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MONETARY POLICY EFFECTS ON BANK DEPOSITS AND LENDING

Bachelor thesis

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I have written this bachelor thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

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Introduction

A successful implementation of monetary policy is needed to fulfill the objectives set by central banks that helps with a stable growth of the economy. Activities of commercial banks are crucial for the success of central banks as they act as intermediaries through which monetary policy can steer the economy.

Disruptions within the banking system can lead to adverse effects in the larger economy and lead to increased risks, lower economic output and economic downturn. The Great Recession with its pivotal moment coming with the collapse of Lehman Brothers in 2008, demonstrated that a balanced and well-capitalized banking sector is needed to avoid large downside risks and regulations need to be in place to discourage excessive risk-taking. Adrian and Shin (2010) have linked growth in bank balance sheets during the period preceding the financial downturn to increased leverage of banks. While the banking system can be an important contributor to economic growth, the risks stemming from its activities need to be managed.

Banks can fund activities by internal and external resources – capital, deposits and various forms of loans. Regulations around the world set the minimum capital amounts banks need to maintain and though there can be differences between regions, they are largely similar. As per Basel II regulations banks need to maintain a minimum of 8% total capital and 4.5% of Tier 1 equity (International Convergence of Capital Measurement and Capital Standards – A Revised Framework, 2004). With the implementation of Basel III banks Tier 1 equity requirements are being increased. Although regulation of capital structure can be beneficial for reducing potential risks in the financial system it also has some drawbacks. There has been evidence that regulation of bank capital can amplify business cycles and recessions (Blum & Hellwig, 1995). However, this risk can be mitigated when central banks take bank capital structure into account (Cecchetti & Li, 2008). The differential effects of monetary policy on banks' capital and funding and ratio of debt and equity are thus an important topic that requires further research as bank activity can have larger economic consequences.

The work at hand is primarily interested in how effects of monetary policy on bank lending and funding vary by banks' existing capital structure. As banks' reaction to changes in monetary policy and the economy can be different based on their capital structure and funds' sources (Gambacorta & Mistrulli, 2004), the effectiveness of bank lending channel and monetary policy transmission can be affected, and bank intermediation of monetary policy might be either reduced or amplified. Previous literature has focused more on the aggregate effects of monetary policy on banking (e.g. Bernanke & Gertler, 1995) or the different effects for banks based on asset liquidity or size (Kashyap & Stein, 2000). As there has less focus on the differential effects on bank lending and funding depending on bank capitalization, this section of monetary policy transmission warrants further inquiry.

As such, the goal of the bachelor thesis is to study how bank capital facilitates a bank's balance sheets reaction to a monetary policy shock. The thesis answers the following questions: (1) are there differences in how banks react to a monetary policy shock depending on bank capitalisation and (2) what kind of differences in their funding composition consequently follow the monetary policy shock. If there are differences in how banks change funding structures, this could be important when banks have capital levels close to the regulatory minimums and might be forced to either reduce their assets or increase equity, which can be costly. Before answering these questions, the following research tasks are raised:

1. Create an overview of existing theoretical and empirical literature regarding the bank lending topic;
2. Prepare and transform the bank-level data to be used in macroeconomic model;
3. Create groups of banks based on a theoretical and previous empirical research that could provide explanations to potential differences among different groups;
4. Carry out statistical and econometric analysis to create models for bank groups' behaviour following monetary policy shock and analyse any differences or similarities between them.

The thesis contains both an empirical and theoretical section bridging various topics such as bank capital structure and bank lending channel thereby expanding on existing literature. Previously carried out studies and theoretical papers that have been foundational to the topics of monetary policy transmission and the dynamics of bank funding and lending are discussed and presented in the theoretical part of the thesis. The empirical part contains a monetary policy and bank balance sheet vector autoregressive (VAR) model with data collected for the years 2011-2021. The macroeconomic components of the model are sourced from the FRED data repository maintained by the Federal Reserve Bank of St. Louis and bank balance sheet data is taken from Bloomberg with the sample made up of banks listed on the Nasdaq Stock Market.

Keywords: bank lending, monetary policy, VAR

2. Theoretical framework and literature overview

2.1. Theoretical framework

The thesis is based largely around the framework that monetary policy affects the economy through a bank lending channel. The framework used in the thesis can generally be referred to as a credit channel that has both a load demand and loan supply component.

The loan demand part of the monetary policy transmission can be referred to as the balance sheet channel. Bernanke and Gertler (1995) refer to the theory that by raising short-term interest rates the Fed policy affects both market interest rates and the financial positions of borrowers by (a) increasing interest expenses which reduces net cash flows and (b) reducing the ability to loan by lowering the value of collateral due to higher interest rates being associated with lower asset values. There is also an indirect effect that comes from customers spending less on goods which leads to a reduction in revenue, net worth and creditworthiness (Bernanke & Gertler, 1995). It has been pointed out, that loan demand could also be seen as being dependent on economic output (GDP) as better economic conditions have a higher number of investment projects with an expected net present value which increases the demand for credit (Kashyap *et al.*, 1993). Regardless of the exact dynamics of loan demand formation, it falls outside the control of banks and is dependent on macro-economic factors.

The bank lending channel however represents the loan supply part of aggregate loans in a system and can be affected by bank-specific effects. The bank lending channel is based around the ideas that the central bank can affect loan demand by influencing the cost of funding for banks which will lead to a subsequent decline in lending due to those higher costs. As the central bank raises interest rates it drains reserves and insured deposits from the financial system forcing banks to substitute those deposits with other sources of non-deposit funding which carry higher costs due to being subject to adverse-selection problems (Stein, 1988). When banks act as borrowers to source managed funding to offset to loss of deposits they can lend at level of premium that is affected by their credit quality and any higher cost incurred during that process is passed by raising loan rates (Black *et al.*, 2007). Kishan and Opiela (2000) that banks that are undercapitalized will not be able to offset those deposits by selling large time deposits and Kashyap and Stein (2000) further point out that small banks are unable to use instruments where credit risk is an issue. Therefore, depending on market perceived bank credit quality and dependence on deposit funding the effects of a monetary policy change and the effectiveness of a lending channel can vary between banks.

The lending channel also requires that there are at least some borrowers who due to information costs will be bank-dependent borrowers and cannot substitute bank loans with bonds or commercial paper (Kishan & Opiela, 2000). If there were no bank-dependent borrowers and loans had perfect substitutability with other forms of credit (e.g. bonds, commercial paper) then this credit channel could not work through banks.

To measure monetary policy stance multiple measures have been used like qualitative analysis of FOMC meeting minutes (Romer & Romer, 1989) while others have advocated for the use of the Federal Funds rate (Bernanke & Blinder, 1992). In either case, the different measures have largely moved in the same direction (Kashyap & Stein, 2000), but using the Fed funds rate gives an unambiguous measure which can be useful for analysis.

Monetary policy can be considered to be conventional (changes in Federal funds rate) or unconventional (asset purchase programs). While generally the Federal Reserve has conducted monetary policy through the conventional measure of changing the Federal Funds rate, after the events of 2007 there have been increases in unconventional measures such as lending in private credit markets (Gertler & Karadi, 2011). These operations are needed in situations where the Federal Funds rate is nearing the zero lower bound, but further easing of monetary policy is required. Both measures however have the goal of easing access to funds in the financial system and can be used to affect the cost of funding and thereby affect bank lending.

1.2. Empirical studies of monetary policy transmission

There is large body of research about the US economy that shows the economic impact and role of the banking system in various ways. The role of banks for monetary policy transmission could be considered more important for the Euro area where bank loans make up around half of external corporate funding while the figure is around 20% in the US (De Fiore & Uhlig, 2005). While Bernanke and Blinder (1988) link the decrease in loans after an increase in policy rates mainly to a decrease in total supply which raises the cost of capital for borrowers and thereby leads to a contraction in the economy as well as the amount of loans outstanding. Kashyap and Stein (2000) however argue that this reduction in loans can also be interpreted as a decrease in loan demand as higher interest rates also lead to borrowers seeking less credit. There can also be differences in how firms of different sizes react following a monetary contraction, as large corporations tend to issue more commercial paper while loans are decreasing indicating a different response to monetary policy for small and large borrowers (Kashyap *et al.*, 1993).

