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Essays on the Credit Channel of Monetary Transmission

Christoffer Koch
St John's College

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Abstract

This thesis is a collection of three essays with contributions to the empirical literature on banking and the lending channel of monetary policy. The first essay on monetary policy identification addresses the endogeneity of the monetary policy measure employed in most bank level studies of the lending channel. It shows how an identified, exogenous measure of policy evokes different lending dynamics in U.S. commercial banks compared to the standard endogenous measure of monetary policy. The second essay empirically assesses the impact of financial deregulation on the lending channel in the U.S. In particular, it analyses how the gradual phasing out of deposit rate ceilings commonly known as Regulation Q significantly altered bank level frictions as well as the transmission of monetary policy to individual bank lending. While the first two essays consider U.S. bank level data, the third essay analyses individual bank level lending responses in the euro area. Its contribution lies in the construction of a range of exogenous and unanticipated monetary policy shocks as well as in the introduction of a financial conditions index into standard lending regressions. It finds that the lending responses of individual banks to monetary policy do not support the existence of a separate lending channel in the euro area. Further, equilibrium lending responses to policy as measured by a range of policy shocks is non-linear in financial conditions. Specifically, financial conditions as measured by the relative performance of a broad index of euro area banking stocks to the overall euro area stock market reverse the impact of monetary policy on lending.

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Chapter 1

Introduction

So far, however, as bank loans are concerned, lending does not (...) take place according to the principles of a perfect market. There is apt to be an unsatisfied fringe of borrowers, the size of which can be expanded or contracted, so that banks can influence the volume of investment by expanding or contracting the volume of their loans, without there being necessarily any change in the level of the bank-rate, in the demand-schedule of borrowers, or in the volume of lending otherwise than through the banks. This phenomenon is capable, when it exists, of having great practical importance.

John Maynard Keynes (1883 - 1946)[1]

The banking sector is an important contributor to economic growth and business cycle fluctuations. This doctoral thesis focusses on its impact at business cycle frequencies and intends on extending the understanding of the lending responses of commercial banks to monetary policy. Its contribution is threefold and lies, first, in analyzing and highlighting the importance of monetary policy identification in studies of the U.S. lending channel, second, in examining the role of deregulation for monetary transmission through the lending channel in the U.S., and, third, in looking at non-linearities in the lending response to monetary policy of euro area banks by constructing a range of policy measure and by including capital market proxies for banking sector financial conditions.

[1] Keynes (1930) *Treatise on Money.* Volume 1, p. 212

Policy Identification

The thesis first addresses the identification of monetary policy in empirical studies of the lending channel. Beyond the "price" channels of monetary policy that induce expectation and portfolio shifts and due to corresponding asset prices changes lead to altering the inter- and intratemporal patterns of consumption and investment, "quantity" or "credit" channels may be operative. According to the theory of the lending channel, contractionary open market operations reduce banking sector reserves and deposits, forcing a reduction in lending volumes because banks are constrained in their ability to substitute lost deposits with alternative sources of finance. Propagation of monetary policy via these loan supply channels is quite separate to textbook treatments of monetary transmission that emphasize the sensitivity of aggregate expenditure to interest rate movements.

The heterogeneity in individual bank lending responses to monetary policy is often used to evaluate the importance of an aggregate lending channel of monetary transmission. For instance, Kashyap and Stein (2000) find that larger and more liquid banks contract their lending by less when monetary policy is tightened. Similarly, Kishan and Opiela (2000) examine differences in lending responses to monetary policy across different levels of bank capitalization and Ashcraft (2006) looks at the difference in lending responses between banks that are affiliated with a bank holding company and stand-alone banks. Although considerable progress has been made in identifying bank characteristics that isolate the loan supply effects that are central to the theory of the lending channel, most research examines the impact of these characteristics on lending responses to federal funds rate changes. As these changes are endogenous to expectations over macroeconomic fundamentals, the heterogeneous lending responses associated with bank characteristics may be driven by these expectations rather than funding pressures due to monetary policy.

In order to tackle the issues of endogeneity this thesis builds on the policy identification suggested by Romer and Romer (2004) and constructs a series of exogenous monetary policy shocks. It then tests the lending growth responses of a panel of individual banks to these exogenous policy shocks. We obtain estimates of the heterogeneity in lending responses to this exogenous policy measure identified from narrative evidence on FOMC intentions and the real time forecasts prepared by Federal Reserve staff using exactly the same bank level data as Ashcraft (2006) in order to highlight differences in estimation outcomes.

A comparison of the results with those estimated from federal funds rate changes indicates more powerful lending reductions following an exogenous policy contraction and a very different picture of the heterogeneity in bank lending responses. The shielding of loan growth associated with holding company affiliation is larger using the exogenous policy measure. Substantial holdings of securities amplify transmission of exogenous policy shocks but restrict the transmission of general movements in the federal funds rate, challenging the view that securities provide a liquidity buffer. Instead, a high equity capital ratio is the balance sheet characteristic that makes bank lending resilient to exogenous monetary contractions. These effects are mainly driven by banks that are not part of a holding company and whose lending is therefore more closely linked to balance sheet conditions.

Deregulation

Whilst the second chapter's focus is monetary policy identification, the third chapter studies lending parameter constancy. It analyzes the impact of financial deregulation on individual banks and on the lending channel using U.S. bank level data from 1976 to 2010. In particular, it examines the effect of the abolition of deposit interest rate ceilings (Regulation Q) on estimates of bank level financial constraints as well as on the transmission of monetary policy via the lending channel.

Most of the lending channel literature either assumes parameter constancy or does not offer structural interpretations of its non-constancy despite the fact that the U.S. banking industry has gone through dramatic changes over the last thirty years or so.[2] Over the last decades there were a number of technical, financial and regulatory changes that have led to a transformation of the U.S. banking industry (for more details see Berger, Kashyap and Scalise, 1995). First, the technological side of the banking industry featured revolutionary advances that lead to major transformations. Important innovations include advances in telecommunication technologies and information processing that facilitate the rapid and efficient transfer of information and funds. Second, financial innovations include the securitization of many traditional bank assets that have expanded the scope and volume of financial derivative activity and, at the same time, had an impact on the lending channel in the U.S. (Loutskina, 2005; Loutskina and Strahan, 2009) and Europe (Altunbas, Gambacorta and Marques-Ibanez, 2009*b*). Third and finally, on the regulatory side, there were

[2] This criticism is of course also relevant to chapter 2, however, there the assumption of parameter stability was made in order to maintain the comparability with the seminal Ashcraft (2006) results and data.

several major changes in capital requirement, reductions in reserve requirements, expansion of bank powers, and liberalisation of geographic restrictions on intrastate and interstate banking as well as the deregulation of deposit account. The focus of this thesis is the latter's implication for the lending channel. It isolates the effects of Regulation Q on bank level financial constraints and the lending channel using a proxy for the bindingness of Regulation Q. Whilst it is difficult to disentangle the different (potentially interacting) effects of all these aforementioned technical, financial and regulatory changes, in some cases individual measure that clearly identify the e.g. the bindingness of regulation are available. With respect to one major legislative change, the gradual phasing out of Regulation Q exact measures on the bindness of deposit rate ceilings during any particular quarter are available and have already been exploited previously in aggregate and sectoral studies of structural change in monetary transmission due to deregulation (see e.g. Duca, 1995, 1996, 1998).

Introducing this measure in bank level lending regressions we find that whilst Regulation Q was in place bank lending growth was generally higher, however, measures of the degree of bindingness of Regulation Q suggests that lending growth was smaller the more binding the (legally fixed) deposit interest rate ceiling. More importantly, interaction terms with measures of monetary policy indicate that the policy impact on lending growth that was up to ten times larger when Regulation Q was in place. Previous estimates of monetary policy effects on the bank lending without controlling for deregulation have overstated the monetary policy impact on lending in the full sample. Estimates suggest that the lending channel may be much weaker in the more recent period.

Non-Linearities

Finally, the thesis analyzes the response of euro area banks to differently constructed monetary shocks and examines particular non-linearities related to financial conditions. Empirical results on the lending channel in the euro area remain ambiguous as to whether or not an aggregate bank lending channel exists. Thesis develops a number of measures that can be considered monetary shocks and employs these shocks in annual bank lending regressions. It thus contributes to the literature by asking two questions: Do different ways of identifying monetary policy yield different results in euro area bank lending regressions? And are there important non-linearities in the response of individual bank lending to different measures of monetary policy shocks and what are their sources?

The thesis seeks to answer the first question by generating two measures of exogenous and two measures of unanticipated monetary policy shocks. Lending responses of an annual panel of euro area commercial banks to these four annualized shock measures are estimated and contrasted with responses to the standard endogenous change in the nominal policy rate. In order to explore non-linearities in lending responses this chapter introduces an aggregate market-based index of financial conditions and estimates and discusses non-linearities in monetary transmission related to this index. We find, first, that - unlike in the US - standard measures of bank level financial constraints like size, capitalization or liquidity *do not* suggest the existence of a distinct lending channel in the euro area. This finding is robust to the different exogenous and unanticipated measure of monetary policy. However, empirical estimates of responsiveness of individual lending growth to deposit growth yield indirect evidence for a lending channel. Second, bank level lending responses to all different indicators of monetary policy are highly non-linear. A market-based indicator of financial conditions is an important determinant of individual bank level lending responses and it is also the source of interesting non-linearities in lending responses to monetary shocks. In periods of tight aggregate financial conditions individual bank lending is very responsive to monetary policy. In periods of light financial conditions it is less responsive. The qualitative nature of these non-linearities is consistent across the endogenous and the two exogenous policy measures.

Thesis Chapters

So to summarize, chapter 2 starting on page 21 uses an exogenous measure of monetary policy and contrasts individual bank lending responses to this measure with responses to a classical measure of policy, the change in the federal funds rate. The subsequent chapter 3 starting on page 105 analyses the impact of deposit rate ceiling deregulation on the lending channel. Chapter 4 starting on page 187 analyses the lending channel in Europe and, in particular, the implications of financial conditions on the lending growth responses of individual banks. Chapter 5 on page page 261 concludes the thesis with a brief summary.

Chapter 2

Heterogeneous Bank Lending Responses to Monetary Policy: New Evidence from a Real Time Identification

Chapter Abstract

The heterogeneity in bank lending responses to monetary policy is often used to evaluate the importance of an aggregate lending channel to monetary transmission. Although considerable progress has been made in identifying bank characteristics that isolate the loan supply effects that are central to the theory, most research examines the impact of these characteristics on lending responses to federal funds rate changes. As these changes are endogenous to expectations over macroeconomic fundamentals, the heterogeneous lending responses associated with bank characteristics may be driven by these expectations rather than funding pressures due to monetary policy. This chapter estimates the heterogeneity in lending responses to an exogenous policy measure identified from narrative evidence on FOMC intentions and the real time forecasts prepared by Federal Reserve staff. A comparison of the results with those estimated from federal funds rate changes indicates more powerful lending reductions following an exogenous policy contraction and a very different picture of the heterogeneity in bank lending responses. The shielding of loan growth associated with holding company affiliation is larger using the exogenous policy measure. Substantial holdings of securities amplify transmission of exogenous policy shocks but restrict the transmission of general movements in the federal funds rate, challenging the view that securities provide a liquidity buffer. Instead, a high equity capital ratio is the balance sheet characteristic that makes bank lending resilient to exogenous monetary contractions. These effects are mainly driven by banks that are not part of a holding company and whose lending is therefore more closely linked to balance sheet conditions.

Keywords: Monetary Transmission, Monetary Policy Identification, Bank Lending Channel, Expectations

JEL Codes: G21, E52, E58

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2.1 Introduction

The role of the banking sector in the transmission of monetary policy has been studied in great detail in both the theoretical and applied literature. According to the theory of the lending channel, contractionary open market operations reduce banking sector reserves and deposits, forcing a reduction in lending volumes because banks are constrained in their ability to substitute lost deposits with alternative sources of finance. In practice this mechanism may be reinforced by a broader credit channel, whereby tight policy reduces borrower collateral and induces banks to raise the premium on loans relative to the competitive cost of funds (the external finance premium). Propagation of monetary policy via these loan supply channels is quite separate to textbook treatments of monetary transmission that emphasize the sensitivity of aggregate expenditure to interest rate movements, see Bernanke and Gertler (1995) for a review of different elements of the transmission mechanism.

Following the work of Kashyap and Stein (2000) a number of empirical studies have explored heterogeneity in bank lending responses to monetary policy. To the extent that financial constraints vary with banks' access to liquidity and collateral, the existence of a lending channel implies loan responses to policy that are contingent on observable bank characteristics that capture such access. Kashyap and Stein (2000) show that banks with relatively large, and relatively liquid, asset bases are better able to shield their lending growth during periods of tight monetary policy. The same has been documented for banks with relatively high equity capital to assets (Kishan and Opiela, 2000), banks affiliated to a holding company (Ashcraft, 2006), banks whose loan books are readily securitized (Loutskina, 2005) and banks that can raise funds from international operations (Cetorelli and Goldberg, 2008).

A fundamental issue addressed in each of these papers is whether heterogeneity linked to a specific characteristic can be interpreted as a pure loan supply effect, as in the theory of the narrow lending channel and the broad lending channel, rather than an amalgam of possible loan supply and loan demand effects. Consequently an important element of research design in this area has been to provide evidence for homogeneous loan demand along the dimension of one or more characteristics, such that heterogeneity in bank lending responses associated with a characteristic can be interpreted as a loan supply effect relevant to the bank lending channel at the macro level. See Ashcraft (2006) for a discussion along these lines.

In contrast, much less attention has been devoted to the question of what measure of monetary policy is appropriate in assessing bank lending behavior. Most papers use the change in the effective federal funds rate to capture monetary policy, reflecting the fact that the Federal Open Market Committee (FOMC) has targeted the federal funds rate for much of the last 30 years.[1] Whilst federal funds rate changes initiated by the FOMC are surely exogenous to the circumstances facing any single bank, the factors to which policy-makers do respond, for example expected output growth and inflation, are potential determinants of individual bank lending, through both loan demand and loan supply effects. This raises the possibility that lending responses to federal funds rate changes confound the effects of monetary policy and other lending market drivers. Furthermore, if the strength of any effects from

[1] Alternative monetary policy measures to have been used in the literature on bank lending include those due to Boschen and Mills (1995), Strongin (1995) and Bernanke and Mihov (1998), see section 2 for further discussion.

confounding variables depends on bank characteristics, the heterogeneity in lending responses to monetary policy will not be correctly estimated. Motivated by these possibilities, this chapter evaluates the heterogeneity in bank lending responses to federal funds rate changes arising from factors such as errors in policy-makers' information and beliefs, reputational concerns and preference shifts. These policy changes are plausibly exogenous to expected output growth and inflation. The identification of this policy component extends work by Romer and Romer (2004), which combines narrative evidence on Federal Reserve intentions and the Greenbook forecasts produced by Federal Reserve staff in order to control for endogenous policy changes. Bank lending responses to the identified policy measure are compared with lending responses estimated from aggregate federal funds rate changes, which have been the focus of most previous empirical research.

The estimation results indicate a radically different picture of the heterogeneity in bank lending responses to monetary policy using the exogenous policy measure. The comparison can be summarized in six main findings. Firstly, following an exogenous monetary contraction, the reduction in lending growth during the first year at a bank associated with average values of each of the characteristics, is up to twice that following a contraction measured using the aggregate federal funds rate. This is consistent with the hypothesis that lending responses to monetary policy are attenuated when policy changes are partly endogenous to expected output growth and inflation.

Secondly, the amount by which a bank can shield its lending growth from a monetary policy contraction, either through accessing a large asset base or drawing on funds from affiliates in a holding company, is 1.5 times as large when estimated from exogenous monetary policy. One potential implication is that banking industry structure explains a larger fraction of the heterogeneity in monetary policy effects, by region and industry, than previously believed. Furthermore, based on the argument that differences in lending responses by bank holding company status provide the most convincing evidence for a lending channel (Ashcraft, 2006), the results suggest that the theory of the lending channel contributes to the more powerful monetary policy propagation documented here.

Thirdly, the share of bank assets held as securities mitigates the lending response to a general federal funds rate increase, but amplifies the lending response to an exogenous federal funds rate increase. In contrast, the ratio of equity capital to assets shields lending growth from an exogenous monetary tightening, but is only very weakly correlated with lending responses to general federal funds rate increases. This chapter offers explanations for these findings in terms of the endogeneity of monetary policy, and argue that they provide a new perspective on the measurement of balance sheet liquidity and the consequences of shifts in balance sheet composition for the strength of monetary policy propagation.

An important qualification to the results on balance sheet composition is the fourth finding. This is that following the introduction of the source of strength doctrine relating to bank holding companies in 1987, the effects of asset composition on lending responses to monetary policy occur only amongst banks that are not part of a holding company. Affiliated banks appear able to smooth lending in the face of monetary policy shocks using funds from the holding company network, such that balance sheet composition does not condition lending responses to monetary policy.

Fifthly, banks that do a larger proportion of business in the residential sector contract lending by a smaller amount following an exogenous policy tightening, consistent with better access to the finance needed to sustain such loans, via the securitization process Loutskina (2005). In contrast, following general changes in the federal funds rate, this effect is much smaller and only marginally significant.

Sixthly, monetary policy has asymmetric effects on bank lending. Bank lending responses when policy is tight are far stronger than when policy is easy, and again stronger results are obtained using the exogenous policy measure. Furthermore, in contrasting endogenous and exogenous policy shocks there are even qualitative differences in the estimates of the effects of equity capital during easy policy, so attention to the endogeneity of monetary policy in empirical work is also warranted from a policy point of view.

In order to put this chapter in context it is important to consider how potential biases from confounding monetary policy with other loan demand and loan supply determinants have been handled in the literature. Each of the papers discussed at the start of this introduction control for output growth, inflation, or both, in empirical models of lending growth. To the extent that such variables are the sources of endogenous monetary policy, their inclusion in a lending growth regression accounts for extraneous loan demand and loan supply shifters, such that the structural effects of policy can be identified. Heterogeneity in these structural effects is then measured via interactions with bank characteristics, under the assumption that loan demand does not vary with the characteristic. The starting point for this chapter is that current output growth and inflation are not the only sources of endogenous policy – a forward-looking policy maker aiming to minimize cyclical fluctuations also responds to forecasts for its objective variables. If these forecasts correlate with private sector expectations for growth and inflation, loan demand and loan supply may fluctuate, potentially in a way that is systematically related to observable bank characteristics. It is important to address these possibilities in any research design, and to this end the chapter investigates lending behavior at the micro level using an exogenous policy measure and a range of bank characteristics. The heterogeneity associated with some of these characteristics is best interpreted in terms of the overall contribution of the lending market to monetary transmission because they are likely to capture effects from both loan demand and loan supply. On the other hand, the heterogeneity associated with some characteristics is more plausibly a pure loan supply effect that may be interpreted as evidence for a bank lending channel. In both instances, however, the results estimated from an exogenous policy measure offer new insights into the strength of the monetary transmission mechanism, the heterogeneity in monetary transmission and factors that may affect the strength of monetary transmission in future episodes. An important research implication supported by the work in this chapter is that future studies of bank lending behavior should take into account all potential sources of endogenous monetary policy.

The chapter is structured as follows: Section 2.2 reviews the credit channel theory, empirical studies, and explains how endogenous monetary policy movements may induce biased estimates of lending responses to monetary policy, based on a simple textbook model of loan supply and demand. Motivated by these possibilities, section 2.3 outlines an identification of exogenous monetary policy shocks and discusses the origins of such shocks. Further, the section describes the macroeconomic and bank level data and the econometric framework employed in comparing lending responses to identified policy shocks with those that result from changes to the effective federal funds rate. Section 2.4 presents the core results and discusses the principle findings, and in section 2.5 the robustness of these results to various changes to the basic research design is considered. Finally, section 2.6 concludes with a chapter summary and a discussion of the importance of monetary policy identification for future research concerning bank lending behaviour.

2.2 Bank Lending and Monetary Policy

This section summarizes the theory of credit market imperfections that give rise to the credit channel of monetary policy. It then briefly reviews previous empirical research. In addition, a typical stylized regression is discussed in order to motivate the analysis of bank lending responses to exogenous monetary policy shocks. Potential biases in estimates of a standard regression from the literature that uses the effective federal funds rate to measure monetary policy are considered. In each of the cases discussed, the underlying idea is that expectations over output growth and inflation directly determine both policy decisions and bank lending, but that these effects are not captured in the standard lending growth regressions. Consequently there is an omitted variable problem that affects the estimated response of bank lending to movements in the federal funds rate. These distorted lending responses differ from the structural effects of monetary policy that are the focus of the theoretical literature. Finally, the discussion covers lending responses that are contingent on bank characteristics and which have received considerable attention in recent research. Estimates of these cross effects are also affected by the endogeneity of monetary policy. In light of the possible effects described, a comparison of bank lending responses to exogenous monetary policy shocks and the broader measure of monetary policy that has been used in previous research is proposed. This exercise is described in section 2.3 of the chapter.

