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„Liquidity Creation of European Banks from 2008-2018“

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1. Introduction

According to modern theory of financial intermediation the main role of commercial banks is qualitative asset transformation which can be split into two functions: transforming liquidity (maturity) and transforming risk (Bhattacharya and Thakor 1993). Liquidity is transformed as the financing of illiquid long-term assets with short-term liquid liabilities, which creates value because the banks are providing a source of liquidity insurance (Diamond and Dybvig 1983). In this sense, financial intermediaries create liquidity for the economy by offering loans that might otherwise not be available by financing them with funds from investors, savers and lenders who demand liquidity, and to whom they can provide liquidity at any time.

However, this comes at a cost as banks expose themselves to certain risks by carrying a maturity mismatch in their books. Especially the 2007/2008 global finical crisis has shown that the exposure to market and funding liquidity was undervalued and demonstrated how the lack of regard for systemic risk has destabilized the finical system. From this, policymakers and regulators drew lessons that led, among other regulations, to the introduction of two new liquidity requirements as excessive liquidity (maturity) transformation was seen as one cause of the crisis. These reforms were also accompanied by rather exceptional measures taken by central banks to deal with both the aftermath of the financial crisis and the sovereign debt crisis in Europe. The Federal Reserve System as well as the European Central Bank (ECB) implemented unprecedented monetary policy operations like the Quantitative Easing (QE) programs to foster lending in the real economy.

In view of these developments, this thesis has two research objectives. The first objective is to analyze how liquidity creation of European banks has evolved since the financial crisis and to get a better understanding of the driving forces. The measurement of liquidity creation is based on one of the liquidity creation measures designed by Berger and Bouwman (2009). This analysis was carried out by examining financial statements of more than 200 publicly listed European banks starting in 2008 at the peak of the financial crisis to 2018, the latest available data. Since banks expanded their activities through participation in financial markets, the current literature of liquidity creation is extended by including the effects of asset and liability securities.

The second objective of the thesis is to test the net effect of bank capital on liquidity creation. So far, I am not aware of any previous work that discusses this topic from a broader European perspective following the financial crisis. The origin of the question arises from two hypotheses with ambiguous predictions about how bank capital affects liquidity creation. The “risk absorption” hypothesis from Bhattacharya and Thakor (1993) claims that banks create more liquidity when increasing their equity ratio. According to the “financial fragility-crowding out” hypothesis an increase in the equity ratio decreases the liquidity creation of banks (Berger and Bouwman 2009).
The results suggest that the "financial fragility-crowding out" hypothesis applies to small banks with total assets of up to one billion Euro and to medium-sized banks with total assets of up to 25 billion Euro. While, on the contrary, the “risk absorption” hypothesis is likely to apply to large banks with total assets of more than 25 billion Euro.
In further consequence, it will be investigated how the unconventional measures of the ECB, such as the Asset Purchase Programme (APP), have changed the effect of equity on bank liquidity creation. As, in the course of the programs, banks are expected to use the newly injected capital for lending rather than trading, liquidity transformation and creation is likely to have increased.

The master thesis is organized as follows. The first section gives a brief review of existing literature concerning the theory of liquidity creation; how different theories on bank liquidity creation and capital suggest different outcomes and summarize existing empirical evidence regarding the impact of capital on liquidity creation of European and US banks. The second section gives an overview of the sample of examined commercial banks from 2008 to 2018 and explains the model and regression framework used in this thesis.
Under the third section, the three-step methodology Berger and Bouwman (2009) used to construct their liquidity creation measures is described, although the thesis mainly focuses on the measure of on-balance sheet activities. Given that liquidity for the economy can also be provided by off-balance sheet activities such as loan commitments, the measure preferred by Berger and Bouwman, which also includes off-balance sheet positions, is not practicable as there is no standardized reporting on off-balance sheet items in Europe.
In the final section, the second objective of this thesis is tested, namely the effect of capital on the banks' liquidity creation for different sizes.

2. Related Literature

This section provides a brief literature review to put the analysis in this thesis into context. This is done in three subsections: different measurement methods of bank liquidity creation, determinants of liquidity creation in theory, and lastly, existing empirical evidence.

2.1 Measurement of Bank Liquidity Creation

The first to construct a means of evaluating to what extent banks convert liquid liabilities into productive capital were Deep and Schaefer (2004), who tested their measurement on data of 200 US commercial banks in the period of 1997 to 2001. To determine the liquidity creation of the selected banks they defined the liquidity transformation gap ("LT gap") as follows:

$$LT\ gap \equiv \frac{liquid\ liabilities - liquid\ assets}{total\ assets} \quad (1)$$

Equation 1: "LT gap" by Deep and Schaefer (2004, Pg. 9)

According to the equation a high value of the "LT gap" indicates that an institution funds a large share of illiquid loans (and thus has a small fraction of liquid assets) with a relatively large portion of liquid deposits. Liabilities are considered to be liquid if the maturity, the time in which it can be converted into cash or cash equivalent, is equal to one year or less. On the asset side, cash, securities, and all loans with a maturity of less than one year are regarded as liquid. From the 200 US banks the authors used quarterly data from the Reports of Condition and Income (also known as Call Reports) and found out that the majority of banks create a rather small amount of liquidity.

Subsequently, Berger and Bouwman (2009) added the ability to include loan commitments and other off-balance sheet items. Their sample consists of all US commercial banks that have to submit Call Reports. Unlike Deep and Schaefer (2004), Berger and Bouwman (2009) did not use quarterly but rather annual (year-end) reports from 1993 to 2003 for reasons of accuracy.[1] Berger and Bouwman (2009) constructed four variants for assessing liquidity creation, by excluding or including off-balance sheet activities ("non-fat"/"fat") and secondly, classifying all assets and liabilities by either maturity ("mat") or product category ("cat").

The first measure allocates only assets and liabilities on the balance sheet ("non-fat") according to their maturity ("mat") into liquid, semi-liquid and illiquid activities, which is referred to as

[1] Capital is affected by loan loss provisions and according to Berger and Bouwman (2009) these provisions are calculated more accurately at the end of the year.

"mat-nonfat". This measure from Berger and Bouwman (2009) is the most similar one to the "LT-gap" from Deep and Schaefer (2004) as it can be replicated by scaling the "mat-nonfat" measure by total assets.

Additionally, the measure called "mat-fat" uses the same concept dividing the balance sheet depending on the maturity ("mat") but includes off-balance sheet activities ("fat").

The third measure classifies all asset and liability balance sheet items into liquid, semi-liquid and illiquid product categories ("cat") based on the ease, cost, and rapidity with which these positions can be converted into liquid funds, which is defined as the "cat-nonfat".

The last measure, called "cat-fat", which is Berger's and Bouwman's preferred one, uses the category product ("cat") approach as well and adds off-balance sheet activities ("fat") on top of the "cat-nonfat" measure to incorporate the theory of Holmstrom and Tirole (1998) and Kashyap, Rajan, and Stein (2002).

		Categorization of assets and liabilities based on:	
		Category ("cat")	**Maturity ("mat")**
Off-balance sheet activities	**Excluded ("non-fat")**	"cat non-fat"	"mat non-fat"
	Included ("fat")	"cat fat"	"mat fat"

Table 1: Berger's and Bouwman's (2009) four liquidity creation measures

Berger and Bouwman (2009) discovered that in the time period of 1993 to 2003 bank liquidity creation increased every year and doubled in real terms, whereas most of the liquidity was created by large banks due to off-balance-sheet activities ("cat-fat"). Their research also suggests that in this time period bank liquidity creation, including off-balance sheet activities, shows significant positive correlations with the market value of financial institutions[2] (Berger and Bouwman 2009, Pg. 23).

Angora and Roulet (2011) looked at the transformation risk descending of liquidity creation from European and US publicly traded banks during the 2000 to 2008 time period using the product category liquidity creation measure of Berger and Bouwman (2009) without off-

[2] Since there is no theory suggesting a causal relationship between liquidity creation and the value of an institution, the authors only looked at the correlation between liquidity creation ("cat-fat") and the Market-to-book ratio as well as the Price-Earnings ratio.

balance sheet activities ("cat non-fat") scaled by total assets. Furthermore, the authors included an adjusted form of the Net Stable Funding Ratio (NSFR). The NSFR was originally introduced by the Basel Committee on Banking Regulation and Supervision to make sure that banks hold sufficient available liquid funds, due to severe illiquidity issues among European banks during the subprime crisis. Their alternative measure uses the classifications and weights defined by the consultative document of the BIS (2009) and calculated the net stable funding difference (NSFD) as follows:

$$NSFD = \frac{required\ amount\ of\ stable\ funding}{total\ assets} - \frac{available\ amount\ of\ stable\ funding}{total\ assets} \quad (2)$$

Equation 2: Net stable funding difference (NSFD) (Angora and Roulet 2011, Pg. 9)

Their findings confirm that an institutional size plays a role in differences in liquidity creation as large US and European banks create more liquidity and are thus more exposed to maturity transformation risks than small US banks.

2.2 Determinants of Liquidity Creation: Theoretical Background

Theories of financial intermediation have mainly focused on two things. Firstly, the acceptance of savings in the form of deposits or the issuance of shares, which is reflected in the form of equity, and secondly, by investing the collected funds in loans to entrepreneurs or holding them in cash (e.g. Diamond and Dybvig 1983). From the perspective of these theories, banks are primarily holding capital to absorb risk stemming from the maturity transformation, most relevant to assure against credit risk, but also to withstand liquidity bottlenecks on the interbank market or originating from bank runs. However, more recent theories point out that bank capital may also affect liquidity creation, although with ambiguous predictions. As outlined by Berger and Bouwman (2009, Pg. 7), on one hand, an increase in bank capital will hamper liquidity creation via the "financial fragility-crowding out" effect. This effect can be divided in two strands.

The first strand of theory defined as the "financial fragility structure" claims that a fragile capital structure commits the bank management to monitor issued loans, as deposit contracts allow withdrawals from savers at any time. According to this theory, an increase in the capital ratio disrupts the disciplining mechanism of depositors, which is why they withdraw their money, with the result that the bank has less capital available and has to restrict lending (Diamond and Rajan 2001).

