790B) | (-$713B) | (-$725B) | (-$664B) |

Table 2: Shocks to Bank Holding Companies. Top row shows cyclical deviations in percentage points; bottom row shows deviations converted into raw values. Public equity refers to book equity of publicly traded BHCs. Loans net of ALL refers to loans minus the allowance for loan losses. All variables deflated using the seasonally-adjusted GDP deflator. Market returns deviations are cumulated since end of 2007 Q3, and dollar values for market returns are obtained by multiplying the cumulative percentage point deviation by real market capitalization at the end of 2007 Q3.

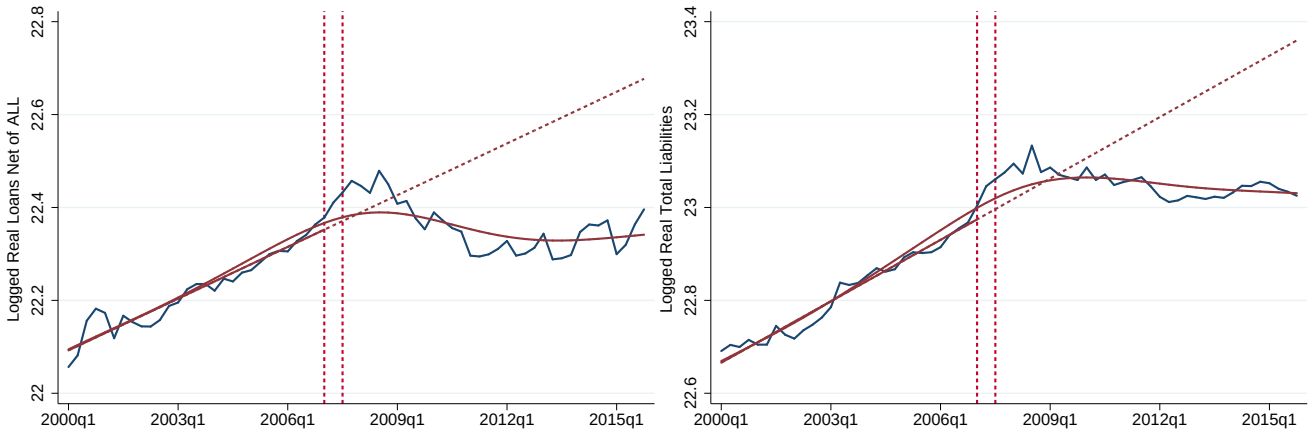



Figure 12: Shocks to BHC Loans Net of ALL and Liabilities

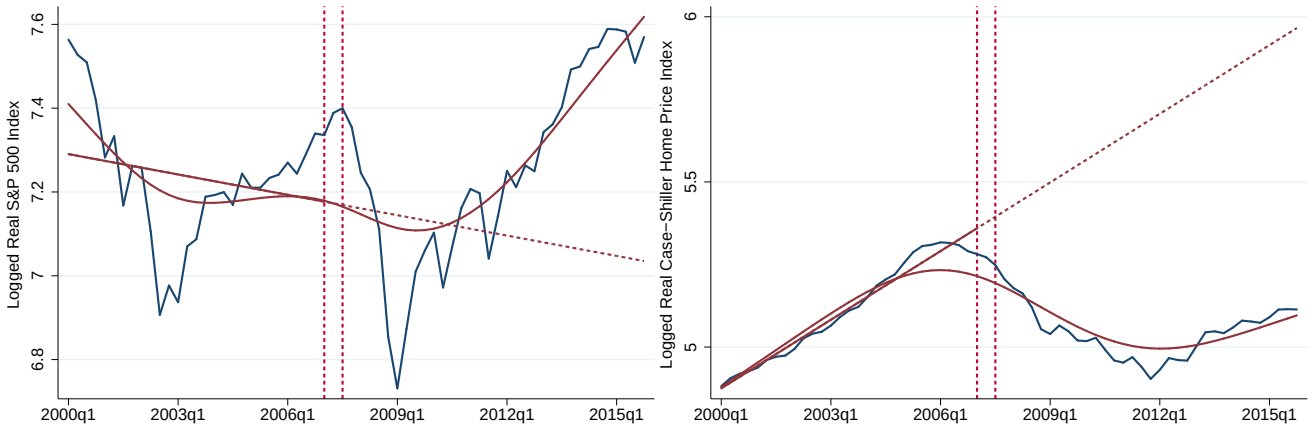



Figure 13: Shocks to Overall Stock Market and Housing Prices

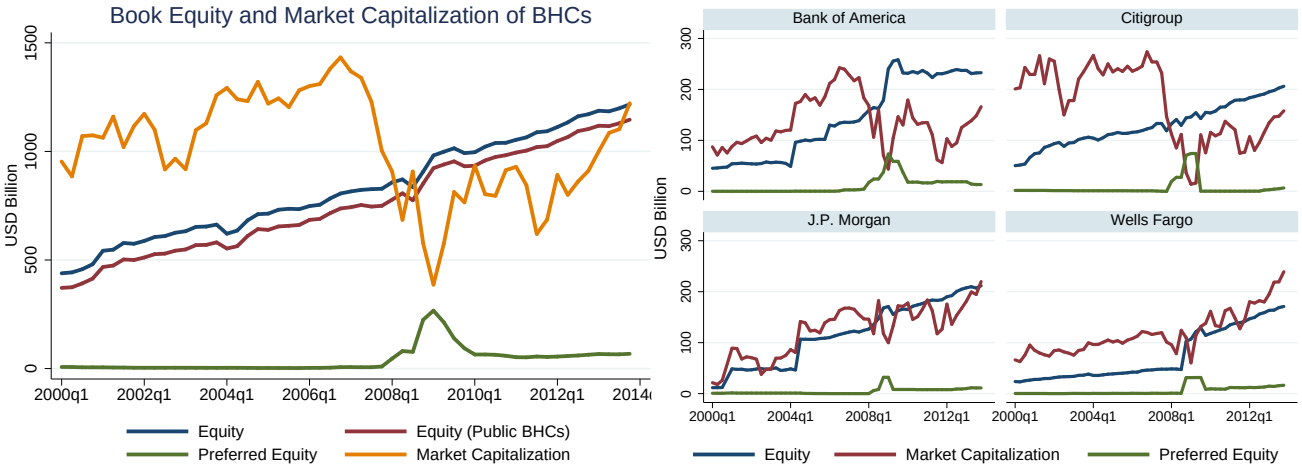



Figure 14: Book Equity and Market Capitalization for Bank Holding Companies.

## 3.4 Book vs. Market Based Equity

The previous subsection described that banks registered $60 billion in book losses of during the crisis. Compared to the total value of book equity, those losses are very small even after correcting for non-tangibles. Furthermore, book losses were entirely offset by equity issuances. Market values show a completely different picture. This comparison is found in Figure 14, both for the aggregate of publicly traded BHCs[20] and for the Big Four. An uninformed observer, looking only at data on banks' book equity, could have not guessed there was a major financial crisis going on. The pattern for the Big Four is very similar.[21] Citigroup is a dramatic example: it shows a 90% drop in market capitalization, but no perturbation in the trend of book equity.[22] The figure also makes clear that this discrepancy cannot be explained by preferred equity, which is included in book equity but not in market capitalization.[23]

Our take on this evidence is that it is probably a combination of intentional and unintentional slow adjustment of book assets. Were market-based valuations picking up any of this information? Next, we turn to this question.

## 3.5 Predictive Power in Book Values and Market Capitalization

To study the the information content of market capitalization, we run cross-sectional regressions of Tobin's Q, the ratio of market equity to book equity, against a few important

[20]The fact that book equity for public BHCs is so close to book equity for all BHCs is a result of the high concentration of equity in the largest banks.

[21]The discontinuities in the individual bank series reflect mergers and acquisitions, such as the acquisition of Wachovia by Wells Fargo during the crisis.

[22]Citigroup suffered heavy losses during the crisis, and did undergo any major mergers or acquisitions, making it a particularly clean test case.

[23]Preferred equity rose temporarily during the crisis due to TARP.

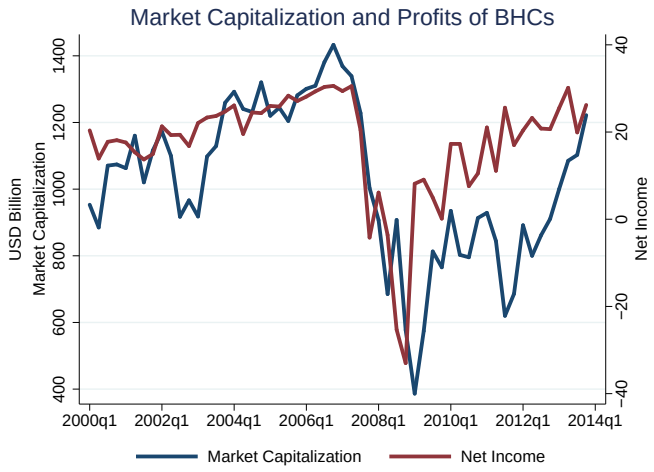



Figure 15: Market Capitalization and Profits of BHCs

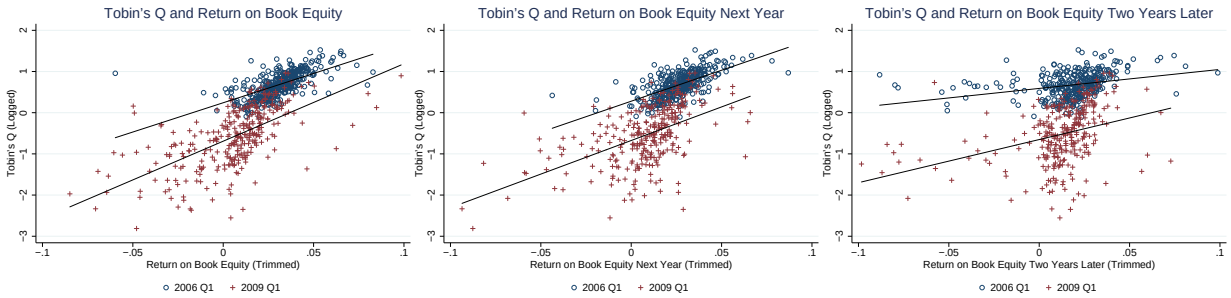



Figure 16: Logged Tobin's Q and Return on Book Equity

explanatory variables. We work with Q rather than raw market capitalization to control for scale effects.[24] We examine how current and future profits, dividends, and loan delinquencies are correlated with the log of Tobin's Q. The extent to which these variables are correlated with Q reflects market values are picking up cross-sectional information that books were not.

Let's summarize the main findings: First, there is evidence that current and future returns on book equity are predicted by Tobin's Q. Figure 15 shows the time series for market capitalization and profits: profits crash along with market capitalization during the crisis, and the two series appear highly correlated. Figure 16 shows the relationship between logged Tobin's Q and return on book equity (profits over book equity), with return on book equity being measured in the present year, one year ahead, and two years ahead, but now in the cross-section of banks. The slope of the relationship is stable over time, and if anything is steeper post-crisis for two year ahead return on book equity. This shows that changes in Q predict book returns going forward.