According to the findings of Blum and Hellwig (1995), the monetary policy shock to aggregate demand reduces the ability of corporations to service their debt thus lowering bank equity and due to the limits set by capital requirements, banks also need to decrease lending as a response to increased risk of borrowers defaulting. These findings are consistent with the ideas of a “bank lending channel” of monetary policy transmission, which constitutes that increases in rates decrease the creditworthiness of businesses and their ability to secure external funding (Bernanke & Gertler, 1995). The transmission mechanisms and channels for monetary policy are important for sound policy choices and stable economic growth where inflation and financial stability are well-managed. Thus the importance of monetary policy effects on bank lending is well demonstrated by previous authors. Monetary policy effects for bank funding and accompanying financial developments have been noted by different authors.

While the effect of monetary policy on bank loans has been established on an aggregate level there has been less discussion how this is affected by differences in bank funding and capital structure and works on a bank level. Bernanke and Gertler (1995) show how following an interest rate increase banks decrease their loan portfolios. In addition, it has been found that banks increase shorter term loans to larger corporations with the aim of increasing the overall quality of the portfolio (Black & Rosen, 2007). However, in addition to effects of the asset side of the bank balance sheet, the way banks structure their funding can also be impacted differently by monetary policy and thus have differential effects for bank lending and financial stability. Diamond and Rajan (2001) illustrate how bank capital provides a safeguard against negative changes in assets especially during times when markets are in a state of uncertainty, change or downturn (e.g. recession, policy rate hikes). However, if a bank’s capital is low, it might not have enough room to increase its debt and remain within regulatory requirements and therefore might need to decrease assets (loans) or obtain new equity. Most empirical research has focused on either bank capital, which is important from a financial stability and macroprudential standpoint, and on deposits, which on an aggregate level makes up most of bank funding and has become a crucial part of it. As of December 2022, deposits make up around 80% of commercial bank funding (as measured by deposits to assets) on an aggregate level in the US according to the Federal Reserve’s H.8 reports.

The effects of monetary policy have been previously studied and it has been found that there is both an immediate and longer-term effect on levels of bank risk. While following an interest rate decrease there is a short-term decrease in bank risk, as due to interest rate decrease the assets of borrowers increase in value, in the long-term risk level increase (Altunbas *et al.*, 2010). The differences between long- and short-term effects can be due to banks' existing loan portfolio's risk decreasing following the interest rate change (as borrowers' interest payments decrease), though loans emitted *ex post* already begin to carry higher levels of risk (Angeloni *et al.*, 2015). Changes in policy rates can be tied to both changes in risk present in the financial and banking system as well as the loans emitted that influence the larger economic output. As less focus has been on the role of debt as it tends to be an insignificant part of bank funding, in the following sections the role of deposits and bank capital in bank funding, loan growth and their reactions to monetary policy changes will be discussed.

1.3 Bank funding

Deposit funding remains an important part of commercial bank liabilities. Previous research has found deposits to make up around 90% of total funding for the short term and around 70% of long-term funding (Illes *et al.*, 2019). While bonds are mostly used for long term funding, central bank operations affect both long and a short-term source of funds (Illes *et al.,* 2019). Monetary policy affects the cost of capital and can influence the composition of both liabilities and assets for the bank. Following a rise in policy rates the loan portfolios, securities on the asset side and deposits on the liabilities side have been noted to decrease (Sun *et al.*, 2010). In addition, there is a negative effect on GDP, stock prices and CPI, the latter of which comes with a delay (*ibid.*). The decrease in deposits can be linked to increased risks and higher competition for client deposits between banks. Illes *et al.* (2019) link the deposit liabilities from both MFI entities and non-MFI entities to both long term and short-term lending rates, which show the higher costs of uninsured deposits due to increased counterparty risk in case of MFI deposits and increased competition for non-MFI deposits (Illes *et al.*, 2019). This creates a link between funding activities from deposits and using alternate short term funding sources such as repos, certificates of deposit or central bank operations and alternate long term funding sources such as bonds and even new capital emissions. Previous articles have shown that as banks have grown increasingly dependent on deposits and an increase in the policy rate could significantly increase the cost of funding for deposits and create a need to increase funding from other sources, which are likely to be more costly and less stable (Gerlach *et al.*, 2018). This creates a source of funding risk for banks that on an aggregate level can have implications for the larger economy. The opposite is also true. Lowering policy rates increases bank risks especially in bank funding (Angeloni *et al.*, 2015). In addition, as per Bernanke and Blinder (1992) an increase in the federal funds rate can lead to decreases in loans. Gerlach *et al.* (2018) have pointed out that in the current low interest rate environment deposits make up around 75% of bank funding and any monetary policy increases can have significant effects on funding costs. Therefore, in addition to an effect on bank liabilities and funding costs, there is an effect on the assets side of the balance sheet and the risk present in the financial system.

As previously mentioned, monetary policy can have different effects on banks based on their liquidity and size, differences between banks can also come from other factors. Sun *et al*. (2010) found different reactions to a monetary policy shock between state and non-state banks. Larger state-owned banks initially decreased loans following a policy rate hike, and increased loans again after four quarters while non-state banks tended to increase loans after a rate increase, and decreased again in time (Sun *et al.*, 2010). Their differences were attributed to differences between political goals. State owned banks are more motivated to follow the political goals set by the state while non-state banks are more persistent to increase the value for shareholders (Sun *et al.*, 2010). They also found evidence that deposits are a substantial part for creating new loans and assets and thus reiterating the importance of deposits to bank funding and found support for the bank lending channel and as a monetary policy transmission mechanism in China and strong effect of total loans, deposits and bank securities on the real economy (Sun *et al.*, 2010). However, this explanation of diverging political goals does not consider the potential differences that can come from different funding structures. This contrasts somewhat with Kashyap and Stein (2000) that monetary policy is more effective for smaller banks which non-state banks tend to be.

Bank capital is the alternative to external sources such as customer deposits, funds from central bank operations, bonds and money market instruments and is especially important during economically precarious times. While a large body of research has been done regarding effects of levels of different deposits (time deposits, demand deposits) or reserve requirements, bank capital is another important part of the balance sheet that has only recently been ascribed more attention. The importance of internal funding is an important topic that is salient to both bank performance, cost of funding and lending.

It has been shown that bank capital is especially important during times when the economy is deteriorating but having capital in excess of regulation minimums has little benefit to banks during normal market conditions (Berger & Bouwman, 2013). This is consistent with other articles and can explained by the fact that better capitalized banks are less dependent on business cycles and tend overall to be more risk-averse by choosing borrowers with higher credit ratings (Gambacorta & Mistrulli, 2004). Due to higher costs for capital as compared to debt or customer deposits, banks prefer to keep lower amounts of capital when possible. Issuing of new equity can be especially costly for riskier and poorly capitalized banks (Stein, 1995) thus hindering their ability to issue new loans during adverse periods in the markets. Bank capital is an important factor that helps to reduce risks in the financial system (Diamond & Rajan, 2001) and as a higher capital ratio should decrease bank riskiness it should also make any debt held by the bank less risky and improve their access to liquidity during periods of uncertainty. In addition, it has also been shown that while increases in regulatory capital minimums can produce a short-term increase to funding costs, in the long run funding costs decrease (Babihuga *et al.*, 2014), which can at least in part be due to decrease in (counterparty) risks.

Due to banks holding increasingly high levels of deposits for finding activities, a monetary policy shock that decreases those deposits, can have a significant effect on bank balance sheets as banks need to substitute stable and lower cost deposits for other alternatives. However, banks do not have equal access to new non-deposit funds as differences in their leverage and capital and imperfections in fund-raising (Gambacorta & Mistrulli, 2004) and therefore banks' funding is expected to react differently following a monetary policy shock. Altunbas *et al.* (2009) found that bank riskiness was an important part in determining how banks' loan supply changed in size following a monetary policy shift and showed that banks with lower risk were better able to shield their portfolios from the adverse effects coming from that change. The ability of low-risk banks to better protect themselves against a shift in monetary policy is explained in the bank lending channel framework by being more able to secure new funds.

