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Bachelor Thesis in Macroeconomics

U.S. Commercial Banks: Trends and Cycles

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Contents

1 ChangeLog

Date	Section: Contribution	Comment
04.05.2020	Extended and Improved Introduction	ready for review
04.05.2020	Leverage General section improved and additional figures added	ready for review
07.05.2020	Introduction, Data, Methods section improved	
12.05.2020	Overview section completed	ready for review

2 Introduction

This thesis is an explorative investigation of the historical balance sheet filings of U.S. commercial banks. Its objective is to shed light on the financial development of arguably the most important backbone of the U.S. economy - commercial banking. Not least, the severe financial crisis in 2008, which originated from the banking industry, proves the importance of regulating commercial banking. However, only with a deep empirical understanding of the behaviour of commercial banks, one can design regulations that are ultimately effective. Using a dataset of balance sheets originally provided as call reports by the FFIEC[1], we analyse the cross-section over time to unveil interesting stylized facts about financial trends (long-term) and cycles (short-term) among commercial banks. The data gives us the unique possibility to get a detailed view into every balance sheet account of both assets and liabilities. We study the dynamics of each account on an aggregated level (all commercial banks) and by different bank sizes. With careful consideration of contextual information such as crisis and regulatory efforts in our time-frame - years 1976-2013 - we are able to gather time-sensitive analytics. For instance, different than one would expect commercial banks balance sheets expand from 2007 to the first half of 2008. Only in the second half of 2008 it begins to contract significantly. This behaviour was related to a variety of factors involved such as: Investment banks bore the first impacts of the crisis, loans prepared for syndication needed to stay on commercial banks balance sheet as demand stalled, monetary interventions by the FED and more. We also use correlation analysis to reveal possible positive or negative relationships between balance sheet accounts. Part of our thesis focuses on the problematic commonly referred to as *"Too Big to Fail"*, where we show the rising unequal distribution of assets among commercial banks and find that economic downturns act as a way of redistributing assets among banks,

[1] Federal Financial Institutions Examination Council

suggesting that larger banks tend to be more affected by crises. Dividing commercial banks into by asset size into categories also conveys large heterogeneity among banks of different sizes. Large and small banks differ in their overall balance sheet composition and risk appetite. For instance, the larger the bank, the more alternative ways of financing are utilized. Different banks sizes also tend to respond differently to major economic incidents. Overall, we find that the two banking crises around 1990 and 2008 impacted the stability of commercial banking the most. Part of the thesis focuses on leverage of commercial banks, as not only Geanakoplos (2010) has emphasized its importance in times of crisis. They show that leverage has a large impact on asset prices, contributing to boom and busts. We analyse leverage over-time and discover that in the crisis 2007/8 there was a spill-over effect among banks, with large banks falling into distress first and smaller banks following with a lag. Furthermore, in the literature, a common area of interest regarding leverage is its pro-cyclicality with assets. Adrian and Shin (2011) found pro-cyclical leverage for all commercial banks.[2] To confirm that their findings are robust, we apply similar methods to our data and compare the results. We discover that Adrian and Shin (2011) results are only partially true. While large commercial banks do show pro-cyclical leverage, small banks actually show no clear cyclical leverage pattern in regards to changes in cyclical assets over the time-frame from $1976 - 2013$. While the leverage of the small bank sector as a whole is pro-cyclic, the average small bank does express no pro-cyclic leverage. In addition, we find that pro-cyclicality is not consistent over the time-frame from $1980 - 2010$. The average commercial bank does have pro-cyclical leverage from $1980 - 1990$, but it is counter-cyclical from $2000 - 2010$. On the other hand, the industries leverage is pro-cyclical from 1990 to 2010. Thereby, although we can not observe consistent pro-cyclical leverage among commercial banks we can confirm Adrian and Shin (2011) notion that commercial banks tend to actively manage leverage in regards to cyclical asset variations. In general, this thesis should be seen as an enhancement and a way of clarification of the wide variety of existing literature exploring similar subjects. This thesis is structured as follows. We begin by outlining the data and methods used. Then, we give a more general overview of commercial banks and elaborate on each balance sheet position. A section about the development of distribution of assets follows. We then continue by analysing banks by different asset sizes. Lastly, we examine commercial banks' leverage.

[2]Adrian and Shin (2011) compute the industries leverage by aggregating assets and equity.

3 Main part

3.1 Data

The analysis in this thesis is build upon a dataset of balance sheets originally provided by the FFIEC. Also named call reports, the FFIEC collects balance sheet information quarterly from every FDIC insured institution. Drechsler et al. (2017) used these reports and formed a consistent time-series from year 1976 quarter 1 to 2013 quarter 4, accounting for variable and other changes over the years. They only included commercial banks (Charter Type 200). To plot these time-series we create a horizontal axis with a tick for every quarter. We also add a year label for every first quarter. This axis is consistently used throughout the analysis. Bank filings with negative equity are removed from the dataset, since they indicate a bankrupt bank. To prevent skewing the data, the two big investment banks Goldman Sachs and Morgan Stanley becoming commercial banks in the proceedings of the financial crisis 2008, are removed. When looking at leverage, we aggregate all commercial banks to their belonging bank holding companies. For our use-case it is not necessary deflate the data.[3] Along the way of our analysis it was often a few key players that drive the measurements. This aligns with the interdependent bank system of today, where just one "too big" bank going bankrupt can lead to significant spillover effects. Hence, we took those key players into careful consideration and did not filter them out as outlier. In the proceedings of the analysis, we took recession definitions provided by the National Bureau of Economic Research into account. They define a recession not in terms of two consecutive quarters of decline in real GDP, but a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production and wholesale-retail sales (NBER (2010)). In addition, we differentiate between so called "banking" (originated in the banking sector) versus "market" (originated from outside banking sector) crisis as in Berger and Bouwman (2012). The assumption is that banking crisis are more strongly reflected in bank data. The banking crisis are the credit crunch of the early 1990s (1990:Q3-1991:Q2) and the 2007/8 financial crisis (2007:Q4-2009:Q3). The market crisis are the two 1980s recessions (1980:Q1-1980:Q3 and 1981:Q3-1982:Q4) and the dotcom bubble (2001:Q2-2001:Q4). Additional events that could be considered as crisis, but not mentioned by the NBER, are the 1987 stock market crash (1987:Q4), the Russian debt crisis and the Long-Term Capital Management (LCTM) bailout of 1998 (11998:Q3–1998:Q4) and they terrorist attacks in early 2000s. Berger and Bouwman (2012), for example, also included this in their analysis. Apart from those crisis, it is

[3] We are only interested in the actual priced value of the banks assets and not the quantity of the assets. Meaning for instance the banks could hold ten assets in 2000 with a value of 100$ and ten in 2013 with a value of 150$ caused by a rise the overall price level. Although there was no welfare increase as the quantity did not rise, the value the banks held still increased.

important to consider other structural events that affected the U.S. commercial banks landscape considerably. We describe the most important ones here. The Gramm-Leach-Bliley Act in 1999 repealed part of the Glass-Steagal Act of 1933, removing barriers that prevented banks from offering traditional commercial banking services and investment banking services or insurance company services at the same time. The Reigle-Neil law in 1994 removed several obstacles to banks opening branches in other states and provided a uniform set of rules regarding banking in each state. The FDIC Improvement Act (FDICIA), passed in 1991, gave the FIDC the responsibility to rescue banks with the least-costly method. Aimed to relativize the evolving moral hazard. To improve banking sectors' stability, regulators started to implement capital and liquidity regulations with the Basel 1 framework in 1988. They released further improvements of this framework with Basel 2 in 2004 and Basel 3 in 2010. Lastly, during our time-frame the banking sector experienced a wide-spread adoption of financial innovations, the main ones being interest rate derivatives, asset securitization and adjustable rate mortgages.

3.2 Methods

We use a number of methods to aid the analysis of banking data over time and in the cross-section. For most methods we transform the data with the natural logarithm. As a result all changes can be seen as percentages. Furthermore, we apply the recognized Hodrick-Prescott Filter with the recommended parameter of 1600 for quarterly time-series to the data.[4] The resulting graphs show the relative cyclical variations of the underlying variable and can be interpreted as percentage changes. For correlations and autocorrelations, we use the linear Pearsons' correlation coefficient. To determine significance we compute the 2-tailed p-value. Significance is then determined according to standard levels.

3.3 U.S. commercial banks

This section provides an overview about the distribution of financial components held by the U.S. commercial banking sector as a whole. We will see what types and amounts of financial instruments banks hold and how these positions have evolved over time.

3.3.1 Stylized balance sheet

Table 1 shows the balance sheet of a typical U.S. commercial bank.

[4]Potential seasonal effects are not accounted for.

Assets	**Liabilities**
Cash	Equity
Fed funds sold and securities purchased under agreements to resell (fedfundsrepoassets)	Fed funds bought and securities sold under agreements to repurchase
Securities: - Treasury - Mortgage-backed Security (MBS) - Other	Deposits: - short - other
Loans net	
Trading assets:	Trading liabilities
- net interest rate derivatives - net other fixed income - net other trading	
Other assets	Other liabilities

Figure 1: Stylized balance sheet of U.S. commercial bank

We simplify the balance sheet of a typical U.S. commercial bank similar to Drechsler et al. (2017). It is important to note that every position besides the trading assets are not held "for trading purposes". Meaning for instance the securities position and the loans position are not held for trading. Cash consist of noninterest-bearing balances, with currency and coin included, and of interest-bearing balances. Federal funds sold and securities purchased under agreements to resell are both ways of lending excess cash to fellow commercial banks in return for interest. Fed funds bought and securities sold under agreements to repurchase in turn are ways of borrowing cash in the short-term. Securities can be divided into held-to-maturity and available-for-sale. These categories then include a large amount of different types of securities, with Treasury and MBS being the largest. Loans are netted by unearned income and allowance for loan and lease losses to gather their existent value. Trading assets are securities held with the intention to sell them with profit. They are intended to be held only for short-term. Trading asset can be in any type of form such as a derivative, Mortage-backed Security (MBS) or a loan. Trading liabilities tend to be in the form of short positions or derivatives. Deposits can be divided into transaction and non-transaction deposits. Time and savings deposits make up non-transaction deposits, while the major part of transaction deposits are demand deposits. Other assets are composed of derivatives "not for trading" and other items that have a small share and do not fit into the named categories.

3.3.2 Overview

Figure 2 gives a general overview how the aggregated total assets held by all banks per year and quarter have evolved over time.

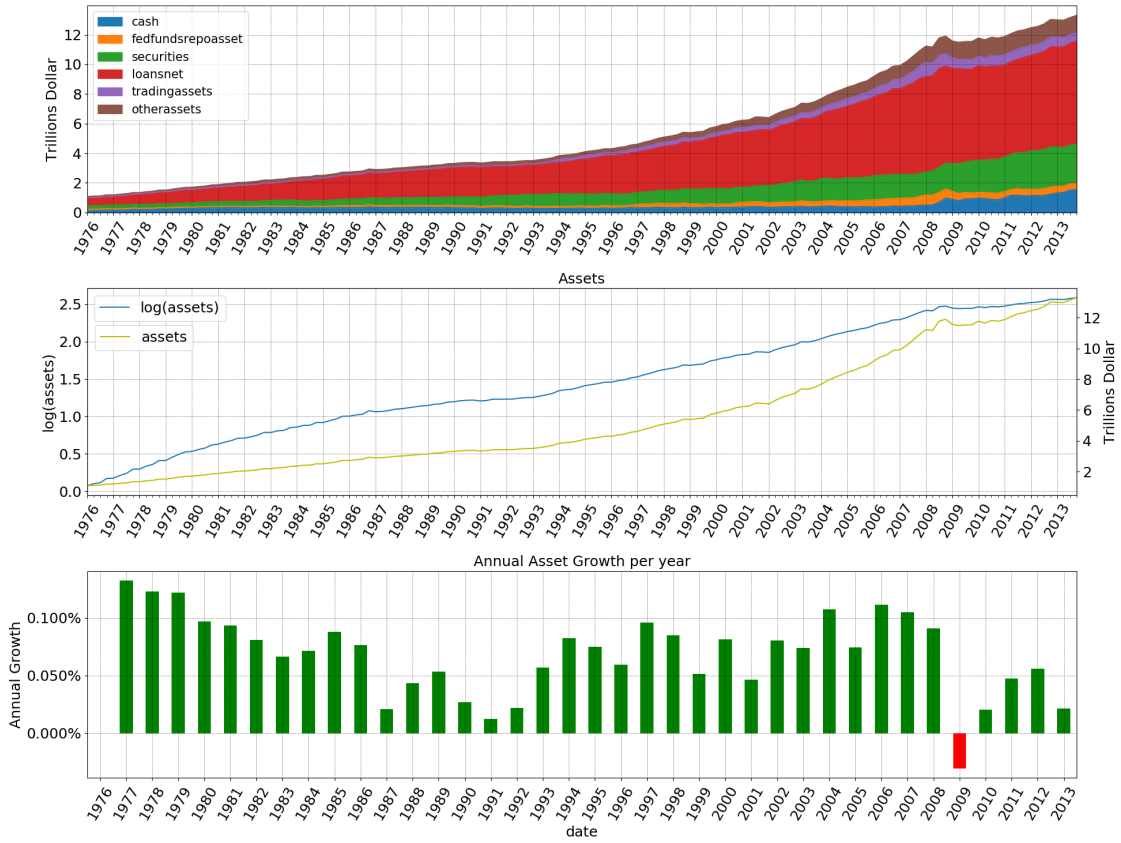

Figure 2: Assets

The first panel in Figure 2 shows how the aggregate total assets split into its accounts have evolved over time. The value of assets rose from below 2 trillion to above 13 trillion dollars. In comparison, the GDP of U.S. rose from 1.9 trillion in 1976 to 16.78 trillion in 2013. The second panel in Figure 2 compares the logged with the absolute value of total assets. The logged assets are plotted on the left vertical axis and grow linearly while the absolute assets are plotted on the right vertical axis and grow exponentially. Finally, the third panel shows the growth rate of assets per year. From the first three panels in Figure 2 we already get a glance of possible special time periods for the assets of commercial banks. We can identify two periods with low growth - credit crunch in 1990*s* and the 2007/8 financial crisis.

3.3.3 Banks' balance sheet: Cycles

To analyse commercial banks business cycles, we plotted the cyclical component of aggregate assets in Figure 3. Additionally, we plotted the cyclical component of each balance sheet account in Figure 6. In Figure 6, the left column represents the asset side and the right column the liabilities side of a balance sheet. The movements in these figures can be interpreted as percentage changes and the gray areas indicate crises, as defined in section 3.1. Note, the analysis of aggregate balance sheet accounts mainly represent the large

banks, because of their large market share. We address this high market share in section 3.4 and cover banks of different sizes in section 3.5.

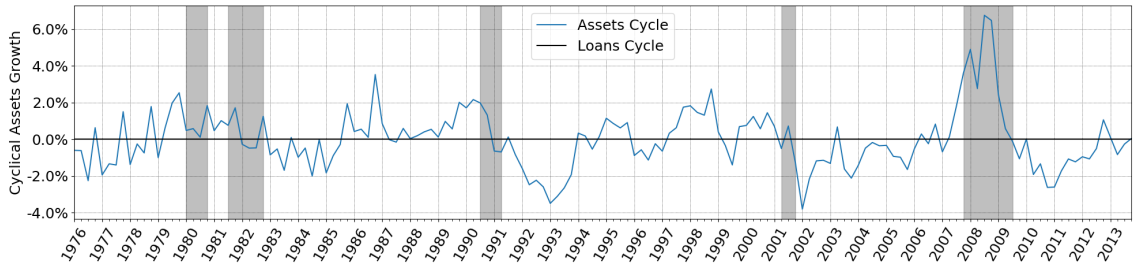

Figure 3: Cyclical Assets

Overall, the crises defined by the NBER, do not always align with the balance sheets of commercial banks. After all, the NBER does consider more factors than the business cycles of commercial banks. However, since commercial banks lending and transaction practises play a key role for the overall economic welfare of a country, we would expect that their business cycles do match an economies boom and bust cycles to some extent.

Financial crisis 2007/8 The financial crisis 2008 is reflected in the asset cycle of commercial banks with a lag. The assets experience a significant boom leading up the crisis and only after 2008 Quarter 3 we see a rapid decrease in value.

To give an explanation of this behaviour, several factors need to be accounted for. First, especially in the beginning of the crisis the major and more direct effects were born by the investment banks. In Antoniades (2019) it is argued that the crisis itself was marked by sudden aggregate funding pressures. These funding pressures had a much stronger impact on investment banks than on commercial banks. Hence, the assets of investment banks might have decreased immediately with the beginning of the 2007/8 crisis, but not those of commercial banks. They provided a key source of liquidity at the beginning of the crisis for investment banks as financial markets liquidity dried up. Commercial banks were later affected by the general deterioration of assets in the real estate sector, which was a longer process beginning in 2006 and lasting until 2013 according to Antoniades (2019). Second, the Federal Reserve Bank (FED) used a series of regulatory efforts to ease the impacts of the crisis.[5] These had an effect on the valuation of commercial banks' assets and might be the reason why the spike in assets in the crisis was substantially larger than the fall that followed. Next to other activities, a Troubled Asset Relief Program (TARP) was passed by congress to reduce the negative impact of the substantial amount of illiquid structured securities and mortgages still held by hanks. Last, as outlined in Bech and Rice (2009), major restructuring events occur over the crisis period, with acquisitions and mergers boosting aggregate assets by more than 580 Billion dollar. Removing the most

[5]See the Monetary Policy Report to Congress mentioned in the bibliography - (Reserve, 2009)

relevant restructuring event in 2008, that is the acquisition of Washington Mutual Bank's by JPMorgan Chase, we can see a reduced second spike in Figure 4 in the crisis period.