Second, the data also shows a positive correlation between dividend rates and Tobin's Q.

[24] If we had simply regressed market capitalization on the stock of delinquent loans, without dividing by book equity, we would have mistakenly found that delinquent loans increase market capitalization!

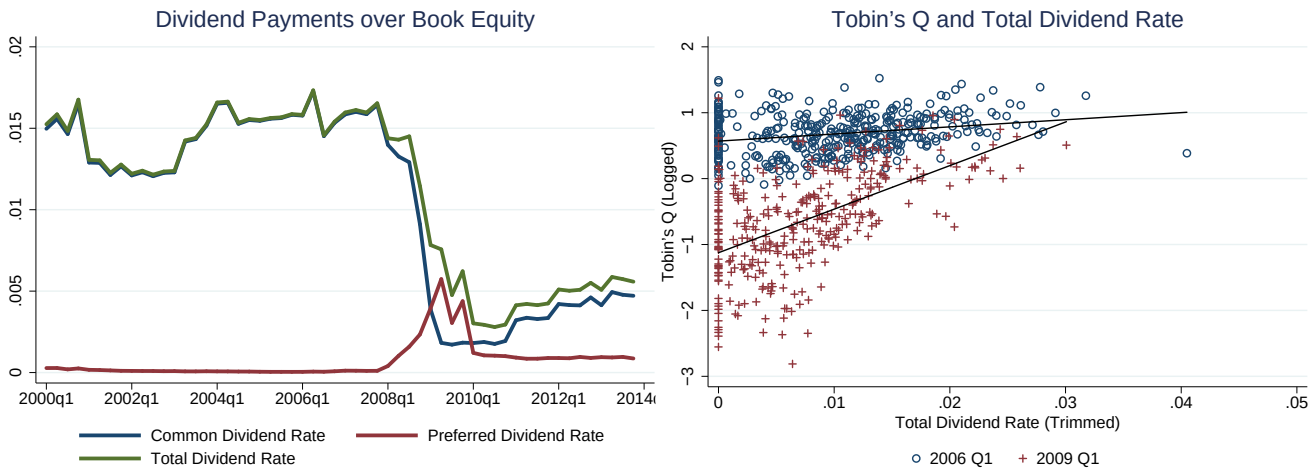



Figure 17: Logged Tobin's Q and Dividend Rates

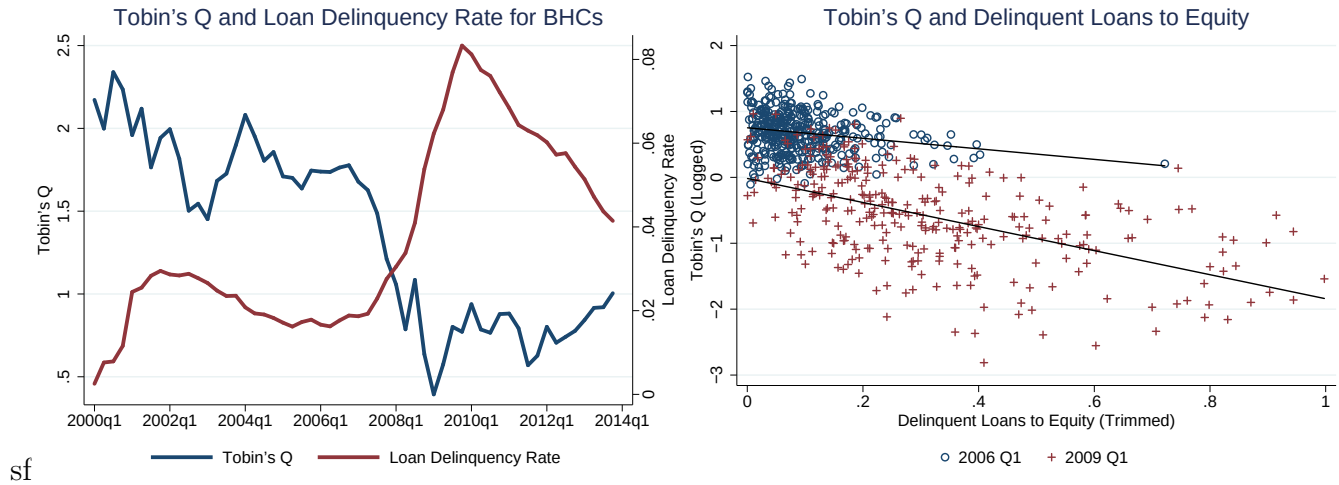



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Figure 18: Logged Tobin's Q and Loan Delinquency and

Figure 17 shows our results in the time series and cross-section. Dividend rates, computed by dividing dividend payouts by book equity, drop dramatically during the crisis, although preferred dividends actually rise substantially. Excepting the rapid drop in dividend rates during the crisis, banks tend to change their dividend rates rarely.

Finally, we loan delinquency rates are negatively correlated with Tobin's Q. Figure 18 shows the time series and cross-section for this relationship. Loan delinquency rates are defined as the share of loans which are delinquent,[25] skyrocket as Tobin's Q plummets, and the two series appear to be highly correlated. Switching to the cross-section, logged Tobin's Q is negatively correlated with the ratio of delinquent loans to book equity, especially during the post-crisis.

We formalize these graphical relationships and consider these determinants of Tobin's Q jointly in a regression. We maintain a consistent sample throughout the analysis: the

[25] A loan is considered delinquent if it is overdue 30 days or more, or if it is in non-accrual.

regressors are trimmed to drop any extreme outliers as in the graphical analysis, and any observation that is not used in one of the specifications is not used in any of the specifications. The results are reported in Table 3. The regressions bear out the same conclusions: return on book equity one year ahead remains statistically significant predictor of Tobin's Q up to two years.[26] A Oaxaca decomposition using the the sample for this table and the variables in the final column suggest that between 40% and 45% of the difference in logged Tobin's Q can be explained just with these variables. To summarize market capitalization during the crisis was reflecting cross-sectional information not contained in the books. The next section cross-sectional differences in market values lead to differentiated behavior of banks. We ask what does this tell us about the constraints faced by banks, and what does it mean for macro models?

## 3.6 Taking Stock

The discrepancy between book and market values on such a scale as Citi's is puzzling. It makes us wonder whether book values are useful at all for macroeconomic modeling. One possible explanation is that the discrepancy is mostly reflecting a large discounting. However, banks did substantially worse than the S&P index. Discounting cannot be a complete explanation. An alternative view is that banks —and regulators perhaps— had incentives and the ability to understate book losses. For example, if management compensation is linked to book equity returns, there would be obvious incentives to overstate. Beyond principal-agent problems, banks are also required to meet capital standards and might have overstated book equity to avoid penalties.

An alternative for the discrepancy between books and market values is the ability "massage" the accounts. This issue is studied in the accounting literature. In practice, banks can record securities on the books using two methodologies: either amortized historical cost (the security is worth what it cost the bank to buy it with appropriate amortization) or fair value accounting.[27] In addition to mis-pricing securities, another degree of freedom is

[26] A careful treatment of this analysis would note that the regressors which we truly want is expected future profits, and realized future profits are in fact expected profits measured with noise. The lower coefficients on future profits, compared to current profits, thus represent not just time discounting, but also the extent to which variation in future profits was anticipated, conditional on the other regressors.

[27] Fair value accounting can be done at three levels: Level 1 accounting uses quoted prices in active markets. Level 2 prices of similar assets to account as a benchmark to account assets that trade infrequently. Level 3 is based on models that do not involve market prices (e.g. a cash flow model). Banks are required to use the lowest level possible for each asset. In practice, most assets are recorded at historical cost. The majority of fair value measurements are Level 2 (Goh et al. 2015; Laux and Leuz 2010). Recent work has shown that the stock market values fair value assets less if they are measured using a higher level of fair value accounting. This leaves room to mis-price assets on books. Particularly during 2008, Level 2 and Level 3 assets were valued substantially below one (Goh et al. 2015; Kolev 2009; Song et al. 2010). Laux and Leuz (2010) document sizable reclassifications from Levels 1 and 2 to Level 3 during hhe period. They highlight the case of Citigroup, which moved $53 billion into Level 3 between the fourth quarter of 2007 and the first quarter of 2008 and reclassified $60 billion in securities as held-to-maturity which enabled Citi

Table 3: OLS regression estimates of the effects of predictors on logged Tobin's Q

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| Post | -1.164*** | -0.720*** | -1.542*** | -0.786*** | -0.890*** | -1.219*** | -0.559*** | -0.783*** |
| | (0.0409) | (0.0640) | (0.0741) | (0.0579) | (0.0578) | (0.0528) | (0.0875) | (0.0894) |
| Delinquency | | -0.780*** | | | | | -0.691*** | -0.682*** |
| | | (0.207) | | | | | (0.149) | (0.148) |
| Post*Delinq | | -1.087*** | | | | | -0.294 | -0.273 |
| | | (0.279) | | | | | (0.257) | (0.250) |
| Dividend Rate | | | 10.93*** | | | | | -0.614 |
| | | | (2.533) | | | | | (1.828) |
| Post*DivRate | | | 47.04*** | | | | | 32.32*** |
| | | | (5.897) | | | | | (5.184) |
| ROE | | | | 17.91*** | | | 13.61*** | 13.67*** |
| | | | | (1.413) | | | (2.246) | (2.253) |
| Post*ROE | | | | 1.348 | | | -1.424 | -5.221 |
| | | | | (2.425) | | | (3.049) | (2.980) |
| F4ROE | | | | | 16.88*** | | 6.184** | 6.265** |
| | | | | | (1.238) | | (1.997) | (2.022) |
| Post*F4ROE | | | | | -0.755 | | -1.240 | -2.181 |
| | | | | | (2.502) | | (3.252) | (3.017) |
| F8ROE | | | | | | 4.663*** | -0.310 | -0.279 |
| | | | | | | (1.045) | (0.532) | (0.547) |
| Post*F8ROE | | | | | | 6.466** | 1.990 | 1.143 |
| | | | | | | (2.268) | (2.013) | (1.815) |
| Constant | 0.674*** | 0.743*** | 0.560*** | 0.115* | 0.224*** | 0.589*** | 0.152*** | 0.153*** |
| | (0.0170) | (0.0281) | (0.0338) | (0.0450) | (0.0371) | (0.0261) | (0.0417) | (0.0420) |
| Observations | 590 | 590 | 590 | 590 | 590 | 590 | 590 | 590 |
| $R^2$ | 0.564 | 0.659 | 0.669 | 0.727 | 0.678 | 0.616 | 0.768 | 0.790 |

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

the extent to which banks acknowledged impairments: . Banks have the right to delay acknowledging impairments on assets held at historical costs, if they deem those impairments as temporary (i.e. they believe the asset will return to its previous price). This gives banks substantial leeway, and has led to notable cases of overvalued assets on the books. Merrill Lynch, for example, sold $30.6 billion dollars of CDOs for 22 cents on the dollar while the book value was 65 percent higher than its sale price. Similarly, Lehman Brothers wrote down its portfolio of commercial MBS by only three percent, even when an index of commercial MBS was falling by ten percent in the first quarter of 2008 (Laux and Leuz 2010). Laux and Leuz also document substantial underestimation of loan losses in comparison to external estimates.