It is also important to note, that the previous results may be more able to explain differences in bank responses during periods, where there were problems in the credit market, such as the period of 2007–2008, where high-risk banks may not have been able to secure necessary funding at good terms. However, compared to the previous recessions, during 2020 the Federal Reserve as well as other central banks provided tremendous support to financial markets in terms of liquidity and credit availability (Mosser, 2020). The conventional reduction in interest rates was followed by large-scale quantitative easing measures to provide support for U.S. Treasury, corporate bond and commercial paper markets as well as additional lending operations to financial institutions (Mosser, 2020). While previous recessions have often been preceded by financial crises, the recession in 2020 was caused by large shocks to both aggregate demand and supply as firms in many countries had to stop daily operations (Mosser, 2020). Therefore, the most recent crisis is different from the ones preceding it and it is possible that the banks' reaction to any monetary policy changes can be affected by this.

2. Methodology and data

As the goal of the thesis is to study how bank capitalization facilitates balance sheet reaction to monetary policy a vector autoregression (VAR) model is utilized to assess how a bank capitalization facilitates bank funding and lending following a shock in the Federal funds rate (FFR). A VAR model is a system of linear equations which include lags of the variables in the equations. VAR models have been extensively used in econometric analysis and are suitable to assess the effects of endogenous shocks. The use of FFR has been advocated by different scholars and has become a standard way to model the changes in monetary policy. To assess the effects, bank-level data of 162 financial institutions is used which are divided into three groups based on their Tier 1 capital levels, which measure the bank's financial strength from a regulator's point of view. Looking at subsets of banks based on capital levels has been done previously (e.g. Kashyap & Stein, 2000; Carpenter & Demiralp, 2012) and their advantageous position in a contractionary period is theoretically supported by the idea that better capitalized banks carry less risk and have access to funding at better terms (e.g. Stein, 1995). The variables in the VAR are based on a standard monetary policy model which incorporates the FFR, unemployment rate, GDP and the GDP deflator which has been previously used by other researchers extensively. Both the macroeconomic as well as the bank balance sheet part of the model are similar to models used by Carpenter and Demiralp (2012) and Gerlach *et al*. (2018) with modifications made to incorporate the bank balance sheet variables salient for the research questions and goal of the thesis. The suitability and use cases of FFR has been discussed previously in the theoretical section and is widely accepted to be a relevant measure for the current case by different authors.

The bank side variables chosen are total loans, total deposits and total assets which capture the essential parts of the bank lending channel. The importance of deposits for bank funding has been discussed in the preceding section and the (in)ability to substitute lost deposits and the following effects in bank balance sheet size and composition of assets should be sufficiently captured with this model. Deposits are positioned before loans as based on the theory that contractionary monetary policy reduces deposits available to banks and thus reduces loan supply as banks do not fully replace the deposits lost (Kashyap and Stein, 2000).

For the thesis, two VAR models are constructed using bank-level data in quarterly frequency from between 2011Q1 and 2021Q3 of publicly traded banks listed on the Nasdaq stock exchange. The balance sheet data is gathered from Bloomberg Terminal and consists of 162 financial institutions. Only banks that had complete data points for the entire sample period were included in the analysis, meaning that banks that were been privatized, delisted or have missing observations during the periods have been omitted from the analysis. All bank timeseries data are adjusted using Holt–Winters seasonal smoothing to mitigate the effects that may come seasonal influences before any other analysis or transformation is done.

For the purposes of this thesis, VAR models are used where the identification uses a recursive scheme. The models used in the thesis are specified as:

$$Y_t = \nu + AY_{t-1} + u_t,$$

where,

Y_t is a (Kp×1) vector of variables at time t,

ν is a (Kp×1) vector of intercepts,

A is a (Kp×Kp) coefficient matrix,

u_t is a (Kp×1) vector of error terms.

The first model uses aggregated balance sheets of each Tier 1 capitalization group to assess the effects of a contractionary shock on a macroeconomic level. For this, for each period the balance sheets of all banks in that group are added up. A second model uses the averaged changes of banks' balance sheets to assess how bank in that group reacts on average. For this the bank balance sheet items are first transformed into natural logarithm and then first differenced. The identification of the monetary shock with the interest rate follows recursive approach, this means that the macroeconomic aggregates and bank-specific variables are allowed affect interest rates contemporaneously, but the monetary shock itself does not affect the variables in the economy at the same time. This is also used by Carpenter and Demiralp (2012) and Gerlach *et al.* (2018).

For the lag length selection previous studies as well as information criteria tests were considered. When specifying maximum four lags for the tests, most information criteria also suggest four lags as the optimal lag length for both aggregated and averaged balance sheet data. When specifying maximum three lags, most information criteria show that using two lags is most appropriate for the model for all three datasets for both aggregated and averaged bank balance sheet data (Appendix A). This is also consistent with previous studies that have used either two lags at the quarterly frequency or six lags at the monthly frequency (Carpenter & Demiralp, 2012; Bernanke & Blinder, 1992). The fact that four lags is suggested in the first specification could show that there remains some level of seasonality in the data, which was not fully adjusted for by using the Holt-Winters seasonal smoothing. Therefore, two lags are used in the VAR model which is consistent with the previous studies.

Unit root tests are performed *ex ante* to ensure that analysis in the next sections are not based on spurious regressions. Unemployment and FFR are used in level form, while other variables are used as a first difference of logarithm to ensure stationarity of the data. Existence of unit roots of all variables is tested using Augmented Dickey-Fuller and Phillips-Perron unit root test for which the results can been seen in Table 1 and Table 2 for the macroeconomic variables.

Table 1.
Augmented Dickey–Fuller test for main macroeconomic variables

	Test statistic	Critical value			
	Z(t)	1%	5%	10%	p
UNEMP	-2.565	-3.64	-2.95	-2.61	0.100
GDP	-7.755	-3.64	-2.95	-2.61	0.0001
GDP DEFL	-2.845	-3.64	-2.95	-2.61	0.052
FFR	-0.921	-3.64	-2.95	-2.61	0.122

Note: T=41

Table 2.
Phillips–Perron test for main macroeconomic variables

	Test statistic		Critical value			p-value
			1%	5%	10%	
UNEMP	Z(rho)	-9.476	-18.288	-13.012	-10.52	0.1224
	Z(t)	-2.47	-3.64	-2.95	-2.61	
GDP	Z(rho)	-48.453	-18.288	-13.012	-10.52	<0.001
	Z(t)	-7.83	-3.64	-2.95	-2.61	
GDP DEFL	Z(rho)	-20.512	-18.288	-13.012	-10.52	0.0356
	Z(t)	-2.99	-3.64	-2.95	-2.61	
FFR	Z(rho)	-4.616	-18.288	-13.012	-10.52	0.528
	Z(t)	-1.51	-3.64	-2.95	-2.61	

Note: T=41

As can be expected, the only two variables used in level are non-stationary, however using the federal funds rate and unemployment rate in level form is common practice for this type of VAR model. While GDP is stationary based both on Augmented Dickey-Fuller and Phillips-Perron testing, GDP deflator is stationary only based on Phillips-Perron. However, as the p-value of the ADF test is only slightly above the 5% threshold, it is likely not much of an issue.

As previously stated, the banks in the sample are divided into three equally sized groups based on Tier 1 Common Equity Tier levels (Low, Mid and High capitalization). Banks are admitted to a group based on its mean Tier 1 capital ratio of the entire period meaning that regardless of the magnitude or dynamics of changes in Tier 1 equity during the sample period, a bank cannot move from one group to another. Figure 1 shows that the Low and Mid groups are comparable in size, while the highest capitalization banks are smaller in size. Summary statistics for all three groups' asset sizes can be found in Appendix B.