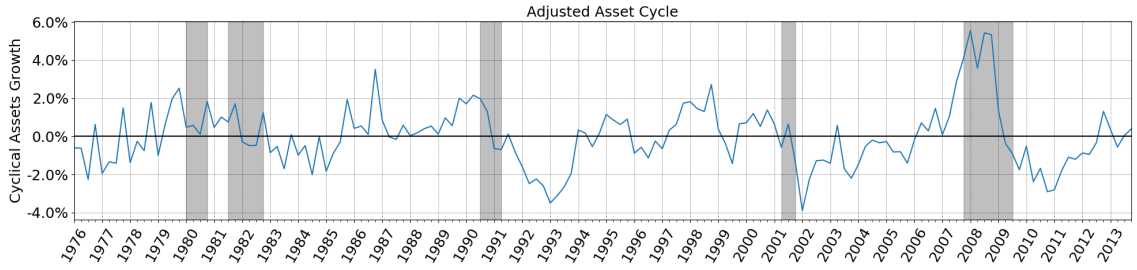

Figure 4: Cyclical Assets adjusted to 2008 merger activities.

We are also interested in the actual balance sheet account that drove the cyclical behaviour in 2008. In general, loans and securities both have the largest share in regards to total assets and were likely the driver of aggregate assets. All other accounts have a share below 10% during the crisis.[6]. While every account falls at some point in the crisis, securities have its lowest point at the beginning and then rise over the period of the crisis. Hence, securities might only have contributed for the second spike in mid-2008. Loans, however, match the behaviour of aggregate assets and could be the main contributor to cyclical aggregate asset movements in 2007/8. Bassett and King (2008) mention that the reason for the strong loan growth in 2007, results from loans that banks planned to move off the balance sheet by selling them to investors. However, investors suddenly lost interest in these loans towards the end of 2007, because of concerns about their quality. They fall significantly in the second half of 2008, marking the losses experienced by commercial banks in the crisis. Although the loans are netted by loan loss provision. An additional way to observe the losses experienced by commercial bank industry during crisis is to examine the loan loss provision account. Figure 5 plots the loan loss provision cycle. We see an increase of more than 50% in the crisis.

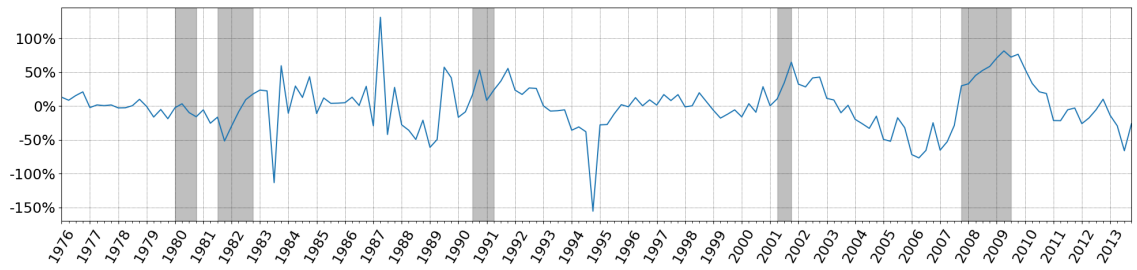

Figure 5: Cyclical Loan Loss Provision

Other balance sheet accounts also behave differently than normal in the crisis, as seen in Figure 6. Cash, for instance, rose over 25% in the crisis, outshining every cyclical

[6]Figure 8 shows the share of balance sheet accounts. We will address this figure in detail in section 3.3.4

movement of cash in other time periods. With the background of the crisis it seems reasonable that banks liquidated assets in 2008 to be prepared for potential liquidity pressures. Other borrowed money and foreign deposits show significant growth in end of 2007 and beginning of 2008. This was followed by an immediate drop in the second half of 2008, similar to loans. Here, part of the loan growth observed leading up to crisis, as mentioned by Bassett and King, 2008, was financed by other borrowed money and foreign deposits.[7] A positive correlation of both accounts with loans supports this thought.[8] Finally, trading assets cycle falls over the period of the crisis from +25% to just below 0%.

Other crisis The early 1980*s* recession does not have a stronger impact on the cyclical movements than periods without crisis. But the 1990*s* credit crunch and 2001 dotcom bubble triggered downward movements of the commercial bank asset cycles below the trend. These two crises lead the asset cycles to reach their lowest points - in 1993 around -4% and 2002 around -4.2% . The two minimum points occur after the crises, indicating a lag between the crises and its effect on the balance sheet size of commercial banks.

Other anomalies Equity has its lowest downward variation in 2003. We will see more of equities behaviour in the leverage section, when we analyse it in regards to total assets. Another interesting observation is that some positions show larger fluctuations in more recent times. The volatility of fedfundsrepoasset increased from 1996 onwards and of foreign deposits from 1992 onwards.

[7] Section 3.3.4 deals with other borrowed money in more depth.

[8] Other borrowed money has a correlation of 0.45 with a p-value below 0.01 and foreign deposits a correlation of 0.59 with a p-value below 0.01 with loans as seen in Table 3. Note, correlations are computed over the whole time-period $1976 - 2013$. Hence, this reduces their value for this hypothesis. We will address correlations in a following paragraph.

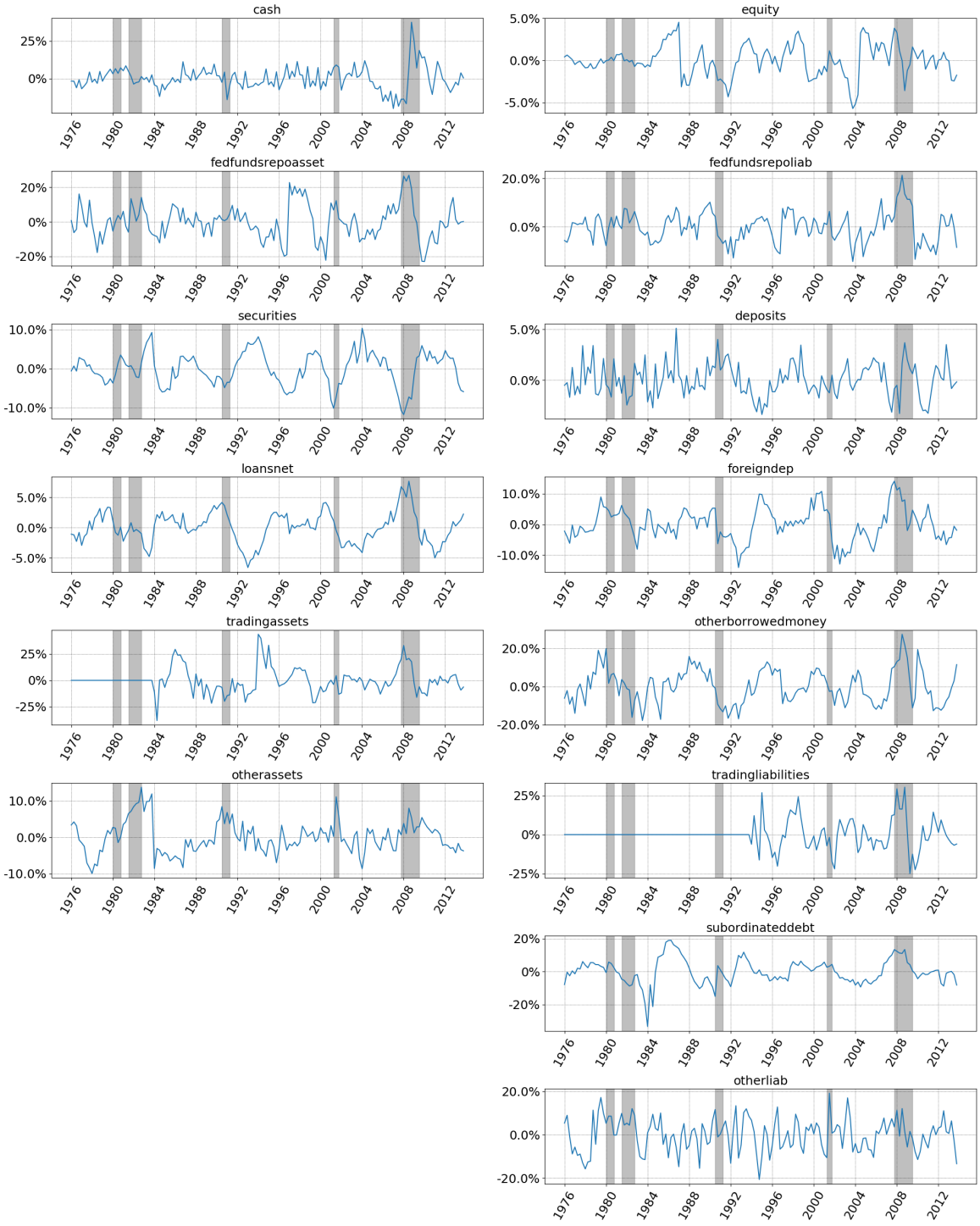

Figure 6: Cyclical asset accounts(left column) Cyclical liability accounts(right column)
Trading assets and liabilities have missing data in the beginning of the time period.

Relationships between balance sheet accounts In this paragraph we take a look at possible relationships between commercial bank balance sheet accounts. Table 1, 2 and 3 show the correlations between each of the balance sheet accounts.[9] We find a

[9]Note, the mere assumption of a correlation between the two sides of a balance sheet contradicts the Modigliani-Miller-Theorem. The Theorem states the independence of assets by the financing capital structure. In addition, a key part of asset liability management for banks is maturity transformation. For correlation analysis, we should have differed between the different maturities of assets and liabilities.

strong inverse relationship of -0.73 between loans and securities as seen in Table 1. When securities fall, loans rise and vice versa. The scatter plot in Figure 7 illustrates this negative relationship. This does not come as a surprise, as in the process of securitization usually part of the loans are packaged into securities, such as, mortgage backed securities and other.

Furthermore, there is a small positive relationship between the account covering federal funds and repurchase agreements (fedfundsrepoassets) and trading assets. This could indicate that banks lending out excess federal funds or purchasing repurchase agreements are in such a healthy position to be able to increase trading assets as well. The scatterplot of this relationship in Figure 7 confirms a possible positive linear correlation. A similar positive relationship can be seen between fedfundsrepoassets and loans. However, the scatterplot in Figure 7 does not support a clear relationship.

Domestic deposits are also negative correlated with foreign deposits ($-0.34, p-value < 0.01$) and other borrowed money ($-0.23, p-value < 0.01$). Bassett and King, 2008 mention that in the financial crisis 2007/8, commercial banks turn to foreign deposits and other borrowed money for financing as domestic deposits fall. This behaviour could explain the inverse relationship in general. Foreign deposits and borrowed money can be seen as alternative ways of financing to compensate for fluctuations in deposits. In addition, there is a positive correlation of $r = 0.37$ between equity and trading assets, indicating that increases in equity lead to increases in trading.

	cash	fedfundsrepoasset	securities	loansnet	tradingassets	otherassets
cash	1.0***	-0.07	0.06	-0.01	-0.08	0.1
fedfundsrepoasset	-0.07	1.0***	-0.34***	0.23***	0.34***	0.15*
securities	0.06	-0.34***	1.0***	-0.73***	-0.12	-0.01
loansnet	-0.01	0.23***	-0.73***	1.0***	0.11	-0.06
tradingassets	-0.08	0.34***	-0.12	0.11	1.0***	-0.12
otherassets	0.1	0.15*	-0.01	-0.06	-0.12	1.0***

Table 1: Pearson Correlation Coefficient for Assets

	equity	fedfundsrepoliab	deposits	foreigndep	otherborrowedmoney	tradingliabilities	subordinateddebt	otherliab
equity	1.0***	0.21***	-0.02	0.04	-0.06	0.12	0.27***	0.08
fedfundsrepoliab	0.21***	1.0***	0.04	0.32***	0.23***	0.28***	0.25***	0.07
deposits	-0.02	0.04	1.0***	-0.34***	-0.23***	0.04	0.11	-0.11
foreigndep	0.04	0.32***	-0.34***	1.0***	0.59***	0.16**	0.13	0.06
otherborrowedmoney	-0.06	0.23***	-0.23***	0.59***	1.0***	0.08	0.15*	0.01
tradingliabilities	0.12	0.28***	0.04	0.16**	0.08	1.0***	0.18**	0.15*
subordinateddebt	0.27***	0.25***	0.11	0.13	0.15*	0.18**	1.0***	0.04
otherliab	0.08	0.07	-0.11	0.06	0.01	0.15*	0.04	1.0***

Table 2: Pearson Correlation Coefficient for Liabilities

Correlations between positions of different maturity would have a more causal relationship. Furthermore, canonical correlation analysis could have been used to consider that balance sheet positions are jointly determined by the other positions.

	equity	fedfundsrepoliab	deposits	foreigndep	otherborrowedmoney	tradingliabilities	subordinateddebt	otherliab
cash	-0.25***	0.06	0.38***	0.04	0.28***	-0.03	0.03	-0.14*
fedfundsrepoasset	0.21***	0.57***	0.32***	0.03	-0.12	0.48***	0.3***	0.14*
securities	-0.06	-0.23***	0.08	-0.38***	-0.33***	-0.16**	-0.18**	-0.18**
loansnet	0.06	0.41***	0.17**	0.59***	0.54***	0.15*	0.21**	0.14*
tradingassets	0.37***	0.36***	-0.09	0.23***	0.14*	0.49***	0.35***	0.01
otherassets	0.02	0.1	-0.01	0.12	-0.07	0.04	-0.18**	0.35***

Table 3: Pearson Correlation Coefficient between Assets and Liabilities

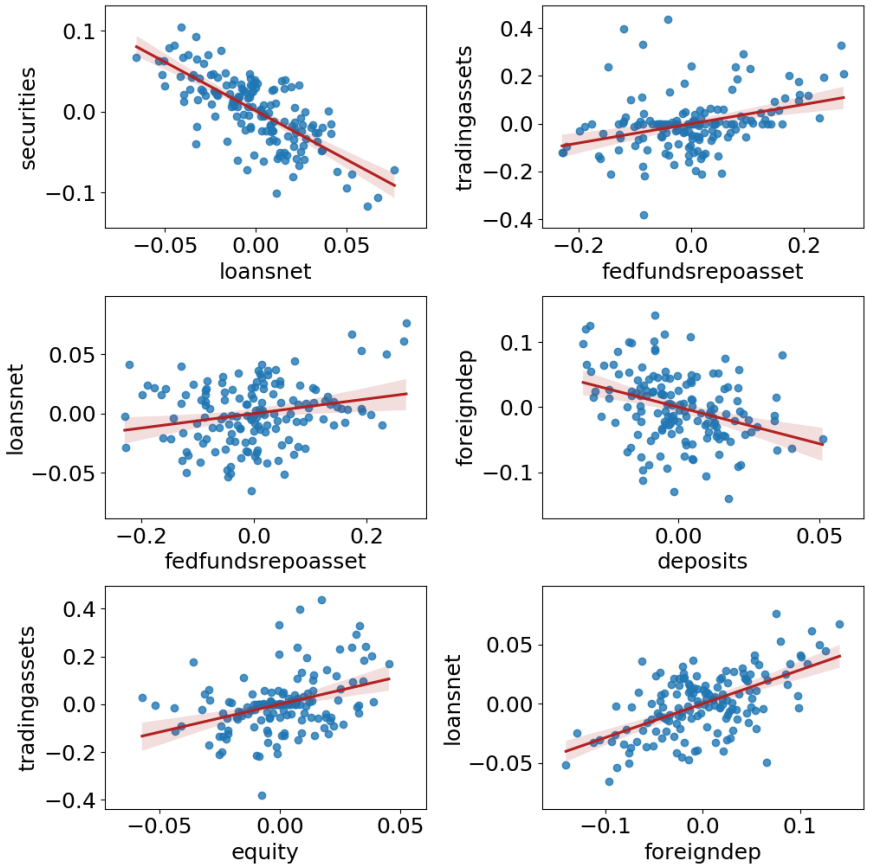

Figure 7: Scatterplot for selected positions and linear regression based on the detrended data used in Figure 6. Shaded area indicates error margin.

3.3.4 Banks' balance sheet composition: Trends

Further elaborating on Figure 8, we can see that on the asset side, loans are the main target of investment for commercial banks. Throughout the 37-year time frame the share of loans stays between $50 - 60\%$. The banks start with a share at 55% until it rises to just above 60% from 1985 onwards. The credit crunch crisis in 1991 causes a fall of the share back to 55%. This fall continued until 1995. From then on, the share of loans rise back to 60% until 2008, where it starts to fall again. It falls to an all-time low in 2013 with a share of just above 50%. With the observed negative relationship between securities and loans, this came along with a rise in securities. The development of the cash share is also interesting. Cash continuously falls from a share of just below 20% to a share of below 5%. Here, the crisis 2008 also marks a turning point with the share

rising to above 10%. On the liability side, deposits are the dominating source of funding for commercial banks. The share starts in 1976 with 70% and falls until 2008 to an all time low of just above 50%. From there it goes back to roughly 65%. This decrease in deposits, especially until 2008, must obviously come along with the increases of other types of finance. In particular, other borrowed and foreign deposits rise with the decrease of domestic deposits. This again confirms the thought raised in the sections before that they are seen as an alternative source of financing when domestic deposits decrease. Other borrowed money has a peak in 2008. Other borrowed money consists of Federal Home Loan Bank advances (FHLB) and other borrowings not clearly defined. After the crisis in 2008 there is a rapid decrease in other borrowings. FHLB advances are mainly used in funding mortgages for low income households, which explains the alignment with the housing crisis in 2008.[10] Lastly, Figure 8 shows a general increase in the share of equity commercial banks hold from just above 5% to above 10%.