2.2.1 Credit Market Imperfections

The idea that monetary policy may not only impact upon the real economy through a price, that is, 'interest rate' or 'money' channel but that this channel is complemented by a 'quantity' or 'credit' channel dates back to the 1930s and earlier. The Modigliani and Miller (1958) proposition that the capital structure of companies was largely irrelevant, however, undermined the argument that credit provided by commercial banks may play a special role. Furthermore, in the 1960s the empirical literature found a very robust correlation between money and real variables which led many to believe that monetary policy influenced real variables mainly through the interest rate channel, that is through a change in the cost of capital and its impact on investment and consumption. The economics of information literature that emerged in the 1970s shifted attention back to the special role of banks in collecting and processing information about lenders and the importance of bank credit. Empirically, investment is not very sensitive to the cost of capital (Caballero, 1997) which implies that quantity of credit could potentially be crucial for explaining economic fluctuations.

The economics of information centers around four theoretical concepts that can give rise to a credit channel: adverse selection, moral hazard, monitoring costs and agency costs related to balance sheet quality, for model expositions see e.g. Walsh (2003).

Jaffee and Russell (1976) developed a model of adverse selection, an application of the 'Lemons' market principle (Akerlof, 1970), to the credit market. They construct a model of two types of borrowers 'honest' and 'dishonest' ones. Honest borrowers never default, dishonest ones default if the cost of default is smaller than the loan repayment. If differences between the two types cannot be observed by the lender then a pooling equilibrium emerges where all borrowers have to be offered the same lending contract terms. Contracts for loans are one-sided, in the event of default a borrower surrenders a fixed amount of collateral, whereas if a project succeeds the lender retains all the surplus. Consequently, a rise in the interest rate will make the projects of honest borrowers less profitable, relative to those of dishonest borrowers, and honest borrowers will leave the market. Adverse selection occurs as the borrowers remaining in the markets will be more likely to default than in the population as a whole. As the selection of the pool of interested borrowers is adversely affected by interest rate increases the expected profit of a lender may decrease in the level of interest rate charged beyond a certain point and thus at some threshold level of interest rate the quantity of credit supplied by optimising commercial banks remains fixed. If there are no forced transactions and the short end, the loan supply, clears the market then credit rationing occurs in equilibrium.

Second, rather than unobservable differences in types unobserved differences in borrower behaviour might reasonably explain credit rationing. Ex-post behavioural problems of moral hazard may exist. Stiglitz and Weiss (1981) show that if there is a fixed cost of default and the cost of capital rises then the borrower has an incentive, after having signed an incomplete credit contract, to pursue more risky projects in order to increase expected profits. At the same time the probability of default increases. The higher average default risk associated with a higher interest rate and the resulting discontinuities in the profit function may again lead to equilibrium credit rationing.

Third, building on Townend's (1979) costly state verification model, Williamson 1986 shows that the existence of monitoring costs, where lenders pay auditors to verify the claims of borrowers in the case of bankruptcy, can lead to backward bending loan supply curves. As such, for sufficiently high levels of loan demand there may be credit rationing independent of adverse selection and moral hazard.

So adverse selection, moral hazard or monitoring may lead to credit rationing in equilibrium at some threshold interest rate (see figure 2.1 on page 35). The discontinuous loan supply curve arises due to the contraction in expected bank profits when the interest rate exceeds the threshold level (that alters the pool of borrowers or the project choice in a simple binary model setting in the case of adverse selection or moral hazard, or alters the optimal loan repayment amount in the case of monitoring). In this setup the central bank can take action to directly increase the amount of credit available at each interest rate by injecting liquidity into the banking system, and thereby increase the amount of (rationed) equilibrium lending.

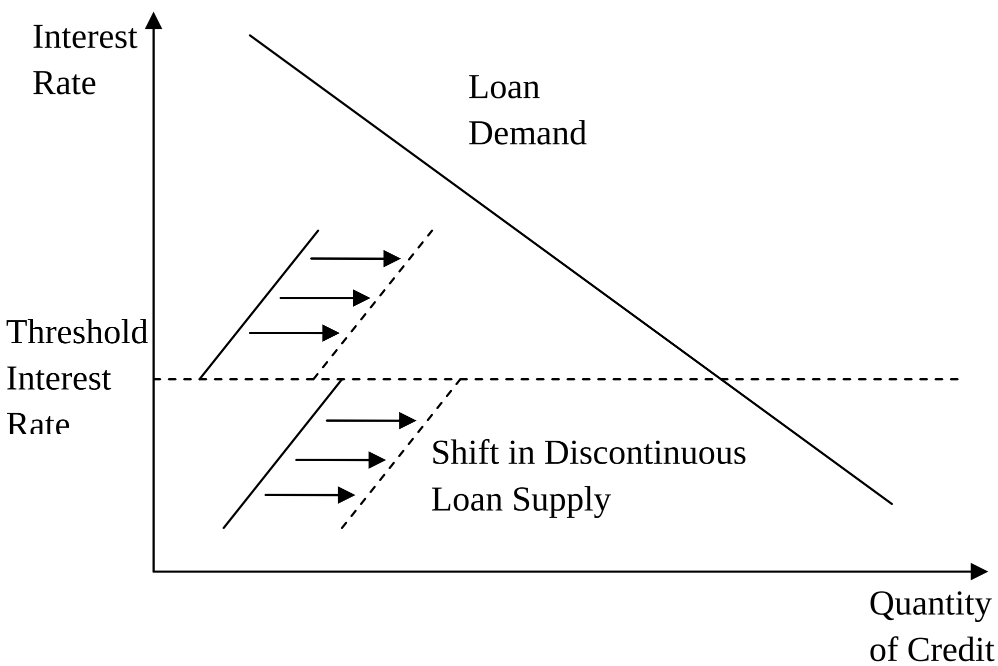

Figure 2.1: Illustration of how policy induced loan supply shifts with credit rationing at a threshold interest rate may lead to changes in observed equilibrium lending

Finally, Bernanke and Gertler (1989) and Gertler (1988) point to agency costs that arise when there is incomplete collateralisation of loans. These balance sheet related project monitoring costs give rise to an external finance premium which might, on the one hand, complement the bank lending channel and, on the other hand, amplify the classical interest rate channel. This is where the special function of banks as information processors comes in. If such a wedge between internal and external finance exists commercial banks may be in a special position to narrow that wedge. This may happen because a bank can threaten to terminate credit (Stiglitz and Weiss, 1983) or insist on exclusive financial relationships with the firm which gives banks an exclusive, full picture of a lender's financial position. This, of course, is more relevant for small firms that have difficulties raising finance by placing debts directly in bond markets or issuing commercial paper. It should also be noted that, in order for monetary policy to really affect loan supply, it is further necessary that banks have no close substitutes for the liquidity drained from the market by the Federal Reserve (i.e. the banking sector as a whole cannot easily issue more debt in the market). Structural change in the strength of the credit channel might be related to the ease of the banking system's access to liquidity from international capital and debt markets.

2.2.2 Previous Empirical Research

This section will give a brief introduction to the development in the previous literature and some important findings and methods. Detailed surveys on the credit channel can be found in Gertler (1988), Bernanke (1993), Gertler and Gilchrist (1993), Ramey (1993), Bernanke and Gertler (1995), Cecchetti (1995), Hubbard (1995), and Bernanke, Gertler and Gilchrist (1999) or Walsh (2003).

Early attempts to identify an independent credit channel in aggregate data in the 1980s were largely ambiguous. Bernanke (1986) finds that evidence of the credit channel is typically sensitive to choice of specification and to the identifying assumptions. Bernanke and Blinder (1992), however, show that aggregate bank lending declines in response to monetary tightening. Kashyap, Stein and Wilcox (1993) looking at the composition of external finance of firms find that the issue of commercial paper, a more costly non-bank substitute for bank loans, increases following monetary tightening. This substitution in combination with the decline in bank lending found by Bernanke and Blinder (1992) implies the existence of a distinct bank lending channel, as the changing composition in external finance implies constraints on bank loan supply rather than merely a decline in loan demand.

The availability of both more extensive bank level data sets and computational capacity allowed more detailed micro-level studies of the credit channel. Important papers in that area are Kashyap and Stein (2000), Kishan and Opiela (2000), and Ashcraft (2006). Kashyap and Stein (2000) were the first to study the response of U.S. commercial banks to monetary policy using a two-step method. They find the monetary policy impact on bank lending of smaller and less liquid banks is stronger than for larger and more liquid banks. Rather than differentiating banks on the basis of the liquidity of their balance sheets or asset size Kishan and Opiela (2000) use the bank capital leverage ratio as the differentiating bank characteristic. Kishan and Opiela justify this by pointing to capital's role in absorbing shocks (loss writedowns) to assets. Capital is an indicator of a bank's financial prowess and, hence, its ability to raise alternative funds during contractionary policy. They find that capital is an important determinant of the impact of policy on loan growth of an individual commercial bank. They also find that smaller banks are significantly affected by policy and the more so the less well-capitalised the bank. Ashcraft (2006) appeals to access to internal capital markets through bank holding companies as a decisive factor in identifying loan supply shifts and points to potential inadequacies in using heterogeneity in liquidity, size (different customer mix) or leverage (shocks to equity correlate with the riskiness of the loan portfolio) for loan supply identification. Using affiliation with a bank holding company as the characteristics that helps to identify shifts in loan supply he finds evidence for a lending channel, especially through stand-alone banks that are not affiliated with a holding company.

Bank level heterogeneity with a differential impact on the lending responses to monetary policy shocks that have recently been studied include 'securitizability' of the loan portfolio, international exposure and cost-efficiency. Loutskina (2005) looks at differences in the degree to which a bank's loan portfolio can be securitized. She finds evidence that increased access to the securitization market has the potential to offset the impact of the central banks policy on banks loan supply. A weaker lending channel due to securitization might then require larger monetary policy reactions for banks' lending to contract. Cetorelli and Goldberg (2008) using a method similar to Kashyap and Stein (2000) show that banks with international exposure and, hence, access to international internal capital markets are shielded from domestic monetary policy. Jonas and King (2008) find that more cost efficient banks that are closer to the efficiency frontier are more sensitive to monetary shocks.[2]

Whilst due to its peculiar banking structure the U.S. is the most widely studied country, there is also evidence for a credit channel in Japan (Hosono, 2006), the UK (Chrystal and Mizen, 2002), Germany (Worms, 2001; Ehrmann and Worms, 2001; Kakes and Sturm, 2002) and Greece (Brissimis, Kamberoglou and Simigiannis, 2001), weak evidence in France (Loupias, Savignac and Sevestre, 2002) and Italy (Gambacorta, 2001), yet no strong evidence in the Netherlands (Kakes, 2000; Garretsen and Swank, 2003) and Spain (Hernando and Pagès, 2001). The credit channel of monetary transmission of a number of EMU countries is analysed in detail in Angeloni, Kashyap and Mojon (2003).

2.2.3 Policy Endogeneity and Lending

Empirical studies of bank lending responses to monetary policy like the ones discussed above typically estimate regressions of the following form:

$$\Delta L_{i,t} = \alpha + \beta M_t + +\zeta' \mathbf{X}_{i,t-1} + \gamma' \mathbf{X}_{i,t-1} M_t + \text{other controls} + \varepsilon_{i,t} \tag{2.1}$$

[2]Apart from using bank characteristics to identify shifts in credit supply, there have been other less standard ways of testing for the existence of the lending channel. While the 'stylized' lending regression, discussed in more detail below, focusses on a direct test of the bank lending channel by examining a panel of bank balance sheets, Nilsen (2002) provides an indirect test by looking at the development of trade credit, a close and yet more inconvenient and costly substitute to bank loans. A further unorthodox approach to overcome the identification issue is provided by natural experiments, as in the research of Hernando and Pagès (2001) on monetary transmission in Spain. Here, the response to an exogenous deposit-reducing shock, a tax induced shift from deposits to mutual fund shares that can be considered a loan supply shock, is examined in terms of its effects on banks of different size, liquidity and capitalization.

where L denotes the natural log of total loans measured at current prices, M is a monetary policy measure, $\mathbf{X}$ a vector of bank characteristics, ε an error term, and i denotes a bank and t a time period. It should be emphasized that in practice bank lending regressions are much richer than specification (2.1), and include autoregressive terms, dynamics in M and and $\mathbf{X}$ and a wide range of controls. In section 2.3 a more complex version of model (2.1) is described that incorporates these features and which provides the basis for the empirical work in this chapter. The present specification is sufficient to illustrate the arguments developed in this section, however.[3]

As noted, the vector $\mathbf{X}$ comprises bank characteristics that capture access to finance. These might include total bank assets, affiliation to a bank holding company, an indicator variable for whether a bank operates internationally, measures of balance sheet composition such as equity capital to assets and securities to assets, and information concerning the bank loan book, for example the ease with which it can be securitized. In the aftermath of contractionary monetary policy, banks that can access funds from these sources may shield lending growth from the effects of an erosion of reserves and deposits. In the literature, an important issue is the interpretation that can be given to a cross effect between monetary policy and a bank characteristic. It is commonly argued that whilst factors such as bank size and the bank equity ratio may capture access to funds that matters for loan supply, they also

[3] Alternative regression frameworks have been considered in the literature. Most notably, Kashyap and Stein (2000) adopt a two-stage procedure in which the cross-sectional sensitivity of lending growth to balance sheet liquidity is estimated at the first stage, and a time series regression relating these cross-sectionally estimated liquidity constraints to monetary policy is estimated at the second stage. The two-stage approach is not adopted in this chapter.

reflect features of loan demand, for example large banks may cherry pick customers whose loan demand is relatively stable, whilst poorly capitalized banks may be overlooked by safe borrowers and forced to do business with risky customers whose loan demand is relatively volatile. On the other hand, Ashcraft (2006) presents evidence that bank holding company affiliation is less closely linked to the customer mix, and is to be preferred as an indicator for loan supply conditions. Nothing is added to this particular debate, but instead this chapter considers the range of characteristics that have been studied in the literature. Throughout the discussion is mindful of the interpretations that can be given to cross effects between monetary policy and individual bank characteristics, however.

The monetary policy measure M most often employed is the change in the period average effective federal funds rate, which has been the Federal Reserve's operating target since at least 1994, and arguably for many episodes from the post-war period. In some papers alternative monetary policy measures due to Boschen and Mills (1995) and Bernanke and Mihov (1998) are used. These are intended to be robust to changes in the operating target, for example the switch to targeting non-borrowed reserves under Volcker during 1979-81. These alternative policy measures are not considered here, but as they are also measures of the endogenous stance of monetary policy the arguments developed in this section are applicable to them too.[4]

One way to think about the endogeneity of the federal funds rate is to think

[4]Loutskina (2005) considers results for the Strongin (1995) policy measure, which treats non-borrowed reserves in the inter-bank market as the policy instrument and uses data on total reserves to net out influences from reserve demand shocks. Whilst this identification may control for some aspects of policy endogeneity, it is not clear that the approach deals with policy moves by a forward-looking central bank. Given that policy measures linked to the federal funds rate are the focus of the literature, the rest of the chapter concentrates on such measures.

about the reaction function of the central bank and especially its reaction to output and inflation expectations. If the central bank uses the interest rate as a policy instrument and responds to output gaps in a forward-looking way in order to fend off inflationary pressures then the interest rate can be considered endogenous with respect to future economic conditions which the central bank has information about. Empirically, since Taylor's (1993) ex-post description of U.S. monetary policy, there has been a development of forward-looking 'Taylor type rules' (e.g. as in Clarida, Galí and Gertler, 2000; Orphanides, 2004). For instance, Clarida, Galí and Gertler (2000) specify a forward-looking linear rule of the kind

$$r_t^* \;=\; r^* + \beta \cdot (E[\pi_{t,k}|\Omega_t] - \pi^*) + \gamma \cdot E[y_{t,q}|\Omega_t] \tag{2.2}$$

where $\pi_{t,k}$ denotes the percent change in the price level between periods t and $t+k$, π^* is the target for inflation, $y_{t,q}$ is a measure of the average output gap measured as the percent deviation between actual and target GDP between t and $t+q$. E is the expectations operator and the expectations are conditional on the information set Ω_t at time t when the policy rate r_t^* is set. The crucial bit for the argument in this chapter is that β and γ, the coefficients on the expected future development of inflation and the output gap in (2.2), are significant and positive, and monetary policy is endogenous with respect to these expectations given the current information set.

The potential effects of monetary policy endogeneity on empirical estimates of (2.1) can be illustrated using a textbook model in which loan supply and loan demand (in nominal units) are functions of the interest rate on loanable funds. This interest rate will increase with the federal funds rate, which influences loan supply via the cost of overnight finance for banks. Now suppose that the Federal Reserve targets a rise in the effective federal funds rate via open market operations. All else equal, the theory of the lending channel predicts a leftward shift of loan supply and a reduction in equilibrium lending, because an erosion of reserves forces banks to substitute away from deposits towards more expensive types of funding.[5] In many instances, however, rises in the federal funds rate target are a response to forecasts indicating higher inflation and strengthening economic activity. In that scenario, the loan supply contraction may coincide with a rightward shift of loan demand, as consumers borrow against expected future income and firms invest in response to an improving outlook for profits. If banks respond to these improved lending opportunities, the reduction in lending from a monetary tightening will be attenuated, and the β estimated from (2.1) will not capture the full response of lending to monetary policy.[6] A similar result may arise via the effects of expected inflation. In particular, reductions in bank lending from a rise in the federal funds rate may be muted because the demand for loans in nominal units rises with expected inflation. As in the example based on expected economic growth, equilibrium lending is subject to countervailing effects from loan demand and loan supply, such that β estimates from (2.1) are attenuated.

The drivers of endogenous monetary policy may also influence equilibrium lending via bank loan supply curves. Firstly, the availability of non-deposit finance to banks

[5] Alternative sources of funding such as equity and securities are imperfect substitutes for deposits because they are not insured and are therefore subject to risk premia from adverse selection and moral hazard effects.

[6] The logic that underpins this argument is similar to that employed by Romer and Romer (2004) in explaining biases in the effect of federal funds rate changes on output growth.

may vary positively with expected economic growth. At the start of cyclical upturns pension funds and sovereign wealth funds may invest more heavily in equities and loan backed securities, at the expense of fixed income assets, based on greater appetite for high yields and risk. To the extent that banks use equity issues and securitization of loans to generate funding for new lending, loan supply will increase at each level of market interest rates. Secondly, to the extent that lender risk aversion plays a role in explaining holdings of excess reserves (at the expense of loans) the prospect of a business cycle expansion may boost loan supply through reducing excess reserves relative to loans. This could occur either because banks anticipate smaller losses from bad loans during episodes of strong economic growth, or because banks' valuation of the risk from loan writedowns declines during cyclical upturns when possibilities for hedging risk improve. Thirdly, in models featuring information asymmetries and monitoring costs, loan supply incorporates an external finance premium that varies inversely with borrower net worth, see Bernanke and Gertler (1989). Expansion phases of the business cycle are typically associated with increases in agents' net worth, such that the external finance premium falls, loan supply increases and lending rises.[7] None of these three channels are emphasized ahead of another, rather it is highlighted that when loan supply responds to expected economic conditions via any one of them, the response of lending growth to a policy measure such as the federal funds rate will be attenuated. Furthermore, this will be the case even when controlling for current economic growth and inflation, because the effect derives from the fact that expectations may influence both monetary policy decisions and loan

[7] An external finance premium may also characterise inter-bank lending rates, creating a further channel through which expected cyclical conditions may propagate to loan supply.

supply.

2.2.4 Policy Endogeneity and Bank Characteristics

An important question is whether or not pro-cyclical loan demand and loan supply affect the cross effects in regression (2.1) that measure heterogeneity in bank lending responses. As discussed above, these are the terms that proxy financial constraints at the bank level, and it is such constraints that underpin the aggregate lending channel of monetary policy. If banks are homogeneous and equally affected by expected macroeconomic conditions, endogenous variation in monetary policy may attenuate the γ coefficients, because policy endogeneity would imply a component of M_t that exerts a net effect on lending growth that is not correlated with characteristics. The regression point estimates would otherwise be unaffected, however.

The alternative scenario is that in which the attenuation of lending responses to monetary policy varies systematically with bank characteristics, in which case estimates of equation (2.1) obtained using the aggregate federal funds rate may either obscure or induce systematic heterogeneity in bank responses to monetary policy. Given the complexity of individual bank lending decisions, it is not possible to pin down the precise direction of these effects. Instead, the remainder of this section outlines mechanisms behind potential biases, some of which build on scenarios that have been emphasized in previous research.

There are four types of situation considered: i) expected macroeconomic conditions induce common loan demand shifts, but bank responses depend on characteristics; ii) expected macroeconomic conditions induce loan demand shifts that vary with bank characteristics; iii) expected macroeconomic conditions induce common loan supply shifts, but adjustment of equilibrium lending depends on bank characteristics; iv) expected macroeconomic conditions induce loan supply shifts dependent on bank characteristics.