Beyond intentional overstatement, there may be a delay in acknowledging loan losses. Under the current "incurred loss model," banks are only allowed to provision for loan losses when a loss is "estimable and probable". Recent work has shown that it is possible to construct an index, based on information available in the given time period, that predicts future losses substantially better than the allowance for loan losses.[28] (Harris et al. 2013)

# 4 Bank Portfolio Constraints

In the previous two sections, we described the re-configuration of the financial system during the crisis and measured the direct equity losses suffered by banks. These calculations should interest us only if they affect the supply of credit. For that to happen, banks must face some form of financial frictions. In this section, we use microdata on bank holding companies to provide insights on the frictions that banks faced during the crisis. We analyze a number of possibilities discussed by the theoretical literature.

## 4.1 Regulatory and Market Constraints on Leverage

Regulation requires banks to maintain their leverage below a multiple of their book values. We do not claim that regulatory constraints do not have an impact on bank decisions. However, the fact that accounting rules give banks a certain degree of flexibility suggests that at least in the short run regulatory constraints may not be strictly binding.

In the previous section, we studied how book-equity losses underepresented market losses that were predictors of book returns going forward. This discrepancy is also reflected in leverage. Figure 19 shows how book leverage rose moderately before the crisis and actually fell rapidly after the crisis. Market leverage behaves completely different.[29] It

to use a historical costs.

[28]The ALL is the stock variable corresponding to the PLL.

[29]We compute this market-based measure as market capitalization plus total book liabilities, divided by market capitalization. Although book assets may suffer from substantial mispricing, book liabilities are

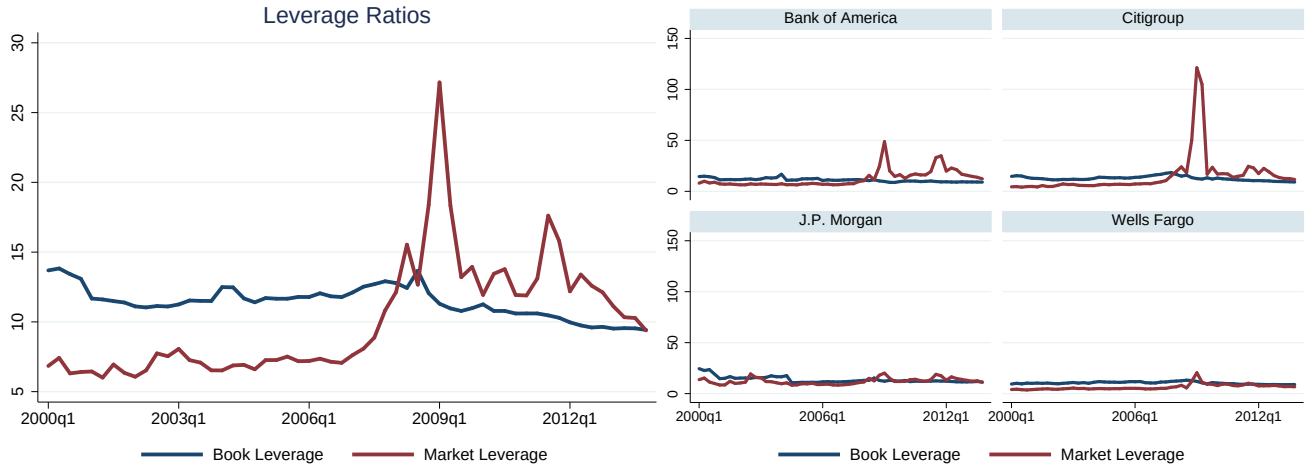



Figure 19: Book and Market Leverage of Bank Holding Companies

spiked dramatically during the crisis, and remained almost twice as high for at least four years. Within the big four banks, the spike in leverage is particularly pronounced for Citigroup and Bank of America.

The enormous post-crisis rise in market leverage suggests that capital requirements based on books may be met because books are not reflecting the value of bank assets. Although we do not have evidence that banks purposefully mis-priced their assets, the post-crisis saw many banks consistently failing stress tests. This suggests a tension between regulators and bankers about the actual valuation techniques used in valuing books.

Many macroeconomic theories use leverage constraints based on market values, i.e. a constraint that stipulates that leverage cannot exceed a multiple of market-valued equity. Thus, we expect that as asset prices fall during crisis, the constraint should tighten. Figure 19 challenges this assumption. The data shows that market-based leverage rose dramatically during the crisis. Some market-valued leverage models, like Gertler and Kiyotaki for example, can reproduce countercyclical leverage as in Figure 19. However, it is hard to explain the massive differences in leverage that appear in the cross-section.

In summary, it seems that if book or market leverage funding constraints tightened during the crisis, they did it in a way that appear to not have been systematically binding. One possible explanation is that banks were able to maintain their funding by switching to different types of liabilities such as deposits that were not subject to the same constraints. In fact, deposits held by BHCs rose post-crisis, both in absolute terms and as a share of liabilities. We later show that BHCs do not appear to have been up against the mechanical constraint imposed by margins on Repo and other short-term debt, which tightened during the crisis, in contrast to what we see in Figure 19.

fairly straightforward to compute and thus difficult to mis-price; we thus believe this measure of market leverage does not suffer from the same mispricing issues faced by a book-based measure.

## 4.2 Impulse-Response Functions: Bank Behavior

In this section we explore how bank balance sheets adjust to excess-return shocks in order to study banks' response to changes in future wealth. For the rest of the paper we refer to these innovations as return shocks. So far, we saw how market values contain information not reflected in the books. Thus, we expect innovations in market-based excess returns to contain information on the future payoffs of banks, information which is not contained in book data. By tracking how the bank's portfolio reacts to return shocks, we are indirectly tracking how banks behave in response to information about their future wealth.

### 4.2.1 Econometric Specification

We estimate the following panel regressions:

$$\Delta \log(y_{i,t}) = \alpha_t + \sum_{h=0}^{k} \beta_h \cdot \log(1 + r_{i,t-h}) + \gamma_h \cdot Post_t \ \log(1 + r_{i,t-h}) + \epsilon_{i,t}$$

where $i$ indexes over banks, $t$ indexes over quarters, $r_{i,t}$ indicates the market return over the past quarter for bank $i$ in quarter $t$, $\alpha_t$ is a time fixed effect, and $Post_t$ is an indicator variable equal to one if the current quarter is post-crisis (we treat 2007 Q4 as first quarter for which $Post_t = 1$), and $y_{i,t}$ is bank balance-sheet variable. Time-fixed effects soak up the time-series variation giving us a supply-side impulse response estimate of the cross-section.

The choice of market returns instead of equity shocks, both measures which contain information not present in books, merits some discussion. Market capitalization is a choice variable —banks can affect their equity. Under the efficient-market hypothesis, variation in excess returns should be unpredictable *ex ante*, except, of course, for a risk-premium adjustment. Returns in a given period may be correlated with other variables *ex-post* — e.g., banks with higher exposure to subprime mortgages should suffer heavier losses during the crisis. This means that returns in one period may be correlated with returns in another period *ex post*. This correlation will cause omitted variables bias if the outcome variable is affected in more than one period. To deal with this issue, we include many lags of market returns. We also implement a placebo test where we add leading values of returns into the specification —future return shocks should not affect the present, otherwise they aren't exogenous "shocks". Our placebo tests suggest that the bias in our estimates is not large.

Another identification concern is omitted variables bias from unobservables that affect market returns and bank reactions simultaneously. For example, news about profitability might affect returns and and leverage choice. We acknowledge this draw back but defend the approach because news shocks do not necessarily have a strong effect on the marginal profitability of future loans, and by the fact that banks can reallocate their portfolios, especially the big diversified ones.

In all specifications, we use $k = 20$. Given the high number of lags, we extend our data to 1990 Q3, which is the first quarter in which we can identify which banks are top-tier BHCs from the FR Y-9C. This extension is necessary to obtain precise pre-crisis estimates. Also, we cluster standard errors by bank. Finally, to report the impulse response function, we cumulate the coefficients: the pre-crisis contemporaneous response is $\beta_0$, the next period is $\beta_0 + \beta_1$, and so on. For post-crisis, we add the corresponding $\gamma$ terms.

### 4.2.2 Estimated Responses

We estimate impulse response functions for logged stock variables (liabilities, market capitalization, book equity, and market leverage), as well as for log flows (issuance rates, common dividend rates, and book return). Results are shown in Figure 20 for stocks and in Figure 22 for flows. The x-axis of our plots shows the contemporaneous response ($\beta_0$ for pre-crisis and $\beta_0 + \gamma_0$ for post-crisis) as quarter 1, the response one quarter later ($\beta_0 + \beta_1$ and $\beta_0 + \beta_1 + \gamma_0 + \gamma_1$) as quarter 2, and so on.

*Responses of stock variables.* First, we study the response of the first difference in log liabilities.[30] Models that feature a leverage target feature adjustments in liabilities or equity recapitalization in response to a negative wealth shock. The data is consistent with an adjustment of liabilities in response to return shocks. However, the data reveals that this response is slow: after a 10% return shock, five years out, there is an increase of 3-4% higher in liabilities in the pre-crisis environment and of 2-3% in the post-crisis. Although banks appear to be adjust liabilities slower post-crisis , this is reversed for market capitalization. Mathematically, the log change in market capitalization should respond one for one with return shocks as long as the outstanding stock of shares does not change. In the pre-crisis, this mechanical appears in the initial quarter of the impulse response and remains constant. By contrast, in the post-crisis, five years out, a 10% shock to returns yields only a 5% increase in market capitalization post-crisis. We can interpret the responses this way. Think of a negative shock. The computed responses are evidence of an active equity-issuance policy in the post-crisis environment, that was not present pre-crisis. In turn, banks were less actively decreasing their assets and liabilities —balance-sheet policy— in the post crisis. This is already revealing that something changed during the crisis.

The impulse response of log market leverage is simply the difference between the response

[30]Since market returns are changes in equity, taking first differences provides a tighter conceptual link. Using levels would mean that the outcome was highly correlated with bank size. This would raise concerns about stationarity, and if the market returns of banks exhibit a size premium then this would also lead to omitted variables bias. Using levels could also result in a regression that was heavily influenced by a few large banks, given the highly skewed bank size distribution. For the same reason we do not weight our regressions: the bank size distribution is highly skewed, and so a weighted regression would be equivalent to a regression with only the handful of largest banks. If the variance of the residuals were lower for larger banks, then using weights would yield a more efficient estimator. Empirically however, the variance of the residuals does not appear to vary substantially by bank size.