[10]See the Affordable Mortgage Lending Guide by the FDIC mentioned in the bibliography Corporation (n.d.)

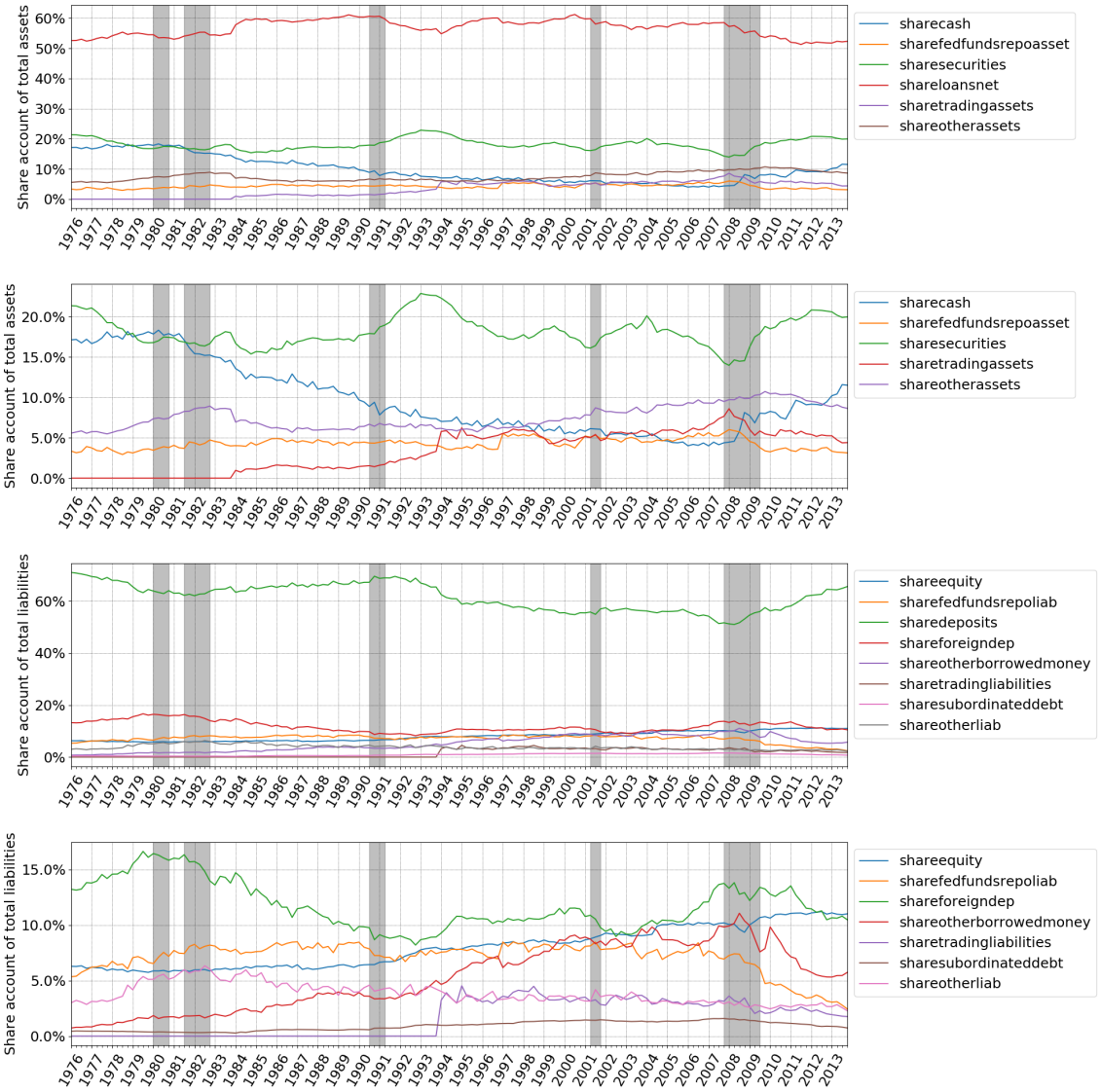

Figure 8: Share of balance sheet positions. The second/fourth graph is a focus of the first/third, just without loans/deposits position.

3.3.5 Defaults

Bank failures are another way of examining the stability of the commercial banking sector over time. In Figure 9 we show the banks default rate per year. For instance, in 1989 over 0.6% default. It is based on the negative equity recorded by banks. Hence, it is not exact and some banks might continue to exist in case of mergers or bailouts. Also, sometimes banks are double counted, if negative equity does not immediately result in bankruptcy.

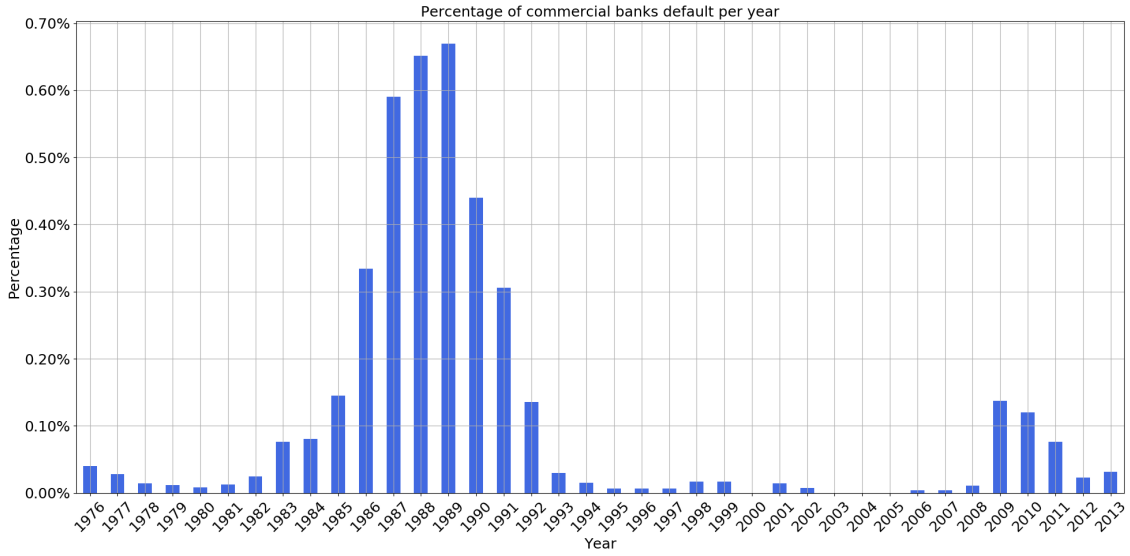

Figure 9: Bank Failures

Bank failures align with the asset growth graph shown in Figure 2. During periods with a lot of defaults we have a low growth rate. Periods that mark high default rates are from $1983 - 1992$ and $2009 - 2013$. These periods might be strongly interconnected with the two banking crisis - the credit crunch in 1990 and the financial crisis in 2007/8. The first high default period has much higher default rates and lasts much longer than the second. The significance difference in numbers might be related to the fact that in the 1980s the amount of small banks in general and that of the defaults were considerably higher. In the first period, 74% of the banks that defaulted is small, while in 2010 the share of small banks defaults was only at 35%. We elaborate on the change in banking landscape in section 3.4. The reason why the first period lasts much longer cannot be easily explained. According to Corporation (1997) there were various forces working together to produce this long period of defaults. Hence, the 1990 credit crunch might be related to the defaults, but is not seen as the major cause. Another point regarding the crisis 2007/8 is the timing of the defaults - two years after the beginning of the crisis. This again, might be related to the argument Antoniades, 2019 makes about the funding pressures being a main characteristic of the crisis 2007/8. Funding pressures caused investment banks to default in the crisis 2007/8, but not commercial banks. These default later by the deterioration of assets in the real estate sector.

3.4 Too Big to Fail: Distribution of total assets among banks

This section empirically illustrates a problem commonly referred to as *"Too Big to Fail"*. Banks are considered as "*too big to fail*", when their size and interconnections with other banks are so high that its individual risk impacts the systemic risk of a whole economy. Regulators tend to be reluctant to close those banks when they default allowing a moral hazard to emerge. The term first came into play with the failure and bailout of Continental Illinois National Bank and Trust Company in 1984 (Nurisso and Prescott (2017)). From that point onwards, it developed into a world-wide phenomenon with its severe consequences unveiled in the financial crisis of 2008.

Indeed, over the last few centuries the number of banks on the U.S. landscape has fallen significantly from 14419 banks in 1976 to 6035 banks in 2013. While the mere reduction would not impose such a problem, the distribution of total assets developed more and more unequal. In 1976, the top 0.1% a total of 14 banks held 32.4% of all assets. In comparison, in 2013 the top 0.1% - a total of 6 banks - held 50% of all assets. Table 4 and Figure 10 show these numbers by looking at the assets distribution by banks percentiles.

	Top 0.1%	01Share	Top 1%	1PercentShare	Top 10%	10PercentShare	Top 50%	50PercentShare	Total all banks
1976	14	0.324922	144	0.558099	1442	0.780650	7210	0.946214	14419
1980	14	0.340622	144	0.581818	1442	0.793497	7208	0.948957	14417
1984	14	0.288709	144	0.556493	1439	0.790446	7194	0.948429	14389
1988	13	0.240856	130	0.546860	1298	0.811423	6491	0.954550	12982
1992	11	0.228150	114	0.539679	1136	0.811301	5682	0.954310	11363
1996	9	0.273671	95	0.609738	946	0.850118	4732	0.964386	9464
2000	8	0.348473	83	0.701729	825	0.881838	4126	0.972520	8252
2004	8	0.452258	76	0.741929	757	0.891446	3784	0.975372	7567
2008	7	0.510510	70	0.794367	702	0.910356	3511	0.980069	7022
2012	6	0.506170	60	0.801828	604	0.916754	3018	0.980764	6035

Table 4: Count of banks by percentiles

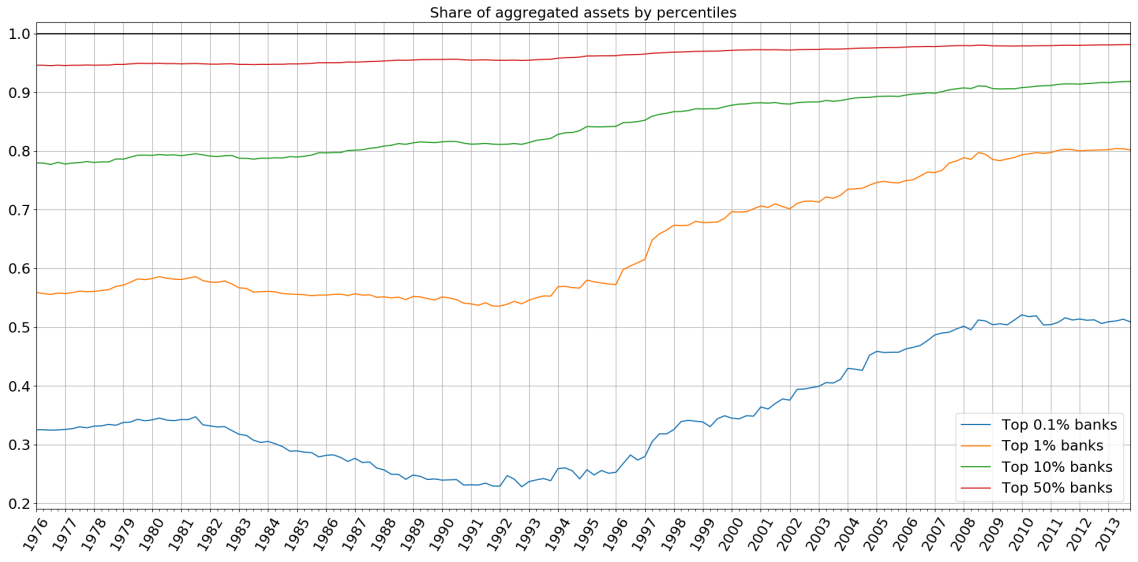

Figure 10: Aggregate assets by percentiles

The unequal distribution of assets can also be seen in Figure 11. The curved lines show the Lorenz curve per year. The more curved the lines become, the more unequal is the distribution. The horizontal line represents perfect equality. Although in 1980 unequal distribution was high already, it increased even more. In year 2013, the top 5% held almost 90% of all assets. Figure 12 shows us the Gini coefficient over time. Its range is from zero to one. A value of one means one bank owns everything, while a value of zero indicates perfect equality.[11] The higher the value, the higher the inequality in asset distribution. The trend of the coefficient supports our observation of rising inequality. An interesting observation here is the impact of crises on the asset distribution. Crisis tend to reduce the inequality and act as a way of redistributing assets. Assuming that assets values fall in times of crisis, the impact of crises must be higher on larger banks. We will look into how different bank size categories are impacted differently by crises in section 3.5. Reasons for the trends we have just documented are not absolute clear. However, geographic deregulation and other regulation reforms such as the repeal of the Glass-Steagall act in 1999 did support the increasing inequality. In addition, larger banks are more likely to be bailed out. This puts them in an easier position to finance themselves and creates the perverse consequence of a moral hazard. A bank with a high likelihood to be bailed out takes on too much risk (Emmanuel and Tirole (2012)). The severe consequences of this problem are clear since the financial crisis in 2008. Authorities responded to this issue by setting additional capital requirements on larger banks with frameworks such as Basel 1,2 and 3.

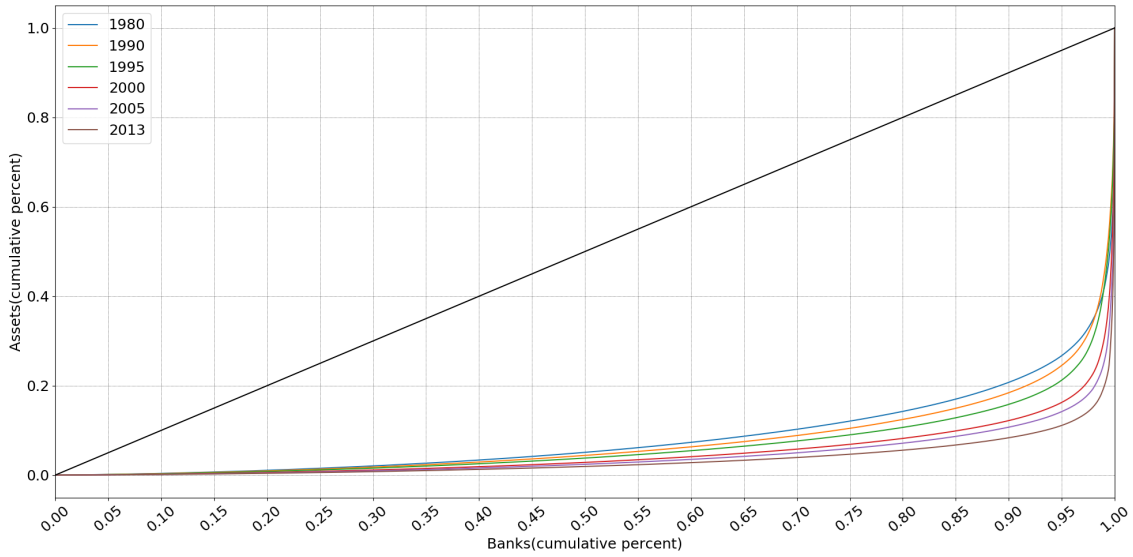

Figure 11: Lorenz Curve. Values taken are always from quarter 1

[11] 10% of banks own 10% of assets, 50% of banks own 50% of assets and so on...

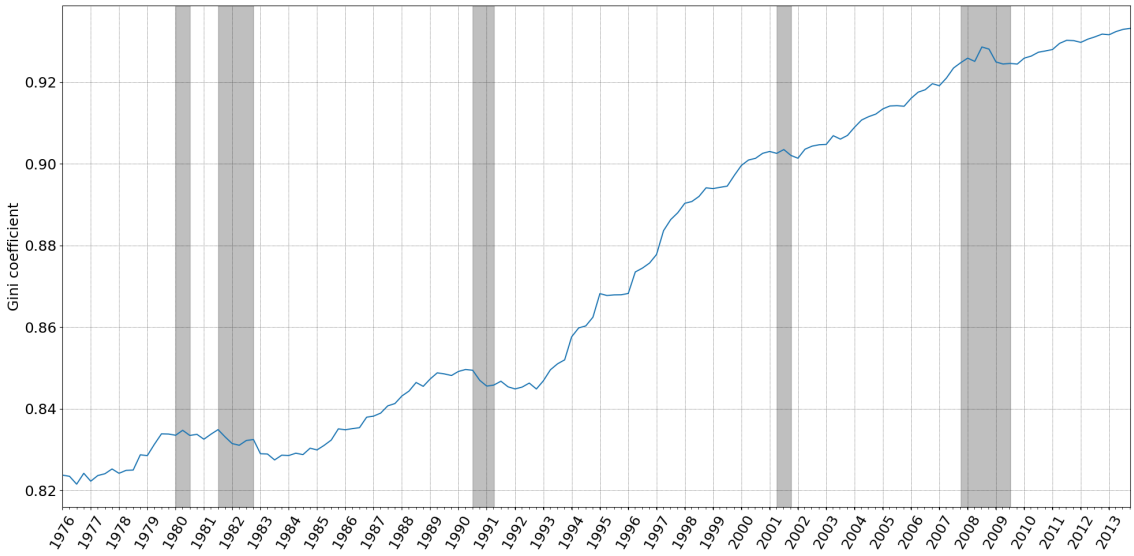

Figure 12: Gini coefficient

3.5 Banks by total assets

3.5.1 General

In this section we allocate banks into different categories ranked by asset size to see differences in their balance sheet behaviour. It is common approach by regulators and academics to categorize banks by their total assets. It measures the gross nominal volume of a bank's activity, but suffers from significant valuation problems, not only for derivatives, and it does not account for differences in individual bank business models. There are alternative ways of categorizing banks, such as, using capital or employees as a measure of size.