The other strand argues that an increase in capital reduces the liquidity creation overall, as relatively illiquid equity "crowds out" relatively liquid deposits (Gorton and Winton 2017).
On the other hand, under the "risk absorption" theory, an increase in capital strengthens the ability of banks to increase their liquidity creation, as capital expands the risk-bearing ability since it enables banks to absorb more risk (Bhattacharya and Thakor 1993).
As shown in the next subsection, more empirical work on the effect of capital on liquidity creation has been published prior to the crisis. In contrast, relatively little has been done when looking at the balance sheet composition of European banks regarding securitization.

It is not only important how equity affects the creation of liquidity on the liability side but also into which assets the increase in equity is invested.
Over time the activities of modern banks have expanded to new opportunities on the asset as well as on the liability side through participation in financial markets (Shleifer and Vishny 2009, Pg. 306). Banks can both lend (short-term) on the market, which is beneficial regarding liquidity creation on the liability side, and securitize and sell extended loans on the asset side.
To extend the theory of financial intermediation in this spirit, Shleifer and Vishny (2009) include the possibility for banks to invest capital in market trading or to borrow funds from the financial market in their model. The effects of these market activities on the liquidity creation of banks depend on the asset prices of securitized loans. If the market prices of securitized loans are high enough, the bank will create more liquidity by extending the loan-supply to securitize them subsequently. Their model states that banks with the option of securitizing loans can increase investment beyond what would be possible with direct lending. This comes at a cost as it amplifies cyclicality and can lead to bubbles as banks prefer to invest in projects that are more easily securitized rather than in projects that are harder to securitize.
If asset prices of securitized loans then fall, banks do not liquidate securities to fund new loans but rather hold on to them due to expectations of capital gains. Moreover, during crisis, as long as the prices of distressed assets are below their fundamental value, banks will preferably use fresh injected funds for trading instead of lending in the real economy.

As pointed out by Thakor (1996) changes in the asset mix have an effect on liquidity creation as well as the enhancement of possibilities in market activities by financial innovations in the banking industry, Berger's and Bouwman's (2009) category liquidity creation measure incorporates the effects on both sides of the balance sheet.

Since existing empirical literature so far only analyzed liquidity creation to a small extent – both in crisis years and the years after – , one aim of this thesis is to investigate whether banks greatly suppress lending in crisis years and instead hold on to their securities as outlined by Shleifer and Vishny (2009).

2.3 Capital and Liquidity Creation: Existing Empirical Evidence

The first ones who tested capital ratios on parts of liquidity creation components were Gatev and Straham (2006) with ambiguous results. The authors found that an increase in capital could increase liquidity creation, as loans and deposits increase correspondingly, whereas liquidity creation could also be reduced by a larger share of liquid assets and non-deposit liabilities.
In order to get a clearer picture of the effect of capital on the maturity transformation, Berger and Bouwman (2009) were the first ones to focus explicitly on the role of capital linked to liquidity creation. Their sample consists of more than 7.000 US commercial banks, divided into three different size classes (small, medium, and large) and also includes off-balance sheet activities ("cat fat") in the liquidity creation measure. By testing the theories, the authors find that the capital ratio of a large bank has a positive impact on liquidity creation, while for small banks capital has a negative effect on liquidity creation. They argue that the result suggests that the "risk-absorption" effect dominates for large banks, whereas for small banks the "financial fragility-crowding out" theory prevails, and the two effects are offsetting for medium-sized banks (Berger and Bouwman 2009, Pg. 28).

The first paper including European banks when looking at bank capital and liquidity creation is the one from Distinguin, Roulet, and Tarazi (2013), who test regulatory capital on the il-liquidity of an individual bank using Berger's and Bouwman's (2009) "cat-nonfat" measure divided by total assets. The rationale behind this approach is that a bank makes itself illiquid by creating liquidity for the public through its maturity transformation. Additionally, the au-thors took the inverse of the NSFR (I_NSFR) for the comparability of the "cat non-fat" measure of Berger and Bouwman (2009). Given that high values of both measures indicate higher levels of illiquidity individually the authors adjusted the regulatory ratio as follows:

$$I\_NSFR \equiv \frac{Required\ amount\ of\ stable\ funding}{Available\ amount\ of\ stable\ funding} \tag{3}$$

Equation 3: Inverse net stable funding ratio (I_NSFR) (Distinguin, Roulet, and Tarazi 2013, Pg. 3301)

Their sample consists of publicly traded commercial banks from the US and Europe before the introduction of minimum liquidity requirements between 2000 and 2006[3]. At the time of observation Distinguin, Roulet, and Tarazi (2013) did not only find a strong correlation between the inverse NSFR (I_NSFR) and the liquidity creation measure scaled by total assets of Berger and Bouwman (2009). They also discovered that banks were more likely to decrease their solvency standards when they were more exposed to liquidity risk as Tier 1 and 2 capital ratios are decreased while Tier 1 capital ratios are not adapted. In their analysis Distinguin, Roulet and Tarazi (2013) explain the result due to the fact that the bank management takes some liquid liabilities as stable and hence shifts stable liabilities to capital when they are more exposed to liquidity risk (Distinguin, Roulet and Tarazi 2013, Pg. 3304).

In addition, other studies find that bank capital significantly and negatively affects liquidity creation testing samples in China (Lei and Song 2013), the Czech Republic (Horváth, Seidler and Weill 2014), India (Umar, Sun and Majeed 2017), France, the United Kingdom (Mazioud Chaabouni, Zouaoui and Ellouz 2018), and 14 Asia-Pacific economies (Fu, Lin and Molyneux 2016) using Berger's and Bouwman's (2009) measure.

Since newly designed capital and liquidity requirements of the Basel committee were introduced in the years after the financial crisis, the current empirical analysis will be extended by new evidence on how these changes affected the liquidity creation behavior in the aftermath. The final data sample covers 238 European publicly listed commercial banks.

[3] Distinguin, Roulet, and Tarazi (2013) intentionally excluded the crisis years 2007 and 2008 in their sample.

3. Sample and Method

3.1 Presentation of the Sample

The sample analyzed consists of European publicly traded commercial banks from 2008 to 2018. In order to measure liquidity creation a sufficient granular breakdown of the balance sheet needs to be reported, which is more frequently and accurately available for listed banks. To ensure that all banks in the sample are considered as commercial, some characteristics must be fulfilled: 1) banks must have deposits and loans; 2) loans must be divided in commercial or consumer loans; 3) information on deposits must be provided such that the distinction between saving or demand and time or other term deposits is possible; 4) banks must have positive equity capital.

Some of these banks may not solely perform commercial banking activities (e.g. Deutsche Bank, BNP Paribas, Barclays), however as Berger and Bouwman (2009) and Distinguin, Roulet and Tarazi (2013) carried out robustness checks by running estimations on a sub-sample limited to "true commercial banks" the main conclusions are consistent with those obtained with their full sample (Distinguin, Roulet and Tarazi 2013, Pg. 3296).

Winding-down or bailed out institutions have been excluded from the sample due to their different risk-taking and maturity transformation behavior as they no longer follow the going concern principle. Regarding different accounting principles across European countries, annual consolidated financial statements were taken from Bloomberg and only banks reporting in International Accounting Standard (IAS) or International Financial Reporting Standard (IFRS) were included.[4] In some cases individual financial statements had to be downloaded from the banks' websites to obtain missing entries or a more detailed breakdown of the balance sheet. To compensate for inflation, all financial values are expressed in real 2018 terms by using the implicit GDP price deflator extracted from the World Bank Open Data database.[5]

From the time period 2008 to 2018 238 publicly listed commercial banks were selected. The by country distribution of these banks is shown in Table 1. The table also displays the share of total assets of the included banks relative to total assets in the entire banking system in each country.

[4] Banks from Latvia, Turkey, and Russia were excluded due to their reporting in Local Generally Accepted Accounting Principles (L-GAAP)

[5] Berger and Bouwman (2009) prove that the result is similar if values are expressed in another year's real term.

Country	Banks included in the sample	Total assets of included banks/ Total assets of the banking system (%)
Austria	10	65.3%
Belgium	4	76.5%
Bulgaria	4	34.1%
Croatia	8	60.0%
Cyprus	1	35.0%
Czech Republic	4	41.5%
Denmark	21	74.5%
Finland	5	96.6%
France	22	63.2%
Germany	18	44.5%
Greece	5	85.2%
Hungary	1	36.2%
Iceland	2	64.7%
Ireland	2	47.3%
Italy	26	65.4%
Liechtenstein	1	33.6%
Lithuania	1	7.9%
Luxembourg	1	5.4%
Malta	3	44.4%
Netherlands	6	84.2%
Norway	25	82.1%
Poland	11	71.7%
Portugal	5	51.1%
Romania	2	28.8%
Slovak Republic	6	64.0%
Slovenia	3	24.9%
Spain	11[6]	92.3%
Sweden	6	71.8%
Switzerland	17	61.3%
United Kingdom	6	58.2%
Europe	**238**	**70.8%**

Table 2: Distribution of included banks

Share of total assets of the included banks relative to total assets in the entire banking system in each country as of 2018. Source: Bloomberg, ECB, Bank of England, National Bank of Switzerland, Sveriges Riskbank, Demarks Nationalbank, Central Bank of Iceland, and Finance Norway.

For further analysis, the sample is divided into three size classes, as empirical work by Berger and Bouwman (2009) and Distinguin, Roulet and Tarazi (2013) has already shown that the size of an institution affects the allocation of bank capital to liquidity creation. Another reason is the assumption that funding costs and capabilities of large banks ("too-big-to-fail") differ from those of small banks. The sample is thus split into the following subcategories: small banks which have total assets up to one billion Euro, medium banks with total assets between one and 25 billion Euro, and large banks with total assets of more than 25 billion Euro.

[6] In 2017 Banco Popular Español, S.A. was bought by Banco Santander.

The cut-off for small banks of one billion Euro is in line with the definition of "community banks" and the remaining sample is simply split in half.

In total the sample consists of 2.562 bank-year observations, while 392 bank-year observations correspond to small banks and around 1.085 observations to medium and large banks. Table 3 provides information on the descriptive statistics of all 238 included European publicly traded commercial banks. Of the 238 banks analyzed, 36 are small, 102 are considered as medium-sized banks and 100 as large. Since the size of banks is determined annually, there are banks that switch between categories if they increase or decrease total assets in a given year.