Asymmetric responses to common loan demand shifts may arise because bank characteristics capture access to liquidity, e.g. via affiliation with a bank-holding company or globalized banking network, or due to balance sheet composition. Banks that are able to access liquidity may be able to grow their loan portfolio more rapidly following a surge in loan demand. Given that the rise in loan demand facing each bank occurs against a backdrop of tighter central bank policy (in response to the factors driving loan demand) attenuation of bank lending will be more pronounced amongst the group of banks exhibiting the access to liquidity characteristic – estimates of the elements of γ from (2.1) will be biased away from zero, and evidence for heterogeneity in lending responses to monetary policy will be over-stated when estimated from the federal funds rate.

Turning to the second of the four possibilities, Kashyap and Stein (2000) advocate a rational buffer stocking theory that may lead to a correlation between loan demand curve shifts and bank characteristics. Under the assumption that some banks concentrate their lending in regions or industries that are especially sensitive to aggregate demand conditions, it is rational for such banks to select characteristics that help accommodate volatile loan demand, for example bank holding company affiliation or high balance sheet liquidity. When the federal funds rate rises during a cyclical expansion, shifts in individual loan demand curves will be largest amongst banks exhibiting the characteristic in question. The attenuation of lending growth reversals following rises in the federal funds rate will then be largest amongst that category of banks. As in the first case discussed, this effect would manifest as positive bias in the estimate of γ – evidence that banks with access to liquidity can shield lending growth from Federal Reserve policy would be over-stated.[8]

The opposite result, whereby estimates of cross effects are subject to negative bias, can arise when common loan supply shifts elicit different lending responses. Consider markets in which some lending opportunities are left unexploited, i.e. loan demand exceeds loan supply at the market interest rate. Adjustment to market clearing may be thwarted because interest rate rises induce moral hazard or adverse selection effects as discussed and illustrated above, see Jaffee and Russell (1976) and Stiglitz and Weiss (1981) respectively.[9] The value of unexploited projects will be lower for banks whose supply curves are further to the right because they can access funds more easily, that is, for banks exhibiting network affiliation or balance sheet liquidity. Consequently, when an upturn in the business cycle stimulates loan supply, lending growth will be smaller amongst that group of banks, because there is less unexploited loan demand to be tapped. This in turn means a smaller offset to any reduction in lending growth from a rise in the federal funds rate that is implemented in response to the cyclical expansion. The result is that the γ estimated from (2.1) using aggregate changes in the federal funds rate will be smaller than that estimated

[8] One caveat must be noted here. Banks trading with cyclically sensitive customers also likely face relatively interest rate elastic loan demand curves, such that cuts in lending from a rise in the federal funds rate will be larger, offsetting the lending increase from a relatively large shift of the loan demand curve.

[9] Freixas and Jorge (2008) model rationing effects in the inter-bank market.

using purely exogenous variation in the federal funds rate.

The final case considered features heterogeneous loan supply responses to expected macroeconomic conditions. Specifically, banks that face financing constraints, either due to a lack of affiliates, assets or liquidity, and are unable to shield their lending from contractionary open market operations may make greater use of the funds available during cyclical upturns, such that their loan supply increases more when policy is tightened endogenously. Similarly, constrained banks may be more risk averse or deal with customers for whom the external finance premium fluctuates more in response to cyclical conditions. In these instances expected macroeconomic conditions will boost loan supply by more, limiting the lending reduction estimated from an endogenously rising federal funds rate. Put slightly differently, lending growth is shielded from monetary policy by the economic forces to which policy is endogenous, and if such shielding effects are more widespread amongst banks that would otherwise be constrained by tight monetary policy, the estimated effects of the constraints (characteristics) on lending responses will be attenuated.

This section concludes by noting that these thought experiments raise the possibility that even a purely exogenous monetary policy measure will elicit estimates of γ that measure something other than banks' ability to shield lending growth by virtue of their characteristics. For example, banks that can access liquidity may face a different loan demand elasticity and therefore adjust their lending differently to other banks. Alternatively, in the rational buffer-stocking case, banks trading with more cyclically sensitive customers may implement a larger leftward shift of loan supply because loans to those customers are relatively more risky after a policy tightening. It is the case that certain characteristics are more prone to such effects than others, for example Ashcraft (2006) contends that bank holding company status allows a comparison between banks that are similar in terms of other factors that may influence loan supply and loan demand. Such a comparison is less susceptible to confounding effects. This issue will be discussed in the empirical results in section 2.4. The point to be emphasized at this stage is that such effects will affect all measures of monetary policy, both endogenous and exogenous. The main advantage of considering exogenous policy measures is that their effects on bank lending are less likely affected by the sources of bias discussed here.

2.3 Econometric Methodology

This section outlines the methods used in comparing bank lending responses to exogenous monetary policy with those to broader movements in the federal funds rate. The discussion comprises four main elements. Firstly, a description of the identification procedure used to isolate exogenous variation in the federal funds rate. Secondly, an explanation of the sources of the exogenous monetary policy shocks and an explanation of the timing employed. Thirdly, an explanation of the regression models estimated in order to obtain the core results. Fourthly, there will be a description of the data used in the empirical work.

2.3.1 Monetary Policy Identification

In order to identify exogenous variation in the federal funds rate this chapter follows the two-step procedure outlined by Romer and Romer (2004), who consider U.S.

monetary policy over the period 1969-1996. In the first step, narrative evidence is used to determine the size of the percentage point federal funds rate change targeted by the Federal Open Market Committee (FOMC) at their scheduled meetings. The advantage of this measure of monetary policy intentions is that during episodes of reserve targeting, for example under Volcker's chairmanship of the FOMC, it does not respond to supply and demand shocks in the reserve market that are unrelated to monetary policy. In contrast, the effective federal funds rate (the market clearing rate in the reserve market) will respond to such factors.[10]

The chapter extends the original Romer and Romer (2004) target series by appending the FOMC's announced federal funds target rate changes for 1997-2001. Such announcements commenced in 1994, overlapping with the original Romer and Romer (2004) series for 2 years. Even though the announced target series does not capture all of the narrative evidence incorporated in the Romer and Romer (2004) series, the pooling of the two is defensible given that policy intentions have been much more transparent since the mid-1990s. During the overlapping period of 1994-1996, the two series have a correlation that is essentially unity.[11] The extension of the target rate series in this way ensures the extraction of exogenous variation in the federal funds rate for a longer sample period than that covered by Romer and Romer (2004).

[10]In previous research the consequences of changes to the operating procedures have been investigated through comparing results from the effective federal funds rate with those from the Bernanke-Mihov (1998) measure of monetary policy, which accounts for changes to the operating procedure, see for example Kashyap and Stein (2000). That option is not pursued here.

[11]There is one instance in which the series differ. For the meeting on September 28, 1994, Romer and Romer (2004) argue that the language associated with the FOMC transcripts amounted to the intention to tighten by 12.5 b.p., even though there was no change in the announced, target federal funds rate.

In the second step, the targeted federal funds rate change is regressed upon the Federal Reserve's Greenbook (in-house) forecasts for real output growth, inflation, and unemployment over horizons of up to two quarters. These represent the central objective variables of the Federal Reserve.[12] Additionally, the Greenbook information is supplemented with measures of capacity utilization and capacity utilization growth in the month of the FOMC meeting. The capacity utilization index is constructed by the Federal Reserve. However, it is not available to policymakers in real-time because the observations for a particular month are inferred by scaling production indicators with capacity measures interpolated from end-of-year observations – actual capacity is only benchmarked annually. The empirical relevance of capacity utilization is emphasized by Giordani (2004), who shows that controlling for such a proxy for production relative to potential is crucial for accurate policy identification. In the present application terms in capacity utilization are treated as proxies for latent policymaker perceptions concerning the cyclical position of the economy, which may contribute to policy decisions even after controlling for the Greenbook forecasts. Formally, the following regression is estimated:

[12] See Federal Reserve (2005), or the International Banking Act of 1978 (the Humphrey-Hawkins Act).

$$
\begin{aligned}
\Delta \mathit{ff}_m \;\; = \;\; & \alpha + \beta \cdot \mathit{ff}_{m-1} + \sum_{j=-1}^{2} \gamma_j \cdot \widehat{\Delta y}_{m,j} + \sum_{j=-1}^{2} \eta_j \cdot \left(\widehat{\Delta y}_{m,j} - \widehat{\Delta y}_{m-1,j} \right) \\
& + \sum_{j=-1}^{2} \theta_j \cdot \hat{\pi}_{m,j} + \sum_{j=-1}^{2} \lambda_j \cdot \left(\hat{\pi}_{m,j} - \hat{\pi}_{m-1,j} \right) \\
& + \sum_{j=-1}^{2} \mu_j \cdot \hat{n}_{m,j} + \sum_{j=-1}^{2} \rho_j \cdot \left(\hat{n}_{m,j} - \hat{n}_{m-1,j} \right) \\
& + \tau \cdot CU_m + \phi \cdot CUG_m + \varepsilon_m
\end{aligned} \tag{2.3}
$$

where m indexes FOMC meetings, j indexes the forecast quarter relative to the current meeting's quarter, ff is the target federal funds rate level, Δy is real output growth, π is inflation, n is the unemployment rate, CU is the capacity utilization index, CUG is the current monthly growth rate of capacity utilization (both capacity terms are measured in percentage points), ε is a mean-zero error term, and a hat denotes the real-time forecast for a variable. Other lowercase Greek letters denote population parameters. Notice that the specification employs a larger set of unemployment forecasts than do Romer and Romer (2004).

The results obtained from estimating equation (2.3) for a sample of 298 FOMC meetings from the period $1969 - 2001$ are reported in table 2.1. The sums of the coefficients on forecast levels are generally of the same signs as those reported by Romer and Romer (2004), indicating tighter policy in response to stronger economic activity and higher prices. An exception occurs in the case of the sum of the coefficients on the growth forecasts, which is negative but insignificant. One explanation is that the capacity utilization terms capture information contained in the growth

$$\begin{aligned}\Delta f\!f_m = \alpha + \beta \cdot f\!f_{m-1} &+ \sum_{j=-1}^{2} \gamma_j \cdot \widehat{\Delta y}_{m,j} + \sum_{j=-1}^{2} \eta_j \cdot \left(\widehat{\Delta y}_{m,j} - \widehat{\Delta y}_{m-1,j}\right) \\ &+ \sum_{j=-1}^{2} \theta_j \cdot \hat{\pi}_{m,j} + \sum_{j=-1}^{2} \lambda_j \cdot (\hat{\pi}_{m,j} - \hat{\pi}_{m-1,j}) \\ &+ \sum_{j=-1}^{2} \mu_j \cdot \hat{n}_{m,j} + \sum_{j=-1}^{2} \rho_j \cdot (\hat{n}_{m,j} - \hat{n}_{m-1,j}) \\ &+ \tau \cdot CU_m + \phi \cdot CUG_m + \varepsilon_m\end{aligned}$$

Intercept	-0.910	Inflation Revision	
	(1.168)	$t = -1$	0.007
Target from Last Meeting	-0.024		(0.03)
	(0.011)	$t = 0$	-0.020
Forecasted Output Growth			(0.041)
$t = -1$	0.006	$t = 1$	-0.016
	(0.01)		(0.066)
$t = 0$	-0.013	$t = 2$	-0.050
	(0.02)		(0.074)
$t = 1$	-0.025	Total Effect	-0.079
	(0.028)		(0.082)
$t = 2$	0.016	Forecasted Unemployment	
	(0.031)	$t = -1$	-0.137
Total Effect	-0.016		(0.162)
	(0.027)	$t = 0$	0.599
Output Growth Revision			(0.352)
$t = -1$	0.005	$t = 1$	-0.290
	(0.025)		(0.475)
$t = 0$	0.134	$t = 2$	-0.218
	(0.029)		(0.319)
$t = 1$	-0.022	Total Effect	-0.047
	(0.041)		(0.035)
$t = 2$	-0.008	Unemployment Revision	
	(0.05)	$t = -1$	-0.189
Total Effect	0.104		(0.216)
	(0.068)	$t = 0$	-0.515
Forecasted Inflation			(0.319)
$t = -1$	0.030	$t = 1$	0.684
	(0.023)		(0.441)
$t = 0$	-0.017	$t = 2$	-0.444
	(0.028)		(0.343)
$t = 1$	0.020	Total Effect	-0.464
	(0.043)		(0.204)
$t = 2$	0.014	Capacity Utilization	0.015
	(0.044)		(0.012)
Total Effect	0.047	Capacity Utilization Growth	0.136
	(0.02)		(0.035)

Notes: Standard errors in parenthesis.

Table 2.1: Determinants of Changes in the Federal Funds Rate

forecasts (capacity utilization growth is positive and significant). The inclusion of the capacity utilization terms is also reflected in the regression R^2, which is higher than that for the original Romer and Romer (2004) specification (36 percent as compared to 28 percent).[13]

In order that the regression residuals from equation (2.3) capture exogenous monetary policy that may be used to estimate bank lending responses it is required that (i) the Greenbook forecasts and capacity utilization are not a function of the change in the federal funds rate target; (ii) the Greenbook forecasts and capacity utilization account for any changes to the target that are endogenous to factors that may influence bank lending via expected economic conditions. The first assumption rules out reverse causation in equation (2.3). As remarked upon by Romer and Romer (2004), the Greenbook forecasts are generally formulated under the assumption that there is *no* change in policy stance at least until the FOMC meeting after next, ruling out this possibility. One caveat is that Greenbook forecasts may be generated from forward-looking variables that embody market expectations over the policy change at the current meeting. In that case, correct identification requires that output, inflation, unemployment and capacity utilization respond to policy with a sufficiently long lag that the forecasts in equation (2.3) are not subject to reverse causation.

The second assumption is key in eliminating policy movements that may lead to biased estimates of lending responses to monetary policy. The Greenbook forecasts are a natural instrument in achieving this objective because they represent the real time information available to policy-makers and are known to perform well

[13] This may also reflect a reduction in the variation in the target federal funds rate over the years 1997-2001.

relative to alternative forecasts, see Romer and Romer (2000, 2008) and Bernanke and Boivin (2003).[14] Instances in which the controls in (2.3) may not eliminate policy movements that are endogenous to lending determinants occur when the Federal Reserve responds to banking sector conditions directly. For instance, if concerns over bank liquidity prompt the Federal Reserve to keep interest rates on hold even when Greenbook forecasts point to higher interest rates, a negative shock would be recorded, but this may fail to stimulate lending growth if the crisis prevents banks from doing new business. In terms of the present application, the banking crisis that followed the collapse of the sub-prime housing market in 2007 is excluded from the sample. However, two other relevant episodes are included in the sample: (i) the years surrounding the Basel I Accord, agreed in 1988 and implemented in 1992, which is often argued to have prompted bank balance sheet adjustment and a looser monetary policy than would otherwise have been the case (Ashcraft, 2006); (ii) the Federal Reserve Bank of New York's rescue of U.S. hedge fund Long-Term Capital Management in 1998, which may have induced similar effects. Section 2.5 presents evidence from robustness tests indicating that the core results are not affected by these particular episodes.

[14]It is of course possible that individual firms, consumers and banks have information concerning their future prospects (as opposed to general economic prospects) that is not reflected in the Greenbook. However, this will not lead to estimation bias provided FOMC decisions regarding the target federal funds rate are not correlated with such information. In essence, it must be the case that any determinant of monetary policy decisions, for example the views of an influential FOMC member, does not contain information for loan supply and loan demand beyond that in the Greenbook.

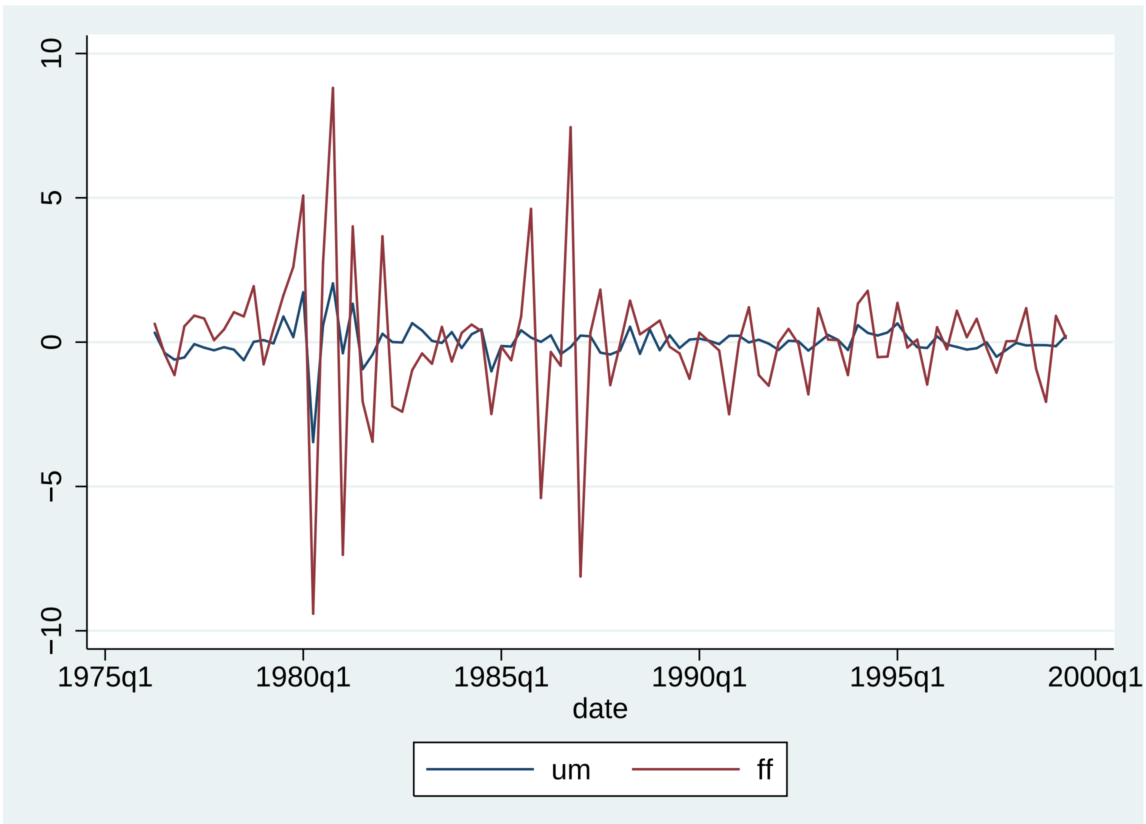

Figure 2.2: Time Series Plots for UM and FF

2.3.2 Sources and Timing of Monetary Policy Shocks

A natural question is what are the sources of the policy shocks estimated from equation (2.3)? An important factor is likely to be that interest rate decisions depend on factors idiosyncratic to FOMC members. For example, even absent a future cyclical expansion, interest rates may be increased if FOMC members are concerned with their public reputation (Bluedorn and Bowdler, 2008, discuss a relevant example), possess a private forecast that points to an expansion that does not transpire (Romer and Romer, 2008), or hold a view of the economy that leads them to favor larger interest rate rises than are warranted given the available forecasts (Romer and Romer, 2004). Alternatively, FOMC membership may change such that policy-maker preferences favor tighter or looser policy irrespective of the cyclical position. In other situations policy-makers may feel obliged to validate market beliefs over policy, even when such beliefs are incorrect, see Christiano, Eichenbaum and Evans (1999). It is these federal funds rate adjustments, driven by errors and preference shifts, that are exploited to obtain estimates of bank lending responses to monetary policy.

The data on bank lending that used in the empirical work are reported on a quarterly basis, and therefore policy shocks defined at the frequency of FOMC meetings, which currently take place eight times per annum, must be aggregated to the quarterly frequency. The appropriate method of aggregation depends critically on whether the data to be studied are measured on a quarter average or quarter end basis, see Bluedorn and Bowdler (2008) for relevant discussion. In the present application, bank level data are drawn from end of quarter reports filed with the Federal Deposit Insurance Corporation. Balance sheet data are reported for the final day of a quarter and banks have up to 30 days in the following quarter to confirm the figures reported. To parallel this treatment, a quarterly series for exogenous monetary policy is constructed through cumulating the post-meeting shocks in a particular quarter, to give a variable denoted UM.[15] This method is equivalent to defining a daily interest rate level from the cumulated value of all past shocks and taking the change in the level from the final day of the previous quarter to the final day of the current quarter. Accordingly, precisely the same method is used to obtain quarterly movements in the effective federal funds rate, denoted FF.[16] Figure 2.2 presents time series plots for UM and FF. During the sample $1976:2$ to $1999:2$ the variance of UM is 76 basis points and that of FF is 157 basis points, suggesting that roughly half the variation in the effective federal funds rate is eliminated from UM as part of the identification procedure. The correlation of the two series is 0.60.

[15] To see the importance of consistent end of period measurement of balance sheet variables and monetary policy measures, suppose that lending responds in full to monetary policy within a month. It is then the case that a monetary policy shock in the third month in a quarter changes lending by the same amount as a shock observed in the first, but a period average interest rate change would be smaller in the first scenario than in the second. The estimated effect of monetary policy on lending growth would then be distorted.