Following the convention of the Federal Reserve Bulletin, we divide commercial banks by assets into four categories.[12] The first category are the ten largest banks. Second category covers the large banks - banks ranked from 11 through 100. The third category represent medium banks - banks ranked from 101 through 1000. Lastly, the last category are the small banks - banks ranked from 1000 and higher. To get an overview of what asset sizes each category covers, Figure 13 contains boxplots for each category and year. Within all categories we can see a consistent rise of overall asset sizes. In 1976, every top 10 bank has an asset size lower than a quarter of a trillion. In 2013, the median asset size of the top 10 banks was 0.32 trillion (10^{12}) with banks going up to an asset size of just under two trillion.[13] We can also see a clear rise in heterogeneity over time regarding the asset

[12]Our choice of categorization could have been different. The asset size ranges they cover, differ over the years. This can be seen as an advantage or disadvantage. On the one side they evolve over the years and possibly match changing asset size levels. On the other side, there is a risk of distributional changes among the asset sizes of banks, making our chosen categorization unsuitable.

[13]Note, we have not combined commercial banks with their matching bank holding company. Bank Holding Companies have asset sizes beyond two trillion.

sizes of the top 10 banks. The Interquartile Range (IQR) get to its maximum size by the end of the time-frame. Large banks began with an asset size far below $0.25 * 10^{11}$ in 1976 and work their way up to asset sizes of up to $1.75 * 10^{11}$ dollar in 2013. The heterogeneity of large banks regarding asset size also increased over time. Medium banks range between $0.25 - 8$ billion (10^9) dollar assets per bank and small banks between $0.25 - 5$ hundred million dollar assets over the given time-frame. Similar to what we will see later, the top two categories benefit more from the asset size increases. Compared to the asset increases within the top 10, the typical small bank did not show any significant gains over time. Overall, the fact that the chosen categories do not have many outliers strengthens our choice of categories. Only the small banks category has a decent amount of outliers with banks that have asset sizes significantly lower than the median small bank.

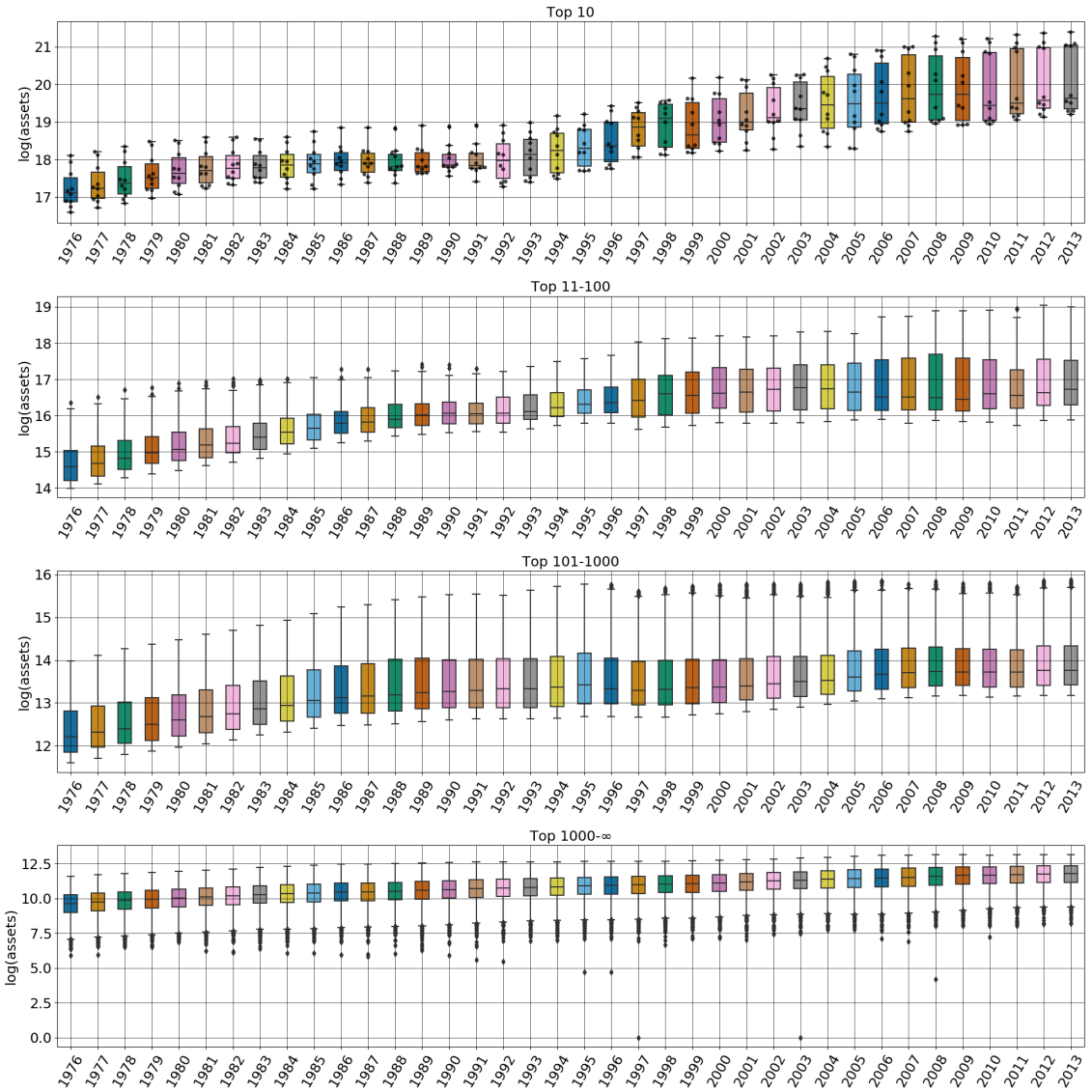

Figure 13: Boxplots for each category. Asset data is logged. Coloured boxes cover the mid 50% of asset sizes - IQR:25th Percentile to 75th Percentile. For the top 10, all individual data-points are marked as dots. For the rest, only outliers are marked as dots. Outliers are data-points above 1.5 times IQR.

3.5.2 Banks' balance sheets by size: Trend and Cycles

Figure 14 shows us the development of aggregate assets by the defined banks categories over time.

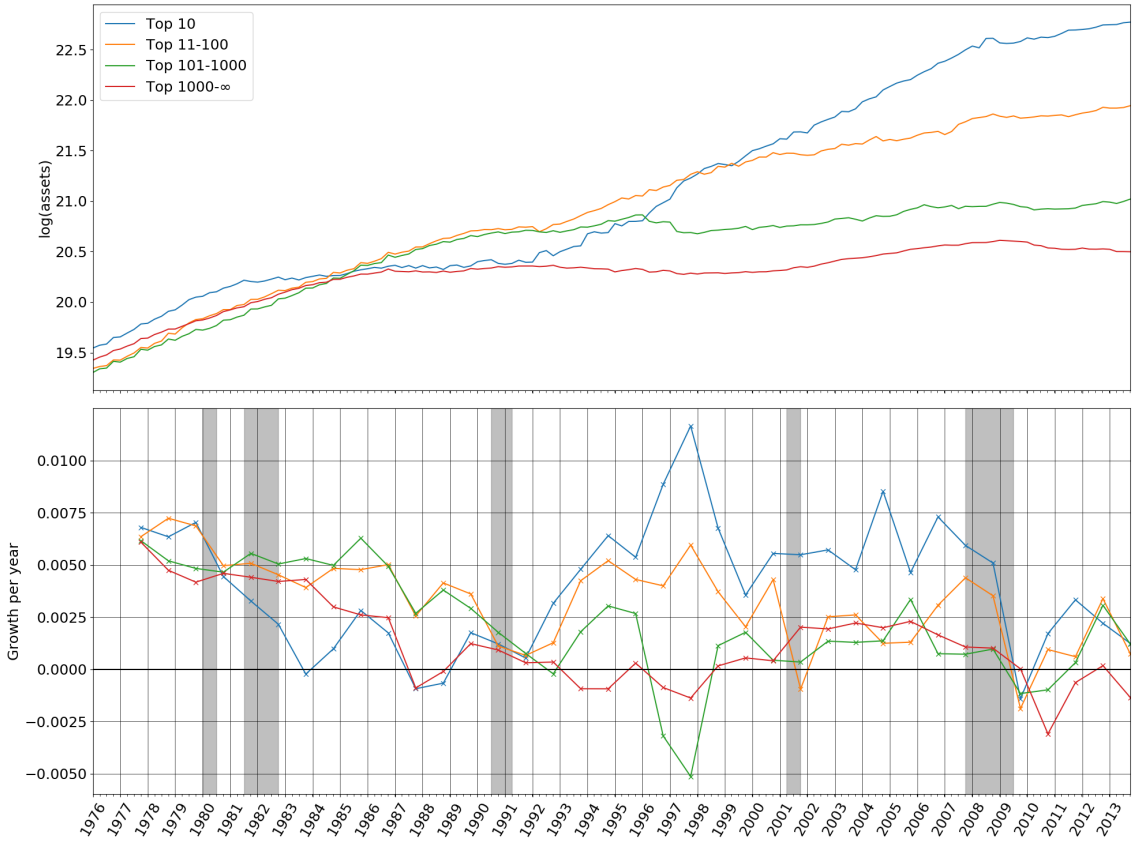

Figure 14: Total assets by bank category

There are key points in time for each category that mark changes in their asset growth. From the start of the given time frame 1976 until 1985 all the categories show similar growth behaviour. Then, in 1984, the growth of the top 10 assets starts to slow. Shortly after that, 1985 marks a starting point of flat, low growth for the small banks. The small banks do not recover from this low growth period until the end of our chosen time frame. An obvious reason for this is the fact that the total number of banks also falls. Table 4 shows 1984 marks a starting point for a continuous decrease in the number of banks. Category two and three asset growth, covering the banks ranked from $11-1000$, are alike until 1992. From this point in time, medium banks enter a period of low and negative growth, while the large banks go on a period of high growth, together with the top 10 banks. In the 1990s, a lot of regulation reforms occur, aiding the growth of larger banks. These reforms are mentioned in section 3.1 and could be the key drivers for the growth of larger banks in the 1990s. In 2001, the growth rate of banks ranked from $11-100$ also declined. The assets of the top 10 banks, however, keep growing until the financial crisis in year 2008.

In Figure 15 we can see asset cycles by each category over time. The figure also shows the standard deviation of aggregate assets by category. It seems that the larger the banks the more volatile its balance sheet size is.

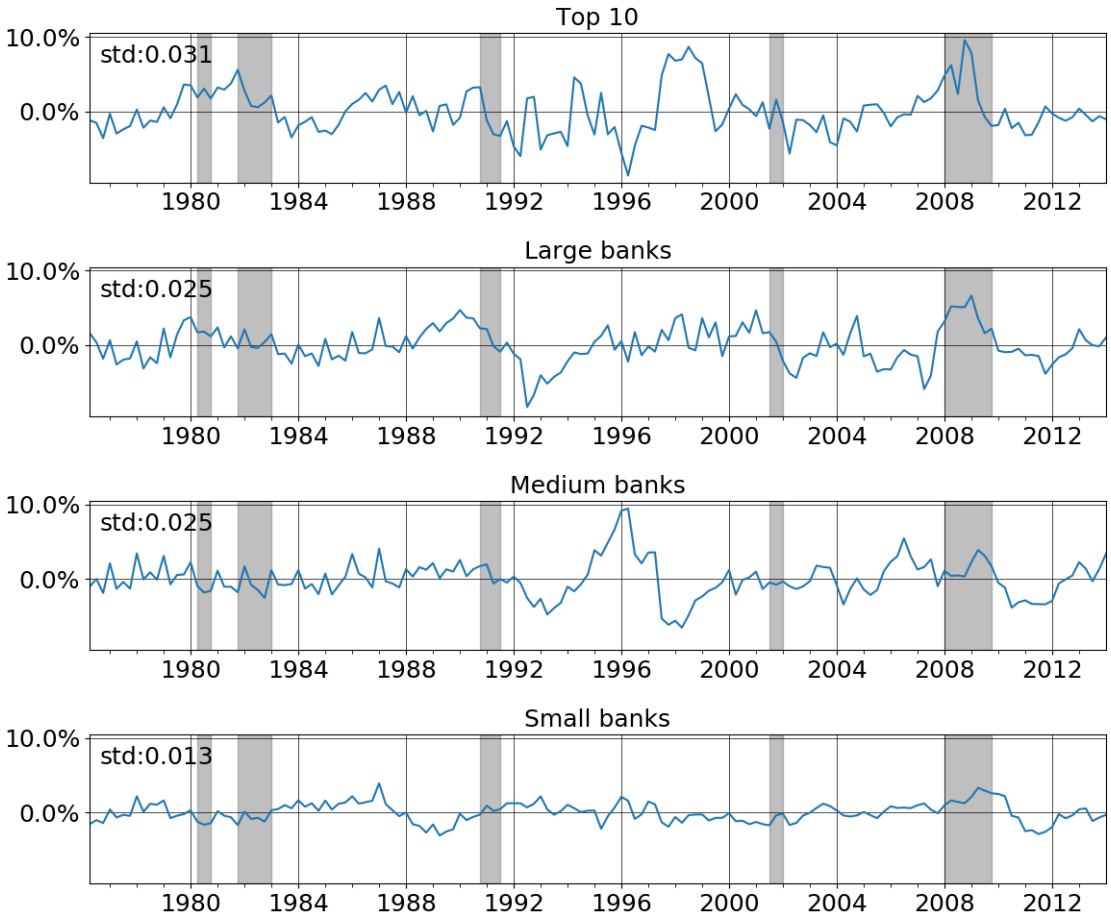

Figure 15: Asset cycles by bank size category

Financial crisis 2007/8 All bank categories are affected by the crisis in 2008. For each category we see a spike, followed by a fall in assets. Note, the top two categories cover almost 90% of all industries assets, hence this discussion connects to the one already held in section 3.3 about the whole industry asset cycle. For a more detailed view, table 5 shows the raw cyclical percentage changes. The top 10 banks are affected the most, but this does not come as a surprise as their asset cycle also has a higher volatility. Similar to behaviour of all aggregated banks in section 3.3, all bank sizes have spikes in 2008, which is after the begin of the crisis defined by the NBER. The downturn that follows is also smaller than expected. In section 3.3, we have outlined a variety of reasons why this might be the case. While for the top 10 and large banks the boom of assets thereupon is much stronger than the downturn that follows, medium and small banks asset boom is around the same size to the bust that follows. It seems like the larger banks show much more abnormal behaviour in the crisis than the medium and small banks. In other words,

the medium and small banks experience a more standard boom and bust cycle. The small banks downturn does not start before the second half of 2010, underlining their passive role in the crisis.

date	cat1_assets	cat2_assets	cat3_assets	cat4_assets
2006-12-31	2.1	-1.5	1.3	0.98
2007-03-31	1.2	-5.9	1.6	1.2
2007-06-30	1.7	-4.1	2.6	0.4
2007-09-30	2.8	1.8	-1.0	-0.1
2007-12-31	4.8	3.2	1.1	0.97
2008-03-31	6.2	5.2	0.39	1.6
2008-06-30	2.3	5.1	0.46	1.4
2008-09-30	9.6	5.1	0.31	1.3
2008-12-31	7.8	6.6	2.2	2.1
2009-03-31	1.4	3.6	3.9	3.3
2009-06-30	-0.77	1.6	3.1	2.9
2009-09-30	-2.0	2.2	1.7	2.6
2009-12-31	-1.8	-0.75	-0.54	2.5
2010-03-31	0.34	-0.97	-1.2	2.2
2010-06-30	-2.3	-0.92	-3.9	-0.43
2010-09-30	-1.5	-0.48	-3.2	-0.67
2010-12-31	-3.2	-1.4	-2.9	-2.5
2011-03-31	-3.1	-1.3	-3.4	-2.4
2011-06-30	-1.5	-1.5	-3.4	-2.9
2011-09-30	0.65	-3.9	-3.4	-2.6
2011-12-31	-0.32	-2.6	-3.0	-1.9

Table 5: Asset cycles by bank size in crisis 2007/2008. Top 10 are cat1, large banks are cat2, medium banks are cat3 and small banks are cat4

Other crises While among the large banks we can see an impact of the dotcom bubble, it passes the medium and small banks with almost no effect on their asset cycle. The dotcom bubble is marked by a significant fall in value among stocks. This underlines the more conservative approach by medium and small commercial banks. They do not, for instance, have a notable amount of trading assets. This might be the reason for reduced effect of this crisis.[14] The credit crunch in 1990 also leaves different footprints on the banks of different sizes. All sizes beside the small banks experience a downturn after the credit crunch. The small banks, however, experience their downturn years before the credit crunch in 1989.