	Total Assets in €-Million	Total loans/ Total assets	Total deposits/ Total assets	Asset-securities/ Total assets	Liability-securities/ Total assets	Total equity/ Total assets
All banks						
Mean	147,849	65.7	55.1	20.1	14.6	8.2
Median	16,318	68.3	56.8	18	10.6	7.6
Min	111	1.4	4.2	0.00148	0.0001	2.3
Max	2,508,713	96.0	96.7	73.4	73.1	26.0
St. Dev.	353,877	16.3	19.3	11.7	13.6	3.6
Small banks						
Mean	478	67.3	67.3	17.6	7.3	11.0
Median	426	65.9	71.7	16.1	5.0	10.5
Min	111	37.1	19.1	0.00238	0.0001	3.0
Max	998	96.0	91.8	58.3	59.9	26.0
St. Dev.	225	13.5	16.2	10.7	8.3	3.8
Medium banks						
Mean	9,541	71.6	59.4	16.3	10.9	9.1
Median	9,048	75.2	62.0	13.7	6.0	8.5
Min	1,015	1.4	4.2	0.00148	0.12	3.2
Max	24,956	94.6	96.7	71.9	66.4	20
St. Dev.	6,699	14.2	18.2	10.3	13.1	3.3
Large banks						
Mean	342,517	59.5	46.8	24.7	20.6	6.4
Median	115,212	62.7	46.5	23.3	18.2	6.0
Min	25,018	7.2	5.6	0.5	0.20	2.3
Max	2,508,713	91.8	94.6	73.4	73.1	21.6
St. Dev.	482,966	16.7	17.7	11.7	13.0	2.8

Table 3: Descriptive Statistics of European banks included in the sample (2008 to 2018)

Total assets of included banks in million Euro; *Total loans/total assets*: (commercial loans + consumer loans + other loans)/total assets; *Total deposits/totals assets*: (demand d. + saving d. + time deposits + other (time) deposits)/total assets; *Asset-securities/total assets*: (all asset-securities + derivative assets)/totals assets; *Liability-securities/total assets*: (short time borrowings + derivative liabilities)/total assets; *Total equity/total assets*: Total equity/total assets. *Small banks* Total Assets (TA) <1.000 Million Euro, *Medium banks TA* between 1.000 – 25.000 Million Euro, and *Large banks* TA > 25.000 Million Euro.

The smallest bank has total assets of 111 million Euro whereas the largest bank has more than 2.5 trillion Euro of total assets, providing a wide variety of banks' sizes. In general, it can be said that European banks mainly carry out traditional financial intermediation activities. This is reflected by the fact that within the whole sample, banks granted loans of about 66% to total assets and were holding deposits of 55% to total assets. When looking at different sizes for small banks the average ratio of loans to total assets is 67.3%, and respectively 71.6% for medium and 59.5% for large banks. An outlier in the loan ratio of only 1.4% in the class of medium sized banks can be explained by the fact that this is an online direct bank which mainly focuses on the collection of deposits. The average share of deposits to total assets goes from 71.2% for small banks, to 59.4% for medium banks, down to 46.8% for large banks. Security holdings on the asset side which consist of all security investments plus derivative assets make on average about 25% of total assets for large banks, 16.3% for medium banks and 17.6% for small banks. When considering securities on the liability side, defined as short time borrowings and derivative liabilities, small banks keep a rather small share of 6.3% to total assets, medium banks 10.9%, while large banks hold on average more than 20%. Regarding capital ratios, in the whole time period the average of total equity to total assets is at 8.2%, and respectively 11% for small banks, 9.1% for medium banks, and 6.4% for large banks.

Analyzing changes in these key accounting ratios from 2008 to 2018 data suggests that banks in general, have shifted their focus back to a more traditional role of a financial intermediary. This is reflected in the fact that the average percentage of loan to total assets increased from 65.8% to 66.7%, as well as the share of deposits to total assets increased from 49.5% to 59.9%. On the other hand, security holdings relative to total assets on the assets side decreased from 19.7% to 17.8% and on the liability side from 18% to 12.3% in 2018. Considering the capitalization across all bank sizes, the average equity ratio in 2018 rose to 9.3% from 7.9% in 2008, while the equity ratio of small banks rose from 11.5% to 11.7%, of medium-sized banks from 8.5% to 10.5% and of large banks from 5.6% to 7.7%. Finally, with regard to total assets, the average size of European banks slightly increased from 143 billion Euro of total assets to 151 billion Euro. In fact, the average amount of total assets for small banks increased from 418 million Euro to 542 million Euro (+30%), of medium-sized banks from 9,3 billion Euro to almost 10 billion Euro (+11%), while for large banks the average amount of total assets fell from 407 billion Euro to 309 billion Euro (-16%). Further information on the descriptive statistics of these ratios in 2008 and 2018 for each bank size (small, medium, large) can be found in Appendix-A.

3.2 Measure of Liquidity Creation

As outlined in the second section, various liquidity creation measures were developed and used for different research objectives. The aim of this master thesis is, on the one hand, to analyze the changes in the provision of liquidity by European banks in the period from 2008 to 2018 following the application of unprecedented monetary policy instruments in Europe. On the other hand, using the latest available data from October 2019, this work shall provide new empirical evidence for the effect of capital on the liquidity creation after the introduction of different regulatory capital and minimum liquidity requirements.

To achieve these objectives, the "cat non-fat" measure developed by Berger and Bouwman (2009), which divides banking activities into specific categories and only considers on-balance sheet items has been chosen. This is reasonable as firstly, it was not possible to take off-balance sheet activities into account to use Berger and Bouwman's (2009) preferred "cat fat" measure, as there was no specific classification of off-balance sheet items into loan commitments, net financial and performance standby letters of credit, other off-balance sheet guarantees and derivatives available. Secondly, neither an adjusted form of the net stable funding ratio (NSFR) nor the “LT-gap” for comparisons were compatible with the data available, as a breakdown of the data not only by product category but also by maturity is needed to use the weighting scheme by maturity.

To provide a more detailed insight into how Berger and Bouwman (2009) constructed this measurement and how it is adjusted and applied in this paper using the standardized balance sheet extracted from Bloomberg, the construction of the liquidity creation measure is explained step by step. In general, the liquidity creation measure of Berger and Bouwman (2009) is carried out in a three-step procedure: first step, the classification of all balance sheet items, second step, the weighting of each asset and liability class, and third step, the combination of the first and second step by calculating the sum product of all classified items.

3.2.1 Classification of Balance Sheet Items

According to the scheme of Berger and Bouwman **(2009)**, all assets are classified as liquid, semi-liquid or illiquid given the ease, cost and time by which financial institutions can obtain liquidity by selling assets. The same procedure applies to banks' liabilities and equity, given the ease, cost and time required for customers to withdraw funds from the financial institution (Berger and Bouwman 2009, Pg. 10).

To illustrate this, Table 4 shows a simplified form of a categorized balance sheet:

Assets	Liabilities
Cash	Demand deposits
Consumer loans	Time deposits
Commercial loans	Subordinated debt + Equity

Assets	Liabilities
Liquid Assets	Liquid Liabilities
Semi-liquid A.	Semi-liquid L.
Illiquid Assets	Illiquid Liabilities + Equity

Table 4: Illustration of a simplified balance sheet categorized in each liquidity class

Following this, on the assets side *Cash & Cash Equivalents*, *Fed Funds Sold & Repos*, and *Total Derivative Assets* are classified as liquid assets. A more precise distinction must therefore be made for short-term and long-term investments, as it is not the maturity of these securities that is important but the ability of the bank to sell them and convert them into cash. Under IFRS 9 all investments are divided into *Trading Securities FVPL (Fair Value through profit and loss), Available for Sale FVOCI (Fair Value through Other Comprehensive Income), Held to Maturity/Amortized at Cost, Real Estate Investments,* and *Other Investments.*

For this purpose, *Trading Securities*, *Available for Sale* as well as *Held to Maturity*[7] are classified as liquid, whereas *Real Estate Investments* and *Other Investments* are classified as semi-liquid.

When classifying loans, the standardized balance sheet from Bloomberg provides information relating to commercial, consumer, and other loans, the latter consisting of loans to the public sector, where the classification depends mainly on how easily a loan can be securitized or sold

[7] Checked for robustness if *Held to Maturity* is classified as a semi-liquid asset

on the market. Consequently, *Total Commercial Loans* are classified as illiquid, *Total Consumer Loans* as semi-liquid, *Other Loans* as semi-liquid as well.
Finally, the remaining assets as *Next Fixed Assets*, *Total Intangible Assets*, *Investments in Associates* and *Other Assets* are classified as illiquid, as these assets usually cannot be sold easily.

Regarding liabilities, items are classified depending on customers or investors promptness to withdraw funds without incurring any costs. Following this, *Demand Deposits*, *Saving Deposits*, *Short-time Borrowings & Repos*, and *Total Derivative Liabilities* are classified as liquid liabilities. Deposits which cannot be withdrawn at any time without incurring costs, such as *Time Deposits* and *Other Term Deposits,* are classified as semi-liquid. Additionally, Long-term Debt, such as *Long-term Borrowings* and *Long-term Finance Lease,* are classified as semi-liquid liabilities.
Equity is considered to be illiquid as the maturity is very long and investors cannot demand their funds at any given time from the bank. Nevertheless, it is important to note that from the investor's perspective, publicly traded shares may be liquid due to the possibility of selling them on the financial market, whereby liquidity is not created by the financial intermediary. For this reason, Total Equity consisting of *Preferred Equity and Hybrid Capital, Share Capital & APIC, Retained Earnings, Other Equity,* and *Minority/Non-Controlling Interest* are classified as illiquid.