[16] The daily effective federal funds rate data are from the FRED database maintained by the Federal Reserve Bank of St Louis.

2.3.3 Regression Specification

In order to evaluate bank lending responses to monetary policy regression models of the following form are estimated:

$$\begin{aligned}\Delta L_{i,t} \quad &= \quad \alpha + \sum_{k=1}^{4} \lambda_k \cdot \Delta L_{i,t-k} + \sum_{k=0}^{4} \beta_k \cdot \mathbf{M}_{t-k} + \zeta \cdot X_{i,t-1} \\ &\quad + \sum_{k=0}^{4} \gamma_k \cdot X_{k,t-1}\mathbf{M}_{t-k} + \mu \cdot \mathrm{trend}_t + \sum_{k=1}^{3} S_{k,t} + \varepsilon_{i,t}\end{aligned} \tag{2.4}$$

where L denotes the natural log of total loans measured at current prices, $\mathbf{M}$ is a vector comprising three macroeconomic variables: (i) a monetary policy measure, either UM or FF, as described in section 2.3.1 (ii) the change in the natural log of GDP at current prices and (iii) the change in the natural log of the consumer price index (CPI), $\mathbf{X}$ is a vector of bank characteristics, *trend* is a linear time trend, S_k, $k = 1, 2, 3$, is a set of seasonal dummy variables equal to 1 in quarter k and zero otherwise, ε is an error term, and i denotes a bank and t a quarter in time. The vector X of j bank characteristics comprises (i) the natural log of bank assets in millions of dollars, at current prices; (ii) an indicator variable set to unity post−1986 if a bank is part of a bank holding company and zero otherwise (following Ashcraft, 2006, this characteristic is dated t rather than $t-1$)[17]; (iii) the ratio of bank securities to assets; (iv) the ratio of total equity capital to assets and (v) the ratio of internal

[17]The indicator recognizes holding company status only in the post-1986 period, to reflect the inception of the Federal Reserve's source of strength doctrine, which underpins the interpretation of holding companies as credit networks through requiring that dominant holding company banks support their affiliates during periods of financial stress. Ashcraft (forthcoming) argues that in practice the functioning of internal capital markets improved significantly in 1989, but here the focus is on the post−1986 period as in Ashcraft (2006).

cash generation to assets. More detailed variable definitions and information on data sources are provided in section 2.3.4.

The regression specification in equation (2.4) is closely related to those employed by Ashcraft (2006) and Loutskina (2005). Bank characteristics lagged once are included as controls, to allow for differences in lending growth contingent on bank size, affiliation and balance sheet composition. The growth and inflation controls in the vector $\mathbf{M}$ account for variations in nominal lending growth arising from drift in prices and economic activity. Interactions between macroeconomic variables and bank characteristics capture heterogeneity in bank lending responses to monetary policy, income growth and inflation. There are three points are worthwhile highlighting in relation to equation (2.4).

Firstly, the interactions between macroeconomic variables and bank characteristics feature measures of characteristics dated $t-1$, except in the case of the bank holding company dummy which is dated t. As such, lending decisions in period t are conditional on characteristics that are pre-determined and therefore less likely influenced by lending behavior (the bank holding company indicator is not pre-determined, but this variable is not derived from the bank balance sheet). This structure mirrors that in Ashcraft (2006) and Loutskina (2005). A natural alternative would be to date interacted characteristics $t-i-1$ such that they are also pre-determined with respect to the monetary policy measure, and this case will be considered in the robustness tests in section 2.5. As shown in section 2.5.3, the results change very little in this case due to the fact that the variation in characteristics across quarters close in time is small relative to the cross-sectional variation in characteristics. It should be emphasized that whilst characteristics considered are pre-determined for the current lending response to monetary policy, there is no claim to have identified exogenous variation in characteristics. In line with most of the literature, bank characteristics are not modeled here. The determinants of characteristics may include the properties of previous monetary policy regimes, raising the possibility that the effects of policy on bank lending are more complex than the estimates indicate. It could even be the case that past values of a bank characteristic are endogenous to current monetary policy, for example via an expectations effect. Any resulting estimation biases are likely to be less important in the case of UM than in the case of FF, because the former is less easily predicted given that it is orthogonal to economic forecasts.

Secondly, each of the bank characteristics are adjusted such that their sample mean is zero, except the binary variable for bank holding company status. One year after the quarter in which a 100 b.p. monetary tightening occurs, the term $\sum_{i=0}^{4} \beta_i$ then measures the percentage change in lending for a bank at the sample average of each continuous characteristic, and not affiliated with a bank holding company (this overlooks contributions from autoregressive terms, a point discussed in section 2.4). The term $\sum_{i=0}^{4} \gamma_{k,j}$ measures the increment to the marginal lending response when characteristic j is 1 unit above the sample average (or a bank is affiliated with a holding company in the case of that characteristic). Section 2.4 explains how to account for the fact that 1 unit represents different contrasts depending on the sample distribution of the characteristic.

Thirdly, the regression includes not only the levels of nominal income growth and inflation, but also a full set of interactions between those variables and bank characteristics. This ensures that heterogeneity in bank lending responses to monetary policy is estimated after controlling for (i) purely nominal effects on lending growth from inflation; (ii) any heterogeneity in the response of real lending growth to macroeconomic factors such as output growth and inflation.[18] As discussed in section 2.3 controlling for inflation and output growth may account for some endogenous movements in the federal funds rate, and represents the main way in which extraneous movements in loan demand and loan supply have been addressed in previous studies. However, as previously discussed, there is no guarantee that such a measure deals with loan demand and loan supply shifts originating from expected future macroeconomic conditions, and which are also correlated with FF. This is the reason one expects to observe differences in results estimated from the identified policy measure, UM, and the broader measure, FF.

The final elements of the regression specification are a set of seasonal dummies and a time trend (although macro variables are seasonally adjusted, bank level variables are not). The trend is included to deal with the fact that one of the covariates, total assets, drifts through time whereas other variables are growth rates or ratios, which are likely stationary (panel unit root tests were not conducted due to the short time series available for some banks in the panel). Separate trends to deal with drift in the interactions between macro variables and total assets are not included. Section 2.5.4 discusses a different approach to dealing with the drift in total assets that handles such effects.

[18]Inflation may affect even real lending volumes if loan contracts are not fully indexed against the effects of inflation.

The maximum lag order in the benchmark regression specification is 4, which is typical of micro bank lending regressions using quarterly data, see Kashyap and Stein (2000), Ashcraft (2006) and Loutskina (2005). Lags in the dependent variable control for serial correlation in the data that is not eliminated by the control variables. As a further precaution, all regression standard errors are calculated through clustering at the bank level, as in Ashcraft (2006), to deal with residual heteroscedasticity and autocorrelation of unknown form.[19] One source of uncertainty that these standard errors do not take into account is the first stage regression used to identify UM. Pagan (1984) shows that this uncertainty affects inference based on non-zero null hypotheses, but not inference based on zero null hypotheses.

2.3.4 Data

Bank Level Data

The bank level data are from the Reports of Condition and Income ("Call Reports") submitted to the Federal Deposit Insurance Corporation at the end each quarter by all insured banks in the United States. I am grateful to Adam Ashcraft for providing a dataset that constructs variables from these sources using guidelines proposed by Kashyap and Stein (2000). The variable definitions outlined follow those used in Ashcraft (2006). The Call Report line numbers used to generate individual series are provided in Kashyap and Stein (2000).[20]

The dependent variable is derived from a series for total loans minus allowances

[19]Wooldridge (2003) notes the importance of clustering in panels that explain micro responses to macro shocks, as in the present case.

[20]Some series are dropped from the Call Reports during the period considered, whilst others are added. See Kashyap and Stein (2000) for notes on how such changes were handled.

for loan losses. This definition spans five major categories of loans (residential, consumer, commercial and industrial, agricultural and municipal) and includes loans under commitment for some period (predominantly lines of credit to firms) as well as loans on flexible terms.[21] The correction for loan losses allows for the fact that a bank may reduce its loan book through writing off bad loans as well as through varying the supply of new credit. However, as discussed by Ashcraft (2001) and Peek and Rosengren (1998), the measure of loans used here does not control for loans being moved off bank balance sheets via securitization. However, distortions to lending growth via this effect may be limited because the sample ends in 1999, and includes just a few years from the period since the huge growth in the market for mortgage-backed securities in the mid-1990s. Consistent with this view, section 4.3 shows that the results change very little after controlling for the commercial and industrial loan share, which should reflect any data distortions from securitization given that relatively few loans from this category are securitized Loutskina (2005).

Total bank assets are reported net of loan loss reserves and form the basis for measuring balance sheet composition, across securities, equity capital and cash flow (each of these terms is measured relative to total assets). Bank securities are the sum of Total Investment Securities and Assets Held in Trading Accounts. Total Equity Capital is the book value of equity issued plus the cumulated value of retained earnings, and internal cash flow is the sum of net income before extraordinary items and loan loss provisions (the definition of internal cash flow follows Ashcraft, 2006, who cites Houston, James and Marcus, 1997).[22] The indicator for bank holding

[21]The data include international lending from 1978 onwards.

[22]Each of the balance sheet characteristics are affected by the fact that prior to 1984, aggregates

company status is taken from Ashcraft (2006), who identifies holding companies from sets of banks that have the same regulatory holder identification number, see Ashcraft (2006) for full details.

Figure 2.2 reports summary statistics for the bank level variables described here, and also measures of loan composition by customer type (see section 2.4.3). Summary statistics are calculated using data from three years corresponding to the beginning, middle and end of sample (1977, 1988 and 1999), and for all banks in the baseline estimation sample (see section "Sample Description" below). An inspection of these statistics supports the assertion from section 2.3.3 that the series are stationary, with the exception of the total assets measure.

for certain asset and liability classes are not reported and therefore are proxied through summing relevant sub-components. For example, through 1983, Total Investment Securities is proxied by the sum of securities on the balance sheet from different issuers. See Kashyap and Stein (2000) for a full discussion.

	1977		1988		1999	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
· Loan Growth	4.51	5.48	1.81	5.65	2.24	5.47
· Assets	84.51	1,105.97	209.00	2,257.81	506.58	6,761.38
· Holding Company Status	26.29	44.02	68.86	46.31	79.67	40.25
· Securities/Assets	30.57	12.17	28.86	15.83	27.16	13.72
· Equity Capital/Assets	8.55	2.48	8.78	2.84	10.23	3.51
· Internal Cash/Assets	1.15	1.27	1.52	2.87	0.88	1.13
· Residential Loan Share	33.15	17.25	44.11	17.53	56.30	18.74
· Consumer Loan Share	28.54	14.34	20.54	13.11	14.60	12.09
· Commercial Loan Share	19.41	12.75	21.17	13.45	17.06	11.35
No. of banks	14,026		12,516		8,030	

Notes: Summary statistics are calculated for all banks included in the baseline estimation sample for at least part of a year, and therefore reflect across bank and within bank variation. All variables are reported as percentages, except assets which is measured in millions of current price US$. The holding company status variable measures the fraction of banks in the sample affiliated with a holding company. See the text for further discussion concerning the measurement of the variables.

Table 2.2: Descriptive Statistics for Bank Level Variables

Macro Data

The two monetary policy measures that are compared were described and discussed in section 2.3.1. The series for income growth is constructed from seasonally adjusted current price GDP, and that for the inflation rate is from the seasonally adjusted CPI. Both series are from the Bureau of Economic Analysis and were extracted from the Federal Reserve Bank of St. Louis FRED database. The output and price data are period average values in that they refer to a flow of transactions within a particular quarter, whereas the bank level data are end of quarter values from stock concepts on balance sheet statements. Unlike in the case of interest rate series, for which one can examine data for the final day from a particular quarter, there are no end of period concepts for output and prices. This measurement mis-match could in theory limit the extent to which current output and inflation control for the endogeneity of the federal funds rate, however in section 2.5 it is shown that the results are robust to measuring the federal funds rate on a period average basis that matches the output and inflation concepts.

Sample Description

The dataset used for the baseline estimations is an unbalanced quarterly panel spanning 1976:2 to 1999:2 and featuring a maximum of 14,026 banks. The average number of observations per bank is 56.9. In line with other studies, this sample is obtained after excluding bank/quarter observations affected by mergers, which may induce spurious movements in balance sheet variables (following a merger the merged banks are dropped and a new bank enters the dataset).[23] In order to deal with other exceptional movements in the data, this chapter follows Ashcraft (2006) in fitting the benchmark regression by OLS for the largest possible sample and then eliminating outliers. These are defined as observations for which the absolute *DFITS* statistic (the scaled difference between the fitted values for the n^{th} observation when the regression is fitted with and without the n^{th} observation) exceeds the threshold $2\sqrt{\frac{\text{slope coefficients}}{\text{sample size}}}$ defined in Walsh and Kuh (1977). The number of observations excluded depends on whether the regression is fitted using UM or FF. Specifically, from a total sample of $1,079,960$ observations this procedure cuts the sample to $1,053,334$ observations when UM is the policy measure and $1,052,453$ observations when FF is the policy measure.[24] These differences are minor in the context of the sample size, and the results across UM and FF do not depend on outlier exclusion, i.e. the comparisons presented in section 2.4 are observed when using the full sample as well as the trimmed sample.

2.4 Empirical Results

2.4.1 Baseline Results

Table 2.3 presents $\sum_{i=0}^{n} \beta_i$ for $n = 0, 1, .., 4$ and associated standard errors, for the two policy measures UM and FF. These statistics measure the percentage change in lending at various horizons following a 100 basis point tightening at a bank that has

[23] Due to consolidation of the banking sector, the number of banks falls to roughly 8000 by the end of the sample, see table 2.

[24] The outlier exclusion procedure offers some robustness against certain changes to variable definitions that occur during the sample and which are documented in Kashyap and Stein (2000).

the sample average balance sheet characteristics and is not affiliated with a holding company (here, such a bank is referred to as the representative bank). The full lending response also depends on the autoregressive parameters, but each of these is very small (less than .1) and virtually identical across UM and FF versions of the regression. As such, they will not affect the inferences. Following Kishan and Opiela (2000), Loutskina (2005) and Ashcraft (2006) the direct effect of policy on lending are reported.

At each of the horizons considered the lending reduction estimated from an exogenous monetary policy contraction exceeds that from a policy contraction measured by general movements in the federal funds rate. Furthermore, the precision associated with the estimates is such that 95 percent confidence intervals for the two estimates are non-overlapping at all horizons beyond the current quarter - equality of the two effects can be ruled out with high probability. The more powerful lending effect estimated from UM is consistent with the basic argument that the effects of endogenous policy movements are obscured by pro-cyclical loan demand and loan supply. The contrast between lending responses to UM and FF is most stark at the one and two quarter horizons, which comes from the fact that lending declines after an exogenous policy tightening are most rapid during this period, before decelerating at horizons closer to one year. In contrast, quarterly changes in loans following a rise in FF are smoother, reflecting a more gradual effect on bank lending behavior. The inertia in aggregate lending estimated from FF has been attributed to factors such as loans under commitment thwarting the withdrawal of credit to firms, see Bernanke and Blinder (1992), Morgan (1998) and Kishan and Opiela (2000).

Time Horizon (Quarters)	UM	FF
$t = 0$	-0.04*	-0.03**
	(0.02)	(0.005)
$t = 1$	-0.40**	-0.18**
	(0.02)	(0.009)
$t = 2$	-0.75**	-0.38**
	(0.04)	(0.014)
$t = 3$	-0.92**	-0.60**
	(0.05)	(0.02)
$t = 4$	-0.94**	-0.73**
	(0.05)	(0.02)

Notes: Cumulative responses to a 100 b.p. tightening at the specified horizon are reported for a bank at the sample average of continuously measured characteristics and not part of a holding company. Standard errors after clustering at the bank level are reported in parentheses. ** and * indicate significance at the 1% and 10% levels respectively.

Table 2.3: Cumulated Bank Lending Responses

While such a possibility is plausible, these estimates suggest that at least part of the sluggishness in bank lending behavior is attributable to policy changes that are endogenous to other macroeconomic fundamentals. Controlling for extraneous loan demand and loan supply movements that may be linked to these fundamentals reveals a faster and quantitatively more important monetary transmission mechanism via credit markets. Such findings clearly indicate that monetary policy identification is an important element of research design in empirical studies of bank lending.

Table 2.4 shows the sums of cross effects between monetary policy and bank characteristics through horizon 4 (labelled "Interaction Effects"), after setting characteristics to one standard deviation of their sample distribution (except in the case of the holding company indicator which is set to unity). Sums of coefficients for other horizons are not reported given the space constraint, but are consistent with the UM/FF comparisons developed in what follows. In order to provide context for the results the table also reproduces the horizon 4 lending response for the representative bank, as presented in Table 2.4, and presents the marginal lending response to a 100 b.p. policy contraction for a bank one standard deviation above each of the characteristics considered,[25] which is the sum of the response at the representative bank and the interaction effect for a particular characteristic.

First, consider the results for total assets and the bank holding company indicator. In both cases the sums of the interaction terms are positive, indicating that the characteristics help banks shield their lending growth from policy contractions. The point to emphasize is that these shielding effects are much larger when monetary

[25] In the case of the bank holding company indicator the marginal effect is calculated for a bank that belongs to a holding company.

	$\Delta log\,(L_{i,t})$	UM	FF
Representative Bank	· Marginal Effect	-0.94**	-0.73**
		(0.05)	(0.02)
Assets	· Interaction Effect	0.26**	0.08**
		(0.03)	(0.01)
	· Marginal Effect	-0.68**	-0.66**
		(0.06)	(0.03)
Holding Company Status	· Interaction Effect	1.88**	1.21**
		(0.08)	(0.04)
	· Marginal Effect	0.95**	0.47**
		(0.07)	(0.03)
Securities Ratio	· Interaction Effect	-0.22**	0.04*
		(0.04)	(0.02)
	· Marginal Effect	-1.16**	-0.69**
		(0.06)	(0.03)
Equity Capital Ratio	· Interaction Effect	0.24**	0.04**
		(0.04)	(0.016)
	· Marginal Effect	-0.70**	-0.69**
		(0.06)	(0.03)
Net Cash Ratio	· Interaction Effect	0.97**	0.08
		(0.26)	(0.14)
	· Marginal Effect	0.03	-0.65**
		(0.30)	(0.13)
	Observations	1,053,334	1,052,453
	R^2	0.16	0.16

Notes: The reported lending responses are the sum of contemporaneous and four lagged responses to a 100 b.p. policy tightening. Interaction effects are calculated for a bank one standard deviation above the sample average for a characteristic and marginal effects sum the direct and interacted effects. Standard errors obtained after clustering at the bank level are reported in parentheses. ** and * indicate significance at the 1% and 10% levels respectively.

Table 2.4: Bank Lending Responses to Monetary Policy

policy is measured using UM as opposed to FF, and that differences in the sizes of the interactions across policy measures remain after imposing two standard error bands around the estimates. Controlling for the endogeneity of monetary policy implies not only more powerful lending responses at the representative bank, but also much greater dispersion in lending responses across the population of banks. This is consistent with the argument in section 2.3 that lending responses to the endogenous drivers of policy may correlate with bank characteristics. In the present case, it appears that lending by small banks and banks not affiliated with holding companies is more responsive to factors such as expected economic growth, such that lending responses to monetary policy are attenuated to a greater extent amongst banks exhibiting such characteristics. As discussed in section 2.3, a possible reason for this is that cyclical upturns provide access to finance that is used more intensively by banks that cannot access other sources of funds. The result is that cross effects between monetary policy and characteristics such as holding company status and total assets are smaller when policy is measured using FF as opposed to UM.

These findings have important research implications. Ashcraft (2006) argues that the composition of loan demand by borrower size and creditworthiness varies relatively little with holding company status, compared with other characteristics such as total assets and leverage. Therefore heterogeneity in lending responses associated with holding company status is more readily interpreted as evidence for differential loan supply responses of the sort predicted by the theory of the bank lending channel. The more powerful holding company effect estimated from the exogenous policy measure raises the possibility that the lending channel is quantitatively more important than previously believed. As discussed by Ashcraft (2006), a potentially important caveat is that although unaffiliated banks may be subject to a lending channel, the borrowers turned away from such banks may be accommodated by bank holding company networks, whose funds fill the gap in the market. The aggregate lending channel of monetary policy could then be weak or non-existent. The estimation results indicate that after an exogenous policy contraction the representative unaffiliated bank *reduces* lending 0.94 percent in the first year, whilst the representative affiliated bank *raises* lending 0.95 percent over the same period. This evidence is consistent with a redistribution of lending in the aftermath of shocks to bank funding.[26] In order to investigate whether the conflicting loan responses cancel at the aggregate level the baseline regression was re-estimated after excluding all terms from the characteristics vector $\mathbf{X}$, to obtain the marginal effect of a policy tightening for a bank at the sample average of all characteristics, including holding company status. The lending reduction from UM (standard error in parentheses) is 0.36 percent (0.03 percent) and that from FF is 0.17 percent (0.01 percent). Despite the compensating effect from affiliated banks it appears that an aggregate transmission mechanism exists. Furthermore, this mechanism is much stronger when estimated from UM.