[14]We address this in the upcoming section 3.5.4, when discussing the balance sheet composition.

3.5.3 Asset cycle similarity between banks of different sizes

This section describes the similarity between the categories asset cycles. It might convey different balance sheet behaviours by bank size. Table 6 shows the linear correlation between asset cycles over time for each category. As one might expect, all categories positively correlate with the category just below themselves. However, there are significant differences when going beyond that. Category 1 (Top 10 banks) has a negative correlation with category 3 (Top $101 - 1000$) of -0.27 and no correlation with category 4 (Top 1000-Rest). Although the negative correlation of $r = -0.27$ is not strong, this difference in asset cycle timings would probably not be expected. It means that while the top 10 banks might go through a period of decreasing assets, the Top $101 - 1000$ might go through a period of increasing assets. However, a closer look at the graph indicates that the main driver for this negative correlation could be the period from 1996 to 1999. Indeed, the exclusion of this time-period from the correlation computation reveals an $r = 0.05$. Similar to the relationship between top 10 and small banks (cat4), this complete lack of cyclical relationship between large banks and small banks underlines their independence of balance sheet decisions in regards to the other category.
We also compute the autocorrelations to take into account different timings. Significant asset changes of the top 10 might not have an immediate effect on the other categories in the same period, but perhaps one quarter later. We go up to ten quarters back to see possible impacts. The associated tables can be found in the Appendix (Figure 33). An interesting observation can be found for the correlation between category 1 and category 2 (lag 1) one period later. The correlation rises from 0.4 to 0.43 with one quarter lag. Indicating that large banks (cat 2) react slightly delayed to the decisions of the top 10 banks. The rest autocorrelations show no sign of anomalies.

	cat1_assets	cat2_assets	cat3_assets	cat4_assets
cat1_assets	1.0***	0.41***	-0.27***	-0.07
cat2_assets	0.41***	1.0***	0.24***	-0.05
cat3_assets	-0.27***	0.24***	1.0***	0.41***
cat4_assets	-0.07	-0.05	0.41***	1.0***

Table 6: Correlation between cyclical assets of each category. The pearson correlation coefficient is used. The stars after the values indicate significance according to standard levels (***: p<0.01; **: p<0.05; *: p<0.1)

3.5.4 Balance sheet composition by bank size: Trends

To get an understanding on the balance sheet composition by category and how they differ, Figure 16 and 17 show the share of each account for both sides of the balance sheet. Loans continue to be the highest share on the asset side for all categories. Interestingly, all other categories beside the top 10 banks, show an increasing trend for share of loans. But the top 10 banks share of loans fall over our time-frame. Furthermore, only the

top 10 are engaging in proper trading with a share of trading assets beginning to rise significantly in 1994. For the liabilities, deposits are a main source of funding for all categories. However, the share of deposits varies between the categories. Larger banks tend to have a lower deposit share than medium and small banks. The share for the top 10 is between $60\% - 80\%$ and for the top 11-100 at 60% most of the time. Medium banks have a share that is consistently at 80% and small banks a share of almost 90%. Hence, other forms of finance are relatively low for smaller banks. Our findings confirm the pattern: The larger the bank is, the more alternative ways of financing beside deposits are facilitated.

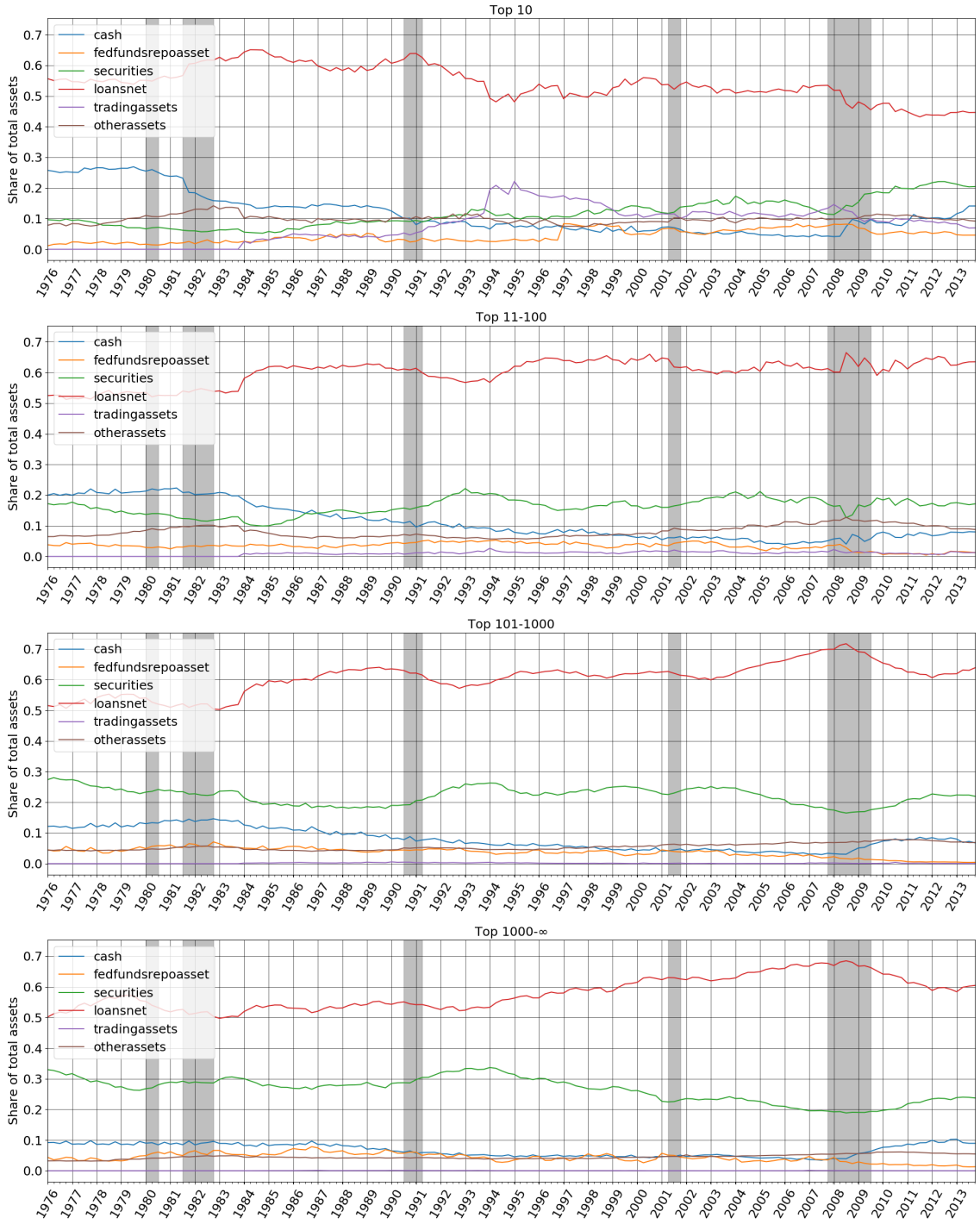

Figure 16: Share of total assets for each balance sheet account

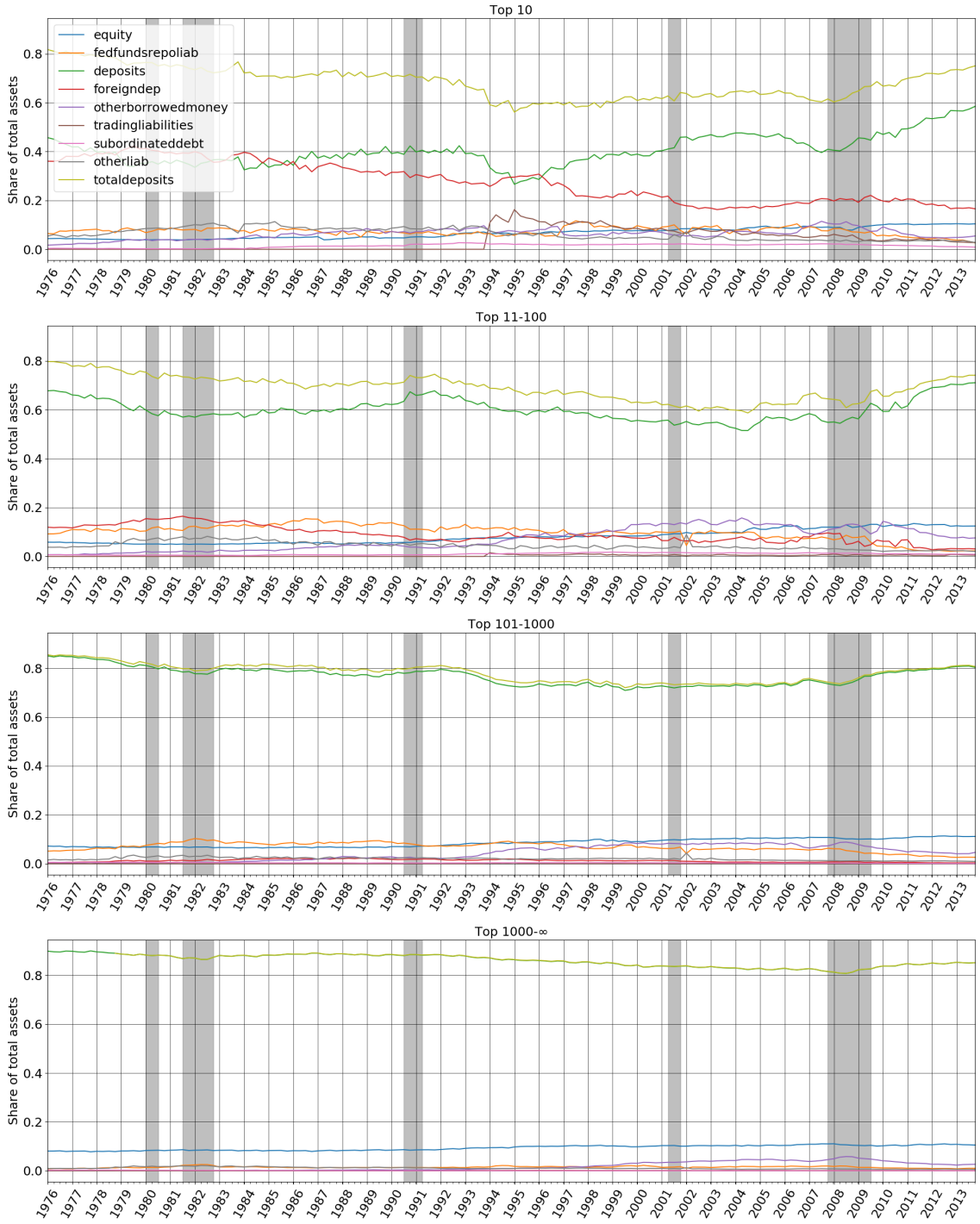

Figure 17: Share of total liabilities for each balance sheet account

3.6 Leverage

3.6.1 General

In this section take a look at the leverage of commercial banks. Leverage is a well known and often used concept for monitoring risk and health of financial institutions. While there are a few definitions of leverage, given the dataset we are working with, the focus is on accounting leverage: $\frac{total\ assets}{total\ equity\ capital}$[15]. Banks use leverage to improve their return on equity. As long as the interest on external capital does not exceed the total capital ratio, raising external capital, thus increasing leverage, is beneficial for a bank. With this incentive in mind, it might not come as a surprise that when a shareholder asks for a high return, increases in leverage follow. As a result the buffer to cover losses in case investments turn bad is reduced. As a result, increases in leverage can be seen as increases in risk.

We took into account that policy makers set capital requirements on banks on their highest organizational level and aggregated all commercial banks to their belonging bank holding company. We are also removing all banks with negative equity from the dataset as they can be considered bankrupt.[16] We only want to assess leverage behaviour of still operating banks. For more information about bankrupted banks in the dataset see section 3.3.

3.6.2 Is Leverage pro-cyclical?

When looking at balance sheet leverage, it is important to realize its dynamics in regards to asset cycle movements. Let us assume, we have a negative asset cycle and the asset values are falling together with the bank experiencing losses. This reduces banks equity. As balance sheet leverage can be written as $\frac{equity + liabilities}{equity}$, this would result in increased leverage, assuming liabilities do not change. Hence, when banks do not actively adjust their balance sheet towards asset cycle changes, leverage behaves countercyclical. However, literature agrees that commercial banks tend to behave pro-cyclical in regards to asset changes. Adrian and Shin (2011) as well as **greenlaw2008leveraged** support this notion. We want to confirm this with our data. But while Adrian and Shin (2011) use the growth rates of both asset and leverage and compute leverage by aggregating assets and equity of all commercial banks first - essentially computing leverage of the commercial banking market as a whole -, we compute leverage in a different way and use the cycles of both assets and leverage instead of the growth rate.[17] The major difference is that

[15] Tier 1 capital, as defined in Basel III.

[16] Banks with negative equity, do not report financial information in the following periods. Only in the rare case of bailouts, they survive.

[17] We compute the leverage of each individual banks first and then take the average of all individual leverage ratios. We also take a look at a larger time-frame than Adrian and Shin (2011). Ours is from $1976 - 2013$ and Adrian and Shin (2011) is from $1983 - 2010$

within the Adrian and Shin (2011) method the leverage has a weighted impact on the computations depending on a banks size, while within the average method, banks leverage is all weighted the same, independent from bank size. Figure **??** shows the result of this approach for all commercial banks together. Although we can derive that commercial banks actively manage their leverage, no pro-cyclicality can be identified. Applying the same leverage computation as Adrian and Shin (2011) gives use Figure **??**, showing a positive relationship. These distinct results between the two Figures, indicate that within Figure **??** the large banks drive the pro-cyclicality. While within Figure **??**, where every banks leverage is weighted the same, the much higher quantity of small banks reduces the pro-cyclical impact of large banks on the average. To reveal more information about leverage pro-cyclicality among commercial banks, we apply the two approaches to different banks sizes. Against the background of our given analysis one would expect to make two observations:

1. Large banks have pro-cyclic leverage behaviour but small banks not
2. The more homogeneous the banks in one bank size category are, the more similar the results of the two computational methods would be. Our upper two categories (top 10 and large banks), always include a smaller amount of banks. In addition, when considering the standard deviation, as seen in Figure 27 in section 3.6.4, the upper categories are much more similar in regards to their leverage than the lower two categories (small and medium). As a result, we might see more similarity between the two computational methods for larger banks.

Figure 21 and 20 give us the scatterplots by bank size. Indeed, we can confirm hypothesis two. The top 10 banks (cat 1) and large banks (cat 2) show similar relationships within both Figures, but the relationships identified for medium and small banks differ significantly between the two Figures. While Figure 20 finds a correlation coefficient near zero for medium banks and a correlation for small banks of 0.15, Figure 21 finds stronger positive correlation for small and medium banks (0.35 and 0.34). Hence, we can deduce that the cyclicality in regards to leverage for large banks is robust to both treatments of the data. But not for medium and small banks. However, hypothesis one cannot be clearly confirmed. The top 10, with a coefficient of 0.24, show less pro-cyclicality than large banks, with a coefficient of 0.44. In addition, because of the different results received for the smaller banks, it is difficult to arrive at a conclusion about their pro-cyclicality. The larger banks within the medium and smaller bank size category might drive the pro-cyclicality seen in Figure 21. One would need to split the smaller banks into additional categories to get a better understanding of their behaviour.

A conclusion that can be drawn about among all bank sizes are that they actively manage leverage, otherwise we would need to observe a negative relationship as we explain above. Finally, it is important to note the consequences of the observed pro-cyclicality

among certain bank sizes.[18]. It means that they do not only actively adjust their balance sheets, but they are increasing leverage in good times and decreasing leverage in bad times. They are taking on additional debt to not only balance the usual negative relationship, but to lever their assets even further. This has severe impacts on a countries business cycle. In good times, banks might lever to much and take on to much risk. On a contrary, in bad times, banks play to conservative hindering recovery.

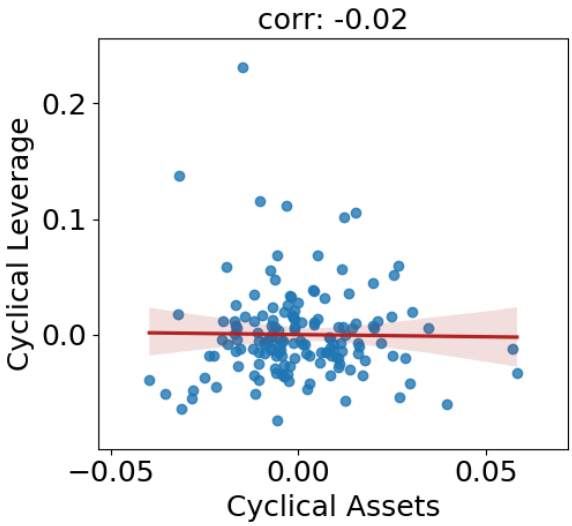

Figure 18: Cylical Assets versus Cyclical Leverage (All commercial banks). We compute the leverage for each bank individually and then take the average. With that average, we then compute cyclical growth by applying the HP-Filter. For the assets we also take the average and the compute the cyclical growth.