3.2.2 Assigning Weights to each Category

In the second step, the measure of Berger and Bouwman (2009) assigns weights according to liquidity creation theory, which states that banks create liquidity on their balance sheet by transforming illiquid assets into liquid liabilities. In general, this is done by the financial institution by investing in illiquid assets with liquid deposits but continuing to provide liquid funds for depositors. To take this into account a positive weight of ½ is assigned to illiquid assets and liquid liabilities. This means that liquidity is created when liquid liabilities such as *Demand Deposits* are used to finance illiquid assets like *Commercial Loans*.
Accordingly, a negative weight of –½ is assigned to liquid assets and illiquid liabilities, as a bank destroys liquidity if it invests illiquid liabilities such as *Equity* into liquid assets such as *Trading Securities.*

The sizes of the weights are set such that one unit of liquidity is created (destroyed), whenever the bank invests one unit of liquid (illiquid) liabilities into one unit of illiquid (liquid) assets as this equals (-) ½*1 + (-) ½*1 = 1 (-1). Like in theory, liquidity creation is not only dependent on the source but also on the funds in which it is invested, reflecting the fact that both the asset and liability side are required to create liquidity at the same time. As a result, banks do not create liquidity for the public by using illiquid liabilities such as *Equity* to invest it in illiquid assets such as *Commercial loans* equaling –½*1 + ½*1 = 0.

A weight of 0 is assigned to semi-liquid assets and semi-liquid liabilities, such that the effect of liquidity creation is balanced. If for example one unit of *Long-term Borrowings* is invested in one unit of *Consumer Loans* which equals 0*1 + 0*1 = 0. For a bank it does not matter as the ease, cost and time it takes for banks to convert their obligations to meet depositor's liquidity needs are the same if it would use semi-liquid liabilities e.g. *Time Deposits* to fund semi-liquid assets e.g. *Consumer Loans.* Table 5 shows the precise allocation of all balance sheet items to their liquidity category and the corresponding weight.

3.2.3 Calculating the Sum Product

In a final step, Berger and Bouwman (2009) combine the first step, the classification of all balance sheet items, and the second step, the weights assigned to the individual liquidity categories, to calculate the sum product. Because a comparison in absolute figures would not make sense, since only publicly traded commercial banks could be included in the sample, the liquidity creation measure is scaled by total assets.

The formula of the calculated liquidity creation measure reads as follows:

$$\frac{-0.5 \times liquid\ a. + 0 \times semi\text{–}liquid\ a. + 0.5 \times illiquid\ a. + 0.5 \times liquid\ l. + 0 \times semi\text{–}liquid\ l. - 0.5 \times illiquid\ l.}{Total\ assets}$$

Equation 4: Formula of the calculated liquidity creation measure used in this thesis

Following this formula, it can be said that on the one hand, a high value means a high creation of liquidity and on the other hand, it indicates that a bank makes itself illiquid.

As can be seen above, a relatively precise declaration of the different balance sheet activities is required to place them in one of the three liquidity categories. Since such a breakdown of off-balance sheet activities is neither standardized, uniformly collected nor retrievably available to European banks, like for example in Call Reports in the US, a liquidity creation analysis according to Berger's and Bouwman's (2009) favorite measure "cat fat", which includes off-balance sheet activities, is not possible.

Assets	Liquidity category	Weight	Liabilities	Liquidity category	Weight
Cash & Cash Equivalents	Liquid	- ½	Demand Deposits	Liquid	½
Interbanking Assets	Semi-liquid	0	Saving Deposits	Liquid	½
ST And LT Investments	-	-	Time Deposits	Semi-liquid	0
+ Trading Securities/FVTPL	Liquid	-½	Other Deposits	Semi-liquid	0
+ Available for Sales/FVTOCI	Liquid	-½	ST Borrowings & Repos	Liquid	½
+ Held to Maturity/Amortized at Cost	Liquid	-½	LT Debt	-	-
+ Real Estate Investments	Semi-liquid	0	+ *LT Finance Leases*	Semi-liquid	0
+ Other Investments	Semi-liquid	0	+ LT Borrowings	Semi-liquid	0
Total Commercial Loans	Illiquid	½	Total Derivative Liabilities	Liquid	½
Total Consumer Loans	Semi-liquid	0	Other Liabilities	Illiquid	
Other Loans	Semi-liquid	½	**Total Liabilities**		
Net Fixed Assets	Illiquid	½	Preferred Equity and Hybrid Capital	Illiquid	-½
Total Intangible Assets	Illiquid	½	Share Capital & APIC	Illiquid	-½
Investments in Associates	Illiquid	½	Retained Earnings	Illiquid	-½
Total Derivative Assets	Liquid	½	Other Equity	Illiquid	-½
Customer Acceptances & Liabilities	Illiquid	½	Minority/Non-Controlling Interest	Illiquid	-½
Other Assets	Illiquid	½	**Total Equity**		
Total Assets			**Total Liabilities & Equity**		

Table 5: Balance sheet categories and weights.

Breakdown of all balance sheet items categorized to each liquidity class applied on the standardized balance sheet from Bloomberg.

3.2.4 Mechanics of the Liquidity Creation Measure

This section briefly outlines how changes in the balance sheet structure and regulatory actions affect the liquidity creation measure to provide a better insight into the mechanisms involved. Since liquidity requirements under Basel III were introduced gradually, such as the Liquid Coverage Ratio (LCR) or the Net Stable Funding Ratio (NSFR), it is almost impossible to assess the effects of implementation. Nevertheless, the adoption of the two new liquidity ratios and adjustments in the balance sheet structure can be analyzed using the liquidity creation measure formulated in Eq. 4. If a bank had not fulfilled its requirements one of three possibilities could have been applied.

In the first scenario a bank raises new equity and reduces either liquid liabilities like *Demand Deposits* or semi-liquid liabilities such as *LT Debt* but maintains the overall size of the balance sheet (*Total Assets*) and the asset allocation. In this case the liquidity creation measure formulated in Eq. 4 would decrease, as liquidity on the asset side does not change, while liquidity on the liability side decreases. An isolated analysis of this change would mean that, without changing its investment portfolio, but by only increasing its capital ratio to meet higher capital requirements, the bank would create less liquidity.

Another possibility is that an institution raises new equity but maintains the amount of liquid and semi-liquid liabilities, thereby total assets increase, and the proportion of liquid and semi-liquid liabilities are reduced. In this case the overall effect on the measure depends on the bank investing the raised funds in liquid, semi-liquid or illiquid assets. If the newly injected capital is invested in illiquid assets like *Commercial Loans* the negative effect of a capital increase would be compensated and there would be no change in the liquidity measure. Accordingly, the measurement would decrease for investments in semi-liquid or liquid assets.

In a third scenario a bank could reduce its total assets by reducing leverage of less stable sources such as short-term wholesale funding, accompanied by asset sales. As a result, the equity ratio would increase, which might lead to meeting regulatory requirements. However, the overall effect according to Eq. 4 would depend on whether the bank sells liquid or illiquid assets. If an institution sells liquid assets such as *Trading Securities,* the overall effect on the liquidity creation measure would be offset. If an institution sells illiquid assets such as a portfolio of *Commercial Loans* the overall effect on the liquidity creation measure would be negative.

4. Liquidity Creation in Europe

One of the main questions of this master thesis is to gain insight into how the creation of liquidity in Europe has developed between 2008 and 2018. For the purpose of this analysis, financial statements of 238 European banks for the period from 2008 to 2018 were evaluated, giving 2.562 bank-year observations. For a first analysis, liquidity creation values of European banks are compared with data from US banks and put into context. The assessment of the liquidity creation of US banks was done by Berger and Bouwman (2009) and downloaded from their website[8], however the data is only available until 2016.

In general, any comparison is limited as, broadly speaking, the US economy is much more market oriented, while the European economy is much more banking-oriented when it comes to financial or investment decisions.
Secondly, Deep and Schaefer (2001) note that many savers in the US have invested their money in money-market deposit accounts or money-market mutual funds, which is why the share of demand deposits in household investments is very low. This can mainly be described by the so-called "Regulation Q" from the Federal Reserve Board, which has imposed interest rates caps for checking accounts and restrictions of any interest payments on demand deposits from commercial and saving banks. After all, the restriction on interest rate ceilings were lifted in 1986 and the permission for interest-bearing demand deposits was granted in 2011 with the introduction of the Dodd-Frank Act (Federal Reserve System 2011).

Figure 1 shows the bank liquidity creation based on-balance sheet ("cat non-fat"), divided by totals assets for publicly traded European banks and all US-banks from 2008 to 2016.
As can be seen on the graph, between 2008 and 2016 liquidity creation relative to total assets has increased by about eight percentage points in the US and Europe. However, already during the financial crisis in 2008, the level in the US is much higher than in Europe. Furthermore, the data shows that since 2009 liquidity creation in Europe remained at a quite stable level between 15% to 17% till 2016, while the level in the US went up from 16% to almost 24% relative to total assets.

[8] Allen N. Berger, Christa H. S. Bouwman, Bank Liquidity Creation, *The Review of Financial Studies*, Volume 22, Issue 9, September 2009, Pages 3779–3837,https://sites.google.com/a/tamu.edu/bouwman/data