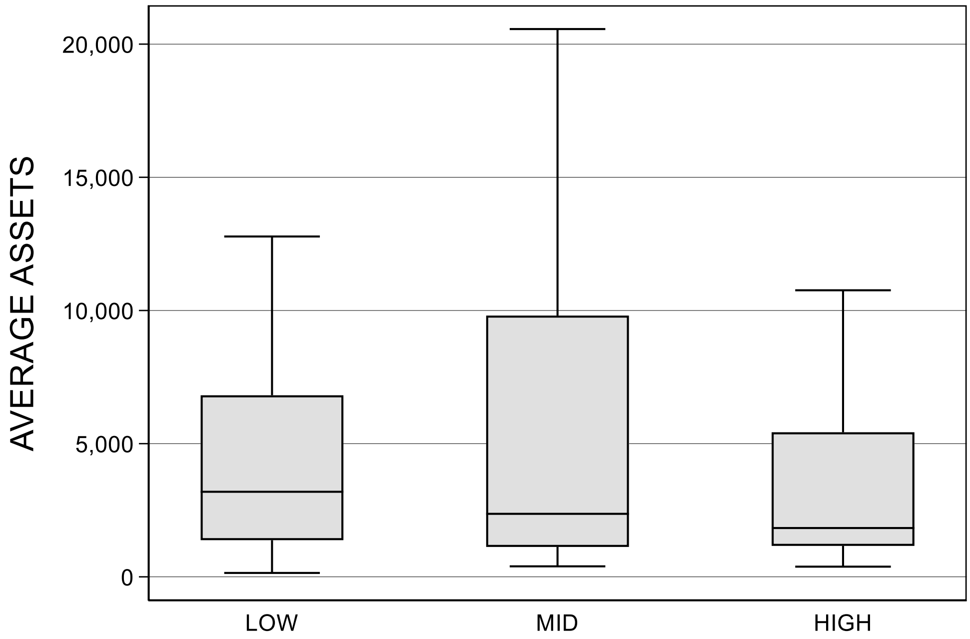

Figure 1. *Average assets of bank assets during the period 2011-2021 for three bank capitalization groups. Outliers have been omitted from the graph.*

For the purposes of the thesis, two VAR models are constructed that follow the same general setup but use different data for the bank variables. The bank variables are used in a first difference of natural logarithm to ensure stationarity of the data in both cases. However, the first model uses aggregated balance sheets of each size group, while the second model uses the average of first difference of logarithm of all banks of each variable as Kashyap and Stein (2000) have shown that size can be an important variable that influences bank lending during a monetary policy. This methodology is used so that results on the aggregate level are not the outcome of only a few large banks that have very large balance sheets.

The Augmented Dickey-Fuller tests for unit root for the bank data using aggregated data shows that there is no unit root in the timeseries (Table 3) nor is there unit root found for the averaged bank data (Table 4). This is to be expected as first differencing the natural logarithm will transform the balance sheet data to be approximately equal to the growth rate and is a widely used practice when constructing VAR models.

Table 3

Augmented Dickey–Fuller test for unit root in aggregated balance sheet data

		Test Statistic for group			Critical values		
		Low	Mid	High	1%	5%	10%
ASSETS	Z(t)	-6.41	-4.02	-5.52			
LOANS	Z(t)	-6.92	-4.72	-4.54	-3.64	-2.96	-2.61
DEPOSITS	Z(t)	-5.53	-4.26	-6.00			

The unit root tests for both averaged and aggregated balance sheet data show similar results, though it seems that for the Mid group. the test statistics tend to be weaker for the three variables, especially in case of aggregated data. While the test still concludes that there is no unit root, the fact that for averaged balance sheet data, the test yields stronger results might indicate that there is a stronger trend in the Mid group.

Table 4

Augmented Dickey–Fuller test for unit root in averaged balance sheet data

		Test Statistic for group Z(t)			Critical values		
		Low	Mid	High	1%	5%	10%
ASSETS	Z(t)	-6.41	-4.02	-5.52			
LOANS	Z(t)	-6.92	-4.72	-4.54	-3.64	-2.95	-2.61
DEPOSITS	Z(t)	-5.53	-4.26	-6.00			

A similar result can be observed in Table 5 and Table 6 where in case of aggregated data, the Mid groups results of somewhat weaker. However, both Augmented Dickey-Fuller and the Phillips-Perron tests accept the hypothesis that there is no unit root in the timeseries. Therefore it can be concluded that first differencing the natural logarithm of the variables has resulted in a stationary timeseries that can be used in the VAR model.

Table 5

Phillips–Perron test for unit root in aggregated balance sheet data

		Bank groups			Critical values		
		Low	Mid	High	1%	5%	10%
ASSETS	Z(rho)	-44.77	-23.96	-34.23	-18.28	-13.01	-10.52
	Z(t)	-6.42	-4.00	-5.49	-3.64	-2.95	-2.61
LOANS	Z(rho)	-49.61	-29.277	-35.498	-18.28	-13.01	-10.52
	Z(t)	-6.91	-4.63	-4.74	-3.64	-2.955	-2.61
DEPOSITS	Z(rho)	-35.36	-27.47	-35.97	-18.28	-13.01	-10.52
	Z(t)	-5.50	-4.31	-5.99	-3.64	-2.955	-2.61

Table 6

Phillips–Perron test for unit root in averaged balance sheet changes

		Bank groups			Critical values		
		Low	Mid	High	1%	5%	10%
ASSETS	Z(rho)	-31.78	-33.61	-34.64	-18.28	-13.01	-10.52
	Z(t)	-4.67	-5.04	-5.37	-3.64	-2.95	-2.61
LOANS	Z(rho)	-26.82	-31.56	-33.29	-18.28	-13.01	-10.52
	Z(t)	-3.76	-4.39	-4.69	-3.64	-2.95	-2.61
DEPOSITS	Z(rho)	-36.18	-37.79	-36.40	-18.28	-13.01	-10.52
	Z(t)	-5.21	-5.46	-5.65	-3.64	-2.95	-2.61

3. Empirical analysis and comparisons

3.1 Analysis of aggregated balance sheets

In this section the VAR model is constructed using aggregated balance sheet data to assess the monetary policy shock and for each bank group on a macroeconomic level. As is expected, the impulse responses for the macroeconomic variables of each group have very minor differences among them so only the graphs of the low capital tier group are shown in this empirical section of the thesis.

After the shock in the FFR, the variables itself continues to increase for up to two or three quarters and the begins to decline (Figure 2). This is consistent with what is expected and the decline after the second quarter has also been observed previously (e.g. Carpenter & Demiralp, 2012).

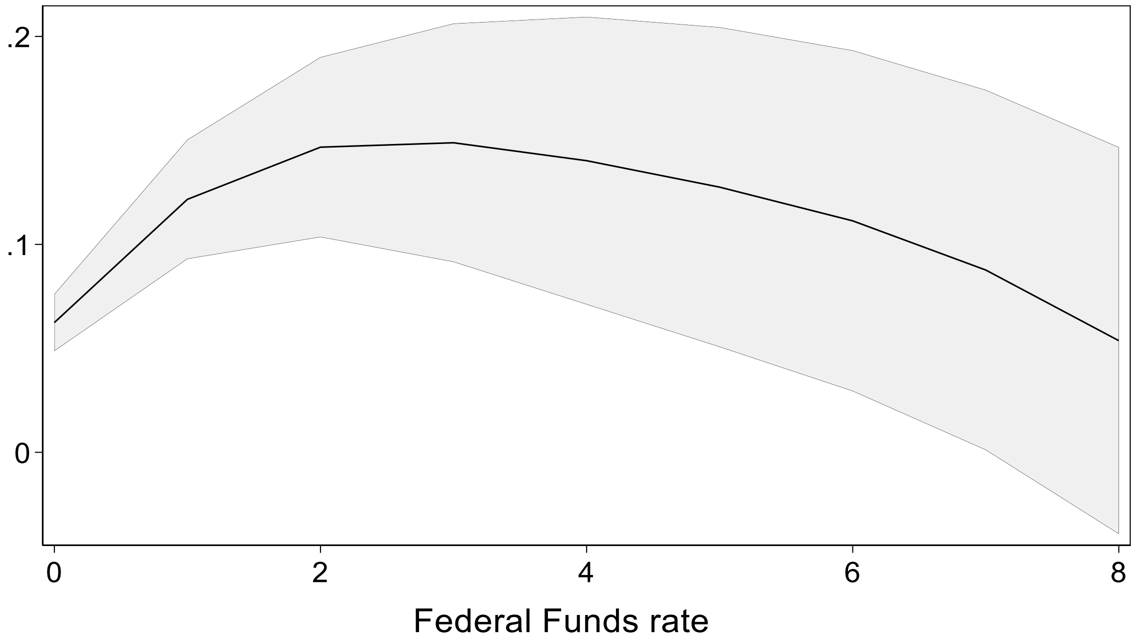

Figure 2. *Response of Fed Funds rate to a shock in FFR eight quarters after the shock, gray areas are 95% confidence intervals.*