The much sharper heterogeneity in bank lending behavior from UM may help explain two important features of the aggregate transmission mechanism. These are (i) the different effects of policy across regions and industries (Carlino and Defina,

[26]These estimates are from the baseline regression specification and contrast affiliated and non-affiliated banks assuming all other characteristics remain unchanged. It is of course possible that the switch to bank holding company status is associated with changes to other bank characteristics that affect bank lending responses at the margin. However, if one excludes all bank characteristics other than holding company status, to estimate the unconditional effect of affiliation, the finding that holding company banks raise lending at the expense of stand alone banks remains intact.

1998), (ii) a possible trend towards weaker propagation of monetary policy in recent decades (see the discussion in Boivin and Giannoni, 2002). Ashcraft (2006) presents weak evidence that state level lending responses to federal funds rate rises depend on the proportion of loans issued by affiliated banks, but finds that similar effects do not carry over to state income responses. The larger cross effects estimated here from exogenous monetary policy suggest that much more of the heterogeneity in the aggregate effects of monetary policy may be attributable to banking sector structure than existing estimates indicate. Similarly, the results in table 2.4 suggest much more scope for banking sector consolidation and the growth of bank holding companies to account for possible trends towards a weaker aggregate monetary transmission mechanism in recent decades.[27] The relevance of these conjectures depends on the precise configuration of banking sector characteristics. Specifically, a region or episode associated with a banking sector dominated by holding companies must not be associated with other characteristics that reverse the impact of holding company affiliation on lending responses. These questions are a subject for future research.

The most striking result of table 2.4 relates to the securities to assets ratio. Following a 100 b.p. increase in the exogenous policy measure, a bank with securities one standard deviation above the mean reduces lending by a further 0.22% compared to the average bank. In contrast, following a 100 b.p. increase in the overall federal

[27] A caveat should be noted in relation to the interaction effect based on bank assets. These assertions rest on interpreting the differential effects by bank assets in terms of loan supply. Ashcraft (2006) argues convincingly that the slope of the loan demand curve varies with bank assets (larger banks trade with customers whose loan demand is less interest rate sensitive). Therefore part of the interaction between monetary policy and assets estimated could reflect heterogeneity in loan demand, and it is less clear that such a feature of lending markets could drive heterogeneity in the aggregate transmission mechanism. An implicit assumption is that at least part of the asset based interaction is from loan supply.

funds rate a bank with securities one standard deviation above the mean *shields* lending by 0.04 percent relative to the average bank. Both effects are significant at the one percent level. In previous work the shielding effect from securities has been related to the idea that such holdings represent a buffer stock of liquid assets which can be used to substitute lost reserves during policy contractions (Kashyap and Stein, 2000, Ashcraft, 2006). The estimation results suggest this interpretation is tenable only when using a measure of monetary policy that responds to expected future growth and inflation. Once these endogenous policy changes are eliminated from the monetary policy measure the shielding effect is eliminated.

One explanation is that banks facing loan demand that is especially sensitive to cyclical upturns (and which therefore decrease lending by less at the time of an endogenous federal funds rate rise) tend to invest more heavily in securities, to smooth their income stream in the face of uncertain lending opportunities. A high securities ratio would then correlate with weaker lending responses to policy measured by the aggregate federal funds rate. The same is not be true of the exogenous policy measure, which is orthogonal to future cyclical conditions. Indeed, the estimates show a positive interaction between the exogenous policy measure and the securities ratio, indicating lending responds more to tight monetary policy amongst banks with a large share of securities in total assets. An explanation for this effects is as follows. An exogenous rise in interest rates is likely to raise the long end of the yield curve and depress securities prices, such that banks suffer a capital loss, see Bernanke and Gertler (1995) for a discussion of this effect in the context of monetary policy and lending markets. Banks with greater exposure to capital losses on securities will be forced to contract lending more aggressively, yielding the amplification effect. In such instances, seemingly liquid assets such as securities exhibit low 'market liquidity', in the sense that the market value of the assets is driven below their fundamental book value as a consequence of the exogenous policy tightening. For this reason banks refrain from liquidating the assets and instead choose to contract their lending base.

The final two rows in table 2.4 relate to the equity capital and net cash ratios. Cash flow contributes to equity capital so these two characteristics can be considered together. However, the equity capital ratio ought to be given prominence as it is a more comprehensive measure of the liquid funds available to banks. Both characteristics play a role in shielding lending from exogenous policy contractions. A bank one standard deviation above the sample average equity capital ratio shaves one quarter less from its lending following a policy tightening. In the results it is equity capital that makes bank lending resilient to contractionary open market operations, not holdings of securities which have typically been interpreted as a buffer to funding shocks.[28] Significantly, equity capital is liquid cash on banks' balance sheets, the value of which is not directly eroded by tight monetary policy. Such funds are available to substitute lost reserves and sustain deposits and loans during periods of tight monetary policy.[29] The estimates in the final row in table 2.4 indicate that cur-

[28]Ashcraft (2006) argues that the interest rate sensitivity of loan demand decreases with bank capitalization, which may account for some or all of the positive interaction between UM and the equity capital ratio. However, both Ashcraft (2006) and Kishan and Opiela (2000) present evidence that the shielding effect of policy is not weakened on controlling for loan composition measures thought to proxy the elasticity of loan demand.

[29]Kashyap and Stein (2000) question the interpretation of cash on the balance sheet as a liquidity buffer on the grounds that cash holdings may reflect required reserves that cannot be freely drawn down. It is important to emphasize that here the effect of the equity capital share in assets relative to the sample mean on lending responses to monetary policy is estimated. As such, equity capital helps to shield lending growth not when it is high in an absolute sense (which may reflect high

rent cash flow relative to assets, approximately the current period increment to the equity capital share, plays an especially important role in shielding lending growth from exogenous policy contractions, perhaps reflecting greater resilience to policy contractions amongst banks that are relatively profitable and able to use operating surplus to support lending activities.

The corresponding results based on the effective federal funds rate provide an interesting contrast with the results from UM. The interaction between equity capital and FF is smaller and less significant than that from UM, while the interaction between the net cash ratio and FF is not significantly different from zero. In annual data regressions, Ashcraft (2006) estimates a negative and marginally significant equity capital interaction and a positive and significant cash ratio interaction. Using quarterly data and regressions for banks from different size and capitalization classes, Kishan and Opiela (2000) find that equity capital mitigates lending responses to FF amongst small banks (consistent with a positive interaction), but also some evidence that it can amplify lending responses amongst large banks (consistent with a negative interaction). The generally weaker evidence for a shielding effect from equity capital when using general movements in the federal funds rate may arise because loan responses are attenuated following endogenous policy changes, and are attenuated to a greater extent amongst poorly capitalized banks who respond more strongly to endogenous policy drivers, similar to the argument above in respect of small or unaffiliated banks.

Attention should be drawn to two implications of the finding that well capitalized

lending activity at a large bank), but when it is high relative to assets amongst the population of banks, and therefore likely to indicate excess liquidity relative to the required amount.

banks are able to shield their lending from exogenous monetary policy. Firstly, banks that are unable to smooth their lending using funds from networks such as holding companies may be able to compensate through accumulating equity capital buffers. At the end of the sample the average equity capital ratio for stand alone banks is 4 percentage points higher than for holding company banks, which is consistent with this idea (other interpretations of this observation are possible, of course, e.g. the probability of joining a holding company may be linked to the equity capital ratio). Secondly, reductions in banking sector equity capital from loan write-offs during the recent housing market collapse and credit crunch may leave banks less able to shield their lending from contractionary open market operations. This in turn may embed a more powerful monetary transmission mechanism during the period in which banks restore capitalization ratios to levels seen prior to the current period of credit market turmoil.[30]

2.4.2 Stability of the Baseline Results

An important issue in studies of the transmission of monetary policy to the banking sector is the stability of the results through time, see Bernanke and Blinder (1992), Kashyap and Stein (2000) and Ashcraft (2006). In this sample an important structural change may arise from the introduction of the source of strength doctrine (Ashcraft, 2006).[31] The Federal Reserve Board issued a statement in 1987 indicating

[30]It should be noted that both interpretations are subject to the caveat stated in the previous footnote.

[31]Another source of structural change is the abolition of Regulation Q, which restricted banks' ability to vary interest rates in order to attract deposits, an important source of funding. The abolition of this restriction was largely implemented via the Monetary Control Act of 1980, and is therefore likely to induce heterogeneity in the results across a much shorter period than the source

that failure by a parent bank to inject liquidity into a financially distressed subsidiary when funds are available would be considered an unsafe banking practice. In section 2.3.3 it was argued that following the inception of the source of strength doctrine, from 1987 onwards membership of a bank holding company should condition bank lending responses to monetary policy. The baseline results are consistent with this idea. In particular, post-1986 the lending reductions at stand alone banks estimated from both exogenous and general movements in the federal funds rate are countered by significant lending increases at networked banks.

This section takes the analysis of this structural change one stage further through interacting each of the cross terms in $\sum_j \sum_{k=0}^{4} \gamma_{k,j} X_{k,j,t-1} \mathbf{M}_{t-k}$ with the binary variable that is set to unity post-1987 in the case of banks that are part of a holding company (excepting the cross term that already features the bank holding company indicator). These extra terms are added to the baseline regression in (2.4), allowing the effects of characteristics such as the asset base and balance sheet liquidity on lending responses to monetary policy to vary from 1987 onwards amongst banks affiliated with a holding company. Table 2.5 reports interaction coefficients for policy measures and characteristics similar to those in table 2.4, and also the changes to those interaction coefficients associated with the inception of the source of strength doctrine.

The key feature of the results is that post-1986 changes to the interaction coefficients amongst holding company banks are approximately of equal magnitude but opposite sign to the main interaction effects (the one exception is the interaction of

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of strength doctrine. The examining abolition of Regulation Q in more detail is beyond the scope of this chapter and will be addressed in the subsequent chapter 3

	$\Delta log\,(L_{i,t})$	UM	FF
Representative Bank	· Marginal Effect	-0.81**	-0.70**
		(0.06)	(0.02)
Holding Company Status	· Interaction Effect	1.60**	1.09**
		(0.10)	(0.04)
Assets	· Interaction Effect	0.48**	0.03
		(0.04)	(0.02)
	· Interaction with Policy and BHC Status	-0.65**	0.09**
		(0.07)	(0.03)
Securities Ratio	· Interaction Effect	-0.57**	0.04*
		(0.05)	(0.02)
	· Interaction with Policy and BHC Status	0.76**	-0.07
		(0.08)	(0.03)
Equity Capital Ratio	· Interaction Effect	0.21**	0.07**
		(0.04)	(0.02)
	· Interaction with Policy and BHC Status	-0.14	-0.09**
		(0.08)	(0.03)
Net Cash Ratio	· Interaction Effect	1.40**	0.14
		(0.27)	(0.09)
	· Interaction with Policy and BHC Status	-1.12**	-0.19
		(0.40)	(0.12)
	Observations	1,053,673	1,052,665
	R^2	0.16	0.16

Notes: The reported lending responses are the sum of contemporaneous and four lagged responses to a 100 b.p. policy tightening. Interaction effects are calculated for a bank one standard deviation above the sample average for a characteristic and marginal effects sum the direct and interacted effects. Standard errors obtained after clustering at the bank level are reported in parentheses. ** and * indicate significance at the 1% and 10% levels respectively.

Table 2.5: Holding Company Status and Lending Responses to Monetary Policy

FF with bank assets). As such, the total effect of balance sheet related characteristics on lending responses to monetary policy, both exogenous and endogenous, is close to zero during the second half of the sample for affiliated banks (and recall that affiliated banks represent over two thirds of all banks in this period). During the late 1980s and the 1990s the principal source of heterogeneity in lending responses to monetary policy is affiliation with a holding company, not balance sheet composition. The roles of holdings of securities in amplifying the effects of exogenous policy on lending growth, and equity capital in making lending growth resilient to exogenous tightening of policy, are quantitatively smaller from the late 1980s onwards because they are observed only amongst banks that cannot access the financing networks provided by holding companies. In contrast, when affiliated banks experience funding shocks from write-downs in securities prices or loan values following a policy tightening, they are able to tap loanable funds within the network provided by the holding company, and as a result shield their lending growth.

2.4.3 Loan Decomposition

This section incorporates information on the composition of bank loan books in the investigation of lending responses to monetary policy. The Call Reports provide information on bank loans across five categories: residential loans, commercial and industrial loans, individual (consumer) loans, agricultural loans and municipal loans, see table 2.2 for some summary statistics relevant to this sample. This information is relevant to lending responses for a number of reasons. Firstly, loans that are at least partially collateralized are more easily sold via the securitization process. In such instances, banks effectively serve as warehouses for loans and may liquidate them quite readily in response to funding shocks (Strahan, 2008). Collateral is a more common feature of loans to customers in the residential and consumer sectors, and banks concentrating in those areas may be more able to shield their lending growth from monetary policy via securitization.[32] Secondly, it is possible that the interest rate sensitivity of loan demand varies across sectors of the market, for instance the shorter maturity of commercial and industrial loans may render them more responsive to monetary policy (Kishan and Opiela, 2000). Equally, the pro-cyclicality of loan demand and loan supply discussed in section 2.3 may vary across sectors, for instance consumer loan demand may respond more strongly to income expectations. If such heterogeneity is a feature of the banking system, it can be captured using information on loan composition.

In order to test for this the total loan shares for residential loans, consumer loans and commercial and industrial loans are used as additional bank characteristics in the baseline regression in (2.4). Just three elements of the loan decomposition from the Call Reports are considered here. The reason is that municipal lending is typically a very small share of total lending. The four remaining loan categories account for almost 100% of bank lending and as such are almost collinear. In order to handle this, the agricultural loan share is omitted. Table 2.6 reports output analogous to that in table 2.4. The responsiveness of bank lending to a 100 b.p. tightening is reported for the representative bank. Also reported are the increments to the lending

[32]Loutskina (2005) develops a more precise measure of the securitizability of bank loan books that incorporates information on the extent of securitization of different loan categories at the aggregate level, as well as the composition of bank loan portfolios.

	$\Delta log\,(L_{i,t})$	UM	FF
Representative Bank	· Interaction Effect	-0.80**	-0.70**
		(0.05)	(0.02)
Residential Loans	· Interaction Effect	0.13**	0.04*
		(0.04)	(0.02)
	· Marginal Effect	-0.66**	-0.66**
		(0.06)	(0.03)
Consumer Loans	· Interaction Effect	0.05	-0.24**
		(0.03)	(0.02)
	· Marginal Effect	-0.74**	-0.94**
		(0.05)	(0.03)
Commercial Loans	· Interaction Effect	0.08*	-0.003
		(0.04)	(0.02)
	· Marginal Effect	-0.71**	-0.70**
		(0.06)	(0.03)
	Observations	1,050,736	1,049,694
	R^2	0.17	0.17

Notes: The reported lending responses are the sum of contemporaneous and four lagged responses to a 100 b.p. policy tightening. Interaction effects are calculated for a bank one standard deviation above the sample average for a characteristic and marginal effects sum the direct and interacted effects. Standard errors obtained after clustering at the bank level are reported in parentheses.
** and * indicate significance at the 1% and 10% levels respectively.

Table 2.6: Monetary Policy and the Structure of Bank Lending

response associated with a loan share measure one standard deviation above the sample average share for loans of that type. The results for the bank characteristics discussed previously are not reported here, but they confirm those presented in tables 2.3 and 2.4.

Using overall changes in the federal funds rate, a bank whose participation in the residential loan market is one standard deviation above the sample average contracts lending by roughly twice as much as a bank that does an average amount of business in that market. A similar result holds for banks whose business is concentrated in the consumer loans market. In contrast, commercial lending is only slightly more responsive to federal funds rate rises than the average loan, and by implication agricultural loans must be less responsive to policy than loans in general. These results are consistent with those reported by Kishan and Opiela (2000), who show that residential and consumer lending at small and poorly capitalized banks contracts more rapidly than commercial lending. Remarkably, the heterogeneity in lending responses by loan type is completely reversed when the exogenous policy measure is employed.

The results in table 2.6 support the hypothesis that residential lending is less sensitive to monetary policy. The reduction in the sensitivity of lending growth to monetary policy for a bank whose participation in the residential loan market is one standard deviation above the sample average is 0.13 when the policy measure is UM, compared to 0.04 when the policy measure is FF.[33] The evidence for resilience in

[33] The result using FF contrasts with that reported by Kishan and Opiela (2000) who show that residential lending at small and poorly capitalized banks contracts more rapidly than commercial lending.

residential lending growth is stronger using the identified policy measure, UM, possibly because loan demand and loan supply shifts, which distort the estimated effects of FF, vary in intensity across different parts of the market for loans. Results based on the exogenous policy measure are less affected by these biases and yield stronger support for the proposition that more widespread securitization of residential loans leads to reduced sensitivity of such loans to monetary policy.

The changes to the responsiveness of bank lending growth to monetary policy when banks' operations are concentrated in the market for consumer loans are 0.05 and -0.24 for UM and FF respectively. Although the shielding of loan growth following a rise in UM is significant only at the 15% level, it provides a stark contrast with the FF case which suggests lending contracts by more at banks whose business is concentrated in the consumer sector (Kishan and Opiela, 2000 , report a similar result using the effective federal funds rate). On the other hand, the UM measure suggests slightly stronger shielding effects apply to commercial and industrial loans than to consumer loans, even though the former are less readily securitized. Overall, the evidence suggests a less important role for loan securitization in shaping the response of consumer lending growth to monetary policy when compared to residential loan growth. This may reflect less widespread securitization of consumer loans. One option for future research would be to control for differences in the extent of securitization using a method such as that introduced by Loutskina (2005).

2.4.4 Non-Linearities

This final section explores asymmetric responses of bank lending to monetary policy. The motivation for this is to provide further empirical support for the observation that tight monetary policy slows the economy more than easy monetary policy accelerates it. At the aggregate level, Morgan (1993) presents findings in support of that for the United States. If the credit channel contributes to such asymmetric effects one would expect observed lending to be more responsiveness to contractionary policy shocks than to expansionary ones.

The literature points to at least two reasons why monetary policy might have non-linear effects on output in general, see Morgan (1993). First, prices might be less flexible downwards in which case tight policy may depress output more than easy monetary policy may boost it. Second, credit constraints and monetary policy interact in a way that makes tighter policy more powerful than easy policy. It is the latter point that is the focus of this chapter.

Tight monetary policy pushes up market rates on deposits and their substitutes, so banks' cost of funds increase. In order to maintain or regain profitability, commercial banks, lending long-term and borrowing short-term, need to pass on this cost-of-funds increase to their own borrowers. However, due to asymmetric information problems in the market for bank credit discussed in section 2.2.1, problems of adverse selection, moral hazard or monitoring costs may arise. Furthermore, as lending rates increase, so do the borrowers' obligations to the banks. Consequently, the probability of bankruptcy and related agency costs for the commercial banks will increase as well. Hence, banks might prefer to ration the volume of credit available even more in response to tighter policy.

So tight policy, which may attempt to combat boosting demand in the case of the endogenous FF, introduces a binding constraint. In contrast, easy policy, in an attempt to stimulate demand using the actual federal funds rate, relaxes credit constraints at a time when these constraints might not be the binding constraints in the first place, when the slowing economy has reduced the demand for credit. In such circumstances, easy policy, may be less effective and monetary policy might be "pushing on a string".[34]

In order to explore, whether there are asymmetries in bank lending responses to monetary policy specification (2.4) was augmented by a dummy intended to capture such non-linearities. A dummy **D** equal to unity was introduced when monetary policy was contractionary at time t according to *both* of the policy measures (i.e. if $FF > 0$ and $UM > 0$ at t) and then interacted with all terms in monetary policy shocks.[35] Hence, what is not included in this definition of contractionary policy are cases when (i) according to the forward looking policy model described in equation (2.3), that determines the endogenous part of policy, the broader policy measure contracts only in response to forecasts and (ii) only the exogenous part of policy contracts, i.e. UM is positive. So whilst the argument made in the last paragraph applied to the subset of episodes selected in such a way, not all episodes to argument appeals to are part of this subset, in particular episodes when the policy rules requires

[34] Friedman (1968): "Monetary policy was a string. You could pull on it to stop inflation but you could not push on it to halt recession. You could lead a horse to water but you could not make him drink."

[35] Both indicators FF and UM are jointly positive in 29.58% of the panel sample. $FF > 0$ in 54.33% of the panel sample, $UM > 0$ in 49.14% as it is more symmetric by construction. Note, however, that this is an unbalanced panel.