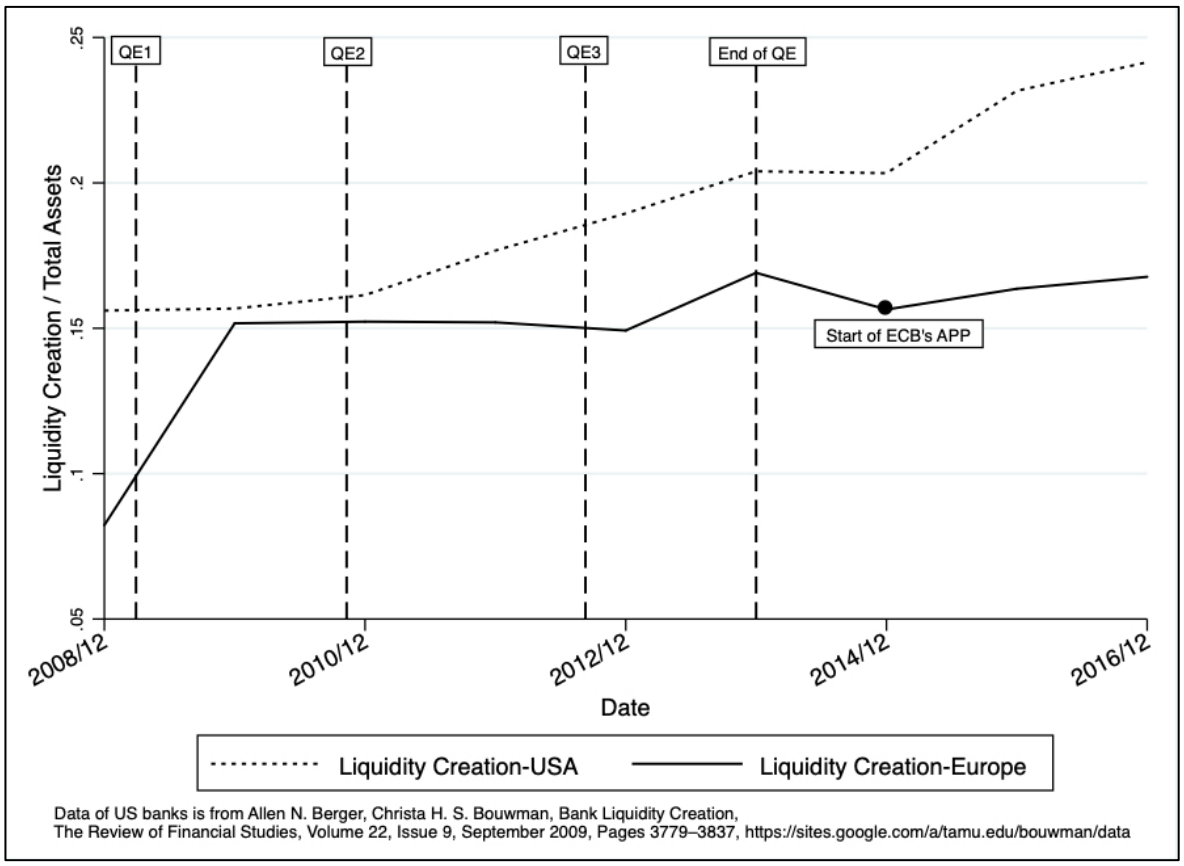

Figure 1: Graph on bank liquidity creation in Europe & the US (2008 to2016)

This graph shows liquidity creation based on-balance sheet ("cat non-fat") in Millions, divided by the total assets from 2008 to 2016. The "cat non-fat" measure excludes off-balance sheet activities. On the graph the mean of the liquidity creation values, weighted by total assets, for European and US banks were taken. Data from European banks are financial statements extracted by Bloomberg and data from US banks are downloaded from Bouwman's website (https://sites.google.com/a/tamu.edu/bouwman/data), obtained from Call Reports. The horizontal dashed lines indicate the three Quantitative Easing (QE) programs executed by the Fed. The "Start of ECB's APP" shows the date in which the European Central Bank has started its Asset Purchase Program (APP), also referred to as QE, in October 2014.

According to this measure one could argue that it seems like that European banks must have been quite liquid, what can also be explained by the high share of asset securities relative to total assets in 2008 (mean across all bank sizes: 20%).

Nevertheless, during the financial crisis between 2007 and 2009 (Q1) it became apparent that the market for liquid funds was disrupted as presumed liquid assets like securities and short-term funds were suddenly illiquid, resulting in severe liquidity issues in the inter-bank market, ending in the intervention of central banks as a lender of last resort. Additionally, central banks have implemented other monetary policy instruments, like the Quantitative Easing (QE) program, to free up lending to the real economy again.

QE stands for a large-scale asset purchase program (often abbreviated as LSAP) with the aim of reducing interest rates on certain credit types (Mishkin 2016, Pg. 426).

In particular, the Fed started the first program to combat the financial crisis of 2008, and subsequently three of these packages were implemented until October 2014. The first QE program (retrospectively referred to as QE1) was approved on November 25, 2008, which ultimately resulted in purchases of $1.25 trillion of mortgage-backed securities (MBS) primarily backed by Fannie Mae, Freddie Mac, and Ginnie Mae (Federal Reserve 2008).
Subsequently, in November 2010, a second program (QE2) was launched with the purchase of $600 billion ($75 billion per month) in long-term treasury securities to reduce long-term interest rates (Federal Reserve 2010). The third purchase program (QE3) was announced in September 2012 which was basically a combination of QE1 and QE2, purchases of $40 billion of MBS and $45 billion of long-term treasury securities (Federal Reserve 2012).
In October 2014, the Open Market Committee of the Fed decided to terminate the asset purchase and thus the QE program at the end of 2014 (Federal Reserve 2014).
Obviously, it is extremely difficult to filter out the direct effect of the asset purchase programs on bank liquidity creation. Nonetheless, it can be seen that liquidity creation has constantly increased since the start and kept its rising trend even after the end of the QE programs.

After a first comparison between the liquidity creation in the US and Europe, a closer look is now taken at the European development since 2008 and the whole observation period until December 2018. In Europe, as in the US, it is very difficult to isolate the effects of the many unconventional instruments introduced by the ECB in a relatively short period.
Nevertheless, two measures taken by the ECB are important to highlight, as they were aimed at both, the asset and liability side of banks' balance sheets. The measures in focus are the longer-term refinancing operations (LTROs, TLTROs, and VLTROs) and the Asset Purchase Program (APP), where the latter was introduced in October 2014 and consisted of different individual programs (ECB 2014a).

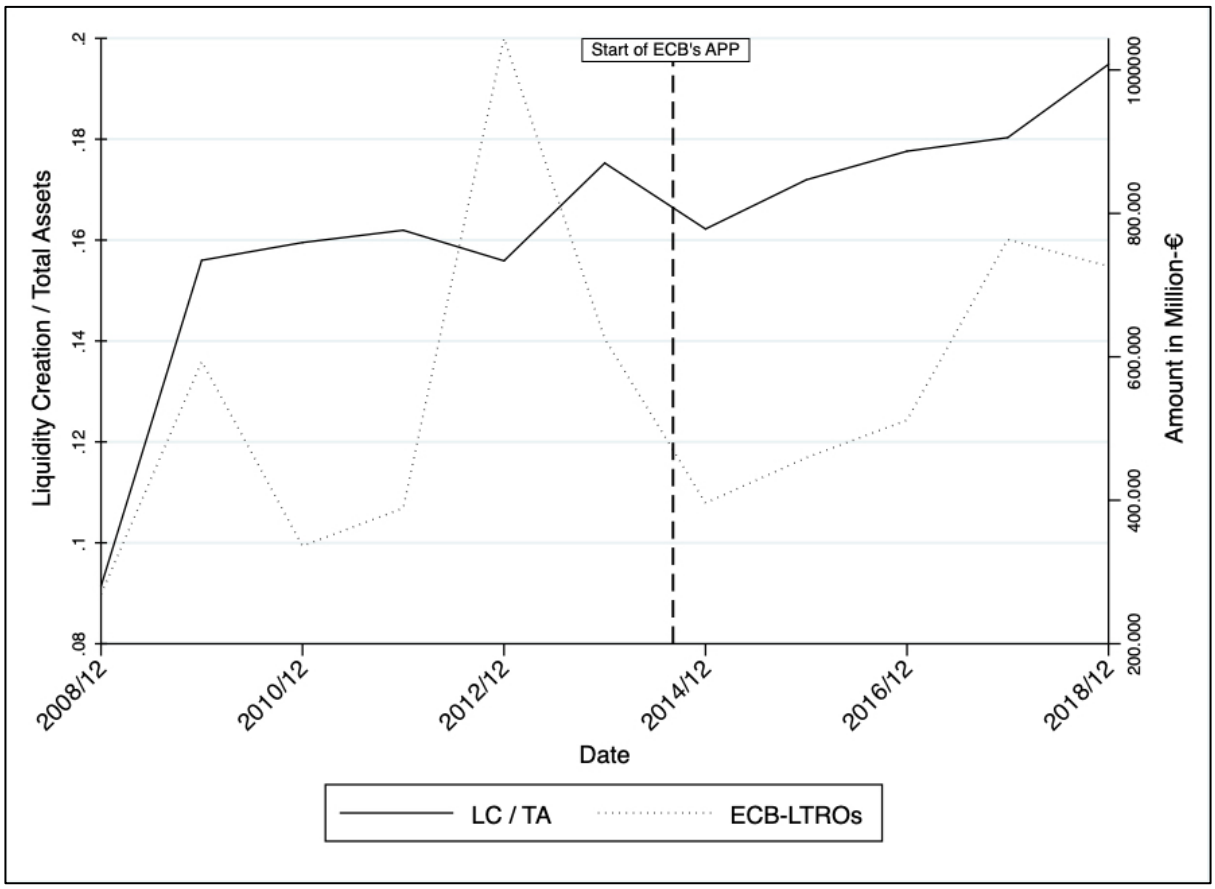

Figure 2: Graph on bank Liquidity Creation scaled by total assets in Europe and the ECBs longer-term refinancing operations (LTROs)

This graph shows the liquidity creation based on-balance sheet ("cat non-fat") in Millions, divided by total assets from 2008 to 2018. The "cat non-fat" measure excludes off-balance sheet activities. For the graph the mean of the liquidity creation values, weighted by total assets, of banks based in the Euro-area are taken. Data from European banks are financial statements extracted by Bloomberg. The dotted line shows the amount of Euro system holdings in millions of euro of longer-term refinancing operations (LTROs). Source: ECB (for further information see List of Data). The "Start of ECB's APP", also referred to as QE, indicates the date in which the European Central Bank has started its Asset Purchase Program (APP), in October 2014.

Figure 2 shows the development of liquidity creation by European banks participating in the Euro system between 2008 and 2018. Notable is the strong increase from 9% to over 15% in 2009, but since then there has been no significant increase in liquidity creation relative to total assets until 2014. Thereupon a continuous increase from 16.5% to over 19% can only be seen from 2015 to 2018.

To be able to assess the development of bank liquidity creation in Europe more accurately, relevant monetary policy instruments conducted by the ECB must be included in the analysis. According to the measurement, banks were very liquid in 2008, which in turn can be explained

by the relatively high proportion of asset-securities. Unfortunately, as described above, the inter-bank market experienced a liquidity shock and forced the ECB and other central banks to step in as lender of last resort (Garcia-de-Andoain, et al. 2016).[9]

In a first step, it appears to have helped banks, although banks have also used another open market operation, namely LTROs, which usually mature within three months. As it can be seen in Figure 2, a strong increase from 269 billion to 593 billion Euro show the strong need of funding banks faced in 2009. These operations are likely to have helped financial intermediaries primarily in terms on the financing, the liability side, which led to a strong increase in liquidity creation from 2008 to 2009.