The GDP and unemployment rate react differently in the model that would be expected. The unemployment rate falls initially following the contractionary shock and recovers by the sixth quarter and starts increasing from there on. This differs somewhat from Bernanke and Blinder (1992) who found that following a contractionary monetary policy shock in the FFR, unemployment will rise after having very little changes in the first six months. In the current model the initial decrease is more pronounced, and unemployment doesn’t rise until later. These differences could be because the two periods of analysis have fundamental differences between them. The 1970s and 1980s that Bernanke and Blinder (1992) used in their analysis saw much higher levels of inflation, unemployment as well as increasing federal funds rate. The sample period from 2011 onwards can instead be characterized by low inflation, unemployment and for much of the period the FFR has remained relatively unchanged and near the zero levels. From 2011 to 2015 unemployment declined, while FFR was relatively unchanged. Furthermore, after a sharp increase in unemployment in 2020 it declined to previous levels by 2021, while FFR declined backdown to the effective zero lower bound and showed little changes (see Appendix C).

The response in the GDP deflator (Figure 3) is as expected which other studies have also found to decline after a short period of delay (e.g. Sun *et al.*, 2010). Regardless of any period difference that were observed for unemployment, the GDP deflator is showing the same dynamics in the current period of 2011-2021 as well as in the analysis of Bernanke and Gertler (1995) using data from 1965 through to 1993. That shows that monetary policy effects on price stability seem to have remained consistent through time.

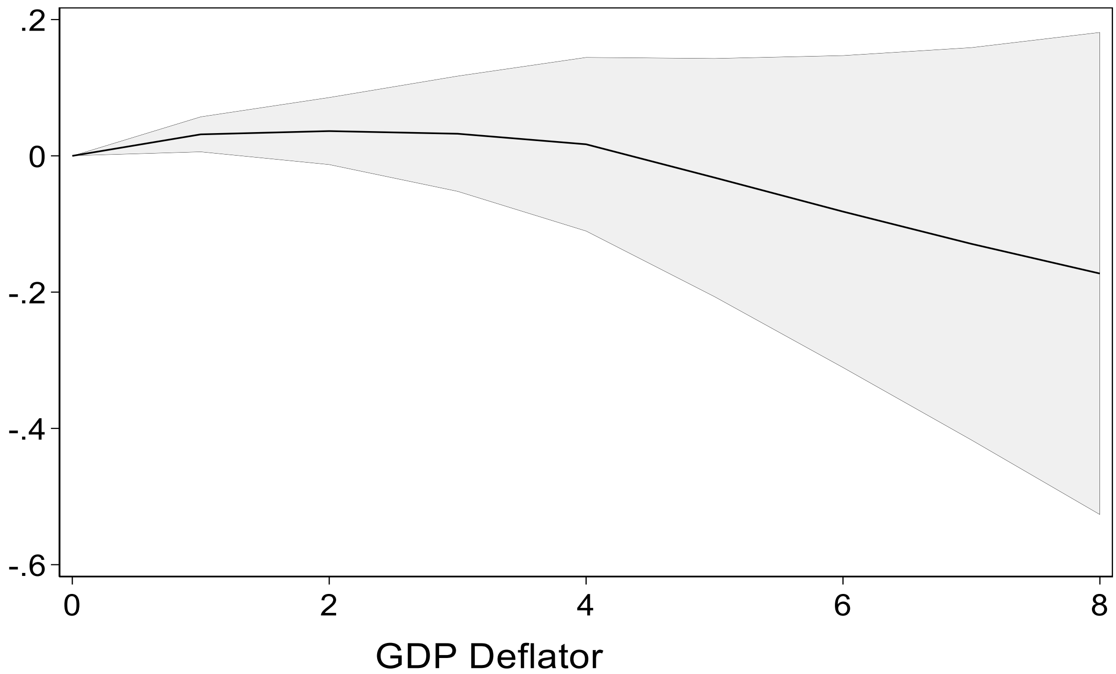

Figure 3. *Response of the GDP deflator to a shock in Fed funds rate (cumulative orthogonalized impulse response), gray areas are 95% confidence intervals.*

As a result of an increase in the FFR, GDP and the GDP deflator both rise during the first two quarters and then begin falling. The impulse response functions of assets, deposits and loans for the three groups of banks are shown in Figure 4. The graphs represent cumulative IRF graphs as the bank values were transformed into natural logarithm and then first differenced (approximately equal to growth rate) and then used in the VAR model. The response functions are orthogonalized.

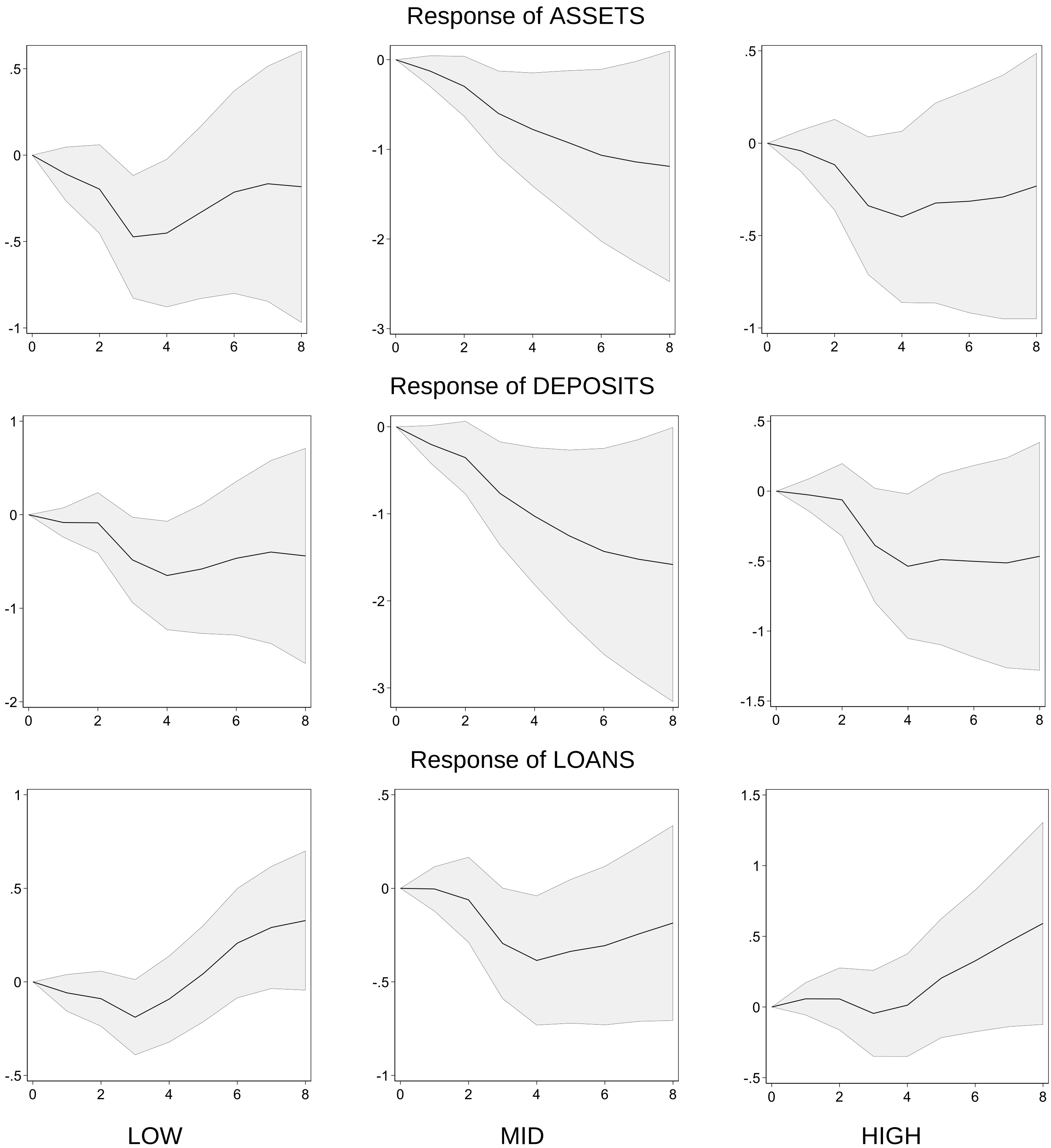

Figure 4. *Response of bank balance sheet eight quarters after a shock in FFR for three bank capitalization groups, gray areas are 95% confidence intervals.*

The changes in the bank balance sheet items are consistent with what can be expected from a theoretical standpoint as well as what has been found by previous studies. The assets and deposits of all three groups decreases following the policy rate increase and especially so for the middle group. This shows that banks have had to find substitutes to make up for the shortfall in deposits, but possibly due to higher costs and lower stability of those alternative sources cannot replace those deposits entirely. This speaks in favor of a bank lending channel as its states that for each dollar of (insured) deposits lost, a smaller amount will be substituted (Kashyap & Stein, 2000) leading to decreases in loan portfolios.