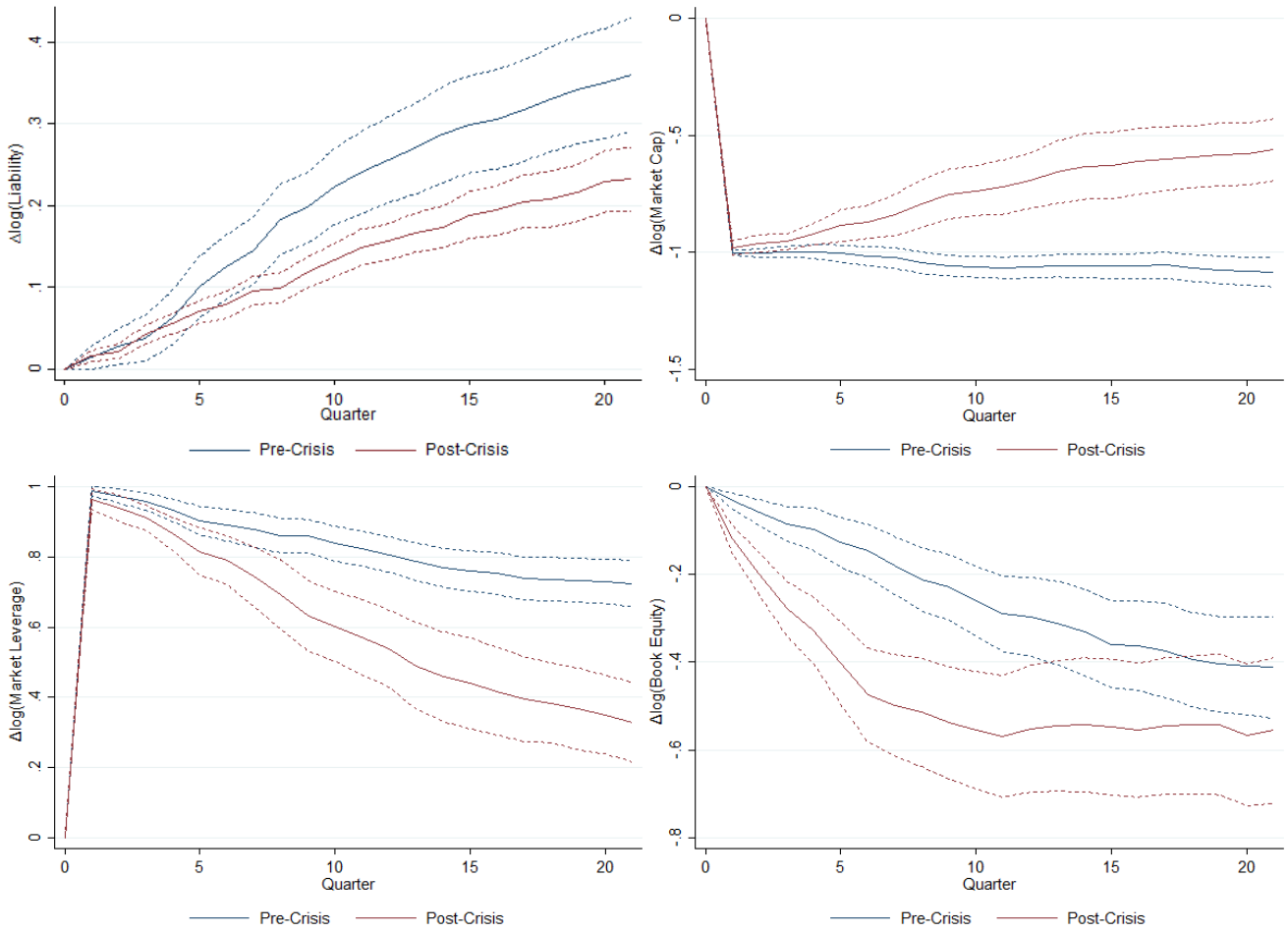



Figure 20: Estimated Impulse Responses for Stock Variables

of log liabilities and log market capitalization. In the initial quarter, the mechanical effect on the denominator dominates. Thanks to the great deal of post-crisis action on the equity raising side, banks adjusted their market leverage faster in response to cross-sectional shocks post-crisis than pre-crisis. However, the effect of return shocks on market leverage does not vanish, even five years out. This response tells is not immediate. Finally, the analysis of the previous section suggested that book values respond only slowly to asset impairments that are information in market returns.[31] Book returns should exhibit a delayed response to market returns.This is indeed what we see in the data.

*Response of Flow Variables.* We now describe movements in flow variables. We estimate the following equation:

$$\log(1+y_{i,t}) = \alpha_t + \sum_{h=0}^{k} \beta_h \cdot \log(1+r_{i,t-h}) + \gamma_h \cdot Post_t \ \log(1+r_{i,t-h}) + \epsilon_{i,t}.$$

[31] Although we focused on impairments and impairments are the main area in which banks have an incentive to mis-price assets on the books, accounting rules are intended to be conservative and thus may also make books slow to respond to positive shocks to asset values.

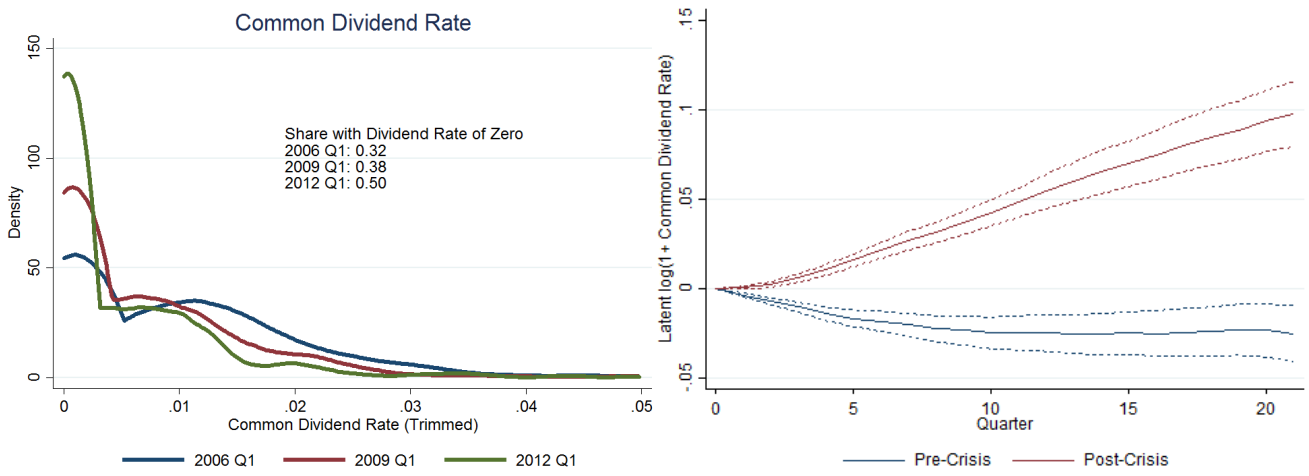



Figure 21: The Effects of the Zero Lower Bound for Common Dividends

where now $y_{i,t}$ now represents dividends, issuance payments or book returns. To report the cross-sectional impulse responses, rather than tracing the rate, we sum up cumulative deviations from the mean.[32]

Corporate finance makes a distinction between internal and external equity financing. Agency theories suggest that internal financing should be cheaper. We find that the cumulative response of common dividend rate to return shocks is positive pre-crisis and negative post-crisis. This is an indication that post-crisis banks tend to lower dividends to raise equity internally. The pre-crisis bank acts differently. It raises its dividends in response to negative returns.[33] By contrast, issuance rates have the exact opposite pattern: pre-crisis shocks lead to higher issuance rates, while post-crisis banks participated in active issuances.

Another lesson is that the cumulative response of issuance rates is much larger than that of dividend rates. The post-crisis response of issuance rates is 3 times the magnitude of the dividend rate response. This may be in part due to the zero-lower bound on dividends. To investigate this further, Figure 21 shows kernel density estimates of the distribution of common dividend rates. This robustness check shows a new impulse response function for the common dividend rate estimated via a Tobit model with left censoring of dividend at zero. The kernel density estimates and accompanying summary statistics indicate that a dividend rate of zero is common. The alternative estimate suggests that the cumulative response of post-crisis common dividend rates to return shocks would have been larger

[32]We do this because for flows we are interested in how the flows cumulate over time to affect the flows: elevated issuance rates cumulate to an increase in equity, book returns cumulate to a change in book equity, etc. In practice this is also useful econometrically: we are able to get precise estimates when we plot the cumulative response of these flow variables, while attempting to trace out the path of the flows gives us estimates that are mostly noise. Moreover, since our flow variables do not depend on the size of the bank, there is no need to take first differences as we do for the stock variables.

[33]Some of this effect may be mechanical: dividend per share tends to be fixed, and so a return shock leading to an increase in market cap will automatically lower the dividend rate, and this effect will cumulate until the dividend per share is newly set.