In order to provide further assistance to banks, so-called very longer-term refinancing operations (VLTROs) were offered in December 2011 and February 2012 by the ECB, in which the securities had a maturity of three years and could be repaid after one year at the earliest (ECB 2011). Demand was extremely high, bringing a record of 1.044 trillion Euro of LTROs at the end of 2012, but the available funds were not passed on to loans.

These operations leaded to enormous excess liquidity (= money borrowed - required reserves) stated by Garcia-de-Andoain, Heider, Hoerova and Manganelli (2016), which also explains why liquidity creation remained more or less at the same level.

To resolve this issue, the ECB announced the introduction of eight targeted longer-term refinancing operations (TLTROs) in June 2014, which have the purpose of improving lending to the real economy. The main difference between VLTROs and TLTROs is that the amount that banks can borrow is tied to loans to non-financial corporations and households. In retrospect, the first operations were called TLTRO-I, which were conducted between September 2014 and June 2016, where all operations matured in September 2018 (ECB 2014).

A second series of TLTRO-II was carried out between June 2016 and March 2017 with a total of four operations, but this time all operations had a maturity of four years (ECB 2016).

However, as the actual and expected inflation in Europe was still very low, the ECB felt compelled to take further actions in addition to the TLTROs, which lead to the implementation of its first QE program in 2015 (ECB 2015).

[9] Even though there is no formal responsibility of the ECB to act as lender of last resort, Garcia-de-Andoain, Heider, Hoerova and Manganelli (2016) argue that by providing unlimited liquidity to banks the ECB and the European System of Central Banks started de-facto “lending-of-last-resort” in October 2008.

The ECB's QE program (called expanded Asset Purchase Programme) was first announced in January 2015 but was actually an extension of the Asset Backed Securities Purchase Programme (ABSPP) and the Covered Bond Purchase Programme (CBPP3), which were already implemented in 2014 (ECB 2015).
In addition to these programs, two more were added; The Public Sector Purchase Programme (PSPP) and the Corporate Sector Purchase Programme (CSPP).
Between March 2015 and December 2019, the ECB purchased public sector securities through the PSPP, which accounts for the largest share of around 90% of the total Euro system portfolio. The expanded APP started in March 2015, initially with an overall combined purchasing volume of 60 billion Euro per month. From April 2016, the volume was increased by 20 billion, which meant a total of 80 billion euros per month until December 2018. After that the volume was initially reduced to 30 billion by September 2018 and ultimately phased out by December 2018 (ECB 2019).

It can be seen that since the implementation of the TLTROs as well as the introduction of the APP, liquidity creation of European banks has increased continuously since 2015. However, it should be noted that even after the financial crisis, the highest level in December 2018 in Europe did not reach the level US banks had already reached in 2016.

The developments of liquidity creation relative to total assets can, in particular, be analyzed using the model of Shleifer and Vishny (2009). As a first step, it was certainly important to put bank financing back on a solid footing after the crisis, but in the long term it has not led to an expansion of lending to the real economy. According to the authors the low level of lending to non-financial institutions is due to the fact that the available funding was either used for securitization or held as excessive reserves at the ECB. The reason why banks continued to hold or buy such securities can be ascribed to the fact that the price of these securities was below their fundamental value, which made trading more attractive than lending.
Graph 3 illustrates this behavior, as the holdings of debt securities of credit institutions in the Euro area increased even after the outbreak of the financial crisis and then slightly declined until November 2014. In good faith one might argue that after the freezing of the interbank market, banks were primarily interested in reducing their exposure to liquidity risk. However, these activities did not have the intended effects which the ECB strived to achieve by reducing the main refinancing rate and providing funding through LTROs.

During the crisis US banks behaved similarly as they sold these securities very slowly, even though prices were falling rapidly. Ivashina and Scharfstein (2010) state that banks in the US mainly kept their positions of mortgage related debt, but real lending declined not only in the areas where securitization was more prominently, but in all areas.

Since November 2014, exactly at the time when the ECB started applying the APP, the stock of debt securities has been steadily decreasing. At the same time, the creation of bank liquidity has increased in Europe, as it has in the US since the application of the QE programs.

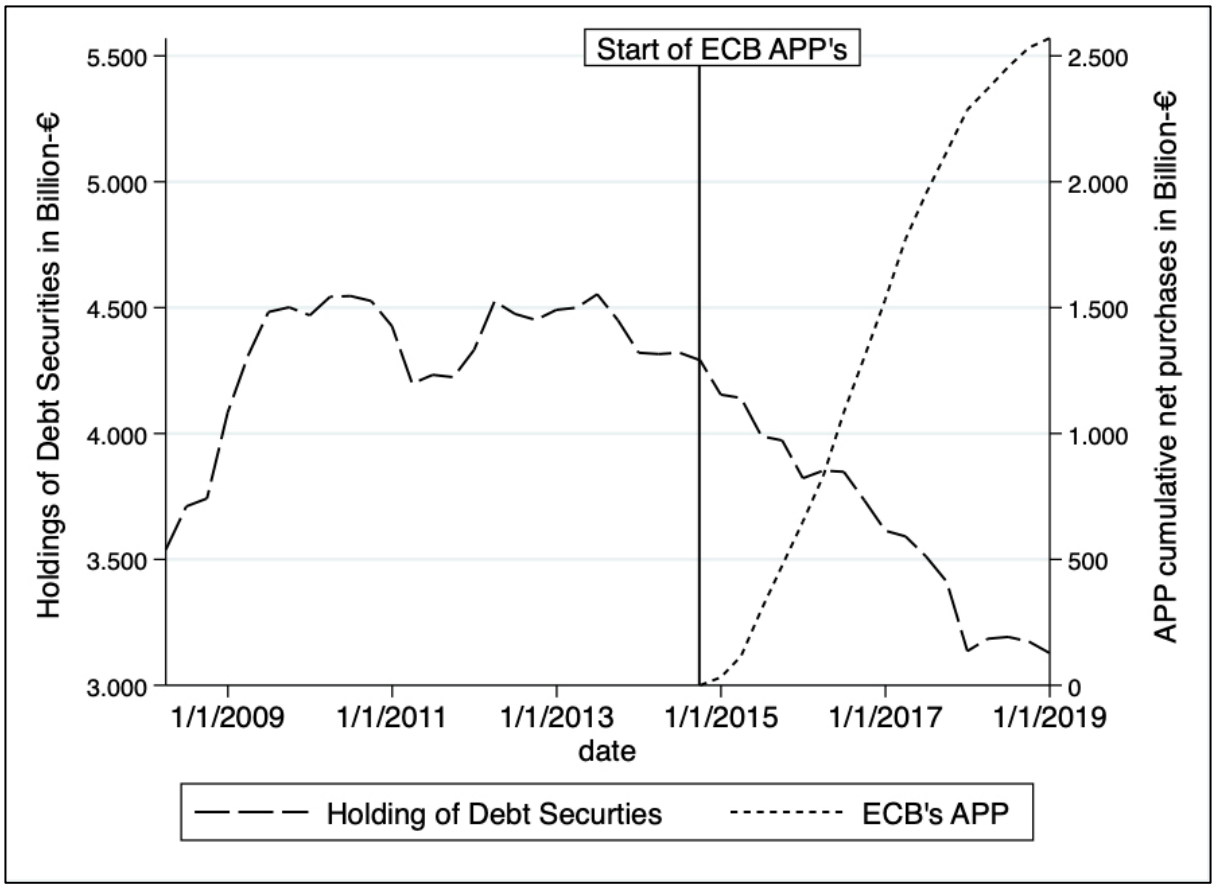

Figure 3: Holdings of debt securities by credit institutions in the Euro area & Eurosystem holdings under the Asset Purchase Programme (APP) (1/1/2008-31/12/2018).

The left y-axis shows 'Holdings of debt securities of credit institutions in the Euro area' and are expressed in Billion Euro. They are defined as securities that are negotiable and tradeable on the secondary market; they do not grant the holder any ownership rights over the issuer; Loans that have de facto become negotiable are called traded loans and once they are traded on the secondary market they are classified under debt securities, otherwise they are classified as loans. The right y-axis shows the cumulated amount of Euro systems holdings under the Asset Purchase Program (APP) in Billion Euro. Source: ECB (for further information see List of Data)

Shleifer and Vishny (2009) explain, that to get an economy out of a financial crisis it is not enough to only address the liabilities of banks, like their funding, but also their assets. In consequence as long as banks have the possibility to hold undervalued securities or to buy even more of them, conventional monetary policies, such as lowering the interest of the main

refinancing operations (MRO), will not release the lending mechanism. To make lending as profitable as trading again, security prices must rise, which means that banks are no longer blocking the lending mechanism and, as a result, conventional monetary policies (e.g. MRO, 3-month LTROs) can fully unfold their effects again.

This should then have the consequence that lending to the real economy increases again not only during, but also after asset purchases have been completed. As Graph 1 shows, liquidity creation of US banks has increased since the introduction of purchase programs. Graph 2 also shows that European banks have continuously increased their liquidity creation since the application of the APP. The question is whether the programs were sufficient to allow liquidity creation to continue to grow in the future.

5. Regression Framework & Results

The second major objective of this thesis is to investigate how bank capital affects liquidity creation. In the first step, the results of Berger and Bouwman (2009) are outlined, then the included variables and the regression model are described and finally, the empirical results are presented.

Berger and Bouwman (2009) have conducted an analysis of the effect of capital on liquidity creation for the period 1993 to 2003 on all US commercial banks. For the dependent variable as a measure of liquidity creation, they used all of their four ("cat fat", "cat non-fat", "mat fat", "mat non-fat") constructed measures. As exogenous variables they included the lagged capital ratio, the Herfindahl index, as well as the market share to control for competition, and the weighted average population, density and income growth in which a bank operates. For the lagged capital ratio, they simply used total equity in relation to total assets as an average of the last previous three years to compensate for fluctuations and the associated problems in applying accounting data. Secondly, to account for bank size, the authors split the sample in three different size classes and ran all regressions with time fixed and bank fixed effects.

Generally, as mentioned in section 2.3, the authors found that an increase in capital had a positive effect on liquidity creation for large banks, claiming that the "risk-absorption" theory applies for larger banks. On the contrary, for small banks the effect of capital on liquidity creation is negative. This is explained by the fact that the "financial fragility-crowding out" theory dominates, while the effect for medium size banks is insignificant.