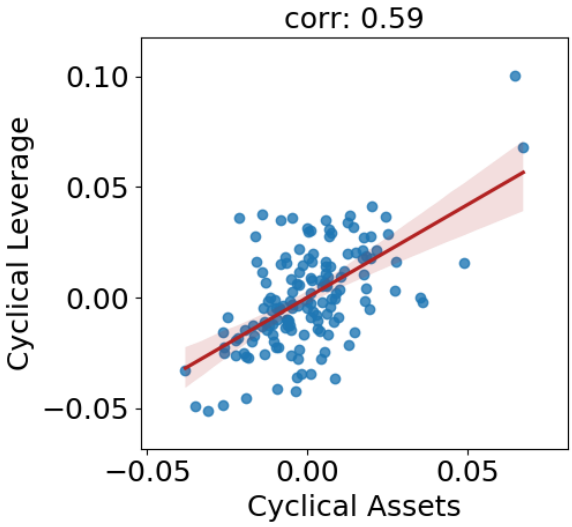

Figure 19: Cylical Assets versus Cyclical Leverage (All commercial banks). We compute the leverage of all banks by (aggregate assets / aggregate equity). We then compute cyclical growth of leverage as well as assets with HP-Filter

[18]Medium-sized banks and on a smaller level of the top 10 banks show clear pro-cyclicality

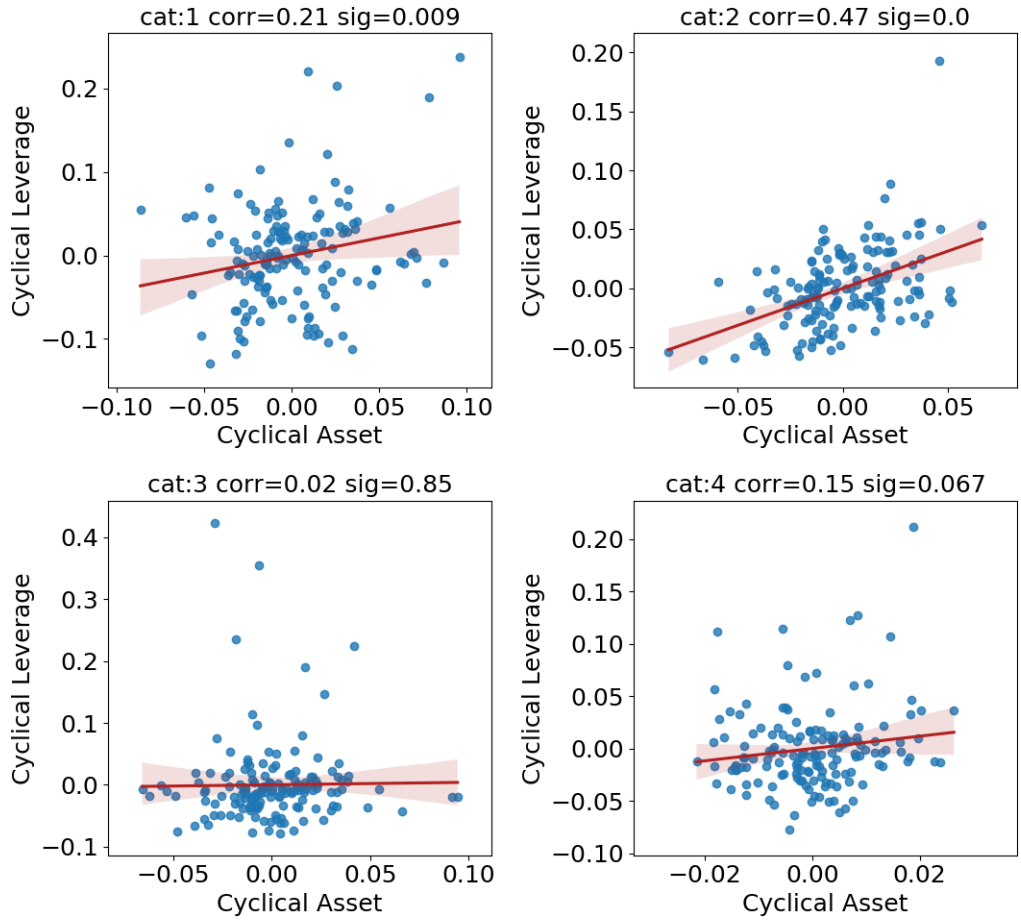

Figure 20: Cylical Assets versus Cyclical Leverage by Category.We compute the leverage for each bank individually and then take the average. With that average, we then compute cyclical growth by applying the HP-Filter. For the assets we also take the average and the compute the cyclical growth. (corr: pearson correlation, sig: 2-tailed p-value rounded to third place after comma, Cat1: top 10 banks, cat2: large banks, cat3: medium banks, cat4: small banks

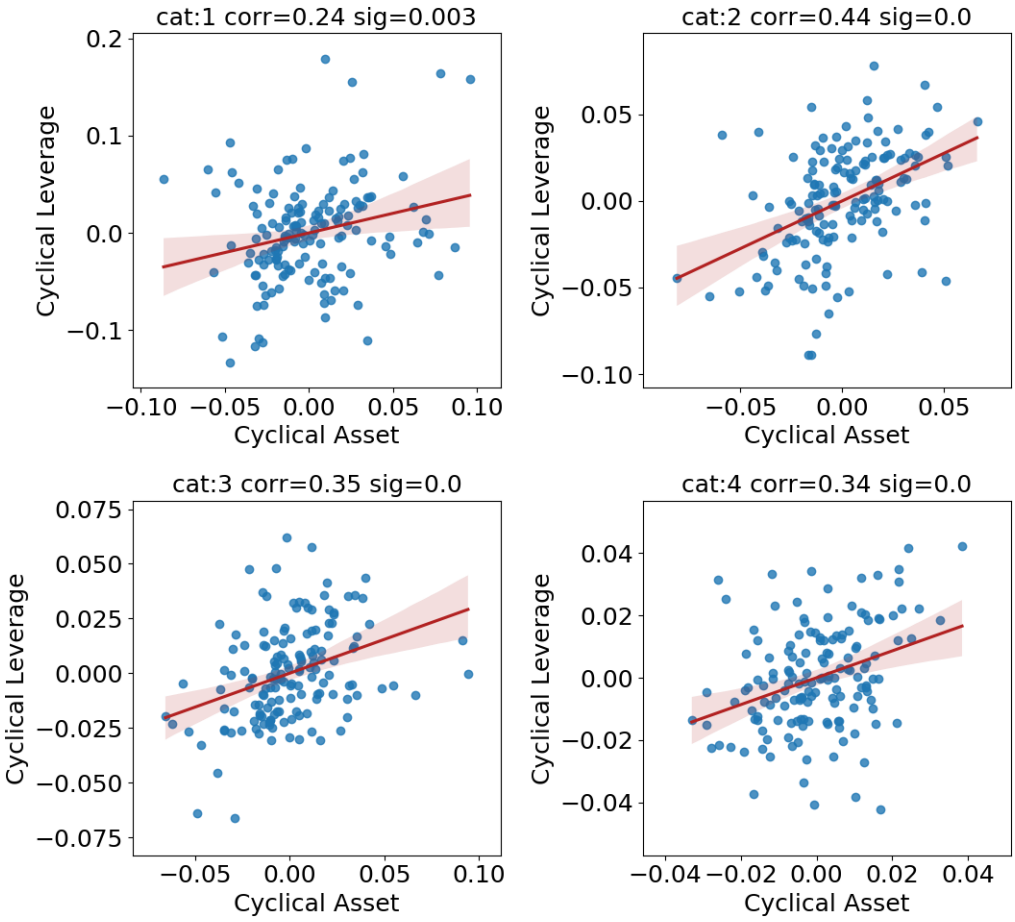

Figure 21: Scatterplot: Cylical Assets vs Cyclical Leverage by Category. We compute the leverage of bank by category with (aggregate assets / aggregate equity). We then compute cyclical growth of leverage as well as assets with HP-Filter.

3.6.3 Did pro-cyclicality change over time?

While the approach in the previous paragraph is to analyse pro-cyclicality of commercial banks over the whole time-frame, in this paragraph we split the time-frame into 10-year time ranges to observe if their cyclic leverage behaviour might have changed over time. Table 7 and 8 below shows the correlations of cyclical assets with cyclical leverage depending on our two types of computation used before for all commercial banks.[19] Table 9 and 10 In Table 7 we can observe positive correlations for latter two 10 year time-periods. The first time-period from $1980 - 1990$ has a positive correlation of 0.24 but its p-value above 0.05 is to high to be significant.[20] These partly positive correlations align with the positive correlation identified for the whole time-frame in **??**. On the other hand, Table 8 shows gives us completely different results. Here we find a significant ($p<0.05$) positive correlation for the first time-period, but an insignificant positive correlation for the period from $1990 - 2000$ and a negative correlation for the most recent time-period. These opposing correlations are probably the reason for a correlation of almost 0 in Figure

[19] See the captions within the tables for more detail.

[20] The lower sample size because of only ten years of data, might have an impact on the p-value

??. It seems like in $2000-2010$ the average commercial bank did not actively manage its leverage, resulting in leverage behaving counter-cyclical.

	year_range	correlation	significance
0	1980-1990	0.24	0.13
1	1990-2000	0.53	0.00
2	2000-2010	0.51	0.00

Table 7: Correlation of cyclical aggregate leverage with cyclical aggregate assets over time. We compute the leverage of all banks by (aggregate assets / aggregate equity). We then compute cyclical growth of leverage as well as assets with HP-Filter. There are N=36 observations per time-range. Significance is rounded to two decimal places.

	year_range	correlation	significance
0	1980-1990	0.41	0.01
1	1990-2000	0.17	0.31
2	2000-2010	-0.62	0.00

Table 8: Correlation of cyclical average leverage with cyclical average assets over time. We compute the leverage for each bank individually and then take the average. With that average, we then compute cyclical growth by applying the HP-Filter. For the assets we also take the average and the compute the cyclical growth. Significance is rounded to two decimal places.

To find the drivers of this observed behaviours we applied the same methods to each bank size category also. We divide the following discussion by the time-periods in question.

1980-1990 Both methods give insignificant correlation results for the top 10 and large banks.[21]. The only significant values with $p < 0.01$ are in Table 9 for medium and small banks. Hence, the only conclusion that can be drawn, is that aggregate leverage of of small and medium banks tends to move pro-cyclical, identical to the conclusion that can be drawn from Figure 21 over the time-frame $1976-2013$ in section 3.6.2 before.

1990-2000 For this time-period, we find that large and small banks behave pro-cyclical. This behaviour is robust towards both computational methods applied. In addition, we find pro-cyclic behaviour for medium banks in Table 9. This pro-cyclic behaviour of the medium and large banks might have driven the positive correlation for all banks found in Table 7 for $1990-2000$. All other results for this time-frame are insignificant.

2000-2010 The most recent time-period shows small pro-cyclical behaviour with correlations of $0.37 and 0.3$ from the top 10 banks. The similarity of both findings means its robust to both data treatments. All other observations for different bank sizes can be considered insignificant.

[21] Again, this might be caused by the lower sample size

Overall, we can conclude that pro-cylicality among commercial banks is not always consistent over time. Table 9 and 10 suffer from low sample sizes. Hence, the often insignificant results received. Moreover, we conclude that leverage of the commercial banking sector as whole does behave pro-cylic. And this finding is to some extent consistent over time as seen in Table 7. The average bank did behave pro-cyclic from $1980 - 1990$, but counter-cyclic in recent times from $2000 - 2010$.

	year_range	Correlation	Significance
Top 10 banks	1980-1990	0.21	0.2
	1990-2000	0.08	0.62
	2000-2010	0.37	0.018
Large banks	1980-1990	0.21	0.18
	1990-2000	0.67	0.0
	2000-2010	0.22	0.18
Medium banks	1980-1990	0.57	0.0
	1990-2000	0.48	0.002
	2000-2010	0.036	0.83
Small banks	1980-1990	0.56	0.0
	1990-2000	0.55	0.0
	2000-2010	-0.2	0.21

Table 9: Correlation of cyclical aggregate leverage with cyclical aggregate assets over time. We compute the leverage of all banks by (aggregate assets / aggregate equity). We then compute cyclical growth of leverage as well as assets with HP-Filter. Significance is rounded to three decimal places.

	year_range	Correlation	Significance
Top 10 banks	1980-1990	0.15	0.34
	1990-2000	0.075	0.65
	2000-2010	0.3	0.063
Large banks	1980-1990	0.25	0.12
	1990-2000	0.58	0.0
	2000-2010	0.072	0.66
Medium banks	1980-1990	0.23	0.16
	1990-2000	-0.041	0.8
	2000-2010	-0.26	0.1
Small banks	1980-1990	0.086	0.6
	1990-2000	0.36	0.022
	2000-2010	-0.086	0.6

Table 10: Correlation of cyclical average leverage with cyclical average assets over time. We compute the leverage for each bank individually and then take the average. With that average, we then compute cyclical growth by applying the HP-Filter. For the assets we also take the average and the compute the cyclical growth.

3.6.4 Leverage development

Long-term discussion Figure 22 shows the mean, median and weighted-average leverage for each point in time. We can see a clear impact of high levered banks on the average. Especially, in the periods around 1990 and 2008 when bankruptcy levels are high, there are major mean leverage increases as seen in Figure 22. The median gives us a clearer indication how leverage among healthy banks look. Hence, depending of what type of measure we choose (average or median), we arrive at different observations. The only consistent information conveyed by all measures is a falling trend in leverage from year 1976 to 2013. The median, representing the typical bank, starts with a leverage of 12.5 in 1976 and falls continuously over the years to 10 in 2013. The mean also falls from 12.5 to 10. It has some short-term fluctuations in 1990 and 2008, which we will elaborate on later. The weighted-average leverage, taking into account the total assets of a bank, starts with a significant higher level of leverage at 18, but then also falls to a leverage ratio of 10 in 2013. The idea behind the weighted leverage is that larger banks with more assets have a stronger impact on the overall systemic risk than smaller banks. The significant measurement differences between the common average and weighted leverage, marks the importance of differentiating between asset sizes in leverage analysis. Also, as seen in Figure 10, the small banks (banks ranked from 1000-Rest) dominate the bank landscape in quantity. As a result, the overall leverage average and small banks leverage average (cat 4) are almost identical. The first graph in Figure 23 shows the average leverage for each defined bank size category. Here we can also see an overall falling trend in leverage along all categories. This can be attributed to regulatory efforts such as Basel $1, 2$ and 3. In addition, the graph shows an interesting pattern until 1993 - the larger the bank the more it levers. However, after 1993, the pattern seems to disappear. In 2013, the pattern even reverses - the larger the bank the lower the leverage. These observations are closely linked to information gathered in section 3.4. If the top 10 banks would have kept their higher leverage, their significant rise in total asset share from 1993 and onwards would have resulted in major leverage increases for the whole banking sector. Hence, regulators adjusted their regulations to target systemically important banks with stronger capital requirements (G-SIB Framework). The top 10 banks, category 1, are affected by these additional capital requirements.

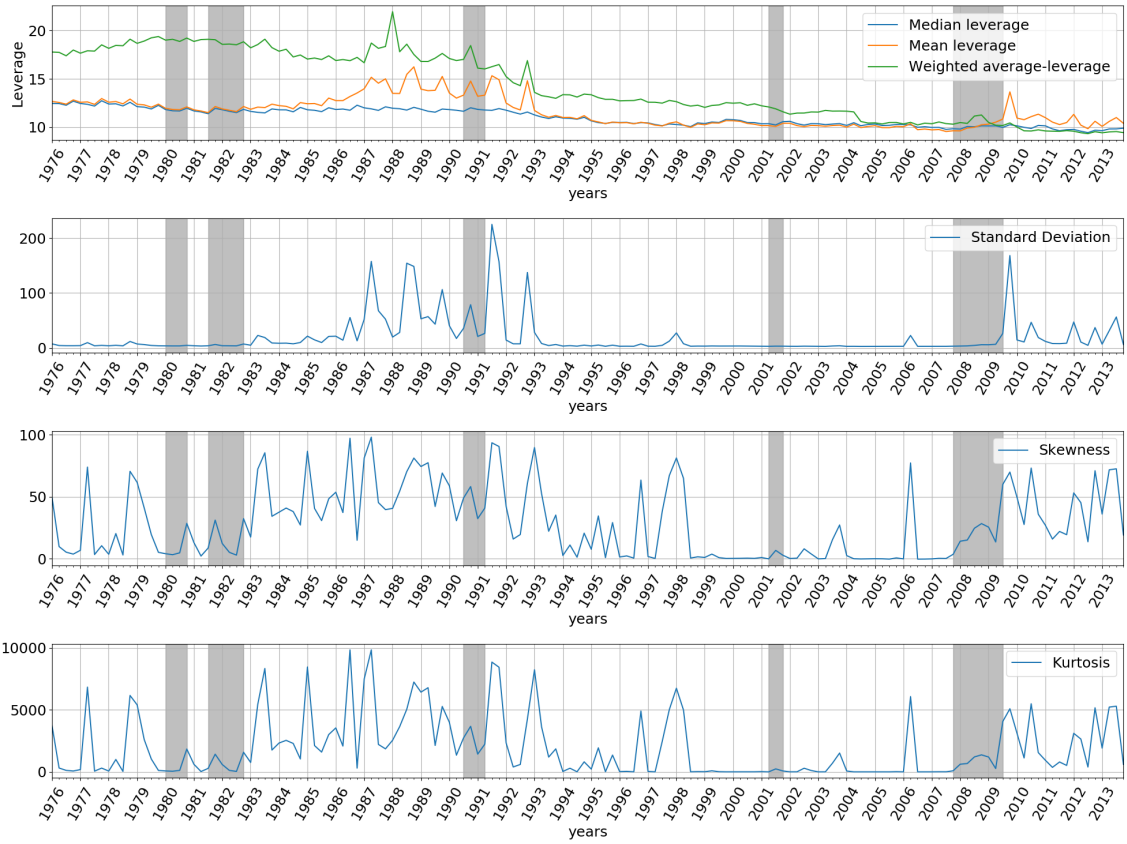

Figure 22: Median and Average leverage for all banks. The weighted-average leverage ratio is calculated by taking into account the asset size for each bank every point in time. Every leverage ratio for each individual bank is only accounted in the weighted-average by its share of assets compared to the total assets of all banks at that point of time.