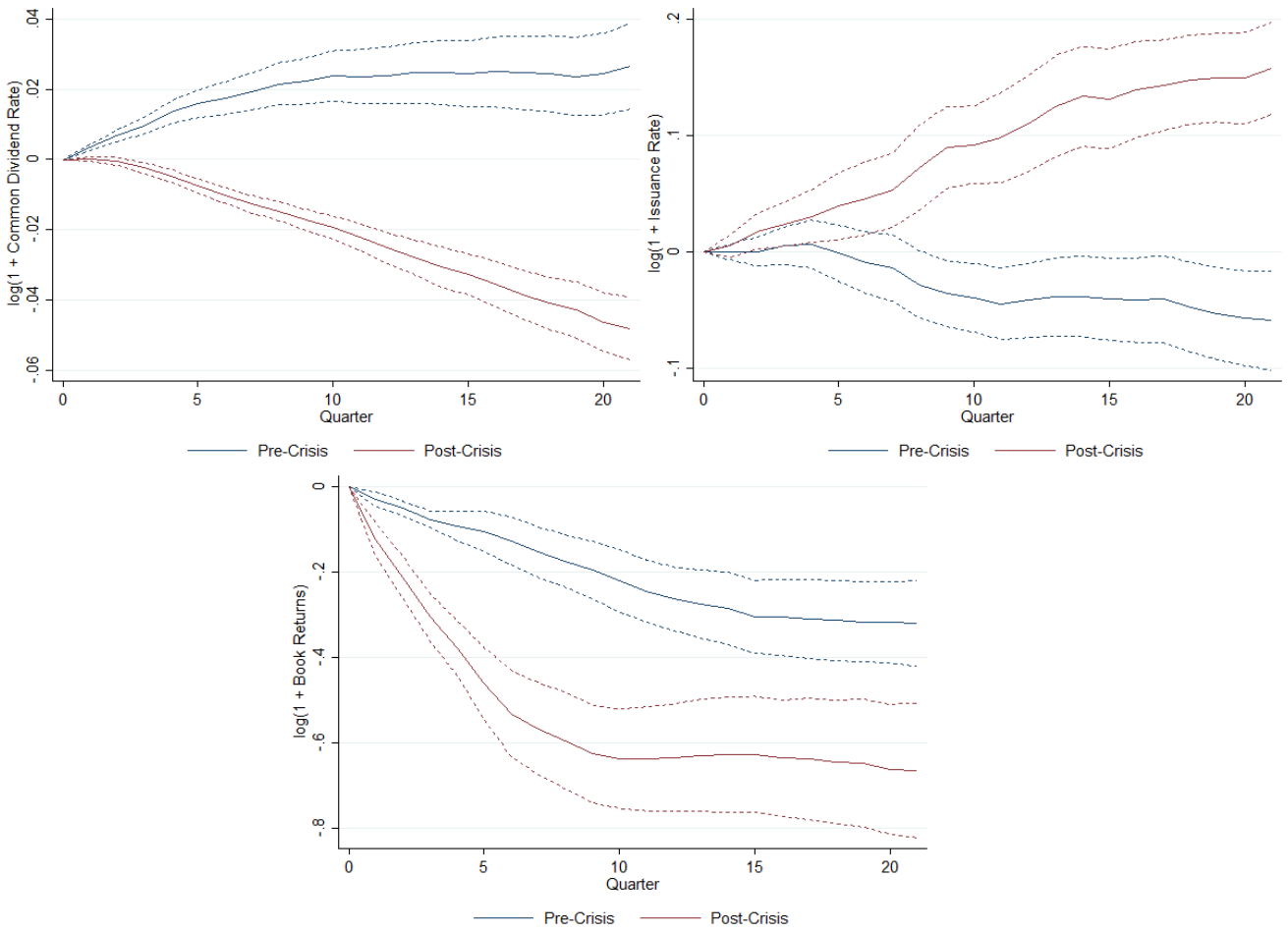



Figure 22: Estimated Impulse Responses for Flow Variables

had dividends not been constrained by 0. However, the Tobit estimates suggest that even without this constraint, the response of dividend rates would still be, if anything, smaller than issuance rates. To interpret both figures, think of a negative shock again. The figure suggests that post-crisis, banks retain earnings and issue equity to decrease their leverage. In the pre-crisis, this equity policy is not present, perhaps because banks would decrease their entire balance sheet as we saw above, reversing the equity policy. Finally, book returns track market returns slowly and only partially with more sensitivity post-crisis.

## 4.3 Equity Issuances and Dividends

The impulse responses show how banks were actively using retained earnings and equity issuances to recapitalize in the crisis. How successful were they in the aggregate? Looking at equity and dividends, we find that banks did a great deal to raise new equity both internally and externally, including a substantial infusion of temporary equity through TARP. However, new equity was insufficient to make up for losses in market capitalization. Observe Figure 23. Prior to the crisis, banks issuance and dividend rates were roughly the same;

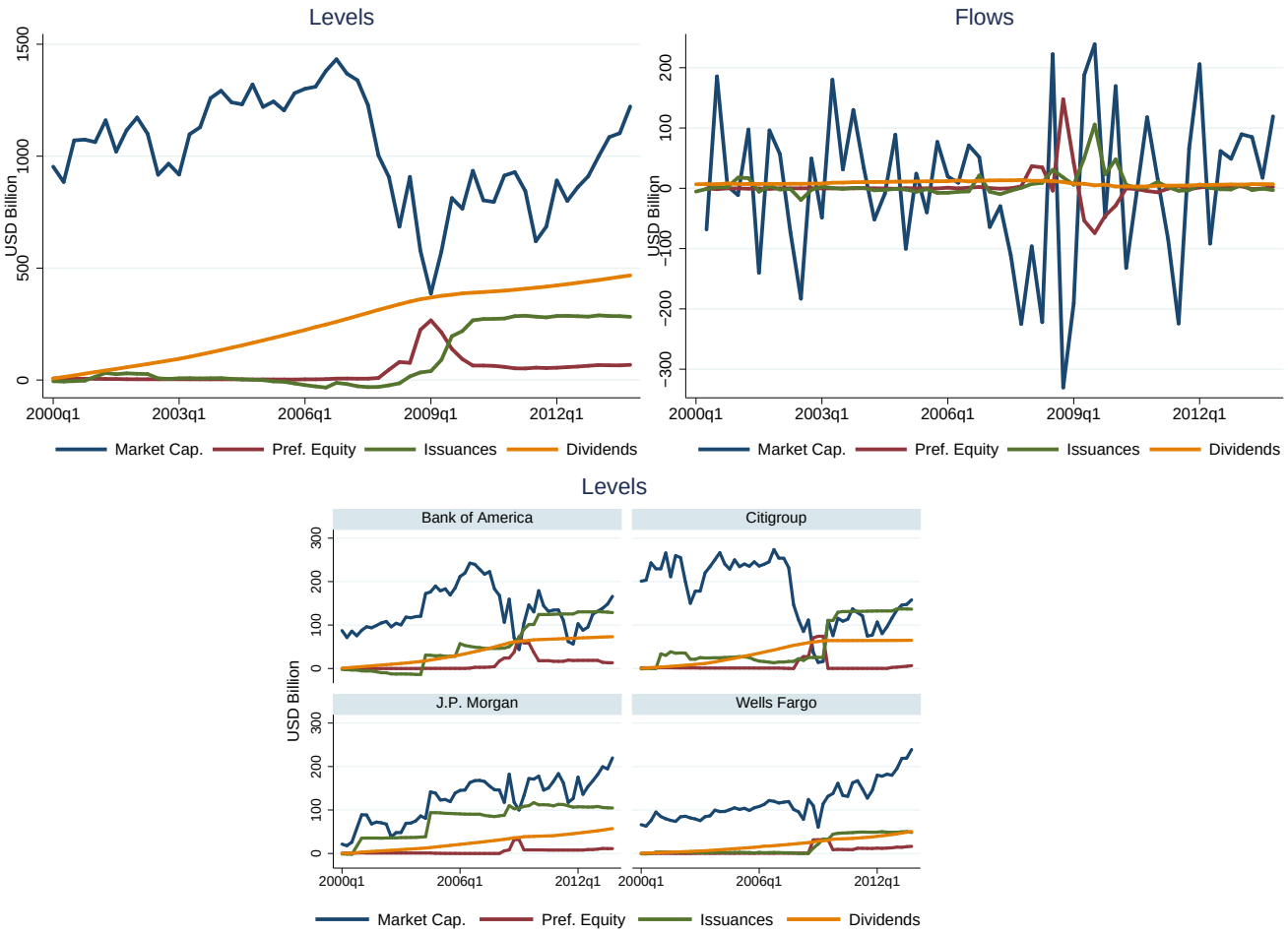



Figure 23: Market Capitalization, Equity Issuances, and Dividends of BHCs
"Levels" figures show the level of market capitalization and preferred equity, along with the cumulative common equity issuances and total dividends since 2000 Q1. "Flows" figure shows the quarterly change in market capitalization and preferred equity, along with quarterly common equity issuances and total dividends.

post-crisis there has been a sharp rise in equity issuances and a decline in dividends.[34] However, movements in market capitalization are substantially larger than the smoothing provided by dividends and issuances. This time series is consistent with the evidence from the estimated impulse responses, which also found sizable but incomplete smoothing through issuances and dividends. This suggests that banks faced important frictions and constraints that slowed their issuances and limited the response of dividends. Several theories suggest that banks can have a target for leverage and that that they should be reluctant to issue new equity. Obviously, they cannot lower dividends to below zero. In tandem, this may have prevented banks from fully smoothing their wealth shocks, and thus, would have inclined them to lend less during the crisis. Next, we investigate why banks face costs to adjust their assets and liabilities.

## 4.4 Sticky Balance Sheets

To shrink its balance sheet, a bank can both sell an asset and payout liabilities. This operation is not an option if there are constraints on either the asset or the liability side. Next, we explore the data to shed light on either possibility.

### 4.4.1 Sticky Liabilities

One hypothesis is that banks cannot pay off liabilities because bank liabilities cannot be pre-paid: a bank cannot call a depositor and ask him to take his money away —this of course depends on the the elasticity of deposit demand. To examine this possibility, compare how banks adjusted their liquid vs. illiquid liabilities. In Figure 24, we present kernel density estimates of the distribution of Repo as a share of total liabilities. We think of Repo as absolutely liquid liabilities because they mature in less than a quarter. We use 2006 Q1, 2009 Q1, and 2012 Q1 as reference quarters, and present both estimates unweighted and weighted by total liabilities. The figures show that most banks had some Repo on their balance sheet and not all of their liabilities were deposits. These facts are particularly strong for the larger banks that drive the aggregate leverage. This suggests that banks indeed had room to reduce their liquid liabilities. Unless Repo is used to finance a safe asset position, like using Repo to exploit an arbitrage, sticky liabilities seem unlikely to have played a role in banks' responses.

[34] In the aggregate series, we have subtracted the value of acquisitions of other BHCs from issuances, since these acquisitions do not raise equity for the BHC sector in aggregate. In the series for the big four, some of the increase in issuances was for the acquisition of failing banks, but much of it was to replenish the bank's own equity e.g. Citigroup $85 billion equity issuance in 2009 Q3.