The fact that loans and deposits do not change as much during the first two quarters and then change more quickly speaks in favor of a loan supply effect as the GDP rises during that same time which would show that GDP levels affect loans. Though as GDP itself is expected decline immediately in the model, this is more likely to be due to an exception specific to the period.

As the decrease in loans is smaller than the decrease in deposits and assets for all capitalization groups, banks have likely had to reduce the securities held on their balance sheet. Loan portfolios of less liquid banks have been found to decrease following a contractionary shock while changes in loans of more liquid banks can be entirely positive (Carpenter & Demiralp, 2012). The fact that low and high capitalization banks have been able to increase their loan portfolios after the fourth quarter while the middle groups' loans have decreased could be due to having higher balance sheet liquidity however, this is not currently controlled for.

As higher Tier 1 capital of banks should be a sign of higher creditworthiness due to having more of a buffer to raise new funds (see Stein, 1995; Diamond & Rajan, 2001) it would be expected to see banks with higher levels of regulatory capital to have lower decreases in deposits and loans though this is not plainly obvious in the current model. Still, the High Capital group's loans do not decrease much in the first three quarters unlike in the other groups and loan portfolio growth also remains stronger at the eighth quarter. While this does show that banks in Tier 1 equity groups have different responses, though it is not certain that the different responses are not to differences in either size, liquidity or some other variable not accounted for and can less likely be attributed to different levels of capital. As smaller banks tend to hold higher levels of securities as well as high capital as they can have more trouble with raising external finance leading them to create more buffers to deal with loan losses (Kashyap & Stein, 2000). This is also observed in the bank-level data showing that the highest capitalization group has on average smaller banks that the other two groups (see also Appendix B)

As on the aggregate level, all three groups have sufficient levels of capital that is not near the minimum levels required by regulations, the results indicate that having a large excess of regulatory capital is less likely to provide tangible benefits to those banks. It is possible, that if the groups were created based on how close or far they were from the minimums based on absolute cutoff levels as opposed to arbitrarily dividing the banks in the sample to equally sized groups, the differences between groups could be more pronounced. A similar analysis has been done by Kishan and Opiela (2000) who analyzed three groups of banks where the undercapitalized group had less than 8% capital, the adequately capitalized banks had capital between levels of 8% and 10% and well-capitalized banks had more than 10% of capital. As Tier 1 equity differs from bank's entire capitalization levels and the regulatory requirements have likely changed during the last 20 years, these cutoff levels would likely need to be revised, but a similar reasoning could be used. However, the current methodology does indicate, that the benefits of higher levels of bank capital likely has diminishing returns and while having adequate levels of capital, other factors like size or liquidity, could be more meaningful.

While the Tier 1 equity could very well be a variable that determines how a group of banks reacts to a contractionary shock, the analysis done on an aggregate level invariably means, that the response of banks with larger balance sheets is seen more than that of smaller banks. As per Appendix B, the group of banks with highest levels of capital are also smaller on average than the banks in the other two groups.

In order to test whether there is serial correlation in the error term of the VAR model, a Lagrange multiplier test was done with all three groups for which the results are presented for in Table 7. Only the low capitalization group has serial correlation in its error term at two lags. For other two groups the probabilities of the test are well above any conventional thresholds and it can be concluded, there for those two groups there is no autocorrelation present in the model at two lags.

Table 7

Lagrange Multiplier test for autocorrelation

Group	Lags	chi2	df	Prob > chi 2
Low	2	72.12	49	0.017
	2	52.68	49	0.334
	2	47.51	49	0.534

Note: H0: no autocorrelation at lag order

The stability condition of the VAR model is verified by analysis of eigenvalues. As has been shown by Lütkepohl (2005), a VAR model is stable if each eigenvalue is less than one in absolute value. As can be visually observed in Figure 5, the stability condition is not met for all groups as there is one eigenvalue that breaches the threshold in the Low group. This is in accordance with the Lagrange multiplier test that also showed that there is serial correlation present in the Low group. However, for other groups the stability condition is met.

Figure 5. *The eigenvalue graphs for low, mid and high capitalization banks*

3.2 Analysis of averaged balance sheet changes

As pointed out in the previous section, the analysis using aggregated figures showed the macroeconomic responses of the different bank groups, but the effects of each group would be swayed by the largest banks in that group. To account for that, the analysis in this section uses the average balance sheet changes of each bank in a group to show a reaction to a contractionary shock that would be more characteristic of that group of banks.

Figure 6 shows the results from the impulse response analysis to a funds rate shock. Variables in the figure show the cumulative orthogonalized impulse responses as the first differences of natural log of variables is used in the model. The VAR model at hand uses the same Tier 1 groups as the previous model and bank variables react in a similar manner as discussed in the previous section with the low and high capital groups' balance sheets faring better to a contractionary monetary policy shock. The reduction in loans and deposits for the middle group however is less pronounced, which indicates that larger bank(s) may have influenced the results in the previous model.