5.1 Definition of Variables and Regression Framework

Similarly, a panel data regression is carried out for the analysis, but the focus relies solely on European banks for the time period of 2008 to 2018. To differentiate between the effects on different bank sizes, the sample is grouped in three categories: large, medium and small banks. Small banks are defined in having total assets of less than one billion Euro, medium-sized banks have total assets between one and 25 billion Euro, and banks exceeding total assets of 25 billion Euro are considered as large.

For the regression, liquidity creation is measured considering all balance sheet items without off-balance sheet activities ("cat non-fat") scaled by total assets. The only two exogenous variables are banks size (small, medium, large) and the lagged capital ratio (EQRAT). To compute EQRAT, total equity is divided by total assets and averaged over the last three years prior to observation. To incorporate the theory and results of previous studies that capital affects the

liquidity creation of small and large banks differently, an interaction term of bank size and the lagged capital ratio (e.g. Medium_banks* EQRAT) was included:

$$\frac{LC}{TA} = size + EQRAT + size * EQART + FE + error \quad (5)$$

Equation 5: Regression model with Bank, Time and Country fixed effects

The effect of capital on liquidity creation is calculated using a fixed effect panel data regression. By including bank and country fixed effects average differences over time across banks and countries that are not captured within the model are accounted for. To capture the effect of average differences across time, in this case years, as well as to reduce the risk of serial correlation, time fixed effects are included as well.

5.2 Regression Results

Table 7 represents all regression results and shows that capital has a different effect on liquidity creation for small, medium and large banks.

By purely considering the effects of size on the creation of liquidity, the impact of this is significantly negative for large banks and statistically insignificant for small banks. The results suggests that, ceteris paribus, a bank defined as large creates less liquidity relative to total assets than a medium-sized bank. This result had to be expected, since summary statistics presented in Table 3 have already shown that large banks hold a lower share of loans and a lower share of deposits relative to total assets compared to small and medium-sized banks.

The results still hold, as can be seen in the second regression (2) in Table 7, when country effects are not fixed.

Estimations also show that for small banks, an increase in the lagged capital ratio (EQRAT) of one percentage point, ceteris paribus, reduces liquidity creation on the balance sheet by about 0.4% (-0.820 + 0.437). Interestingly, the second regression shows a negative relationship between an increase in the lagged EQRAT for medium-sized banks and the creation of liquidity at a significant level of 1%. Consequently, a medium-sized bank with a higher EQRAT of 0.01 would, ceteris paribus, generate less liquidity of around 0.82%. For large banks the result is positive and highly significant at the 1% level, indicating that an increase in the lagged EQRAT of one percentage point increases the creation of liquidity by 0.2% (-0.820 + 1.024), ceteris paribus.

These estimations are also in line with the results of Berger and Bouwman (2009) using their preferred "cat fat" measure, as small banks create far less liquidity off-balance sheet, while large banks create about half of their liquidity off-balance sheet. Under this assumption, it could be estimated that large banks would create about 0.4% more liquidity, both on- and off-balance sheet ("cat fat"), by an 0.01 increase of lagged equity (EQRAT), ceteris paribus.

	(1) LC/TA	(2) LC/TA	(3) LC/TA
Small_banks	-0.0369	-0.0219	-0.0219
	(0.0224)	(0.0272)	(0.0272)
Large_banks	-0.107***	-0.106***	-0.106***
	(0.0156)	(0.0190)	(0.0190)
EQRAT	-0.194	-0.820***	-0.820***
	(0.126)	(0.150)	(0.150)
Small_bank* EQRAT	0.341*	0.437*	0.437*
	(0.203)	(0.248)	(0.248)
Large_bank* EQRAT	1.017***	1.024***	1.024***
	(0.187)	(0.192)	(0.192)
Constant	0.247***	0.295***	0.295***
	(0.0120)	(0.0139)	(0.0139)
Observations	2,562	2,562	2,562
R-squared	0.228	0.732	0.732
Bank FE		YES	YES
Year FE	YES	YES	YES
Country FE	YES		YES

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Regression results of equity on liquidity creation across bank sizes

The table shows the regression results of bank capital on liquidity creation of European banks. Liquidity creation is measured only including on-balance sheet activities scaled by total assets, represented as 'LC/TA'.
'Small banks' are defined of having TA < 1 billion Euro, 'Medium banks' have TA between 1 – 25 billion Euro, and TA > 25 billion Euro are considered as 'Large banks'. 'EQRAT' is the lagged capital ratio, defined as total equity divided by total assets and averaged over the last three years prior the observation. The sample period is 2008 to 2018. The first regression (1) includes only country and time fixed effects, while the second regression (2) includes bank and time fixed effects and the third regression (3) includes bank, time and country fixed effects.

This result suggests two things: Firstly, the hypothesis of "risk absorption" is more pronounced for large banks, while the hypothesis of "financial fragility - crowding out" dominates for small and medium-sized banks. Secondly, large banks make themselves more illiquid – create more liquidity–, if they increase their equity ratio.

These findings also support the need for different regulations of small and large banks, as it could be the case that large banks are less concerned about illiquidity risk, as they believe they

can obtain faster and easier funds through the interbank or financial market when needed, and therefore behave differently than smaller banks.

A clearer picture of the impact is obtained by highlighting the effect of capital on the asset liquidity and liability liquidity. For this purpose, two regressions were performed where capital (EQRAT) is regressed once on the measurement of asset liquidity L(A) and once on the liquidity of liabilities L(L), scaled by total assets.

$$\frac{L(A)}{TA} = size + size{*}EQRAT + FE + error;$$
$$where\ as\ L(A) = 0.5 * liquid\ assets - 0.5 * illiquid\ assets \quad (6)$$

Equation 6: Regression model for testing the effect of the EQRAT on the asset-side liquidity with Bank, Time and Country fixed effects.

$$\frac{L(L)}{TA} = size + size{*}EQRAT + FE + error;$$
$$where\ as\ L(L) = 0.5 * liquid\ liab. - 0.5 * illiquid\ liab. \quad (7)$$

Equation 7: Regression model for testing the effect of the EQRAT on the liability-side liquidity with Bank, Time and Country fixed effects.

Table 8 shows that, for small banks, an increase in the lagged capital ratio increases the proportion of illiquid assets by 0.33% (-0.087 + 0.413) but seems to reduce liquid liabilities by 0.71% (-0.72 + 0.01). When both components are put together the effect is negative by -0.38% (0.33-0.71), which is the overall effect shown in Table 7. For medium-sized banks the effect is barely insignificant being slightly negative (-0.08%) for the measured items on the asset side. This suggests that medium sized banks are increasing their share of liquid assets in the observation period, when increasing the capital ratio by one percentage point in the previous three years. However, on the liability side medium-sized banks reduce their liquidity by 0.72%, ceteris paribus, if the lagged capital ratio is increased by 1%.

Finally, for large banks an increase in the lagged capital ratio has a positive impact on the liquidity of assets with an increase of 0.51% (-0.087 + 0.6) and a negative impact on the liquidity of the liability side with a decrease of 0.31% (-0.719 + 0.407), resulting in an overall effect of +0.2% in the current period.

	(1) L(A)/TA	(2) L(L)/TA
Small_banks	-0.0457**	0.0250
	(0.0191)	(0.0198)
Large_banks	-0.0675***	-0.0377***
	(0.0133)	(0.0138)
EQRAT	-0.0873	-0.719***
	(0.105)	(0.109)
Small_bank* EQRAT	0.413**	0.0114
	(0.174)	(0.180)
Large_bank* EQRAT	0.600***	0.407***
	(0.135)	(0.140)
Constant	0.0569***	0.236***
	(0.00979)	(0.0101)
Observations	2,562	2,562
R-squared	0.782	0.769
Bank FE	YES	YES
Year FE	YES	YES
Country FE	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Regression results of equity on the two components of liquidity creation across bank sizes

The table shows the regression results of bank capital on the measured liquidity of assets and liabilities. 'L(A)/TA' indicates the measured liquidity on the asset side, normalized by total assets. 'L(A)/TA' indicates the measured liquidity on the liability side, normalized by total assets. 'Small banks' are defined of having TA < 1 billion Euro, 'Medium banks' have TA between 1 – 25 billion Euro, and TA > 25 billion Euro are considered as 'Large banks'. 'EQRAT' is the lagged capital ratio, defined as total equity divided by total assets and averaged over the last three years prior the observation. The sample period is 2008 to 2018. Both regressions (1) and (2) include bank, time and country fixed effects.

Finally, the sample is divided into the time before and after the implementation of the Asset Purchase Programme (QE) to find out how the operations have affected the liquidity creation across bank sizes. Therefore, an additional variable has been included to distinguish the impact before (2008 to 2013) implementation of the APP and after implementation (2014 to 2018). Although the QE program was not officially launched until 2015, it technically started in mid-2014 through the Asset Backed Securities Purchase Programme (ABSPP) and the Covered Bond Purchase Programme (CBPP3).

$$\frac{LC}{TA} = QE + \text{QE}^{*}size + QE^{*}size^{*}EQRAT + FE + error \qquad (8)$$

Equation 8: Regression model run with Bank, Time and Country fixed effects.

Eq. (8) shows the regression model to test the influence of the APP on a 1% increase in the lagged equity ratio (EQRAT) on liquidity creation, scaled by total assets (LC/TA).

For this purpose, the same regression as in Eq. (5) is used, but in addition a dummy variable 'QE' is added, which is ‘0-QE’ for the time before 2014 and ‘1-QE’ from 2014 on.

	(1) LC/TA
QE	-0.108***
	(0.0233)
0-QE*Small_banks	-0.0139
	(0.0295)
0-QE*Large_banks	-0.123***
	(0.0216)
1-QE*Small_banks	0.0229
	(0.0418)
1-QE*Medium_banks	0.0895***
	(0.0242)
1-QE*Large_banks	omitted
EQRAT	-0.821***
	(0.183)
0-QE*Small_banks*EQRAT	0.411
	(0.276)
0-QE*Large_banks*EQRAT	1.175***
	(0.246)
1-QE*Small_banks*EQRAT	1.338***
	(0.359)
1-QE*Medium_banks*EQRAT	0.451***
	(0.145)
1-QE*Large_banks*EQRAT	1.328***
	(0.251)
Constant	0.303***
	(0.0161)
Observations	2,562
R-squared	0.740
Country FE	YES
Bank FE	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8: The table shows the regression results of bank capital on liquidity creation of European banks before and after the implementation of the Asset Purchase Programme (QE).