	$\Delta log\,(L_{i,t})$	UM $\ominus$	UM $\oplus$	FF $\ominus$	FF $\oplus$
Representative Bank	· Marginal Effect	-0.19**	-1.75**	-0.36**	-0.25**
		(0.05)	(0.09)	(0.02)	(0.02)
Assets	· Interaction Effect	-0.01	0.64**	-0.01	0.26**
		(0.04)	(0.04)	(0.02)	(0.01)
	· Marginal Effect	-0.20**	-1.11**	-0.37**	0.01
		(0.07)	(0.09)	(0.03)	(0.02)
Holding Company Status	· Interaction Effect	0.82**	2.87**	0.55**	0.81**
		(0.16)	(0.27)	(0.05)	(0.06)
	· Marginal Effect	0.63**	1.11**	0.19**	0.56**
		(0.15)	(0.26)	(0.04)	(0.06)
Securities Ratio	· Interaction Effect	0.01	-0.66**	0.16**	-0.22**
		(0.05)	(0.05)	(0.02)	(0.01)
	· Marginal Effect	-0.19**	-2.41**	-0.20**	-0.48**
		(0.07)	(0.10)	(0.03)	(0.02)
Equity Capital Ratio	· Interaction Effect	0.44*	0.60**	-0.28**	0.19*
		(0.18)	(0.20)	(0.10)	(0.10)
	· Marginal Effect	0.25	-1.15**	-0.64**	-0.06
		(0.20)	(0.25)	(0.10)	(0.10)
Net Cash Ratio	· Interaction Effect	0.19**	-0.18**	0.01	-0.03**
		(0.04)	(0.05)	(0.02)	(0.01)
	· Marginal Effect	0.00	-1.93**	-0.35**	-0.29**
		(0.07)	(0.10)	(0.03)	(0.02)

Notes: The reported lending responses are the sum of contemporaneous and four lagged responses to a 100 b.p. policy tightening. The second column gives the separate effect of a negative monetary shock. A dummy variable is interacted with the policy rate and its bank characteristic interactions. The dummy is unity if there is a negative shock (i.e. if UM and FF are greater zero). Interaction effects are calculated for a bank one standard deviation above the sample average for a given characteristic. Marginal effects sum the direct and interacted effects. Standard errors obtained after clustering at the bank level are reported in parentheses.
** and * indicate significance at the 1% and 10% levels respectively.

Table 2.7: Asymmetric Bank Lending Responses to Monetary Policy

a larger contraction than is implemented in the actual funds rate, i.e. when policy is exogenously more expansionary then it ought to be according to (2.3). The fact that the same dummy is employed in either regression helps to systematically compare the results from the two policy shock measures. Furthermore, the estimates for tight policy for the broad policy measure FF can be considered an upper bound which makes the comparison between UM and FF even clearer, because policy in this subset was always tighter than required by systematic responses to forecasts according to model (2.3). So the actual attenuation of coefficients on the estimated effects of FF might be even larger than presented here. The following model is estimated:

$$\begin{aligned} \Delta L_{i,t} \;=\;& \alpha + \sum_{k=1}^{4} \lambda_k \Delta L_{i,t-k} + \sum_{k=0}^{4} \beta_k^{(+)} \mathbf{M}_{t-k} + \sum_{k=0}^{4} \mathbf{D} \beta_k^{(-)} \mathbf{M}_{t-k} \\ & + \sum_{k=0}^{4} \gamma_k^{(+)} X_{i,t-1} \mathbf{M}_{t-k} + \sum_{k=0}^{4} \mathbf{D} \gamma_k^{(-)} X_{i,t-1} \mathbf{M}_{t-k} \\ & + \zeta \cdot X_{i,t-1} + \mu \cdot \text{trend}_t + \sum_{k=1}^{3} S_{k,t} + \varepsilon_{i,t} \end{aligned} \tag{2.5}$$

In table 2.7 on page 89 an augmented versions of table 2.4 is reproduced. The first column lists the response of bank lending growth to the exogenous monetary policy shock UM, the second column gives the added effect during a monetary contraction captured by the dummy defined as above. The third and fourth column refer to the same results using the endogenous policy measure FF as the dependent variable as earlier in the chapter.

Recall for a 100 b.p. change in UM, the baseline result in table 2.4 was a significant negative lending response of -0.94, for FF the response was -0.73. In contrast, in expansionary periods the response of bank lending growth to a 100 b.p. policy shock from FF with -0.36 is almost twice as strong as the one from UM with -0.19 and there is no overlap within two standard errors. So rather than finding attenuation bias due to endogeneity as in the baseline results one finds amplification when comparing the two measures in non-contractionary times. In times of monetary contraction, however, the effects from UM are seven times (-1.75) as large as for FF (-0.25). So overall there is still the attenuation described, however, the results are primarily driven by periods of tight policy. If the argument is true that loan demand is pro-cyclical then, as argued above, only contractionary policy introduces binding constraints on borrowing, so there is more evidence that endogenous policy drivers are important quantitatively.

Furthermore, the quantitative asymmetry between expansionary and contractionary periods seems reverse for the broad policy measure FF (-0.36 versus -0.25) clearly indicating attentuation due to a pick-up in loan demand during endogenous tightening. This reversal further supports the arguments in section 2. If loan demand and supply are pro-cyclical then, if one orthogonalises with respect to the anticipated economic cycle however, these pro-cyclical effects are controlled for and lending responses are significantly stronger with respect to the exogenous policy measure.

Considering the role of assets it is striking that in expansionary periods assets play not significant role for either policy measure, whilst during contractions there are shielding effects that are 2.5 times as large for the exogenous policy measure, 0.64

in the case of UM and 0.26 for FF. Again, there is far greater dispersion in lending responses across banks during tight policy. In the case of the broad policy measure the lending growth of a bank with an asset size one standard deviation above the mean would not be affected by policy at all. In the case of UM about one third of the lending contraction would be shielded for such a bank. So the earlier result from table 2.4 is primarily driven by contractionary episodes and the contrast in estimates between the two measures is even larger than in the baseline case. Again, these results imply that the banking industry structure strongly affects monetary transmission mechanism.[36]

Ashcraft (2006) considers bank holding company status the most appropriate bank characteristic to identify loan supply shifts. There is very strong evidence that a bank lending channel is particularly relevant for observed lending outcomes in times of contractions. In both cases UM and FF lending is shielded more in periods of contraction than in contractionary periods. The shielding effect during contractions is 3.5 times stronger for UM and 1.5 times stronger for FF. Looking at the marginal effects in either case an affiliated bank increases lending overall and picks up slack from unaffiliated banks. Like in the baseline case, it appears that lending by small and unaffiliated banks is more responsive to factors such as expected economic growth, such that lending responses to monetary policy are attenuated to a greater extent amongst banks exhibiting such characteristics because cyclical upturns provide access to finance that is used more intensively by banks that cannot access other sources of funds. Again, this evidence point to the banking industry structure

[36] In this context note the caveat from section 5.4.

as a key determinant of the strength of monetary transmission via credit.

In line with the observations in section 2.4.1 and table 2.4 on page 2.4, securities play an amplifying role during contractions. For the broad policy measure, securities provide some shielding effects 0.16 in line with the findings of Kashyap and Stein (2000) during easy policy whilst they have no effects during expansions using the exogenous measure. When policy is tight, holdings of securities amplify the lending growth contractions for UM (-0.66) three times as much as for FF (-0.22). As discussed earlier, it could be that exogenous tightening leads to a depression of fixed income securities prices and their simultaneous fire-sale by banks. Again, this finding supports the hypothesis that banks that are invested more heavily in securities might be exposed to more cyclically sensitive customers which will yield amplified (or upwardly biased) estimates in the case of FF (0.16 for easy policy and -0.22 for tight policy) compared to UM (insignificant 0.01 for easy policy and -0.63 for tight policy).

For the equity capital ratio table 2.7 shows, attenuation for estimates using FF (-0.28 for easy policy 0.19 for tight policy) compared to UM (0.44 for easy policy 0.60 for tight policy) for a bank one standard deviation above the sample mean of the equity capital ratio, just as in table 2.4. There are even qualitative differences in the case of easy policy with shielding effects of equity capital from exogenous policy shocks and amplifying effects from the broader policy measure. Again, the difference between UM and FF persists because lending responses are attenuated more amongst weakly capitalized banks that are more responsive to endogenous policy determinants. The response of poorly capitalized banks must be attenuated to such a degree, that even a bank one standard deviation above the sample mean of equity contracts lending further in response to a reduction in a actual federal funds rate. The observation of sign reversals and related opposite qualitative conclusions further highlight the importance of considering the endogeneity of monetary in research design related to bank lending.

The current cash ratio, the flow variable contributing to the stock value of equity capital, neutralizes positive exogenous policy shocks (0.19) and amplifies negative shocks even further (by -0.18). Point estimates for the change in the federal funds rate are similar but not significant during easy policy and of a much smaller order of magnitude when policy is tightened (-0.03). This finding is less emphasized here, for reasons see section 2.5.3.

2.5 Robustness

This section discusses the results of robustness exercises performed for the baseline regression estimates presented in tables 2.3 and 2.4. Each of the exercises addresses questions regarding the baseline econometric methodology that have been raised earlier in the paper. Two robustness tests that were conducted but are not presented in this section relate to the lag structure of the model and to the actual federal funds rate used. The baseline model presented in this chapter was tested with 5, 6, 7 and 8 lags (including bank characteristics interactions). Mostly, the point estimates of the coefficients on the first four lags to not change much, but there is added noise. As the exogenous policy measure derived from model 2.3 was constructed using real time data referring on one quarter lag and two quarter leads, higher order lag structures beyond 4 quarters are not very useful and hinder comparability with the literature. Finally, the results are largely robust to an alteration that uses the change in the average of the federal funds rate differenced over quarters, rather than the difference at the end dates of each quarter in line with the construction of the balance sheet data and the construction of the exogenous monetary policy shock. In the following, this section describes robustness test with regard to banking sector conditions, bank level fixed effects, the lag structure of the bank characteristics and, finally, a robustness test using different method for controlling for drifts in the assets.

2.5.1 Banking Sector Conditions - Basel and LTCM

Firstly, section 2.3.1 noted that the policy measure UM may not eliminate endogenous policy movements during episodes in which the FOMC set interest rates in light of banking sector conditions. The episodes during which such a critique seems reasonable are (i) the tightening of bank capital regulations as part of the Basel I Accord, which may have induced less restrictive monetary policy than would have been implemented based on growth and inflation objectives alone; (ii) the Federal Reserve Bank of New York's rescue of the hedge fund Long-Term Capital Management (LTCM) in the late 1990s, which may have prompted a similar policy response. In order to check for that two separate dummy variables are defined, one equal to unity for all quarters in the period 1990-1993 (this follows the dummy variable procedure used by Ashcraft (2006), to handle the effects of the Basel Accord), and the second equal to unity for all quarter in 1998-1999 (the LTCM rescue occurred in 1998). Then each of these dummy variables is interacted with each term from equation (2.4) featuring a monetary policy measure, and the extended specification is estimated using the procedure outlined in section 2.3. The results from this exercise, for both UM and FF, are presented in the first column of table 2.8. The effect of monetary policy on lending growth at the representative bank increases in absolute size only marginally, indicating little evidence that the estimated effects of monetary policy were attenuated during the two episodes considered. The interaction coefficients are in line with those presented in table 2.4, and the comparison of interaction effects across UM and FF supports each of the main results described in section 2.4.1.

2.5.2 Bank Level Fixed Effects

The second column in table 2.8 reports results obtained after augmenting equation (2.4) with bank level fixed effects. Although substantial fixed effects are unlikely given that loan growth rather than total loans are modelled, this robustness exercise is considered because it has been applied elsewhere in the literature, e.g. Loutskina (2005) motivates a fixed effects lending growth specification based on differences in managerial preferences.[37] The results indicate that the main findings are generally robust to this model extension. A possible exception occurs in the case of the lending response at the representative bank, which narrows such that the intervals spanned after imposing two standard error bands around the point estimates are overlapping (one standard error bands do not overlap). This is mainly due to the selected report-

[37]The inclusion of fixed effects and autoregressive terms raises the possibility of estimation bias of the form discussed by Nickell (1981). The size of this bias declines with the time dimension of the panel, and in this case an average number of time observation per bank of 57 is likely to mean this bias is minimal (Judson and Owen 1999 find quantitatively small bias provided $T \geq 30$). Interestingly, the autoregressive coefficients change very little across the baseline and fixed effects specifications (results not reported).

ing horizon, however. At other horizons in the first year after a monetary tightening the lending reduction from UM is more than twice that from FF and intervals formed from two standard error bands are non-overlapping. Another caveat to be noted is that the shielding effect from bank holding company membership is just one sixth larger when estimated from UM as opposed to FF, whereas in the baseline results it was more than 1.5 times as large. Nevertheless, the precision with which the effects are estimated ensures that the intervals formed after imposing two standard error bands around the estimates are non-overlapping, matching the baseline results.

2.5.3 Lag Structure of Bank Characteristics

The third robustness test addresses the fact that in equation (2.4) each of the bank characteristics interacted with a monetary policy measure are dated $t-1$, even when the policy measure is dated somewhat earlier, for example $t-4$. The dating of characteristics in the baseline regressions is standard in the literature, but leaves open the possibility that a characteristic value is a function of the earlier policy change with which it is interacted. The usual interpretation of interaction effects from regressions such as that in (2.4), namely that characteristics condition bank lending responses to monetary policy, would not be valid in such cases. In order to address this issue all characteristics in interaction terms are dated $t-i-1$, such that they are pre-determined with respect to the policy variable with which they are interacted (the level characteristics, which enter the regression just once, continue to be dated $t-1$). The results from this exercise, performed for both UM and FF, are reported in the third column in table 2.8.

$\Delta log\,(L_{i,t})$	Basel/LTCM Episodes		Fixed Effects		Pre-Determined Characteristics		Scale Total Assets	
	UM	FF	UM	FF	UM	FF	UM	FF
Representative Bank								
· Marginal Effect	-0.96**	-0.77**	-0.86**	-0.75**	-0.88**	-0.69**	-0.74**	-0.55**
	(0.06)	(0.02)	(0.05)	(0.02)	(0.04)	(0.02)	(0.06)	(0.02)
Assets								
· Interaction Effect	0.29**	-0.01	0.24**	0.04**	0.43**	0.09**	-0.05*	-0.09**
	(0.03)	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)	(0.03)	(0.01)
Holding Company Status								
· Interaction Effect	1.56**	0.96**	1.53**	1.24**	1.69**	1.08**	1.79**	1.19**
	(0.10)	(0.05)	(0.08)	(0.04)	(0.08)	(0.03)	(0.08)	(0.03)
Securities Ratio								
· Interaction Effect	-0.36**	0.06**	-0.15**	0.1**	-0.01	0.06**	-0.23**	0.04*
	(0.04)	(0.02)	(0.04)	(0.02)	(0.03)	(0.01)	(0.04)	(0.02)
Equity Capital Ratio								
· Interaction Effect	0.09*	0.01	0.28**	0.04**	0.12**	0.01	0.08*	0.002
	(0.04)	(0.02)	(0.04)	(0.02)	(0.03)	(0.01)	(0.04)	(0.01)
Net Cash Ratio								
· Interaction Effect	1.60**	0.08	0.98**	0.01	-0.74**	-0.05*	1.31**	0.03
	(0.22)	(0.09)	(0.25)	(0.10)	(0.14)	(0.02)	(0.29)	(0.18)
Observations	1,054,328	1,053,721	1,053,334	1,052,453	1,032,780	1,031,899	1,053,403	1,052,489
R^2	0.16	0.16	0.13	0.13	0.16	0.16	0.16	0.16

Notes: The reported lending responses are the sum of contemporaneous and four lagged responses to a 100 b.p. policy tightening. Interaction effects are calculated for a bank one standard deviation above the sample average for a given characteristic. Marginal effects sum the direct and interacted effects. Standard errors obtained after clustering at the bank level are reported in parentheses. ** and * indicate significance at the 1% and 10% levels respectively.

Table 2.8: Robustness Tests for the Baseline Model

The main findings are robust, save two exceptions. Firstly, the amplification of the contractionary effects of UM associated with large holdings of securities is absent in the third set of results, signalling the need for some caution in relation to this finding. The statistically significant negative effect from UM in the baseline results is present in the version of the results that uses pre-determined characteristics if one cumulates the interaction terms out to horizon 3 rather than horizon 4, and is present out to horizon 4 in the version of the results that does not exclude outliers. These conflicting pieces of evidence indicate some fragility in the baseline estimate of the securities ratio effect, but it seems unlikely that the entire effect is driven by variations in the securities ratio arising from policy changes because signs of the basic result are evident when using pre-determined characteristic measures.

Secondly, the interactions between the policy measures and the net cash ratio change sign in column 3 relative to the baseline case. Given that net cash flow is a component of the equity capital ratio, part of the negative effects from the net cash ratio in the column 3 specifications are offset. Nevertheless, it is clear that the effect of bank profitability/cash flow on lending responses to monetary policy is more dependent on the dating of the characteristic than is true for other characteristics. This is unsurprising given that the net cash ratio, closely linked to profits, is less persistent than total assets and asset composition and therefore changes more through time (the relatively low persistence of this series is reflected in its small standard deviation in table 2.2. One interpretation of the previous result for the net cash ratio is that policy shocks exert a large and persistent effect on the lending of a certain group of banks (for whatever reason), which then reduces their profitability and net cash ratio. The relatively large lending reversal for this set of banks then correlates with a low equity capital ratio, yielding the positively signed interaction from this characteristic in table 2.4. In table 2.8 this positively signed interaction is absent because the characteristics are pre-determined with respect to monetary policy and cannot respond to policy changes. Given this possible interpretation of the net cash ratio interaction the results from this particular characteristic are not particularly emphasized, and instead the focus is on those related to total assets, holding company status and the balance sheet shares of securities and equity capital.

2.5.4 De-Trending of Assets

The final column in table 2.8 presents a version of the baseline results that uses an alternative definition of the total assets variable. This is the demeaned series for $\ln\left(\frac{assets_{it}}{\overline{assets_t}}\right)$ where $\overline{assets_t}$ is the cross-bank mean of assets in period t (the baseline case used the demeaned series for $\ln assets_{it}$). Scaling each observation by average bank assets at a point in time eliminates the drift in the assets series that occurs as a result of all bank balance sheets growing in nominal terms through time. In the baseline results this effect was handled via the inclusion of a time trend, an approach that is standard in the literature, e.g. Loutskina (2005). Such a method will account for a linear trend in the assets of a representative bank, but will not deal with changes to the average growth rate for bank assets. Furthermore, the time trend handles drift only in the log level of assets, not the asset terms that are interacted with monetary policy (capturing the latter would require triple interactions between monetary policy measures, bank assets and time trends). In contrast, since the alternative definition is used in all terms that feature assets, including interactions, the new set of results will not depend on the drift that characterizes data for total assets.

The estimations show that the core findings remain intact, except that the interaction between bank assets turns negative and marginally significant when UM is the policy measure, and negative and significant when FF is the policy measure. It appears that the evidence that large banks can shield their lending growth from monetary policy is in part a function of the upward trend in asset values, which correlates with the trend towards weaker monetary transmission through time – notice how in the absence of this effect the impact of UM on lending growth at the representative bank moderates from -0.94 to -0.74. Crucially, however, the other results are very robust in the final column in table 2.8. In particular, the lending contraction at the representative banks is one third larger when policy is measured using UM rather than FF, the shielding of lending growth amongst holding companies is 1.5 times larger using the exogenous policy measure, and it is the equity capital ratio, not the securities ratio, that serves as a buffer to lending growth in the presence of monetary policy shocks measured by UM.

2.6 Conclusion

The credit market turmoil of 2007 and 2008 has highlighted the critical role played by the banking system in the transmission of monetary policy to the real economy. Recently policy-makers have focussed on the way in which banking sector conditions have blunted the stabilizing effects of the large interest rate reductions implemented by the FOMC during the first half of 2008, see Rosengren (2008). During the last decade considerable progress has been made in identifying the features of the banking industry that matter for monetary transmission, especially following the creation of a large database on the activities of insured banks in the United States in work by Kashyap and Stein (2000). The bulk of this research has used the federal funds rate to measure monetary policy. The key point emphasized in this chapter is that such a policy measure is endogenous to expected future macroeconomic conditions, which are likely to exert quite separate effects on both loan demand and loan supply. Examples of such effects were set out and it was argued that they may induce bias in both the direct impact of monetary policy on bank lending, and that part of the transmission mechanism conditional on bank characteristics. The empirical part of the chapter provided a comparison of the heterogeneity in bank lending responses to an explicitly identified monetary policy measure, and the measure which is more commonly used in the literature.

The results indicated both economically and statistically significant attenuation of lending responses to monetary contractions, and the shielding of lending associated with bank holding company affiliation. For some characteristics sign reversals were also estimated. Specifically, the share of securities in total assets was shown to amplify policy transmission from exogenous interest rate changes, but restrict the transmission of broader interest rate changes. One explanation for this result is that many types of securities are subject to an adverse valuation effect following exogenous monetary policy contractions, which limit the scope for lending at banks that hold them in large numbers. In contrast, endogenous rises in the federal funds rate may be associated with the largest lending increases (from the factors to which policy is endogenous) at banks which choose to invest heavily in securities. If the latter effect dominates the former, the positive interaction with the securities share may occur using changes to the federal funds rate. The bank characteristic found to associate with shielding of lending growth after policy contractions was the equity capital ratio, and the association was much stronger using the exogenous policy measure.