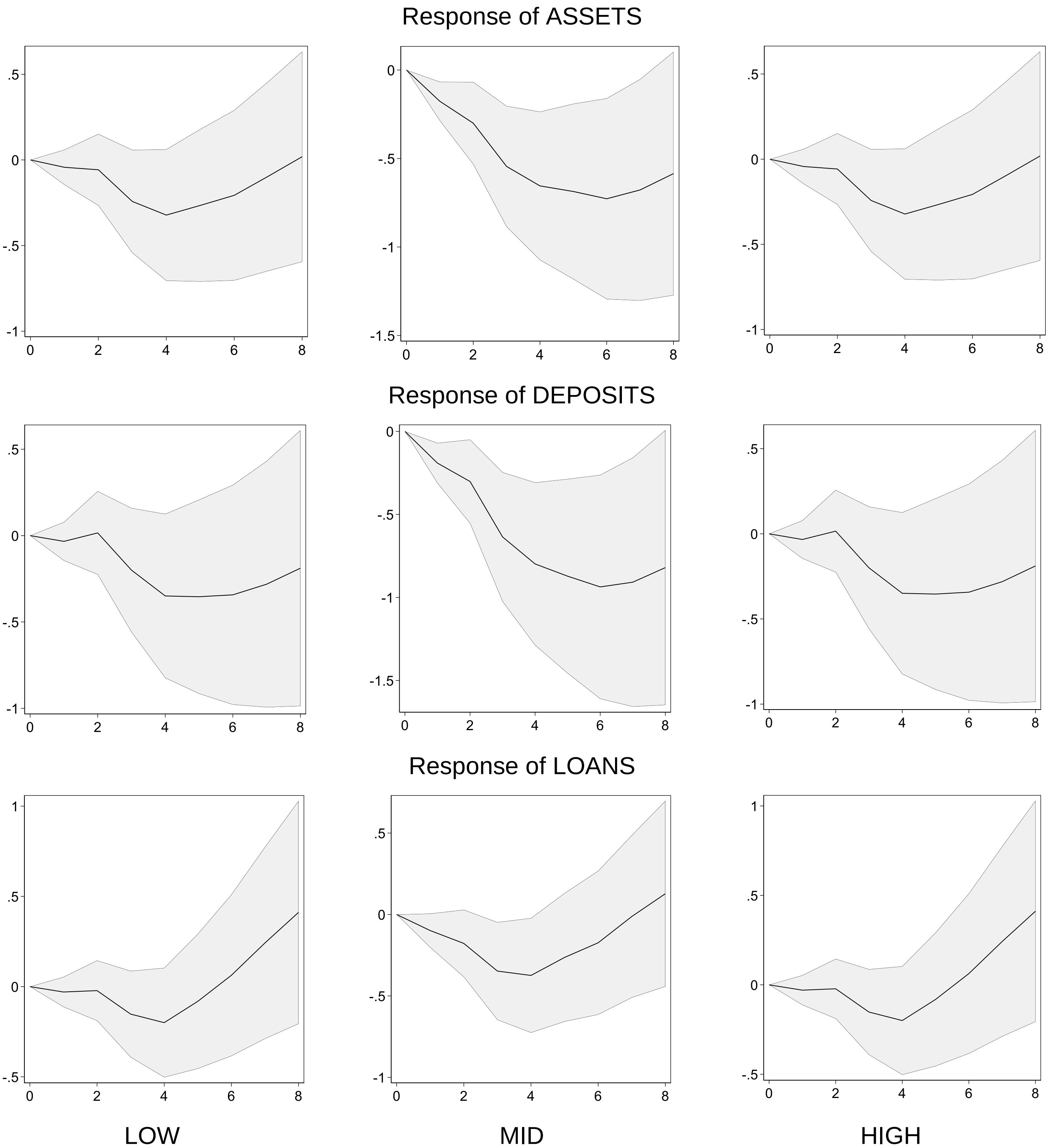

Figure 6. *Response of bank balance sheet eight quarters after a shock in FFR for three bank capitalization groups, averaged balance sheet changes, gray areas are 95% confidence intervals.*

The model using averaged balance sheet variables was also tested for serial correlation in the error term. As the second VAR model uses averaged data of many different banks, the changes in a few large banks would not heavily influence the results. The

Lagrange multiplier test results are presented in Table 8 which show that no group has autocorrelation in the error term at two lags. While in the previous model, the low group did have autocorrelation, the method of averaging the results has solved that issue. This confirms the results found in the first model.

Table 8

Lagrange Multiplier test for autocorrelation

Group	Lag	chi2	df	Prob > chi 2
Low	2	61.30	49	0.112
Mid	2	56.95	49	0.203
High	2	52.40	49	0.343

Note: H0: no autocorrelation at lag order

The analysis of eigenvalues also show that the model satisfies that stability condition for all three groups as the eigenvalues are within the threshold levels (Figure 7). This is affirming of the results of the Lagrange multiplier test and confirms the results. Unlike with the previous model, all three groups are stable.

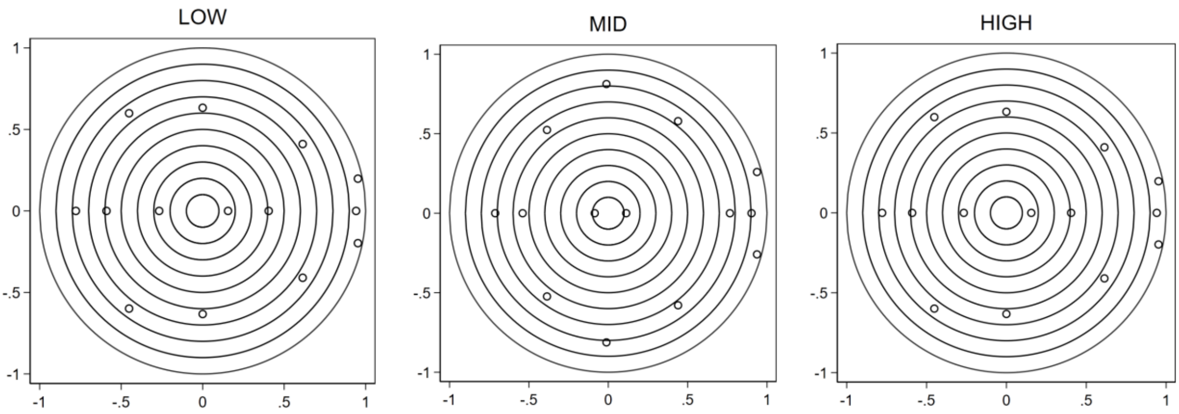

Figure 7. *The eigenvalue graphs for low, mid and high capitalization banks*

While there are small differences in the responses, the underlying directions and dynamics of all three groups remain the same as in the previous set of analysis. Furthermore, the Lagrange multiplier tests also show that the model has no serial correlation when using two lags (see Table 8). This warrants the conclusion, that bank size differences between the groups has not fundamentally affected the results, though, it is likely that some unobserved variables not present in the model are affecting the results in the middle group. There are a few explanations as to why neither VAR model shows the benefits that should come from higher capitalization in the realm of the bank lending channel. A possibility is that as for much of the sample period (2011-2015) the FFR has been at near zero levels while the Fed has also carried out various asset purchase programs and other monetary policy measures that can affect bank funding, but are not captured in the FFR. Another important part that the current model and FFR do not fully capture, are credit frictions and any market operations that the Fed carried out during 2020 as a response to deteriorating market conditions brought on by a wide scale deceleration of economic activity (see Mosser, 2020). These asset purchase programs and lending operations have provided a lot of support to financial firms during the crisis, meaning that credit was widely available to the market. This could mean, that the there was little comparative benefit for having more capital as the Fed provided support for all banks. This contrasts with previous cases, where recessions have often started due to the financial system being in poor condition and receiving less support from the central bank.

Conclusion

The bachelor thesis draws on the bank lending channel of monetary policy transmission and bank funding to study how bank capitalization can affect lending during a monetary policy shock. The lending channel is dependent on the idea that in a contractionary monetary policy environment, the cost of funding will increase for banks that will lead to a reduction in loans for banks. While the bank lending channel has lost appeal and has been deemed to be a weakening transmission mechanism (Carpenter & Demiralp, 2012), it still remains as a relevant topic in research and in the current tightening cycle markets are interested in the effects of monetary policy. While the lending channel may not work on an aggregate level, Kashyap and Stein (2000) have proposed that the channel's effectiveness depends on bank size and liquidity. Others have found that bank capital is another factor that should be considered (Gambacorta & Mistrulli, 2004).

In light of oncoming Basel III that will set further regulations on how bank capital should be managed, the effects of capital on facilitating monetary policy transmission is an increasingly important topic. As deposit levels in the U.S. have grown to very high levels, policy changes to the cost of funding for banks could have a significant effect to the bank balance sheets, lending and economic output. How banks will react to policy changes is certainly important from a regulators point of view.

The goal of the thesis was to study how bank capitalization can facilitate monetary policy effects on bank lending for which the period of 2011-2021 was studied. To assess monetary policy effects on bank lending, two VAR models were considered that assessed the effect on a macroeconomic level for groups of banks of different capital levels as well as the average changes for those banks. To find whether bank capital facilitates bank funding and lending the banks were divided into three capitalization groups based on their mean Tier 1 capital ratio. Both models yielded similar results and showed that when bank deposits fall, there is a subsequent decline in loans. The macroeconomic part of the model was consistent with the results of previous empirical studies where GDP and GDP deflator initially continue to increase, but after two quarters start to decline. The bank balance sheet variables also showed similarities with previous studies and were consistent with the theoretical framework.

The analysis of the data showed that it was suitable for use in a VAR model and the post-estimation test also yielded that the VAR models constructed were stable and had no serial correlation in the error term. While the model itself is valid, the differences found between the different groups cannot fully be explained by differences in bank capitalization as higher levels of capital should lead to better funding opportunities, which was not observed for the middle group of banks. It is also important to note that analysis draws on data where Federal funds rate near the zero or effective lower bound did not capture unconventional monetary policy measures. Furthermore, the end of the sample period includes the effects from 2020 and 2021 where the Federal Reserve conducted large scale quantitative easing programs (see Mosser, 2020) that would affect the bank funding costs differently than during previous recessions and would also not be captured by using FFR as policy measure. It is also possible, that not all banks in the sample participated in the Fed’s lending programs during 2020 which might lead to differences in cost of funding. Future research should aim to take unconventional policy measures into account as well as account for differences that come from participation in lending programs.