Liquidity creation is measured including on-balance sheet activities scaled by total assets only, represented as ‘LC/TA’. ‘QE’ is dummy variable, which is ‘0-QE’ for the time before 2014 and ‘1-QE’ from 2014 on.
‘Small banks’ are defined of having TA < 1 billion Euro, ‘Medium banks‘ have TA between 1 – 25 billion Euro, and TA > 25 billion Euro are considered as ‘Large banks’. ‘EQRAT’ is the lagged capital ratio, defined as total equity divided by total assets and averaged over the last three years prior the observation. The sample period is 2008 to 2018. The first regression (1) includes bank and time fixed effects only, while the second regression (2) includes bank, country and time fixed effects.

On the one hand, Table 9 shows that, all other things being equal, the application of QE has a negative impact (-0.108) on the liquidity creation of banks. On the other hand, the results indicate that since the introduction of the QE program, an increase in bank capital increases liquidity creation across all bank sizes. Ceteris paribus, small banks decrease liquidity creation by 0.4% (-0.82+0.41) by an increase in the lagged capital ratio of 0.01 before the implementation of the QE program and increase their liquidity creation by 0.52 (-0.82 + 1.33) after the implementation of QE. For medium-sized banks, an increase in the lagged capital ratio of one percentage point, ceteris paribus, reduces liquidity creation on the balance sheet by about 0.82% before QE and since the application of QE by only 0.37% (-0.82+ 0.45). For large banks an increase in the lagged capital ratio of one percentage point, ceteris paribus, increases its liquidity creation by about 0.35% (-0.82 + 1.175) before the time of QE and after the start of the QE program by about 0.51% (-0.82 + 1.33).

It should not be forgotten that these results are also influenced by the application of the targeted LTROs (TLTROs), which also started in mid-2014. To filter out the effects of the TLTROs, further research can be carried out, which requires bank specific data.
Additionally, not within the scope of this study is an analysis consisting of all European banks, which is due to the fact that there is no reporting at a European level like the Call Reports in the US.

6. Concluding Remarks

This master's thesis analyzes the development of liquidity creation of European banks compared to US banks, the effects of exceptional monetary policies and the influence of bank capital. In the period from 2008 to 2016, bank liquidity creation in Europe and the US rose sharply after the crisis, although it should be noted that European banks are consistantly producing less liquidity relative to their overall size. An important finding of the unconventional monetary policy operations is that it was important not only to support the liability side of banks, but also to focus on the asset side through the so-called large-scale asset purchase programs (QE) to revive the real economy.

The final objective of this thesis was the question of how bank capital affects the liquidity creation for different bank sizes since the 2007/08 financial crisis till 2018. A review of the period shows that small banks with total assets of up to one billion Euro and medium-sized banks with total assets of up to 25 billion Euro reduce their liquidity creation and thus make themselves more liquid with a 1% increase in the equity ratio. For large banks with total assets of over 25 billion Euro, it has been shown that they create more liquidity if they increase their equity ratio by 1%. This can be taken as an indication that large banks assess their market and funding risk differently than small and medium-sized banks, which is also justified by the different capital requirements of large financial institutions. In this context, it might also be important to investigate if in addition to the specific capital requirements for large banks, liquidity regulations such as the LCR and NSFR should be different for them as well.

Generally speaking, it can also be said that since the financial crisis of 2007/08, banks have returned to a more traditional role of a financial intermediary, as security portfolios have declined and loans as well as deposits have increased relative to total assets. Even if the risk of a capital shortfall in the event of another crisis has not, or not yet, decreased much, the introduction of stricter capital requirements shows that banks have increased their equity ratios on average. Finally, focusing on banks' total assets also shows that inflation-adjusted total assets have fallen on average from 161 billion in 2008 to 146 billion in 2018.

To conclude, bank liquidity creation in Europe has increased since the 2007/2008 financial crisis. Especially the measures taken by the ECB in 2014 have had a positive impact on the increase of liquidity creation till 2018. However, it is also known that credit lines and loan commitments are an important source of liquidity for companies, especially in times of crisis, so it would be very interesting to conduct further investigations into off-balance sheet activities of European banks.

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Appendix–A

2008	Total Assets in €-Million	Total loans/ Total assets	Total deposits/ Total assets	Asset-securities/ Total assets	Liability-securities/ Total assets	Total equity/ Total assets
All banks						
Mean	143,472	65.8	49.5	19.7	18.0	7.9
Median	11,966	69.7	51.3	15.9	14.2	7.1
Min	111	7.2	5.6	0.00438	0.02477	2.3
Max	2,508,713	94.3	94.2	73.4	73.1	22.7
St. Dev.	388,772	18.8	19.7	14.4	15.6	3.9
Small banks						
Mean	418	71.9	60.4	13	12	11.5
Median	356	69.8	56.9	10.1	9.6	11
Min	111	37.3	25.1	0.00438	0.02477	4.2
Max	959	94.3	90.2	48.7	59.9	22.7
St. Dev.	221	13.2	18.3	10.7	11.2	4
Medium banks						
Mean	9,284	72.4	54.7	14.7	16.5	8.5
Median	8,426	75.2	57.8	11.1	9.5	7.7
Min	1,100	2.0	16.4	3.1	0.13	3.2
Max	23,629	90.2	94.2	49.9	66.4	16.5
St. Dev.	6,571	14.2	17.9	9.6	16.9	3.2
Large banks						
Mean	383,661	56	38.8	27.5	22.2	5.6
Median	116,636	59.8	37.1	24	19	5.1
Min	26,035	7.2	5.6	2.2	0.4	2.3
Max	2,508,713	91.5	82.5	73.4	73.1	21.6
St. Dev.	572,800	20.9	17.2	16.2	14.6	3.1

2018	Total Assets in €-Million	Total loans/ Total assets	Total deposits/ Total assets	Asset-securities/ Total assets	Liability-securities/ Total assets	Total equity/ Total assets
All banks						
Mean	150,927	66.7	59.9	17.8	12.3	9.3
Median	20,505	68.2	62.5	16.3	8.0	8.9
Min	160	8.1	7.6	0.11627	0.01473	2.8
Max	2,233,779	94.5	94.6	46.7	60.5	19.1
St. Dev.	348,000	15.5	18.1	9.8	13.7	3.3
Small banks						
Mean	542	67.6	76.1	18	3.2	11.7
Median	476	64.6	77	18.9	1.3	11.7
Min	160	44.6	59.4	0.8	0.01473	6.5
Max	988	93.6	91.8	38.4	17.1	16.5
St. Dev.	220	15.2	8.7	10	4.5	2.5
Medium banks						
Mean	10,309	72.2	61.7	14.7	9.5	10.5
Median	10,359	76.2	62.5	12.8	3.2	10.1
Min	1,237	36.8	22.3	0.11627	0.12	4.3
Max	24,329	94.5	91.2	33.5	60.5	19.1
St. Dev.	7,223	12.4	17.3	9.0	14.5	3.2
Large banks						
Mean	322,775	61.7	54.1	20.6	16.9	7.7
Median	80,353	62.8	56.1	19.4	14.4	6.9
Min	25,064	8.1	7.6	2.2	0.8	2.8
Max	2,233,779	90	94.6	46.7	57.6	14.7
St. Dev.	462,244	16.4	17.7	9.6	12.7	2.7

Table 4: Descriptive Statistics of European banks in 2008 and 2018. Total assets of included banks in €-Million; *Total loans/total assets*: (commercial loans + consumer loans + other loans)/total assets; *Total deposits/totals assets*: (demand d. + saving d. + time deposits + other (time) deposits)/total assets; *Asset-securities/total assets*: (all asset-securities + derivative assets)/totals assets; *Liability-securities/total assets*: (short time borrowings + derivative liabilities)/total assets; *Total equity/total assets*: Total equity/total assets. *Small banks* <1.000 Million Euro, *Medium banks* between 1.000 – 25.000 Million Euro, and *Large banks* > 25.000 Million Euro.

Abstract

This master thesis examines the liquidity creation of European banks between 2008 and 2018 with two objectives; The first objective is to analyze developments in liquidity creation since the financial crisis of 2007/08 and to provide an insight into how the ECB's unconventional monetary policies have affected liquidity transformation. For this purpose, financial statements of 238 listed European banks were evaluated using a liquidity creation measure invented by Berger and Bouwman (2009). The analysis shows that liquidity creation has steadily increased since 2008 and that in particular the conduct of targeted longer-term refinancing operations (TLTROs) and the Asset Purchase Programme (APP) have stimulated liquidity creation. The second objective of the thesis is to test the net effect of bank capital on liquidity creation. The results indicate that bank capital has a negative effect on liquidity creation for small and medium-sized banks and a positive effect for large banks.

Zusammenfassung

Diese Masterarbeit untersucht die Schaffung von Liquidität von europäischen Banken zwischen 2008 und 2018 anhand von zwei Zielen. Das erste Ziel bestand darin, die Entwicklungen bei der Schaffung von Liquidität seit der Finanzkrise von 2007/08 zu analysieren und einen Einblick zu geben, wie die unkonventionelle Geldpolitik der EZB die Liquiditätstransformation beeinflusst hat. Zu diesem Zweck wurden Jahresabschlüsse von 238 börsennotierten europäischen Banken unter Verwendung einer von Berger und Bouwman (2009) entwickelten Messung der Liquiditätsschaffung ausgewertet. Die Analyse zeigt, dass die Liquiditätskreation seit 2008 stetig zugenommen hat und dass insbesondere das Einsetzen gezielter längerfristiger Refinanzierungsgeschäfte (TLTROs) und das Wertpapierankaufsprogramm (APP) die Liquiditätsschöpfung stimuliert haben. Das zweite Ziel der Arbeit war es, den Effekt von Bankkapital auf die Liquiditätsschaffung zu testen. Die Ergebnisse zeigen, dass Bankkapital einen negativen Effekt auf die Liquiditätsschaffung für kleine und mittlere Banken und einen positiven Effekt für große Banken hat.