An important research implication from this chapter is that future studies of the banking system and monetary transmission should consider exogenous policy measures, alongside other measures such as the federal funds rate. In particular, the identification of the exogenous policy measure should take into account the forward-looking drivers of monetary policy such as growth and inflation forecasts, because these forward-looking variables are likely to impact lending markets. Interesting avenues for future work include examining the impact of exogenous policy measures on regions, industries and firms, and asking whether or not those impacts, and their comparison with similar results from the federal funds rate, are consistent with banking sector structures relevant to those regions, industries and firms. One possibility is that heterogeneity in the banking sector may account for a larger proportion of the differential effects of monetary policy across these units when an exogenous policy measure is employed, see the discussion in section 2.4. Other interesting areas for future work include applying the methodology used here to study heterogeneity in lending rates, as opposed to lending quantities, and examining the effects of bank characteristics on responses to policy at a more disaggregated level, for example distinguishing holdings of different types of securities.

Chapter 3

Deregulation and the Lending Channel: Quantifying Its Effects on Monetary Policy Transmission to Credit

Chapter Abstract

This chapter studies the impact of financial deregulation on individual banks and on the lending channel using individual bank level data from 1976 to 2010. It examines the effect of the abolition of deposit interest rate ceilings (Regulation Q) on estimates of bank level financial constraints as well as on the transmission of monetary policy via the lending channel. Measures of the degree of bindingness of Regulation Q suggest that individual banks' lending growth was smaller the more binding the (legally fixed) deposit interest rate ceiling. Interaction terms with measures of monetary policy indicate that the policy impact on lending growth that was up to ten times larger when Regulation Q was in place. Estimates of monetary policy effects on individual bank lending that do not control for the period of financial disintermediation when Regulation Q was in place may have overstated the monetary policy impact on lending. Estimates suggest that the lending channel may be much weaker in the more recent period.

Keywords: Monetary Transmission, Lending Channel, Deregulation, Regulation Q

JEL Codes: G21, E50, E51, E52, E58

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"All the legislative proposals need to be judged first of all against the central objective: We need to strengthen our ability to implement monetary policy in a variety of possible circumstances..."

- Paul Volcker (1979)
Statement to Committee on Banking, Housing and Urban Affairs, U.S. Senate.

3.1 Introduction

What is the impact of financial deregulation on individual banks and on monetary policy transmission through credit? This chapter seeks provide a quantitative answer to that question by analyzing the lending dynamics of more than a million quarterly U.S. bank level observations from 1976 to 2010.[1] In particular, it studies the impact of the abolition of legal deposit interest rate ceilings on bank level financial constraints as well as on monetary policy transmission to lending growth. It also examines in detail how the impact of deregulation varies across bank level proxies for financial constraints such as bank size, liquidity and capitalization that are traditionally employed in the lending channel literature to identify policy induced loan supply shifts.

In doing this, the chapter contributes to and connects two previously disparate streams of the literature: First, a number of prominent studies on the bank lending channel focus on the sample period from the mid-1970s to the mid-1990s (Kashyap and Stein, 2000; Kishan and Opiela, 2000; Ashcraft, 2006), but do not concern them-

[1]Unlike the previous chapter 2 (page 21) this chapter extends the banking sample up to the present day because there are no longer comparability constraints with Ashcraft (2006) and time-constraints with regard to the availability of Greenbook data necessary to identify monetary policy shocks as in the approach chosen in the previous chapter. The first quarter of 1976 is the first publicly available bank level data.

selves with the effects of regulatory changes. In these studies parameter stability over the whole sample period is assumed.[2] Second, macroeconomic and sectoral studies explore the effects of banking deregulation either using aggregate data, for example analyzing the structural change in the interest rate sensitivity of GDP due to disintermediation (Duca, 1995, 1998; Mertens, 2008), or sectoral data, for instance examining of the effects of deregulation on housing (Duca, 1996). A detailed bank level analysis of financial deregulation, however, presents an interesting gap in the empirical literature. Indeed, Frame and White (2004) complain about a lack of empirical backing on the effects of financial innovation and the accompanying deregulation.

Interest rate ceilings in the U.S. date back to the Banking Act of 1933 codified three months after President Roosevelt had declared the nationwide banking holiday in March 1933.[3] Amongst other provisions of the Banking Act, including the creation of the Federal Deposit Insurance Corporation (FDIC), was the regulation of deposit interest rates. The provision was justified by the argument that excessive interest rate competition contributed to financial instability, because the higher the interest rate paid on deposits, the higher the cost of doing business to the banker and thus the lower bank profitability. A second argument was that when banks due to competitive pressures were forced to pay higher deposit rates they would be induced to seek riskier investments and make high risk loans in order to recoup the higher interest rate costs. A final argument was that the deposit interest rate ceiling would compensate banks for the costs incurred by the now compulsory deposit insurance premiums (Gilbert,

[2] Ashcraft (2006) does adjust for the implementation of the Basel Accord in the period 1990 - 1993 at the end of his sample.

[3] For a historical review see Hendrickson (2011) especially pp. 143-148 that the subsequent paragraphs draw from.

1986).

The regulation of deposit interest rates became known as Regulation Q. Section 11(b) of the Banking Act of 1933 prohibited all member banks from paying interest on demand deposits. The same section empowered the Federal Reserve Board with the authority to set the interest rate which could be paid by member banks on time and savings deposits. Regulation Q went into effect on 1st November 1933 at which time the Federal Reserve Board set a maximum rate of three percent on time and savings deposits.[4]

Smaller corporations either issue debt to investors in formal or informal financial markets or they borrow from commercial banks. Historically, nonfinancial firms relied on bank loans because they were often less expensive than debt. However, in the 1960s credit crunches occurred. Partly, that was due to the fact that banks were unable to obtain the funds required to meet loan demand because market interest rates rose above the Regulation Q rates. Consequently, depositors pulled their time deposits out of commercial bank leaving the banks with fewer loanable funds (Hendrickson, 2011, p.166). Such effects were absent after the deregulation of deposit interest rates, so controlling for regulatory change is important when estimating lending responses to monetary policy.

Results from this chapter suggest that policy transmission from federal funds

[4]After its activation in January of 1934, the Federal Deposit Insurance Corporation extended the interest rate ceiling to all insured commercial banks that were not members of the Federal Reserve System. However, early in 1935, when the Federal Reserve and the Federal Deposit Insurance Corporation moved to reduce the interest rate ceiling to two and one half percent, the statutory authority of the Federal Deposit Insurance Corporation to regulate interest rates was called into question. The Federal Deposit Insurance Corporations regulation was consequently suspended until the Banking Act of 1935. Hence, it was not until the passage of the 1935 act that nonmember banks were subject to the rate controls of Regulation Q.

rate changes to lending growth has declined by more than ninety percent and that disturbances emanating from monetary policy might have had less of an effect (at least through the lending channel) on the economy more recently. At the same time, this chapter presents evidence that bank level financial constraints have become less binding and that monetary transmission via credit has been substantially weakened due to deregulation potentially pointing to the need for greater instrument variability in order to offset macroeconomic shocks. As will be explained in detail in section 3.4.2 using figure 3.4 on 163 it is unlikely that a large proportion of these changes is attributable to changes in loan demand sensitivities to monetary policy as non-bank sources of finance have become available over the last decades and hence it likely to be attributable to changes in the lending channel rather than the interest rate channel. The literature on limited asset market participation (e.g. Vissing-Jørgensen, 2002) would also support that view because loan demand should have become *less* sensitive to changes in the federal funds rate as increasing participation in asset markets pushes the elasticity of intertemporal substitution up whilst overall bank lending has become less and less important (Berger, Kashyap and Scalise, 1995).

The contributions of this paper are, first, the inclusion of controls for the presence and bindingness of Regulation Q in bank level financial constraints and lending regressions and thus capturing the effects of deregulation at the bank level for the first time. Second, unlike other papers this study takes bank characteristics seriously in that it does not assume that all banks face a homogenous loan demand, but explicitly controls for the differences in the lending cycles of banks of different size, liquidity positions and capitalization. Third and finally, the chapter extents the bank level data set that has been used by other studies to include the most recently available quarterly observations up to 2010.

The chapter is organized as follows. Section 3.2 outlines how the paper contributes to the bank lending literature, the deregulation literature and the Great Moderation literature. It also includes a brief description of previous attempts to capture structural changes in the lending channel. Section 3.3 explains the bank level, macroeconomic and regulatory data in more detail and justifies the econometric specification used in this study by contrasting it with previous empirical papers.Section 3.4 reports and interprets regression results and section 3.5 concludes with a summary of the main findings and policy implications.

3.2 The Lending Channel and Deregulation

The purpose of this section is to give an overview of the different streams of the literature that this chapter builds on and show how the chapter adds to each of these fields. It first summarizes the previous bank level literature on the lending channel in section 3.2.1. Section 3.2.2 describes the history and effects of Regulation Q in more detail and turns to related work on the effects of financial disintermediation and estimates of the effects of Regulation Q on aggregate and sectoral data. Finally, section 3.2.3 discusses other studies that consider structural changes in the banking industry affecting the lending channel and puts the estimates of this chapter in context.

3.2.1 Lending Channel

The classical interest rate channel suggests that monetary policy affects the real economy via portfolio shifts that induce asset price changes (interest and exchange rates), that then induce households and firms to alter their consumption and investment decisions via inter- (interest rates) and intratemporal (exchange rates) substitution. It is argued, that over and beyond these "price" channels, credit channels are operative. Bernanke and Blinder (1992) use aggregate date from 1959 to 1978 to find that after a policy contraction, bank loans only respond after half a year and do not adjust completely for over two years. Such results are consistent with both a price as well as a credit channel given that real activity also takes about two years to fully adjust.

The empirical literature then moved to identify loan supply shifts from loan demand shifts examining individual bank level balance sheets in particular by identifying differences in lending growth responses to monetary policy across bank level proxies for financial constraints. These financial constraints range from size and liquidity (Kashyap and Stein, 2000) to capitalization (Kishan and Opiela, 2000) and membership in a bank holding company (Ashcraft, 2006). Attempts to identify loan supply shifts and the bank lending channel have focussed on separating banks by their balance sheets characteristics that are tied to a bank's ability to supply loans, but are (presumably) independent of loan demand shifts in response to policy. The seminal paper by Kashyap and Stein (2000) studies a panel of banks from 1976 to 1993 and finds that the impact of monetary policy on lending is stronger for banks with less liquid balance sheets. This pattern is largely attributable to smaller banks in their sample, that is the bottom 95 percent of the size distribution.

Bank level lending regressions focussed on identifying policy induced loan supply shifts use a variety of empirical specifications. Kashyap and Stein (2000) employ two different approaches, two-step and one-step empirical models. Equation (3.1) summarizes their one-step approach. They also consider a bivariate version of the empirical model that controls for changes in overall economic activity by introducing GDP_t which is nested in model (3.1) by square brackets for illustration:

$$\begin{aligned} \Delta\log(L_{i,t}) &= \sum_{j=1}^{4}\alpha_j \cdot \Delta\log(L_{i,t-j}) + \sum_{j=0}^{4}\mu_j \cdot \Delta M_{t-j} \overbrace{\left[+\sum_{j=0}^{4}\pi_j \cdot \Delta GDP_{t-j}\right]}^{\text{``bivariate''}} \\ &+ \Theta \cdot time_t + \sum_{j=1}^{3}\rho_j \cdot \text{Quarter}_j + \sum_{k=1}^{12}\Psi_k \cdot FRB_{i,k} \qquad (3.1) \\ &+ B_{i,t-1}\left(\eta + \delta \cdot \text{time}_t + \sum_{j=0}^{4}\Delta\phi_j M_{t-j} \underbrace{\left[+\sum_{j=0}^{4}\pi_j \cdot \Delta GDP_{t-j}\right]}_{\text{``bivariate''}}\right) + \varepsilon_{i,t} \end{aligned}$$

where $L_{i,t}$ is a bank-level measure of lending activity, $B_{i,t}$ is a measure of balance sheet strength (the liquidity position in their case), and M_t is a monetary policy indicator. Time effects are captured by time_t and Quarter_j dummies and $FRB_{i,k}$ captures geographical effects via Federal Reserve district dummies. Kashyap and Stein (2000) are interested in whether less liquid banks (with lower $B_{i,t}$) are more responsive to monetary policy shocks. So the interest lies in coefficient ϕ in (3.1).

Kashyap and Stein (2000) find that less liquid banks' lending growth responds more strongly to monetary policy. Their estimated effect is particularly strong for smaller banks. This may be a problematic finding if - as is illustrated in table 3.4 and figure 3.2 - their measure of liquidity is correlated with other important bank characteristics that they do not control for in their regression specification. Furthermore, there may be differential shifts in loan demands rather than loan supply due to the liquidity position of the bank. More liquid banks may chose to hold loan portfolios that differ from less liquid banks. There are evidently different sensitivities to nominal and real aggregate factors in banks with different characteristics as table 3.3 on page 137 shows. As one can see more liquid banks do hold more cyclically sensitive loan portfolios (see table 3.3 row 2 for real and row 5 for nominal sensitivities).

At the same time Kishan and Opiela (2000) examine the lending channel using bank level data covering the period 1980 to 1995. They distinguish banks by size categories and capitalization. Examining the different lending growth responses to monetary policy by analyzing six different size and three different capitalization categories they show that smaller banks respond more strongly to monetary policy and the less well-capitalized banks are the stronger is their response. Again, they do not control for other individual bank level characteristics that may be correlated with other bank level indicators of financial constraints, so the same critique as in Kashyap and Stein (2000) applies. They also cover a very limited period with only a single interest rate cycle.

One common critique regarding the papers by Kashyap and Stein (2000) and Kishan and Opiela (2000) is that their strategy to identify policy induced loan supply shifts along characteristics that proxy for bank level financial constraints rests on the assumption of homogeneity loan demand cyclicality across the respective bank characteristic. That is the sensitivity for, say, well capitalized banks to GDP growth is the same as the sensitivity of less capitalized bank, however, their response to monetary policy differs. As table 3.3 show this assumption is rather difficult to justify.

Building on both Kashyap and Stein (2000) and Kishan and Opiela (2000) Ashcraft (2006) uses membership in a multi-bank holding company in order to identify shifts in loan supply from shifts in loan demand. Ashcraft (2006) contrast the response of stand-alone banks and banks affiliated with a multibank holding company and finds that the lending of multibank holding companies is less responsive to monetary policy and that stand-alone banks have the strongest lending growth responses to monetary policy. His sample contains banks from a sample period of 1976 to 1999. Whilst he controls for non-homogenous loan demand shifts he does assume parameter constancy over the whole sample period although he does check that the implementation of Basel II does not alter his results substantively.

In more recent contributions, Jonas and King (2008) examine the relationship between a bank's efficiency and its responsiveness to monetary policy. Cetorelli and Goldberg (2008) examine the international exposure of banks and their lending dynamics. The contribution of this study is to examine in more detail the time-variation in the lending responses to monetary policy at the bank level. Den Haan, Sumner and Yamashiro (2010) find that time variation for total loans is substantial and that it is difficult to find a robust response of total bank loans to a monetary tightening. Other attempts to account for time-variation can be found in Baum, Caglayan and Ozkan (2003) who augment the Kashyap and Stein (2000) framework to account for financial section uncertainty. The argument in this chapter is that a lot of the time variation in lending responses can be explained by regulatory factors and, in particular, by deposit interest rate deregulation.

3.2.2 Regulation Q

The interest rate ceilings termed Regulation Q introduced in the Banking Act of 1933 were not binding for the first three decades of its existence (Gilbert, 1986). However, as nominal interest rates rose in the 1960s and the interest rate ceiling were not adjusted by the Federal Reserve problems of disintermediation arose. An extreme instance of such disintermediation was the credit crunch in 1966 arose. The subsequent passage from Hendrickson (2011) describes the event:

> “By the third quarter of 1966, nonfinancial firms were cut off from the commercial loan market. It was largely monetary policy that kept banks from extending further credit to the corporate sector. Specifically, the Federal Reserve tightened monetary policy at the end of 1965 and increased the discount rate from four percent to 4.5 percent. In response, banks increasingly relied on time deposits as a source of funds because they had a lower reserve requirement than demand deposits. This allowed the commercial banks to accommodate loan demand. However, in June, the Federal Reserve increased the reserve requirement on time deposits making it more expensive for banks to raise funds through the time deposit market. Perhaps part of the motivation for the Federal Reserve was that the President had indicated he was counting on the Federal Reserve

> to keep credit in check to avoid inflation. At the same time, the Federal Reserve refused to raise the regulation Q ceiling on large time deposits and, in the summer, the market interest rate rose above the regulated rate for both long- and short-term certificates of deposit (CDs). These policies of the Federal Reserve made it difficult for banks to continue to lend which is why the corporate sector was shut out of the credit market towards the end of 1966. (...) [T]he credit crunch of 1966 exposed weaknesses in the regulatory regime; specifically in the constraints caused by binding price ceilings." (Hendrickson, 2011, p. 177)

This quote makes the workings of Regulation Q in terms of the lending channel quite clear. If, as was the case since the mid-1960s, short-term rates moved above the legally mandated interest rate ceilings depositors would reduce their deposits and seek alternative investment opportunities leaving banks to shrink their loan supply more strongly than in the absence of deposit rate regulations. Such regulatory ceilings and their abolition are very likely to cause structural changes in the transmission of monetary policy through credit and this is the subject of enquiry of this chapter.

The negligence of deposit deregulation in the bank level literature is in marked contrast with aggregate and sectoral studies that take into account structural change that can be attributed to financial deregulation and, in particular, to the abolition of Regulation Q through the Depository Institutions Deregulation and Monetary Control Act (DIDMCA).

Duca (1995, 1998) shows that the deregulation of deposit rate ceilings has altered the interest rate sensitivity of aggregate GDP in vector autoregressions. Accounting for Regulation Q leads to more stable impulse response functions for different subperiods in vector autoregressions. In single-equation models, the impact of monetary policy has declined due to financial liberalisation and controlling for the bindingness of Regulation Q increases the stability of the estimated coefficients.

This line of aggregate research also extended into sectoral studies. Duca (1996) shows how regulatory actions account for major changes in estimates of important housing coefficients, that is the sensitivity of house prices to changes in the real rate of interest, since the late 1970s with the bulk of these changes due to phasing out of Regulation Q. He finds that empirical models of the aggregate housing stock are unlikely to yield coefficients that are stable enough for practical use unless they accurately control for regulatory changes.

There other papers related to this chapter. For instance, Timberlake (1985) examines the political economy of the DIDMCA and its subsections. Allen and Wilhelm (1988) also examine political economy issues by investigating the differential impact of the passage of DIDMCA on three portfolios of different depository institutions FRS banks, non-FRS banks, and Savings and Loans using intervention analysis and financial market data. This present chapter does not attempt to explain deregulation by looking at the process that brought it about as Timberlake (1985) or at its distributional repercussions as in Allen and Wilhelm (1988). Rather it treats deregulation as a given and examines its impact on the (dynamic) lending responses of commercial banks to monetary policy.

One objection to testing the impact of the abolition of Regulation Q on the transmission of policy to bank lending is that it may be innovations in applied finance (see section 3.2.3) rather than deposit rate deregulation that are the drivers of the process. So rather than arguing Regulation Q has altered the lending channel, the invention of safe, deposit-like instruments like small-saver certificates (SSCs) and money market certificates (MMCs) that were a close substitute to deposits and paid market interest rates was the cause for changes in the lending channel. Whilst the objection may be valid, one might then just alter the subject of enquiry into the question of how innovations in applied finance in the late 1970s and early 1980s have altered the lending channel. The validity of such objections may be further questioned in terms of the timing. SSCs and MMCs with characteristics that were close substitutes to deposits were available mostly at the end of the phasing out of Regulation Q (table 3.14 on page 185 illustrates). Furthermore, this chapter addresses specifically the bindingness of Regulation Q. Moreover, one would expect a differential impact of deregulation across different bank characteristics as the aforementioned substitutes to insured deposits were offered initially by the largest banks only and the later estimates control for that.

Another objection and limitation of this chapter is that there were a number of regulatory changes that may have influenced the behaviour of commercial banks over time. Table 3.1 on page 122 provides a list of banking legislation during the sample period. Changes in the regulatory environment include several major changes in capital requirements, reductions in reserve requirements, expansion of bank powers, and liberalization of geographic restrictions on intrastate and interstate banking (at the federal level through Riegle-Neal Interstate Banking and Branching Efficiency Act). The latter point is of particular interest. At the start of the sample, the national

Wave	Nature of the Regulation	Regulation Title and Date
1	Deregulation	Depository Institutions Deregulation and Monetary Control Act: 1980
1	Deregulation	Depository Institutions Act: 1982
1	Deregulation	Competitive Equality in Banking Act: 1987
2	Regulation	Financial Institutions Reform and Recovery Act: 1991
3	Deregulation	Riegle-Neal Interstate Banking and Branching Efficiency Act: 1994
3	Deregulation	Gramm-Leach-Bliley Act: 1999

Source: Hendrickson (2011, p.177).