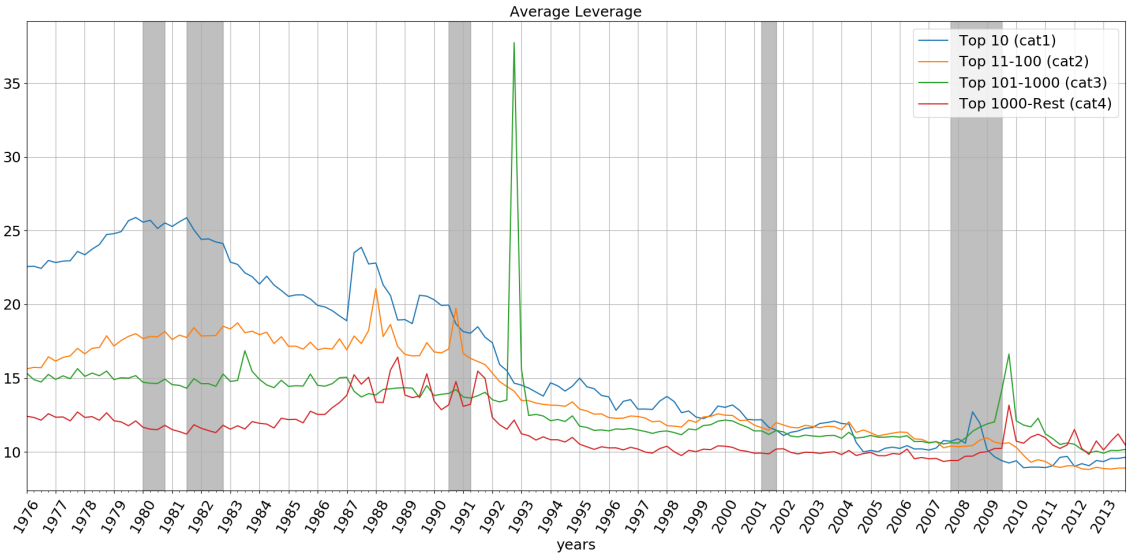

Figure 23: Average leverage by category

Short-term discussion For short term analysis, we consider the cyclical component and standard deviation of leverage. The standard deviation indicates previously identified two critical points in time - 1990 and 2008. Looking at the first graph in Figure 24,

the cyclical graph also highlights those same periods. However, similar to the standard deviation, the spike in average leverage for all banks occurs right after the NBER crisis definition. We know that small banks drive the average leverage with their quantity. Hence, their cyclical components - graph 1 and graph 5 - in Figure 24 are almost identical. In comparison to the small banks, the cyclical leverage of the top 10 banks actually spikes during the crisis in 2007-8. The mid-categories two and three show behaviour right between the two extreme behaviours of categories one and four. Category two has small peaks during and after the crisis. Category three only has a peak up to 2 after the crisis, closer resembling category four. Note, the graph of category three cyclical leverage contains some extreme outliers in year 1992Q4, which increased the limits of the vertical axis up to 20. To ease analysis, table 25 gives us the actual cyclical values of the average leverage for the crisis periods. We marked changes $> 4\%$ with red. Similar to the graph, we can see a spill-over effect of high leverage from large to small banks. Figure 26 gives us a visual insight into the structural changes that occur regarding asset size and leverage. Each data-point represents one bank. We can see a clear increase in dispersion of leverage in 2009 among the small and medium banks. This aligns with the standard deviation shown in Figure 27, where the standard deviation also has a spike in 2009. It is important to mention that the previous defined pro-cyclicality of leverage stands in contrast to the observations made in the crisis 2008. We have defined pro-cyclicality with positive co-movement of leverage with assets and not GDP. While the GDP might be falling in the crisis 2008, total assets of commercial banks do not immediately behave the same, see section 3.3. Another pattern we can observe within the standard deviation is an increase of volatility the smaller the asset size category becomes. Figure 27 show this with the ranges of its vertical axes.

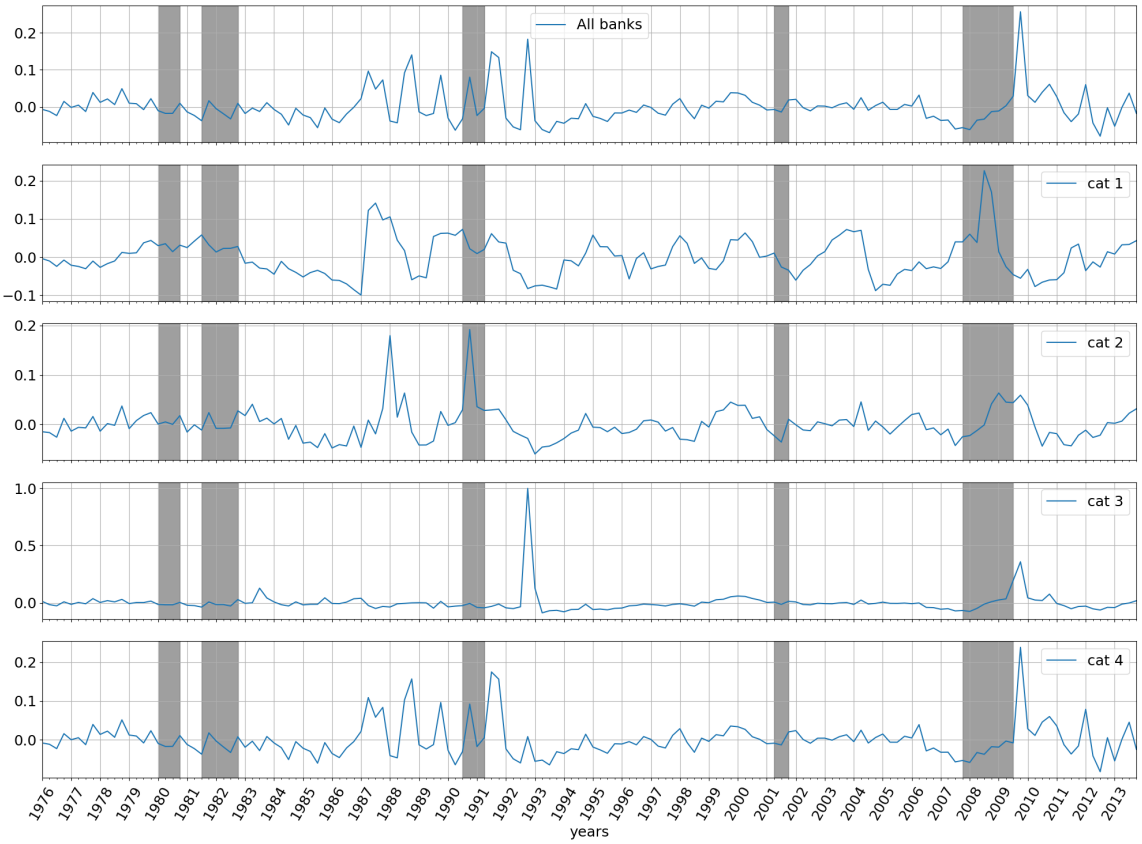

Figure 24: Cyclical average leverage by category. Category 3 contains a banks with leverage over 10000 in year 1992Q4, which results in this exorbitant high spike.

year	quarter	cyclical_leverage_cat1	cyclical_leverage_cat2	cyclical_leverage_cat3	cyclical_leverage_cat4
2007.0	1.0	-0.029887	-0.021031	-0.056249	-0.032116
	2.0	-0.012429	-0.009437	-0.051671	-0.031969
	3.0	0.039798	-0.042668	-0.071142	-0.057048
	4.0	0.039783	-0.024953	-0.067480	-0.053403
2008.0	1.0	0.060017	-0.022654	-0.075584	-0.058472
	2.0	0.038200	-0.012307	-0.048921	-0.032843
	3.0	0.226450	-0.001022	-0.011661	-0.037448
	4.0	0.170388	0.041481	0.009405	-0.017864
2009.0	1.0	0.014133	0.063467	0.024552	-0.018963
	2.0	-0.025306	0.045066	0.034259	-0.003208
	3.0	-0.046115	0.044002	0.195956	-0.008145
	4.0	-0.055506	0.059162	0.358070	0.238390
2010.0	1.0	-0.032219	0.038947	0.043614	0.028410
	2.0	-0.077345	-0.005151	0.023953	0.011182
	3.0	-0.065939	-0.043899	0.019594	0.045642
	4.0	-0.060088	-0.016217	0.075700	0.059942

Figure 25: Cyclical Average Leverage

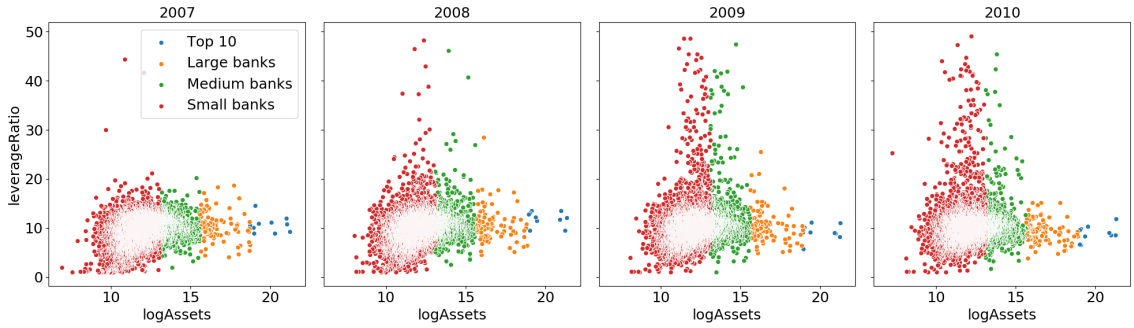

Figure 26: Scatterplot: Assets/Leverage. Banks with leverage ratios beyond 50 are considered as outlier and not included. Each data-point represents one bank.

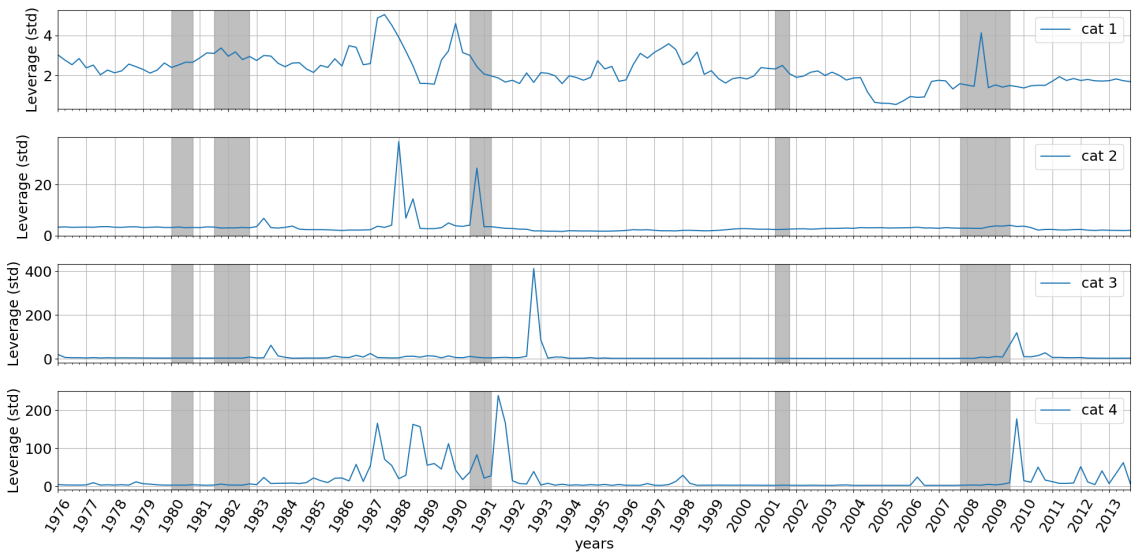

Figure 27: Standard deviation of leverage by category. Category 3 contains a banks with leverage over 10000 in year 1992Q4, which results in this exorbitant high spike.

3.6.5 Leverage distribution

Long-term discussion In regards to the distribution of leverage, we have plotted the skewness as well as the kurtosis for all banks in Figure 22. Both variables behave similar. There are periods of strong as well as low variation. Notable periods of high variation are the periods around the two banking crises in 1990 and 2008. Since high positive skewness means the graph is right-skewed with the mean being higher than the median and high kurtosis indicates heavy tails, together they prove the existence of high positive outliers. The periods with low variation in turn indicate periods of normal distributed leverage. Furthermore, the two variables only move in the positive direction (values of zero and above). For the skewness, this can be explained by the fact that banks are kind of "sticky" to the lower boundaries of leverage, with not much variation happening within banks of the left tail of the distribution. But there is much more variation happening between banks located at the right tail of the distribution - banks with leverage above the mode. Essentially, high levered banks show much higher variation in their leverage ratio than low levered, conservative banks. The consistent positive kurtosis in turn tells us that there are never less outlier than a normal distribution.

Figure 29 and 28 give us the distribution information by asset category over time. It is important to note that the overall distribution is mainly driven by small banks, because of their sheer quantity. Thus, the division by categories gives us a clearer view. Again, skewness and kurtosis behave very similarly. For the top 10 and top 10-100 (cat2) banks we have short periods where the skewness moves below zero. We take a look at those periods in the short-term discussion. The rest of the time, both measures are either zero or above for all categories, suggesting that once you have a certain amount of banks,

the distribution tends to be right skewed. In general, we can deduce that most of the distributional changes in our graphs are driven by two factors:

1. Already high levered banks increasing their leverage even more (high skewness)

2. Increases of outliers (high kurtosis)

These factors seem to be most present around the crisis in 1990 and the crisis in 2008, hence, the significant graph movements around that time-periods. The top 10 banks have negative kurtosis in some periods, which means the top 10 banks have less outlier than the normal distribution. Hence, the top 10 banks tend to act together regarding their leverage decisions. They also show much less distributional volatility around the S&L crisis, compared to the other categories. Actually, when moving along our categories, the distributional changes are higher the smaller the banks become. This aligns with the arguments made about the standard deviation in the paragraph before.

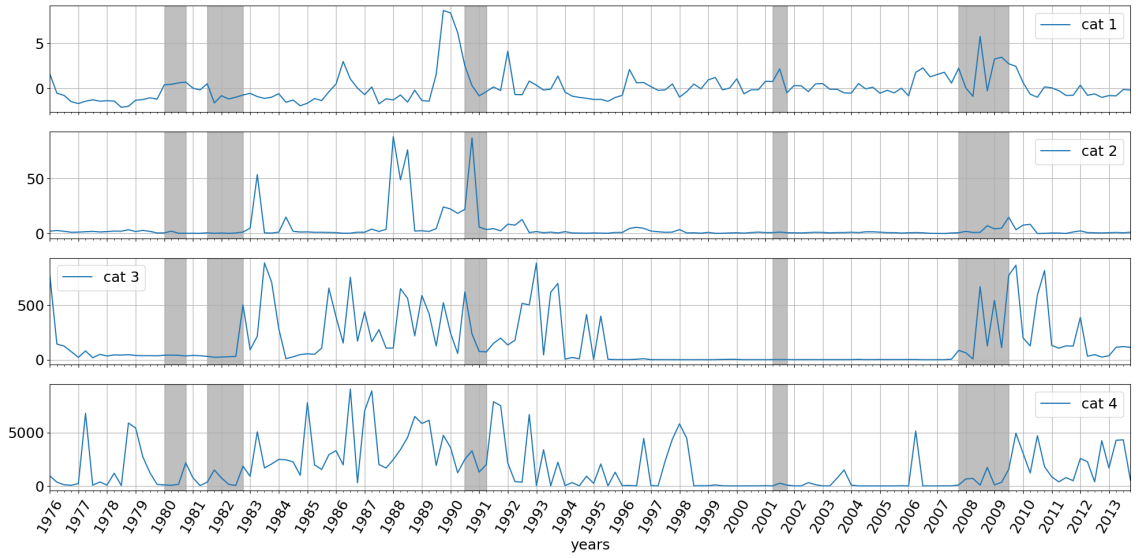

Figure 28: Kurtosis of leverage by category

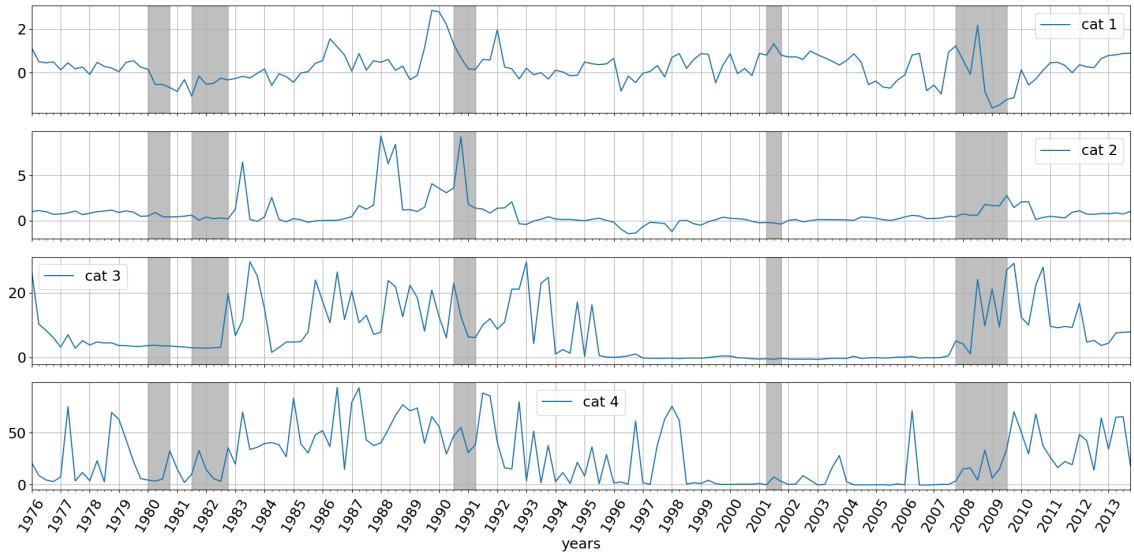

Figure 29: Skewness of leverage by category

Short-term discussion As mentioned, in our short-term analysis, we investigate the reason skewness turns negative in some periods. The negative measurements of the top 10 in the crisis 2008 are particularly interesting, since we associate crises with already high levered banks increasing leverage even more. However, this could indicate some low levered banks within the top 10 became high leveraged as well. The skewness rises from 2008Q1-2008Q3 and then it takes a dive in 2008Q4 and 2009Q1. As a result, the distribution of leverage is left skewed in 2008Q4 and 2009Q1. This left skewness means that the mean is to the left of the peak. To have a better overview, Figure 30 combines a boxplot with the top 10 banks leverage ratios marked as dots for the year and quarter in question. The boxplot as whole and the lower whisker moved significantly up from 2007 to 2008. Both are characteristics of left skewness. Here, we can see an overall increase in leverage among top 10 banks, not only driven by outliers. Despite being small in numbers, the asset share of the top 10 was 60% in year 2013. Therefore, this had a significant impact on the bank industry, documented as a spill-over effect in the sections before.