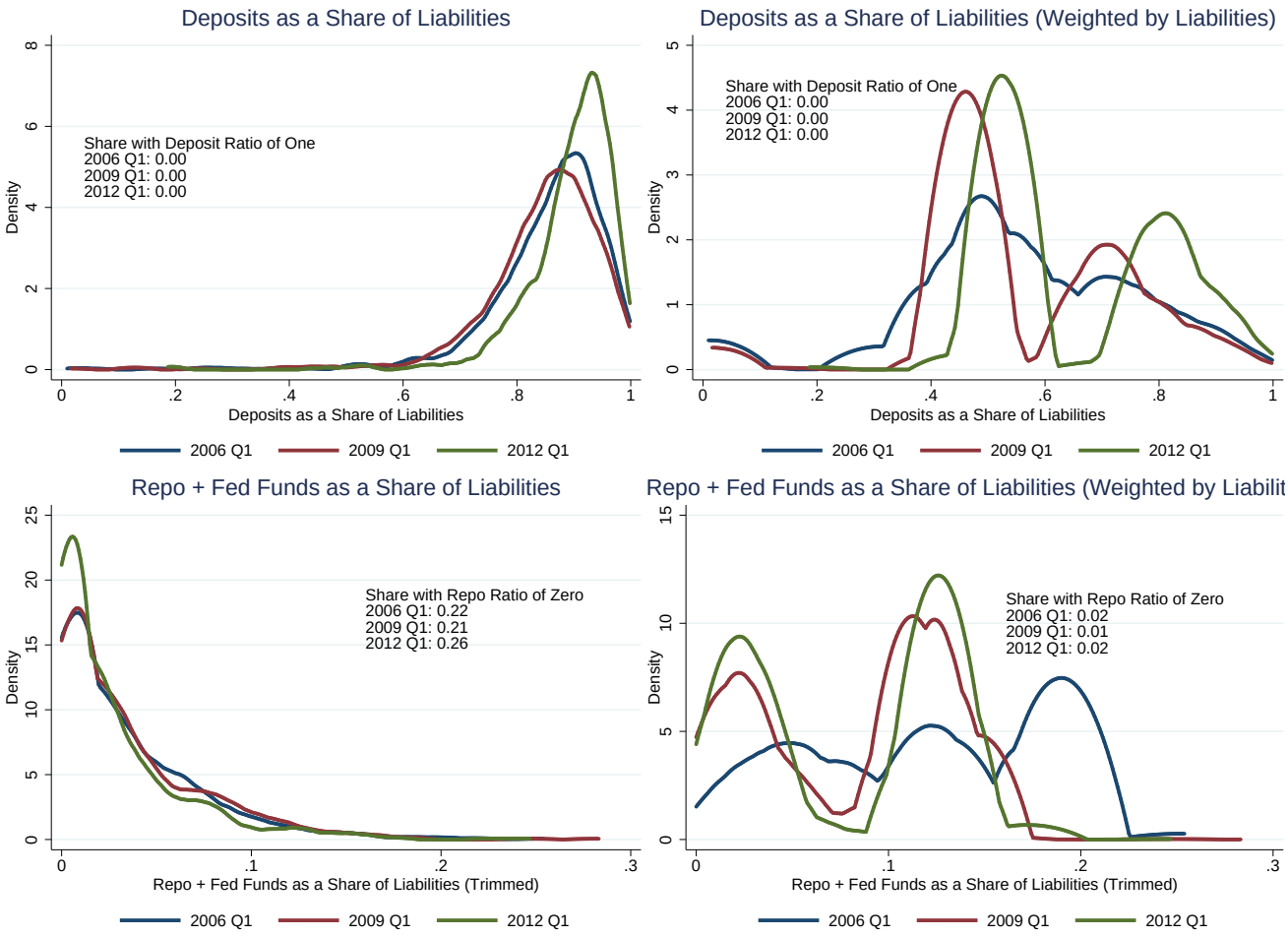



Figure 24: Liquidity of Deposits for Bank Holding Companies

### 4.4.2 Sticky Assets

In case liabilities could be repaid relatively easily, banks can delever by selling assets. Some assets may be illiquid and thus difficult to sell. This illiquidity could have a number of causes, such as relational capital, bank specific expertise, asymmetric information, or the incentives to avoid acknowledging book losses on the books.[35]

## 4.5 Taking Stock

This section has provided evidence on a number of potential constraints faced by banks. We showed that two candidate classes of constraints, book-based leverage constraints and risk-based funding constraints, are not consistent with the data, at least in the way these constraints are typically formulated. In the case of book-based leverage constraints, it is because accounting rules give banks great flexibility to delay acknowledgement of asset impairments, and thus means that books are not tightly connected to market values, at least in the short run. We then provide evidence that a model with market-based leverage constraints that induces a target level of leverage may explain the data, but only when combined with dynamic frictions that slow the response of assets, issuances, and dividends. Such a model of bank behavior, combined with the evidence from the previous sections on the aggregate shocks faced by the banking system, could form the backbone of a more complete model of the banking system during the financial crisis.

The differences between pre- and post-crisis responses suggests that, during the crisis, it was harder for banks to delever by selling assets — potentially in response to the unwinding of shadow banks. Thus, they resorted to their only remaining option, adjusting their equity, which occurred slowly over time. The reluctance to sell assets might have be related to the desire to avoid realizing losses.

# 5 A Simple Model with Strategic Leverage Accounting

## 5.1 Overview

In this section we present a model of bank portfolio decisions. The goal is to present a model that can rationalize the discussions of the previous sections and that can serve potentially illustrate the elements needed in a quantitative macroeconomic model that can explain the facts discussed thus far.

[35] See Subsection 4.1 for a discussion of regulatory constraints on book leverage, and how they might create an incentive not to sell assets whose market value has fallen below its book value.

**Environment.** There is a continuum of banks that differ in their initial asset positions. There are two periods, $t = \{0, 1\}$. In period 0, a set of financial decisions are made. In period 1, banks realize returns.

**Initial Portfolios.** Every bank enters period 0 with with a stock $\lambda$ of loans and $(1 - \lambda)$ in reserve holdings —where $\lambda$is a fraction. Banks also begin the period with an amount of liabilities $l \leq 1$ denominated in deposits. Banks are heterogenous in that they have an idiosyncratic draw for the riskiness of their portfolio. This risk is indexed by a single parameter, $p$, which is drawn from a distribution $G(p)$ with support in $[0, 1]$. The draw of $p$ is available to the market, but not to regulators. Otherwise, all banks are identical.

At period 0, banks extend new loans. Loans are an exchange of claims: the bank gives a borrower an amount of deposits $q$ per-unit of loans borrowed. By period 1, the fraction of loans that don't default, pay back the bank one unit of deposits. The price of loans $q$, can take one of two values $q \in q_l, q_h$ —we assume that $q_l \leq q_h \leq 1$. The law of motion for loans between period 0 and period 1 is:

$$b = \lambda + I$$

where $I$ is the new flow of loans. The stock of deposits evolves accordingly:

$$l' = l + qI.$$

Notice that the inverse of $q$ can be interpreted as a gross interest rate. For now, I is the only choice variable for a bank is $I$ —later we allow for an early dividend and equity issuance decisions.

At the begining of period 1, each bank will have a new draw for performing loans, $\varepsilon$. To keep it simple, we assume $\varepsilon$ follows a binomial distribution:

$$\varepsilon = \begin{cases} 1 & \text{with prob } p \\ \delta & \text{with prob } 1 - p \end{cases}.$$

where $p$ is the risk portfolio of the bank. The wealth for the bank at period 1 for a given draw of $\varepsilon$ is given by:

$$W'(\varepsilon) = \varepsilon b' + (1 - \lambda) - d'.$$

**Regulatory Constraints.** We assume that banks face a constraint on their portfolio given by regulation. However, the regulatory framework makes a distinction between the book value of loans and the market value. In addition to their portfolios, banks enter the period carrying a valuation of their loan, $\tilde{q}$, which can be interpreted as a regulatory estimate of the price at which the bank can sell the old vintage of loans. Within the period,

the bank will update this price as follows:

$$\tilde{q}' = \begin{cases} \frac{\lambda}{\lambda+I}\tilde{q} + \frac{I}{\lambda+I}q & if\ \text{I}\geq 0 \\ q & if\ \text{I¡0} \end{cases}.$$

In words, if the bank increases its lending position, for regulatory purposes, the price is a weighted average of past loans and current loans. However, if the banks liquidates loans, the price is updated to current market values. This object is important for the bank because it is critical for the evaluation of the bank's portfolio constraint:

$$l' \leq \kappa \tilde{q}' (\lambda + I) + (1 - \lambda).$$

This constraint has some features that we see in practice. First, $\kappa < 1$ is a risk-weight on loans. Second, loans are priced according to the valuation of books given by $\tilde{q}'$. Finally, reserves have a risk weight of 1 —the role of introducing cash in the model will be clear in a few lines.

**Objective Function.** The bank evaluates wealth according to a CARA utility criterion:

$$U(W') \equiv -exp(-\gamma(W'))$$

where $\gamma$ captures the bank's absolute risk-aversion. The role of the second shock, $\varepsilon'$, is to introduce risk when new loans are decided so that portfolio problems can be interior in some cases. Banks then have the following objective:

$$V(p, q) = max_{\{I \in \Gamma(q,\tilde{q})\}} \mathbb{E}[U(W'(\varepsilon))],$$

subject to the law of motion of its wealth and the regulatory constraint.

## 5.2 Analysis

### 5.2.1 Characeterization of Constraint Set

When lending flows, $I$, are positive for a bank, we can substitute the law of motion for book prices, and we can rewrite the bank's constraint like this:

$$l + I \leq \kappa(\lambda\tilde{q} + \iota q) + (1 - \lambda). \text{ for I}\geq 0.$$

To reduce the number of parameters, we make an additional assumption. We assume that in the prior date, banks had positive investment, they had no reserves, and the regulatory constraint was binding. Thus, we assume that all banks had deposits in the amount $l = \kappa\tilde{q}$. Under this assumption, the constraint becomes:

$$I \leq \frac{1-\kappa\tilde{q}}{1-\kappa q}(1-\lambda) \equiv \gamma_{+}(q,\tilde{q}).$$

The value of $\gamma_{+}(q,\tilde{q})$ naturally depends on current market prices and past book prices. It imposes a cap on positive lending.

In the region of negative investment, the constraint changes because :

$$l' \leq \kappa q(\lambda + I) + (1-\lambda), \ for \ \text{I¡0}$$

Now, performing the same substitutions, we have that we obtain:

$$I \leq \frac{\kappa(q\lambda - \tilde{q}) + (1-\lambda)}{1-\kappa q} = \gamma_{-}(q,\tilde{q})$$

We make some additional assumptions to simplify things.

**Assumption 1.** $\kappa q \leq 1$ for any q.

The role of reserves should be clear, is that together with this assumption imples there is alwasy a finite maximial investment. We can combine pieces to obtain a single constraint set:

$$I \in (-\infty, min\{0, \gamma_{-}(q,\tilde{q})\}) \cup [0, \gamma_{+}(q,\tilde{q})] \equiv \Gamma(q,\tilde{q}).$$

The constraint set clearly depends on the values of $q$ and $\tilde{q}$. It features two interesting situations. Either $\gamma_{-}(q,\tilde{q}) < 0$ and the constraint set is given by two disjoint intervals or $\gamma_{-}(q,\tilde{q}) \geq 0$ and the relevant constraint set $(-\infty, \gamma_{+}(q,\tilde{q})]$.

Thus, the only interesting situation discussion is about the sign of $\gamma_{-}(q,\tilde{q})$ and what happens when this number is negative. It is easy to show that the sign depends on

$$\lambda \geq \frac{1-\kappa\tilde{q}}{1-\kappa q}.$$

**Assumption 2.** $\tilde{q} = q_h$ and $\lambda < (1-\kappa q_l)/(1-\kappa q_h)$.

Thus, we will consider situations where a high price is inherited from past periods. Furthermore, the constraint set is disjoint if and only if the price drops to $q_l$. Next, we discuss the optimal portfolio decisions.

### 5.2.2 Portfolio Problem

First, we derive the unconstrained solution to the bank's portfolio problem:

$$V(p,q) = -max_{\{I\in\Gamma(q,\tilde{q})\}} p \times exp(-\gamma(\lambda + (1-q)I - q_h\kappa + (1-\lambda))) ...$$

$$+(1-p)\,exp\left(-\gamma\left(\delta\lambda+(\delta-q)\,I-q_h\kappa+(1-\lambda)\right)\right).$$

We make an assumption that guarantees an interior solution for $I$.

**Assumption 3.** $\delta - q_l < 0$ and $(1-p)\,\delta + p > 1$.

With this, we can take first-order conditions for this problem are:

$$p\gamma\,(1-q)\,exp\left(-\gamma\left((1-q)\,I+1-q_h\kappa\right)\right)+(1-p)\,\gamma\,(\delta-q)\,exp\left(-\gamma\left(\delta\lambda+(\delta-q)\,I-q_h\kappa+(1-\lambda)\right)\right)=0.$$

Therefore, the loans demand condition given by:

$$I^*(p,q) = -\frac{1}{\gamma\,(1-\delta)}log\left(\frac{(1-p)\,(\delta-q)}{p\,(1-q)}\right)-\lambda.$$

Here, $I^*(p,q)$ is the optimal unconstrained flow of loans for banks. As $p$ increase, this demand is higher. Banks with high risk, want to delever their banks. However, this may be unfeasible under certain conditions.