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Appendix A

Results of lag length selection tests

VAR lag length selection for averaged balance sheet data information criteria results

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
Low capitalization bank								
0	-346.22				0.174	18.11	18.22	18.41
1	-179.13	334.18	49	<0.001	0.000	12.06	12.92	14.45
2	-68.57	221.13	49	<0.001	0.000	8.90	10.51	13.38*
3	-3.68	129.78*	49	<0.001	0.000*	8.08*	10.44*	14.65
Medium capitalization bank								
0	-348.49				0.195	18.23	18.34	18.53
1	-185.14	326.71	49	<0.001	0.001	12.37	13.22	14.75
2	-54.06	262.15	49	<0.001	.000011*	8.16	9.76*	12.63*
3	8.17	124.46*	49	<0.001	0.000	7.48*	9.84	14.05
High capitalization banks								
0	-346.75				0.178	18.14	18.25	18.44
1	-177.75	338	49	<0.001	0.000	11.99	12.84	14.38
2	-65.73	224.03	49	<0.001	0.001	8.76	10.36	13.23*
3	5.74	142.93*	49	<0.001	.00001*	7.60*	9.96*	14.17

VAR lag length selection for aggregated balance sheet data information criteria results

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
Low capitalization bank								
0	-377.23				0.851	19.70	19.81	20.00
1	-212.76	328.94	49	<0.001	0.002	13.78	14.64	16.17
2	-97.069	231.39	49	<0.001	.0001*	10.36	11.97*	14.84*
3	-38.99	116.16*	49	<0.001	0.0001	9.89*	12.25	16.47
Medium capitalization bank								
0	-389.54				1.600	20.34	20.44	20.63
1	-225.88	327.31	49	<0.001	0.005	14.46	15.31	16.84
2	-117.64	216.49	49	<0.001	.0003*	11.42	13.02*	15.90*
3	-55.043	125.19*	49	<0.001	0.000	10.72*	13.08	17.29
High capitalization banks								
0	-363.43				0.419	19.00	19.10	19.29
1	-185.37	356.1	49	<0.001	0.001	12.38	13.24	14.77
2	-70.11	230.52	49	<0.001	.00003*	8.98	10.58*	13.45*
3	-9.20	121.83*	49	<0.001	0.001	8.37*	10.73	14.94

Appendix B

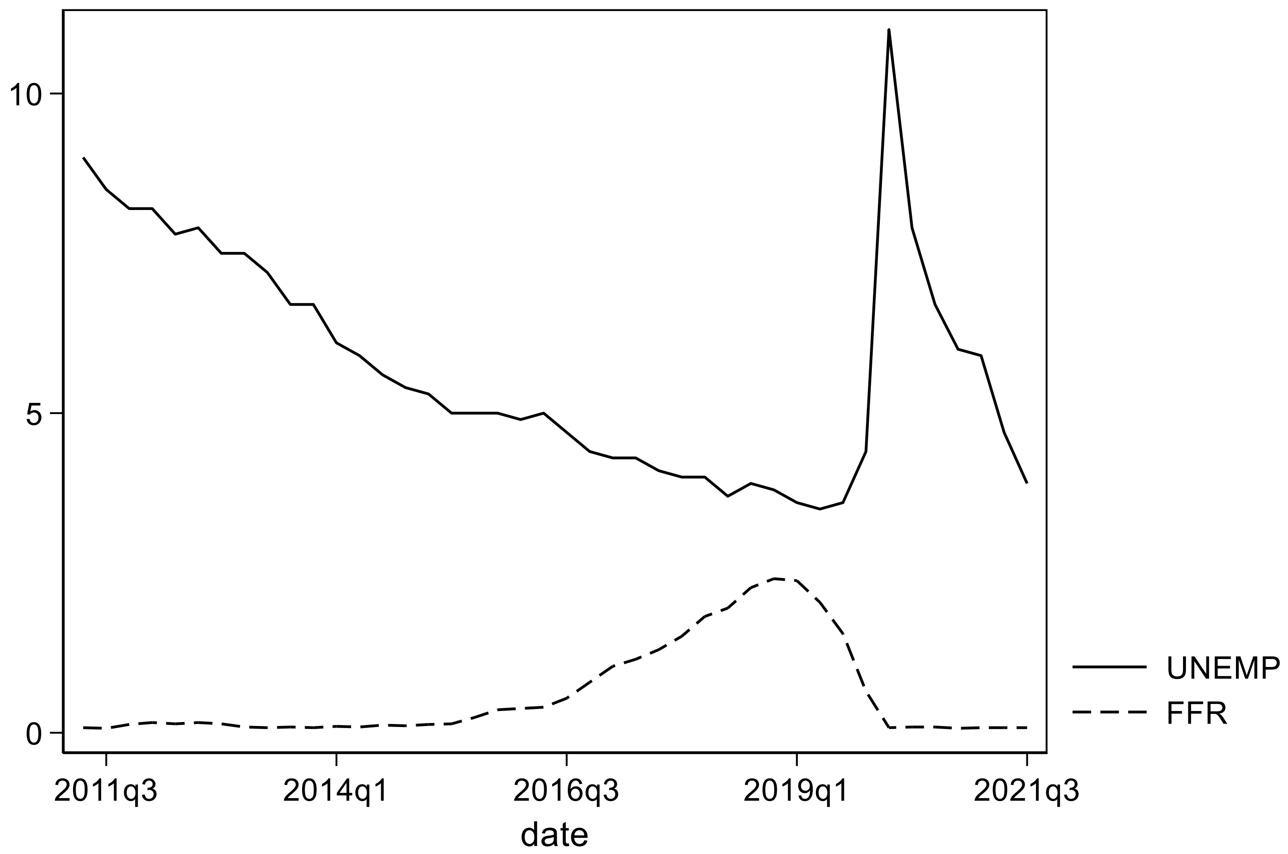
Summary statistics for mean asset sizes of bank capitalization groups

	Low	Mid	High
Minimum	145	393	381
Maximum	147,141	121,561	24,842
Standard deviation	22,868	20,322	4,455
Average	9,659	10,517	4,101
Median	3,193	2,365	1,832

Note: Figures represent the average of total assets of individual banks during the sample period of 2011Q1–2021Q3

Appendix C

Comparison of unemployment rate and Federal Funds rate during the sample period of 2011Q1–2021Q3



Lühikokkuvõte

RAHAPOLIITIKA MÕJU PANGALAENUDELE JA DEPOSIITIDELE

Rasmus Perend

Käesolev bakalaureuse töö uuris rahapoliitilise ülekandemehhanismi toimimist sõltuvalt panga kapitaliseeritusest panga laenamise kanali (*bank lending channel*) kontekstis kasutades vektor autoregressiooni (VAR) mudelit. Analüüsides kasutati 162 Ameerika Ühendriigi finantsinstitutsiooni andmeid perioodil 2011-2021. Tulemused näitasid, et erineva kapitaliseeritusega panga gruppide reaktsioonid on erinevad, kuid nende reaktsioonide eripärasid ei olnud võimalik täielikult selgitada eelnimetatud teoreetilise raamistikust lähtudes. Deposiitide alanemise korral vähendasid kõik panga grupid laenude mahtu ja nende varade hulk langes, mis on kooskõlas panga rahastamise teoreetilise osaga. Kuivõrd kõrgem kapitaliseeritus viitab madalamale panga riskile, siis oli oodatud, et madalama kapitali tasemega pankade deposiitide ja laenude vähenemine on suurem kui kõrgelt kapitaliseeritud pankadel. Selge eelis kõrgema kapitaliseerituse puhul ei tulnud mudelis esile, mis võib olla tingitud eripäradest uuritava perioodi andmetes kui ka laiaulatuslikest mitte-standardse rahapoliitika programmidest, mille mõjusid antud mudel ei võtnud arvesse.

Märksõnad: pangalaenud, rahapoliitika, VAR

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