The skewness of the top 10 also became negative in the years around 1980. Similar to conclusions we have drawn about the crisis in 2008, this indicates a general increase in leverage among the top 10 banks.

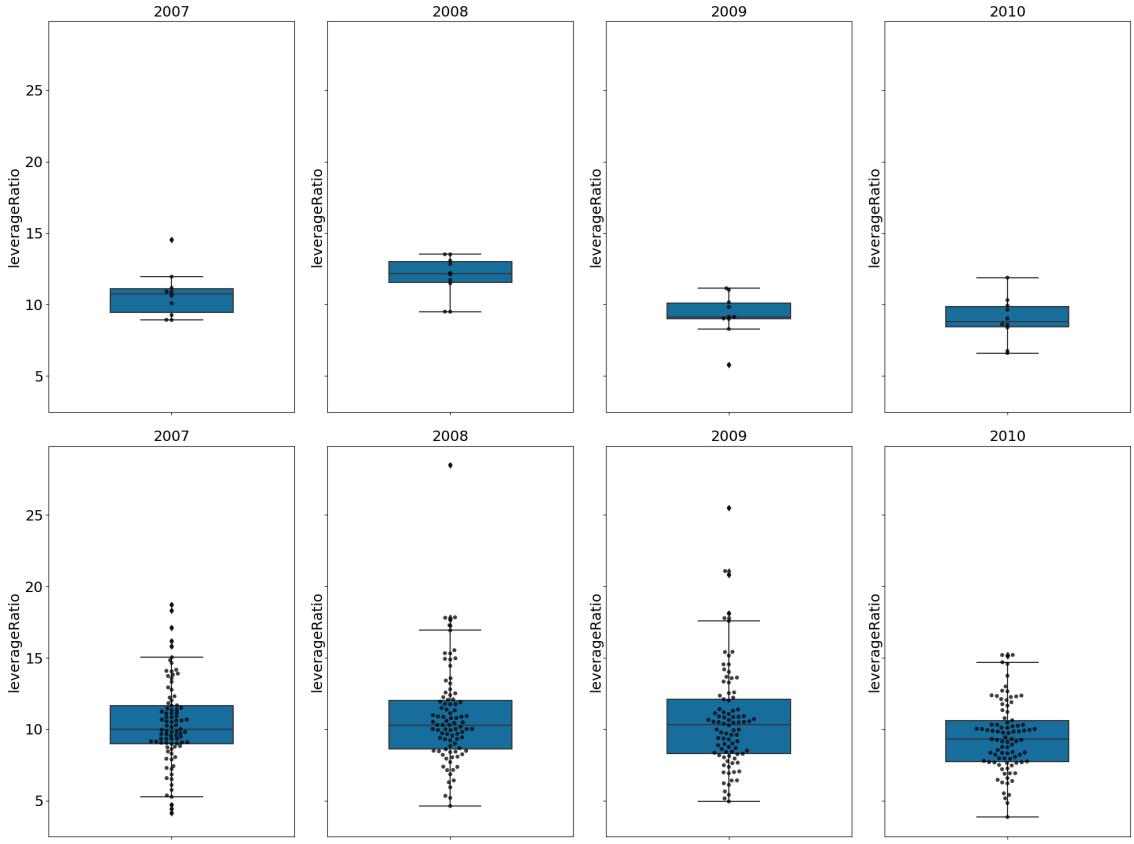

Figure 30: Boxplot: Leverage data points. The first row of plots represents top 10 (cat1) and the second row top 10-100

4 Evaluation and Outlook

In general, this thesis gives a broad overview over the U.S. commercial bank landscape and key important factors that should be considered. We find interesting trends and cycles on an aggregate level as well as for different bank sizes. Many points discussed are open for interpretation and future work should go into more detail about the approached topics. For instance, it would be interesting to find an optimal way to categorize U.S. commercial banks. The literature seems to have found no coherent way of categorization. These categories would obviously be of key importance to regulators. Furthermore, as seen from the large amount of literature about leverage there is a wide variety of possibilities to explore it in greater depths. One might consider the relationship of leverage not just with assets, but GDP and other variables. Moreover, commercial banks are just a part of the financial intermediaries existing economies have. The so called "shadow banking" sector does play a major role in today's financial industry and hold a significant share of total assets. It also was investment banks which had to bear the major impacts of the financial crisis in 2007, not commercial banks. Lastly, another factor we have not considered is that, according to Kalemli-Ozcan et al. (2011), a big fraction of assets, especially for large commercial banks, are off balance sheet items.

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A Appendix

	lag	assets	cash	fedfundsrepoasset	securities	loansnet	tradingassets	otherassets
0	0	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1	1	0.668482	0.543616	0.678344	0.857966	0.874169	0.670577	0.686616
2	2	0.549088	0.385644	0.441868	0.663799	0.750934	0.462435	0.564927
3	3	0.383607	0.185667	0.262141	0.481113	0.582572	0.290667	0.429074
4	4	0.364207	0.276731	0.141942	0.259817	0.426244	0.183740	0.414830
5	5	0.094690	0.003499	-0.063425	0.026585	0.225113	-0.058170	0.243093
6	6	0.023946	0.023056	-0.208787	-0.153482	0.071170	-0.161202	0.167211
7	7	-0.114478	-0.179763	-0.294161	-0.288772	-0.092589	-0.247924	0.069033
8	8	-0.103289	-0.096091	-0.311070	-0.350237	-0.192288	-0.221654	-0.017683

Figure 31: Autocorrelation - Asset side

lag	equity	fedfundsrepoliab	deposits	foreigndep	otherborrowedmoney	tradingliabilities	subordinateddebt	otherliab
0	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
1	0.723293	0.628063	0.328080	0.798504	0.731746	0.529164	0.805696	0.368007
2	0.449616	0.404419	0.292106	0.661453	0.541543	0.243973	0.689890	0.012917
3	0.179874	0.211710	0.055729	0.463610	0.361965	0.147006	0.509253	0.078217
4	0.009426	0.183654	0.348144	0.329830	0.283648	-0.132563	0.336406	0.145914
5	-0.103217	0.005744	-0.196956	0.117763	0.173004	-0.291591	0.190992	-0.091779
6	-0.109206	-0.058821	-0.179869	0.001884	0.064673	-0.387505	0.081116	-0.295527
7	-0.155159	-0.182500	-0.321517	-0.124807	-0.095045	-0.427252	-0.068200	-0.089373
8	-0.143907	-0.143367	0.106174	-0.155675	-0.215672	-0.382195	-0.173296	0.008344

Figure 32: Autocorrelation - Liabilities side

lag	cat1_assets+cat1_assets	cat1_assets+cat2_assets	cat1_assets+cat3_assets	cat1_assets+cat4_assets
0	1.0	0.41	-0.27	-0.069
1	0.66	0.34	-0.26	-0.088
2	0.44	0.27	-0.18	-0.032
3	0.36	0.18	-0.11	-0.007
4	0.26	0.079	-0.084	-0.029
5	0.055	-0.057	0.044	0.0053
6	-0.029	-0.14	0.2	0.12
7	-0.11	-0.19	0.32	0.18
8	-0.18	-0.17	0.36	0.14
9	-0.21	-0.11	0.36	0.12

lag	cat2_assets+cat1_assets	cat2_assets+cat2_assets	cat2_assets+cat3_assets	cat2_assets+cat4_assets
0	0.41	1.0	0.24	-0.046
1	0.43	0.63	0.11	-0.19
2	0.4	0.53	0.12	-0.14
3	0.33	0.32	0.075	-0.16
4	0.31	0.3	0.21	-0.016
5	0.25	0.071	0.084	-0.15
6	0.18	-0.00094	0.12	-0.089
7	0.074	-0.13	0.11	-0.063
8	0.019	-0.12	0.2	0.068
9	0.019	-0.3	0.04	-0.033

lag	cat3_assets+cat1_assets	cat3_assets+cat2_assets	cat3_assets+cat3_assets	cat3_assets+cat4_assets
0	-0.27	0.24	1.0	0.41
1	-0.14	0.12	0.68	0.14
2	-0.04	0.14	0.53	0.025
3	-0.026	0.047	0.35	-0.09
4	0.048	0.1	0.34	-0.0024
5	0.095	-0.076	-0.0006	-0.17
6	0.13	-0.11	-0.14	-0.19
7	0.061	-0.19	-0.31	-0.23
8	0.048	-0.22	-0.29	-0.083
9	-0.089	-0.43	-0.45	-0.11

lag	cat4_assets+cat1_assets	cat4_assets+cat2_assets	cat4_assets+cat3_assets	cat4_assets+cat4_assets
0	-0.069	-0.046	0.41	1.0
1	0.0062	-0.12	0.22	0.71
2	0.036	-0.054	0.2	0.55
3	-0.033	-0.083	0.16	0.39
4	-0.0073	0.019	0.25	0.42
5	0.035	-0.1	0.051	0.15
6	0.055	-0.067	0.0012	0.016
7	-0.043	-0.12	-0.057	-0.13
8	-0.11	-0.08	0.054	-0.063
9	-0.2	-0.22	-0.058	-0.22

Figure 33: Correlations: Category 1-4. This graph shows the correlation of a banks size category assets with the lagged assets of another banks size category. The category after the "+" is the lagged category. Hence, the first graph shows the correlation between categories 1 aggregate assets and all the different other categories lagged aggregate assets.

	1980	1985	1990	1995	2000	2005	2010
(-0.001, 100000.0]	12717.0	11674.0	9145.0	6613.0	4810.0	3435.0	2313.0
(100000.0, 1000000.0]	1507.0	2287.0	2693.0	2843.0	3055.0	3562.0	3670.0
(1000000.0, 10000000.0]	174.0	287.0	325.0	342.0	307.0	381.0	413.0
(10000000.0, 10000000000.0]	18.0	27.0	49.0	75.0	80.0	80.0	83.0

Figure 34: Banks count by asset size. The left column is the asset interval size and the corresponding row the number of banks per year.

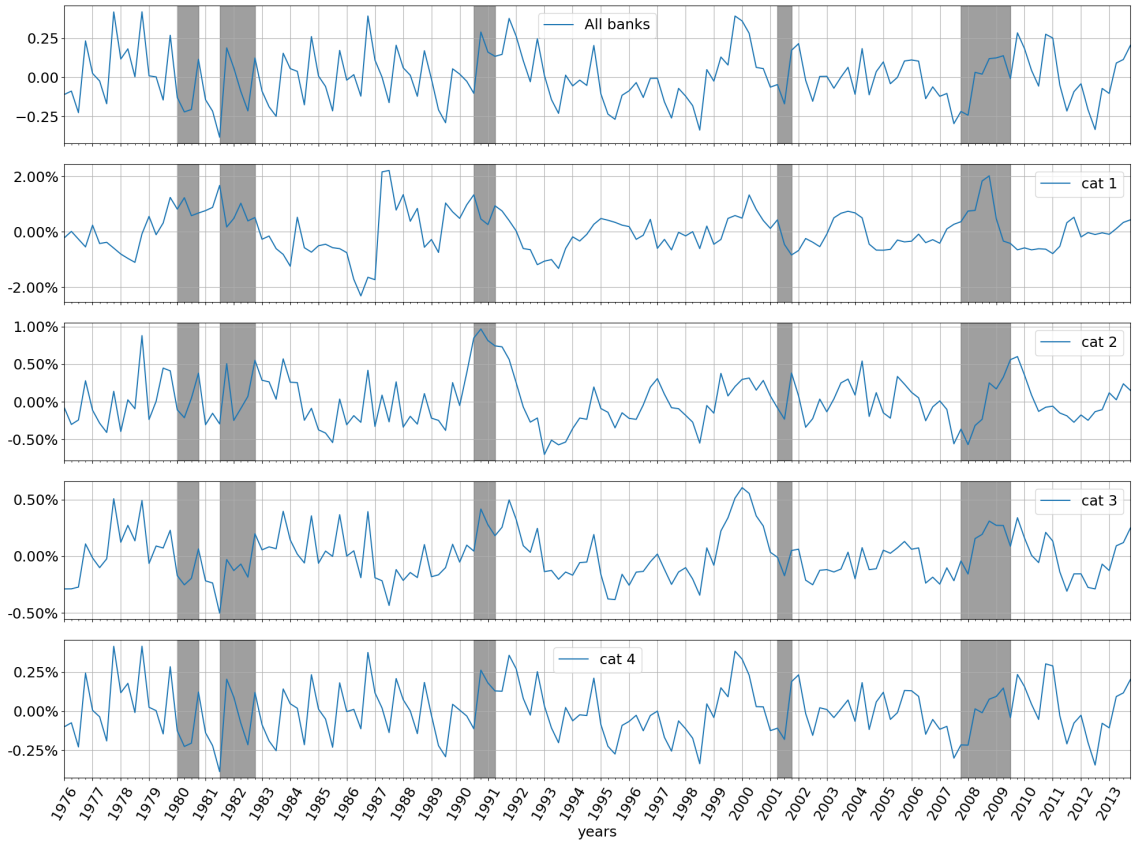

Figure 35: Cyclical median leverage by category

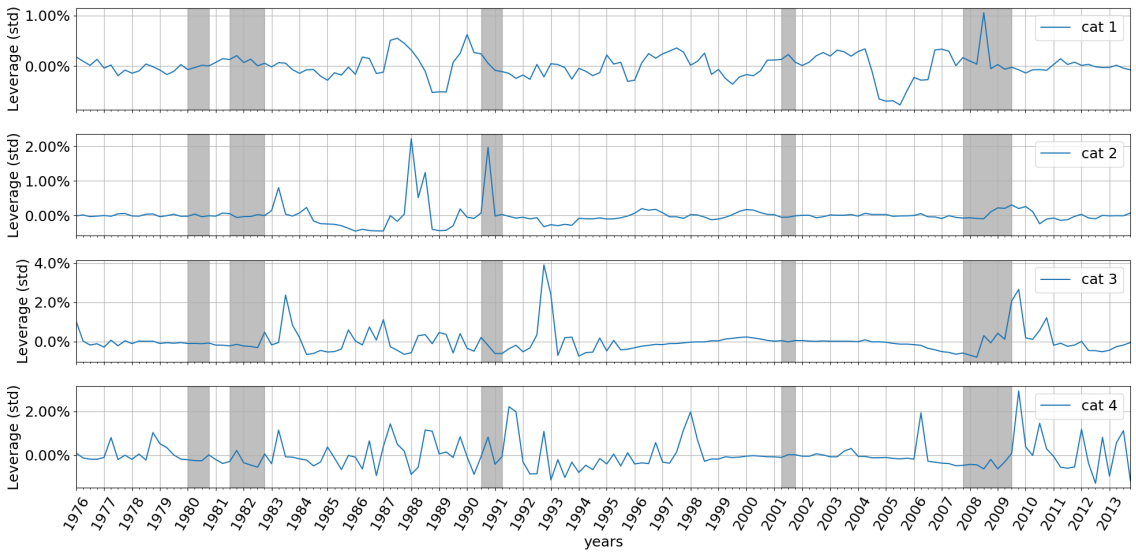

Figure 36: Cyclical standard deviation of leverage by category. Category 3 contains a banks with leverage over 10000 in year 1992Q4, which results in this exorbitant high spike.