### 5.2.3 Deleveraging under different loan-price

**High Price Regime.** Assume that $q = q_h$. Then, by Assumption 2, $\gamma_-(q,\tilde{q}) \geq 0$. Thus, it does not activate the constraint on delevaraing. The only constraints emerge for banks that want to expand their lending.

**Low Price Regime.** Assume that $q = q_l$. Then, by Assumption 2, $\gamma_-(q,\tilde{q}) < 0$. Thus, there is a disjoint interval for the flow of loans. Consider now the case of a bank for which:

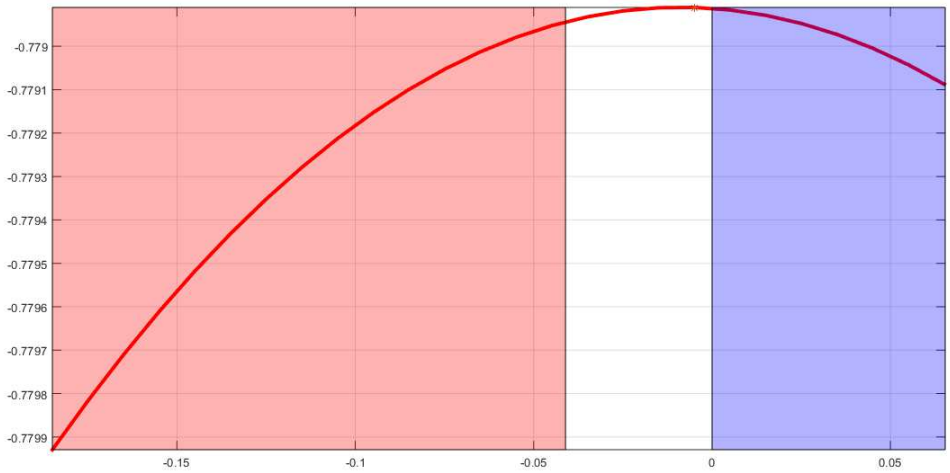
$$I^*(p,q) \in (\gamma_-(q,\tilde{q}),0).$$

Clearly, for that bank, the optimal sale of loans is not feasible. Since his problem is concave, the objective in $V(p,q)$ is decreasing in $I > I^*(p,q)$ and increasing for $I < I^*(p,q)$. Thus, the bank's solution is given by:

$$V(p,q) = max_{I\in\{\gamma_-(q,\tilde{q}),0\}}\mathbb{E}\left[U\left(-\gamma\left(\varepsilon\lambda+(\varepsilon-q)\,I-q_h\kappa+(1-\lambda)\right)\right)\right]$$

It is not hard to verify that whenever $q = q_l$ there is a mass of banks that will set $I = 0$. For those banks, the constraint appears not to bind. However, it is definitely binding. If they chose to delever, they have to update prices. This update in regulatory pricing may tighten the constraint so much, that they chose to remain in a stand-by situation. In this case, leverage remains higher than otherwise. This is the situation in the depiction below. The red curve is the portfolio value for a bank for different choices of investment in loans. The area shaded in red is the area of investment sales that are feasible. The blue is for positive

investment and the white area is unfeasible. In this example, the bank is better off chosing inaction.




### 5.2.4 Dividend Payouts and Equity Injections

**Dividends.** Consider now the possiblity of divident payouts. In this case, deposits evolve as follows:

$$l' = l + qI + d.$$

where $d$ are dividend payments. We assume that dividends are paid out in deposits, but the analysis is the same, even if they are paid out in reserves. Dividends affect the stock of liabilities. Thus, they enter the bank's constraint. Banks solve an alterantive problem that includes the benefit of early dividend payments:

$$max_{d \in \mathcal{R}} u(d) + V(p, q; d)$$

for some concave utility $u$. Now consider effect of dividend payments. Because of CARA utility, they don't affect the unconstrained amount of loan purchases. In fact, CARA allos us to break the bank's problem into:

$$max_{d \in \mathcal{R}} u(d) + V^0(p, q; d)\, exp\left(-\gamma\left((1-\lambda) + d - q_h\kappa\right)\right)$$

where

$$V^0(p, q; d) = max\mathbb{E}\left[U\left(-\gamma\left(\varepsilon\lambda + (\varepsilon - q)I\right)\right)\right]$$

subject to:

$$I \leq \frac{\kappa\tilde{q}'(1-\lambda) + (1-\lambda-d)}{1-\kappa\tilde{q}'}.$$

We can conjecture that as $q$ falls, provided constraints are not active, the bank faces greater invesetment opportunities and retains earnings. If constraints bind, this reinforces the desire to relax constraints. In the low price regime, banks in the inaction region, on the contrary, have incentives to pay dividends. We expect a similar pattern to hold for equity injections. This is work to be completed.

### 5.3 Taking Stock

We end this section with a brief discussion of how the model connects the dots we painted by studying the data. Section 2 suggested that the outflow of assets didn't crowd out bank loans in the direct way we are used to thinking about. However, shadow banks may have affected traditional bank behavior because their decline affected the value of MBS and the secondary value of loans. In an environment with ensued risks, this should have lead to a decline in the flow of new loans by banks. However, rather than selling loans in the secondary market, banks may have chosen to simply stop lending because reallocating loans could have activated severe tightening in book values. This pattern can explain whay we saw such a large discrepancy between book and market values.

Although our constraint is ad-hoc, it is consisntent with anectodal evidence gathered from practicioners and the accounting literature. The reconciles the idea that bank-credit supply could have been constrained even though book and market values appeared not to matter.

## 6 Conclusion

This paper provides a description of the flows within the financial system. When studying the implosion of the shadow-banking system, we found that most of the reduction in shadow-banking assets were channeled through the traditional banking system and landed on the balance sheet of the FED. When we studied the book equity losses of banks, we find that during the crisis, bank books reflect very poorly what will happen with the earning and delinquency rates banks will face in the cross-section. Instead, market values are good predictors. Nevertheless, the cross-section doesn't show a pattern in which banks with largest market value declines shrink there balance sheets in comparison to banks with lower losses. The composition of their liabilities indicates that bank assets were hard to sell. The flow of equity to those banks also reflect a hard time raising equity. We provide suggestions to improve the modeling of banks.

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# A Data Map of the Financial System

In this section we describe the structure of the aggregate data in the Flow of Funds, their challenges, and our ways to deal with these challenges. The Flow of Funds of the U.S. financial system published by the Federal Reserve on a quarterly system provide an aggregate overview about book-value positions of key financial intermediares. Most data for the aggregate tables are sourced at the micro-level, such as banks regulatory filings (call reports) and broker-dealer SEC filings. For some tables though, in particular for the household sector, the data is derived as a residual.

The sectors in the Flow of Funds are defined by function rather than by corporate organization. As a consequence, a large modern bank holding company can show up in different sector tables of the Flow of Funds at the same time, for it can consist of hundreds if not thousands subsidiaries. For example, as of May 2015, JP Morgan Chase & Co has 5624 subsidiaries in a nested hierarchy (see FFIEC web link on organizational hierarchy). The picture that emerges from JPMorgan's organizational hierarchy is that of a complex financial institution that engages in many non-bank related business activities. Bank holding companies such as JP Morgan encompass both traditional depository institutions as well as security broker-dealers, insurance companies, and so on. Each different business segment shows up in its appropriate Flow of Funds table. For example, the commercial banks of JP Morgan are recorded in the depository institution table. The security broker-dealer JP Morgan Securities, Inc is recorded in the security broker-dealers table. Information on the parent holding company is in holding company data table and so on.

During the last quarter of 2008, the largest hitherto independent investment banks began their transition to becoming a bank holding company. The bank- and financial holding company of Goldman Sachs consists among others of the depository subsidiary Goldman Sachs Bank U.S., the security broker-dealer Goldman Sachs & Co, insurance companies, trusts, power marketer, and so on. Figure 25 illustrates the bank holding company structure for the case of Goldman Sachs - one of the new bank holding companies.

The goal of this paper is to measure the extend to which the unraveling of the shadow banking sector has impaired the credit provision ability of the traditional sector. This agenda presupposes that financial intermediaries can be separated into two different types. However, the Goldman Sachs and the JP Morgan example highlight the difficulty to separate financial intermediaries into traditional banks (depositories) and shadow banks (security broker-dealers). With the passage of the Gramm-Leach-Bliley act in 2009, bank holding companies were allowed to become financial holding companies, allowing them to engage in a range of non-bank financial services, while at the same time preserving a stable funding environment through insured deposits.[36] We have thus to be careful to structure financial

[36] A bank holding company with FDIC insured commercial bank subsidiaries and security broker-dealer

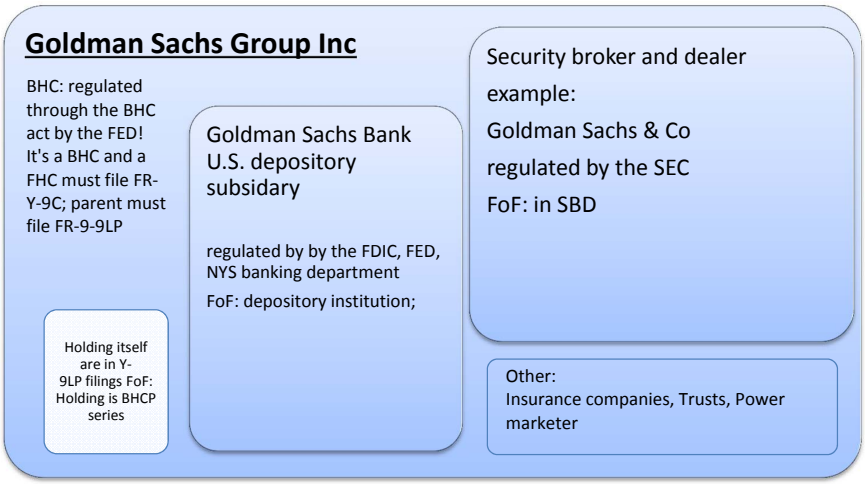


Figure 25: Goldman Sachs

intermediary types according to the Flow of Funds sector tables.

Given the macroeconomic focus of this paper, we separate financial intermediaries into two different types depending on their major line of business: (i) loan and credit providing banks, funded mainly with deposits, (ii) securitizing banks funded mainly with short term debt raised on capital market (shadow-assets), and (iii) short term credit holding institution funded with shares whose value does not fall below one (shadow-liability).

The major challenge in using the Flow of Fund tables directly is in not knowing which shadow-asset institutions are subsidiaries of regulated bank holding companies and to what extend this bank holding company engages in lending. Take the example of Goldman Sachs. It only became recently a bank- and financial holding company. Only a small share of its assets are tied up in a depository institution, however it can take advantage of its funding stability, or at least expectation thereof. A shock to Goldman's security broker-dealer can therefore be much easier absorbed in its own holding company.

Some other investment banks were absorbed by a more traditional looking bank holding company. This led to the transfer of the impaired balance sheet of the shadow-asset institution onto the traditional bank. This has the potential to impair the balance sheet of the traditional bank and lower its credit supply. Moreover, given the complex nature of the regulated bank holding company, some of its subsidiaries are shadow-asset institutions themselves though its liability are backed by the holding company. Given that these banks are important credit providers, a large shock to its shadow-asset subsidiaries or acquiring one can potentially affect its ability to lend. The Flow of Funds data do not allow us to distinguish between these two.

subsidiaries can back up its troubled non-bank subsidiary, though there are some regulatory limitations. This within firm insurance has been possibly an incentive for shadow banks to become a regulated non-shadow bank.

To overcome this challenge we use FOCUS and annual report data whenever applicable. The publicly available portion of the FOCUS reports for a subset of security broker-dealers allows us to differentiate assets and liabilities from security broker-dealer subsidiaries from those of the bank holding company.

A seperate issue arises when using Flow of Funds data for money market mutual funds. The tables aggregate prime and government money market funds. If not corrected for, the aggregation can mask the actual outflows in the system. Whereas prime money market mutual funds suffered large outflows, government money market mutual funds actually experienced large inflows. We use data by the Investment Company Institute (ICI) that are used by the Flow of Funds to separate prime money market funds and their asset holdings from government money market funds.

Finally, hedge funds are not broken out in the Flow of Funds but are part of the household sector, even though they are important financial players. We make use of the Hedge Fund data base from Morningstar in order to get a sense for the changes in their portfolios and the potential losses that they incurred. We only focus on Hedge Funds domiciled in the U.S. that have non-missing information for both returns and asset holdings.

# B List of events of the Financial Crisis

This section draws heavily on the time line provided by the Federal Reserve Bank of St. Louis.

We review the basic events of the recent financial crisis with a particular focus on the response of the Federal Reserve Board. The latter can be roughly divided into two phases. During phase I, the Federal Reserve Board was engaged in more traditional monetary policy actions to support the financial system, meanwhile traditional banks started purchasing assets from the shadow banking sector, i.e. oftentimes assets from their off-balance sheet vehicles. During Phase II, the Federal Reserve Board carried out more unconventional policy actions, such as establishing facilities to buy shadow banking assets directly as well as through the traditional banking system. As the time line makes clear, almost all financial institutions enjoyed the benefits from government support, in one way or another.

On February 27, 2007 Freddie Mac announced that it would no longer buy risky subprime mortgages and related securities. Over the course of the spring in 2007, signs of trouble in the housing market intensified. After Countrywide Financial Corporation (a savings and loan holding company) was downgraded by Fitch and drew down credit from its credit lines (August 16, 2007), the Federal Reserve Board reduced the primary credit rate (rate at which banks could borrow using the discount window) and noted that a crisis might be looming. The federal funds rate was first reduced on September 14, 2007.

In October 2007, three of the largest U.S. banks (CITI, JPM, BOA) announced a plan

for a "Master Liquidity Enhancement Conduit", i.e. a privately funded bailout fund for assets from special purpose vehicles. In other words, traditional banks planned on footing the bill to prevent a potential fire sales of their off-balance sheet assets. However these plans were abandoned in December 2007 on the belief that such a fund was unnecessary at that time. Early 2008, Bank of America announced its plan to buy Countrywide Financial Corporation for $4 billion.

Starting on December 12, 2007, the Fed announced the introduction of the Term Auction Facility (TAF) that allowed depository institutions to borrow from the Fed against a wide range of collateral. In March 11, 2008, the Federal Reserve Board decided to extend its support of the financial sector to primary dealers by introducing the Term Securities Lending Facility (TSLF). The TSLF allowed primary dealers to exchange agency and AAA private label mortgage-backed securities against Treasury securities. This transaction represented a swap of bonds against bond and thus did not require a change in reserve or deposits. A few days later, the FED established the Primary Dealer Credit Facility (PDCF) allowing primary to borrow funds from the Federal Reserve at the primary credit rate against many investment grade securities. These facilities were in line with a lender of last resort role of the Federal Reserve. The only unconventional part of that role was that it also included lending to primary dealers. Over the course of the crisis, the Fed loosened the terms of credit provision with regard to maturity, amount, as well as collateral requirements.

When in March of 2008, it became clear that Bear Stearns was in serious trouble, the Federal Reserve Bank of New York created the limited liability company Maiden Lane LLC to facilitate the unwinding of Bear's risky assets. After the Fed had agreed to buy Bear Stearns $30 billion worth of assets, JPMorgan agreed to acquire Bear Stearns for $2 dollars a share and an exposure to its assets of only $1 billion. The remaining exposure of $29 billion was taken on by the Fed.[37]

In July 2008, the Fed announced that it would lend to Fannie Mae and Freddie Mac if necessary and the Treasury increased its credit lines to the GSEs. Two month later, the Federal Housing Finance Agency placed the GSEs under government conservatorship.

One day before Lehman collapsed, the Fed allowed bank holding companies to use their depository institution subsidiaries to provide liquidity to other affiliates. On September 15, 2008 Bank of America bought Merrill Lynch & Co for $50 billion and Lehman filed for bankruptcy. Shortly after, the Reserve Fund, a money market mutual fund with heavy exposure to Lehman Brothers, broke the buck. This prompted the Federal Reserve to create the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF). This facility provided cheap credit to depository institutions and bank holding

[37]More information can be found on the NY Fed website `https://www.newyorkfed.org/newsevents/news/markets/2008/rp080324.html` and `https://www.newyorkfed.org/newsevents/news/markets/2008/rp080324b.html`.

companies to purchase asset-backed commercial paper from money market funds. The Fed furthermore announced a temporary guaranty program for money market funds that started a few weeks later.

On September 21, 2008 Goldman Sachs and Morgan Stanley were approved to become a bank holding company (i.e. access to TAF, the discount window, etc). A few days later, JP Morgan acquired the banking operations of Washington Mutual that had been closed.

A day after Lehman went bust, the FED set up revolving credit facility to support AIG the unwinding of AIG's assets. The facilities granted AIG initially a credit line of up to $85 billion. In November the FED established two FED funded limited liability companies (Maiden Lane II LLC and Maiden Lane III LLC) to purchases RMBS from `http://www.federalreserve.gov/newsevents/reform_aig.htm{AIG}`.

October 2008 saw the passing of a $700 billion financial institution rescue package, the Troubled Asset Relief Program (TARP). TARP allowed the Treasury to buy mortgages and other troubled assets as well as to provide capital to banks in the form of preferred stock. Eligible institutions were banks, broker–dealers, insurance companies, mutual funds, registered investment companies, certain pension funds, and bank holding companies. In total TARP disbursed $427 billion.[38].

Starting around the same time, the Fed decided to pay interest on reserves with the following rationale:[39]

> The payment of interest on excess reserves will permit the Federal Reserve to expand its balance sheet as necessary to provide the liquidity necessary to support financial stability while implementing the monetary policy that is appropriate in light of the System's macroeconomic objectives of maximum employment and price stability.

# C Financial Assets by Sector

## C.1 Shadow Banking Sector Financial Position

One large portion of assets comes from security brokers-dealers. Most of their assets consist of other securities (see Figure 26 in the appendix) that are mostly borrowed securities. That is, security brokers-dealers held mostly assets that are associated with securitization of assets. Those assets were mostly financed with repos and security credit.

Another important share of shadow asset banking activity is undertaken by asset-backed security issuers (see Figure 27 in the appendix). Most of their assets are related to mortgages

[38] `https://en.wikipedia.org/wiki/Troubled_Asset_Relief_Program`
[39] `http://www.federalreserve.gov/newsevents/press/monetary/20081006a.htm`

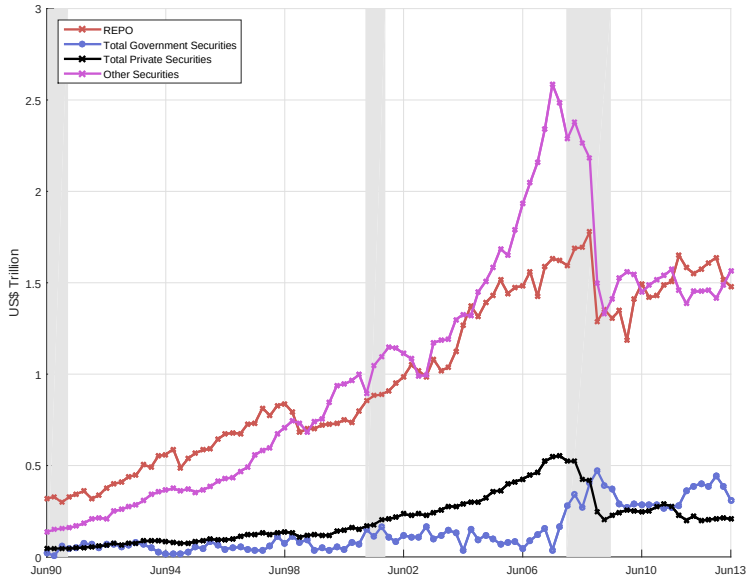


Figure 26: Composition of financial assets: security brokers-dealers

and experienced exponential growth starting during the late 90s and peaking in 2007. Most of their liabilities are either commercial papers or corporate bonds.

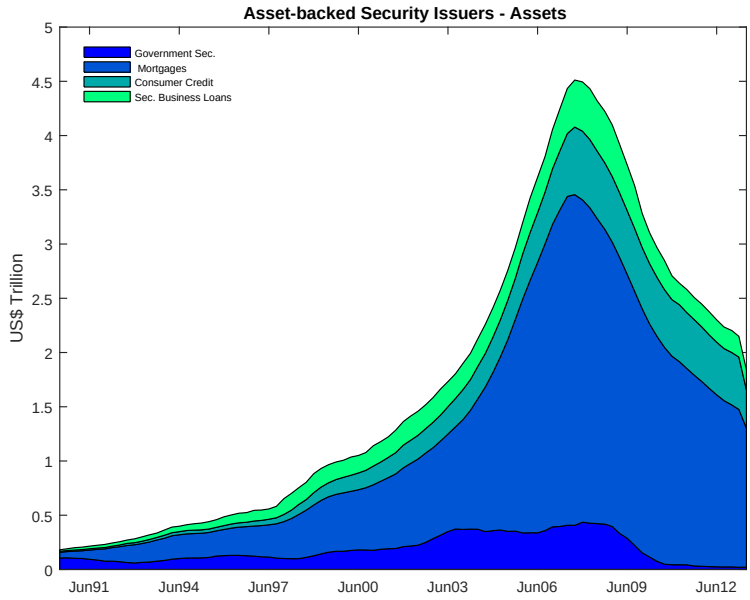


Figure 27: Asset-backed securities issuers