Table 3.1: Waves of Regulation in the Postwar Banking Era

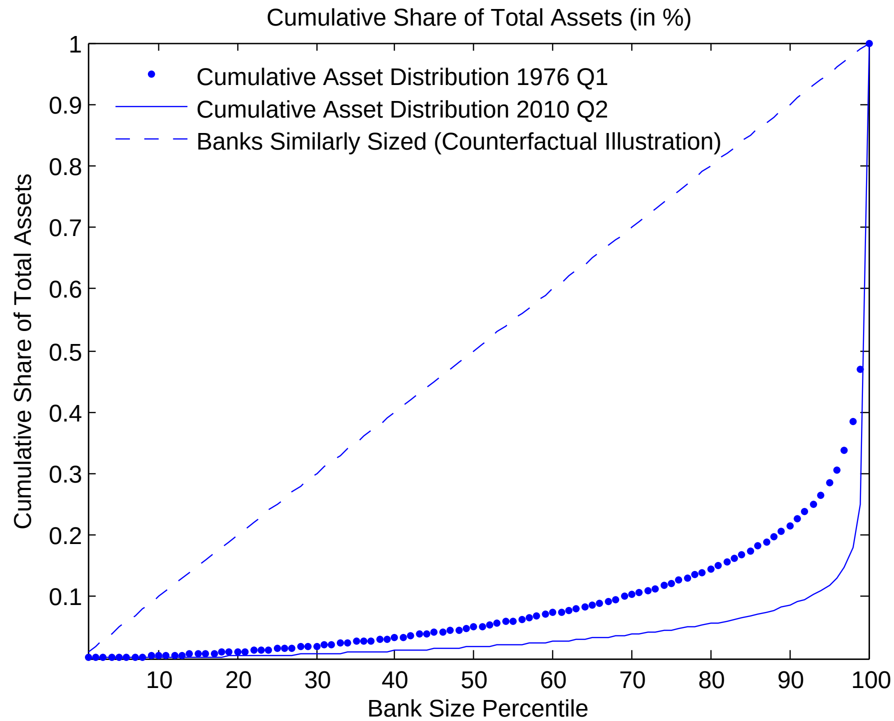
banking assets that were legally accessible from the typical U.S. state was around 6.5 percent, whereas it was 29.0 percent in 1989 and 69.4 percent in 1994, similarly the typical U.S. state's assets that were controlled by out-of-state multibank holding companies increased from 2.1 percent (1979) to 27.9 percent (1994) (see table 3 on p. 71 in Berger, Kashyap and Scalise, 1995). One problem with the abolition of inter- and intrastate restrictions is that they occurred throughout the 1980s and are difficult to control for as these restrictions were phased out in different states in different years. In contrast, the abrupt nationwide phasing out of Regulations Q until 1982 is something readily measurable and yields significant results. However, it is important to bear in mind that that this does not exclude the possibility that some of these findings are also partially due to the phasing out of location restrictions. The other legal changes listed in table 3.1 mostly concerned the powers of the FDIC (Depository Institutions Act, Competitive Equality in Banking Act, Financial Institutions Reform and Recovery Act), and the removal of the Glass-Steagall Act (through the Gramm-Leach-Bliley Act)

A final objection is a reverse causation argument as it is difficult to judge exactly whether financial innovation caused financial deregulation or whether the reverse is true. With respect to deposit rate ceiling at commercial banks as embodied in Regulation Q it is likely that financial innovation played a some role in bringing about deregulation. In particular, money market funds competing with commercial banks for deposits and, later during the phasing out of Regulation Q, more flexible small-saver certificates (SSCs) and money market certificates (MMCs) that became substitutes for bank deposits are also likely to have contributed to infeasibility of fixed legal deposit rate ceilings. However, what is clear is that either financial innovation or financial deregulation caused substantial shifts in the transmission mechanism. This chapter presents the first systematic analysis of such structural breaks and its causes at the individual bank level.

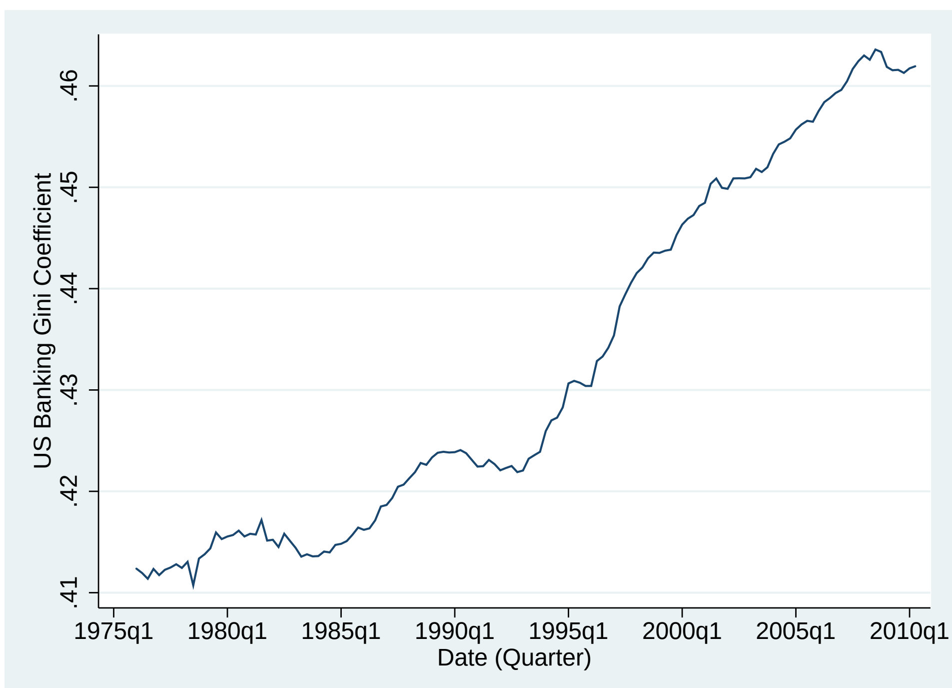
3.2.3 Previous Structural Change Literature

As mentioned earlier there are some studies suggesting a structural change in the lending behaviour of banks due to financial innovation. For instance, Loutskina (2005); Loutskina and Strahan (2009) study the impact of securitization on the lending channel for the United States, whereas examine Altunbas, Gambacorta and Marques-Ibanez (2009*b*) the lending channel in the euro area. Both find that the lending channel is weakened by the ability of commercial banks to shift new loans off the balance sheets rather than pursuing the traditional "buy-and-hold" banking model. Here, we cannot offer controlling for such effects at the bank level as we do not have access to their original data sets. In contrast to their contribution this chapter examines the regulatory effects, potentially offering a different or complementary explanation of the decline of the lending channel.

While securitization might have played a great part in reducing the strength of the lending channel table 3.2 on page 127 suggests that the substantial changes in the U.S. banking industry are due to the very fact that commercial banks lost their monopsony power over depositors in the early 1980s when money market funds became a more prominent way to deposit short-term assets for households. Table 3.2 computes the difference between interest expenses (1) and the one-year treasury rate (2) illustrating a large decline. This is despite the fact that banking service quality has increased as can be seen by the increasing number of automated teller machines (4) and banking offices (5) leading to increasing noninterest expenses (3). This certainly increased the allocative efficiency of the banking system but it also impacted upon its structure and thus has severe implications for monetary transmission through credit that very much depends on the banking structure. Figure 3.1 on page 3.1 illustrates the case in point. Table (3.1.a) plots the cumulative asset distribution by size percentiles at the start and at the end of the sample. In 2010 the larger banking organisations held a proportionately larger stock of all banking assets than in 1976. Table (3.1.b) shows how the process of banking sector consolidation took off after deposit deregulation and accelerated when an increasing number of U.S. states permitted interstate branching and banking by plotting a quarterly time-series of a Gini-type cross-sectional coefficient based on assets. The importance of that is captured in Kashyap and Stein (2000) and Ashcraft (2006) in that their lending regressions recognize the importance of bank size as a determinant of the lending sensitivity to monetary policy changes. It is noteworthy, however, that when pooling the data, the early period has (i) a larger number of banks and (ii) a greater proportion of smaller banks. Thus pooled sample estimates may overemphasize the importance of the earlier period when Regulation Q was binding compared the more recent bank level lending variability.



(a) Asset Dispersion Across Banks



(b) Dispersion over Time

Figure 3.1: Bank Size Dispersion:
(a) At Beginning and End of Sample and (b) Over Time

	Year	1979	1986	1994
· Interest Expenses/Assets	(1)	5.17	5.13	2.73
· One-Year Treasury Bill Rate	(2)	10.65	6.45	5.32
· Interest Expenses/Assets - One-Year Treasury Rate	(1)-(2)	-5.48	-1.32	-2.59
· Noninterest Expenses/Assets	(3)	2.39	3.03	3.55
· Interest & Noninterest Expenses/Assets - One-Year Treasury Rate	(1)+(3)-(2)	-3.09	1.71	0.96
· Number of Banking Offices	(4)	50,136	58,063	65,610
· Number of Automated Teller Machines	(5)	13,800	64,000	109,080

Source: Berger, Kashyap and Scalise (1995).

Table 3.2: Expenses of the U.S. Commercial Banking Industry

3.3 Econometric Specification and Data

The first part of this section discusses the baseline empirical model and contrasts it with previous approaches. Section 3.3.1 outlines how to estimate bank level financial constraints and how to include controls for the phasing out of Regulation Q. Section 3.3.2 discusses the empirical modeling of the impact of deposit interest rate deregulation on the transmission of monetary policy to individual bank lending. The specifications estimating bank level lending constraints as well as lending growth responses to monetary policy are augmented by proxies for deregulation (that is the bindingness of Regulation Q) in *levels* as well as *interactions*. Interaction effects of the regulatory proxies are of particular interest because they indicate the effects of deposit interest rate deregulation, on the one hand, on the individual banks' asset-liability dependencies and, on the other hand, the effects of deregulation on monetary transmission rather than merely their effect on the level of mean lending growth. The second part of this section describes the data used in the empirical models outlined in 3.3.1 and 3.3.2. Section 3.3.3 briefly describes the individual bank level data that extends and augments the bank level data set from chapter 2 to the present day. Section 3.3.4 describes the macroeconomic controls. The regulatory data, in particular the two proxies for the bindingness of Regulation Q (RegQ_t and RegQ_t^{Binary}) used in the subsequent estimations in the results section 3.4, are discussed in the section 3.3.5.

3.3.1 Lending Growth Sensitivity to Cash Flow

Building on Fazzari, Hubbard and Petersen (1988) who pioneered the standard strategy for identifying the presence of financial constraints across non-financial firms by analysing the differences in the investment sensitivity of cash flows across different measures of financial constraints Jayaratne and Morgan (2000) and Ashcraft (2006) identify financial constraints of commercial banks by examining differences in the sensitivity of loan growth (i.e. commercial banks' investment) to insured deposit growth (their cash flow). If the Modigliani and Miller (1958) proposition was valid and there were no increasing marginal costs for external funds, both firms as well as banks should be indifferent between internal and external funds for new investment projects, and hence the sensitivity of investment to cash flow should be zero.

Jayaratne and Morgan (2000) and Ashcraft (2006) argue that for non-financial firms internal funds are retained earnings whereas for commercial banks the underpricing of deposit insurance suggests that a more appropriate measure of internal funds is the growth rate of insured deposits. This chapter follows their approach and estimates the following empirical model (3.2):

$$\begin{aligned}
\Delta\log(L_{i,t}) &= \alpha + \sum_{k=1}^{4}\rho_k \cdot \Delta\log L_{i,t-k} + \sum_{k=0}^{4}\gamma_k \cdot \mathbf{M}_{t-k} \\
&+ \upsilon \cdot B_{i,t-1} + \sum_{k=0}^{4}\tau_k \cdot B^{*}_{i,t-1} \times \mathbf{M}^{*\prime}_{t-k} \\
&+ \sum_{k=0}^{4}\beta_k \cdot \Delta\log(\text{Deposits}_{i,t-k}) + \sum_{k=0}^{4}\phi_k \cdot B_{i,t-1} \cdot \Delta\log(\text{Deposits}_{i,t-k}) \\
&+ \mu \cdot \text{time}_t + \sum_{k=1}^{3}\theta_k \cdot \text{Quarter}_{k,t} + \varepsilon_{i,t}
\end{aligned} \tag{3.2}$$

This is a regression of annualized loan growth ($\log(L_{i,t})$) of bank i in quarter t on a constant and its own lags, nominal and real macroeconomic controls ($\mathbf{M}_t$) and their lags, single period lagged individual bank characteristics ($B_{i,t-1}$), and the interaction of the characteristics ($B_{i,t-1}$) with the macroeconomic controls ($\mathbf{M}_t$).[5] Most importantly, annualized loan growth is regressed on insured deposit growth of bank i in quarter t ($\Delta\log(\text{Deposits}_{i,t})$) and its lagged values as well as on the interaction of these lagged bank characteristics with deposit growth ($B_{i,t-1}\cdot\Delta\log(\text{Deposits}_{i,t-k})$). There are also time and seasonal controls. The three-dimensional bank characteristics vector $B_{i,t} = \left[\text{Size}_{i,t}, \text{Capital}_{i,t}, \text{Liquidity}_{i,t}\right]$ contains bank characteristics constructed as follows

$$\begin{aligned}
\text{Size}_{i,t} &= \frac{1}{\sigma_A}\left[log(A_{i,t}) - \left(\frac{1}{N_t}\sum_i log(A_{i,t})\right)\right] \\
\text{Capital}_{i,t} &= \frac{1}{\sigma_C}\left[\frac{C_{i,t}}{A_{i,t}} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i\frac{C_{i,t}}{A_{i,t}}\right)\right] \\
\text{Liquidity}_{i,t} &= \frac{1}{\sigma_L}\left[\frac{L_{i,t}}{A_{i,t}} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i\frac{L_{i,t}}{A_{i,t}})\right)\right]
\end{aligned} \tag{3.3}$$

where $A_{i,t}$ denotes assets, $L_{i,t}$ liquidity and $C_{i,t}$ equity capital in US$ for each of bank i in quarter t. σ_A, σ_L and σ_C denote the standard deviation of assets, liquidity and capitalization respectively. T is the total number of quarters in the sample

[5] The bank characteristics and the macroeconomic controls are interacted with each other using transformations of $B_{i,t}$ and $\mathbf{M}_t$:

$$\begin{aligned}
B^*_{i,t} &= \left[\text{Size}_{i,t}, \text{Capital}_{i,t}, \text{Liquidity}_{i,t}\right] \otimes [1,1,1] \quad \text{and} \\
\mathbf{M}^*_t &= ([1,1,1] \otimes [0, \Delta\log(p_t), \Delta\log(y_t)])'
\end{aligned}$$

that is all the characteristics are interacted with indicators of real and nominal aggregate factors.

and N_t is the number of banks in quarter t. So stationary balance sheet ratios (the capitalization and liquidity ratio) are de-meaned whilst time-trending assets are additionally de-trended. All bank characteristics are also scaled by their standard deviation in order to ease interpretability of the estimation results later in section 3.4.1.

The macroeconomic controls vector $\mathbf{M}_t = [\Delta\log(p_t), \Delta\log(y_t)]'$ contains both real and nominal macroeconomic controls, real GDP growth and changes in the chain-indexed GDP deflator. Nothing hinges on using either of these measures rather than seasonally adjusted current price GDP and seasonally adjusted CPI as described in 2.3.4 of chapter 2. However, in chapter 2 the choice of the macroeconomic controls was constrained by imposing comparability with Ashcraft's (2006) data set and estimation results. In particular the focus in this chapter on *real* GDP growth rather than current price GDP helps to better disentangle real from nominal effects.

Now, in order to assess the impact of the phasing out of Regulation Q variations of the baseline specification (3.2) will be estimated. First, the baseline specification (3.2) will be augmented by including a Regulation Q bindingness proxy (RegQ_t) in levels as in (3.4)

$$(3.2) \quad + \quad \sum_{k=0}^{4} \psi_k \cdot \mathrm{RegQ}_{t-k} + \sum_{k=0}^{4} \varphi_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \tag{3.4}$$

Note that the proxy is also interacted with the individual bank level characteristics in order to explore whether the role of bank characteristics is stable. This first augmented estimate will show how mean lending growth was affected by Regulation

Q directly. Second, beyond a levels effect one would expect an interaction effect of deregulation. In order to check whether the asset-liability interaction was altered due to deregulation specification (3.5) alters baseline specification (3.2) as follows

$$\begin{aligned}(3.2) \quad &+ \sum_{k=0}^{4} \chi_k \cdot \mathrm{RegQ}_{t-k} \cdot \Delta\log(\mathrm{Deposits}_{i,t-k}) \\ &+ \sum_{k=0}^{4} \omega_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \cdot \Delta\log(\mathrm{Deposits}_{i,t-k})\end{aligned} \tag{3.5}$$

This estimation will show how lending growth was affected by deposit growth differently when Regulation Q was in place. Finally, both level and interaction effects are estimated in a single model (3.6) by combining (3.4) and (3.5):

$$\begin{aligned}(3.2) \quad &+ \sum_{k=0}^{4} \psi_k \cdot \mathrm{RegQ}_{t-k} + \sum_{k=0}^{4} \chi_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \\ &+ \sum_{k=0}^{4} \chi_k \cdot \mathrm{RegQ}_{t-k} \cdot \Delta\log(\mathrm{Deposits}_{i,t-k}) \\ &+ \sum_{k=0}^{4} \omega_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \cdot \Delta\log(\mathrm{Deposits}_{i,t-k})\end{aligned} \tag{3.6}$$

In section 3.4.1 this chapter presents and discusses estimation results of these three empirical models (3.4), (3.5) and (3.6) for two different proxies for deposit deregulation (RegQ_t and RegQ_t^{Binary}) as well as baseline regression (3.2).

Moving beyond the impact of deregulation on the asset-liability interaction we now outline how to estimate changes in transmission from monetary policy to individual lending growth.

3.3.2 Lending Growth and Monetary Policy

This chapter uses a one-step regression of lending growth on the change in the federal funds rate controlling for other important bank level and macroeconomic lending determinants. This contrast with other methods such as running regressions by different size classes whilst assuming homogenous loan demand or using a two-step procedure as in Kashyap and Stein (2000) and is more closely related to Ashcraft's (2006) approach. The specification below includes the critique of Ashcraft (2006) with respect to structural change, building on macroeconomic studies of the effect of deregulation by Duca (1995). Lending growth regression specification (3.7) below explicitly allows for heterogenous loan demand shifts by interacting bank characteristics with both real and nominal macroeconomic factors as lending growth is more sensitive to real output growth and prices for larger banks and for more liquid banks. Table 3.3 on page 137 illustrates this. For instance, rows 2 and 5 show estimates for the real and nominal cyclicality for lending growth of a bank that is one standard deviation above the sample mean in terms of its liquidity position, but otherwise "representative" in terms of its characteristics (i.e. being at the sample mean). The estimation is done for a number of different specifications that will be detailed below. Note how loan demand of banks that are more liquid is much more responsive to aggregate real and nominal controls. This is important for inferences about different lending responses to policy across different banking characteristics.

The baseline specification (3.7) without controlling for regulatory changes is

$$\begin{aligned} \Delta\log(L_{i,t}) &= \alpha + \sum_{k=1}^{4} \rho_k \cdot \Delta\log(L_{i,t-k}) + \sum_{k=0}^{4} \gamma_k \cdot \mathbf{M}_{t-k} \\ &+ \upsilon \cdot B_{i,t-1} + \sum_{k=0}^{4} \tau_k \cdot B^{*}_{i,t-1} \times \mathbf{M}^{*'}_{t-k} \\ &+ \mu \cdot \text{time}_t + \sum_{k=1}^{3} \theta_k \cdot \text{Quarter}_{k,t} + \varepsilon_{i,t} \end{aligned} \tag{3.7}$$

As before, $B_{i,t} = \left[\text{Size}_{i,t}, \text{Capital}_{i,t}, \text{Liquidity}_{i,t}\right]$ is the list of the three bank characteristics constructed as described in section 3.3.1 in equations (3.3) on page 130. $\mathbf{M}_t = [\Delta \text{ff}_t, \Delta\log(p_t), \Delta\log(y_t)]'$ are the macroeconomic controls, GDP growth, nominal factors as proxied by changes in the chain-indexed GDP deflator as well as monetary policy computed as the end-of-quarter difference in the level of the federal funds rate.

Loan demand shifts are not homogenous across various bank characteristics as was argued earlier and showed explicitly in table 3.3 on page 137. Hence, bank characteristics and non-monetary macroeconomic controls are also interacted with each other in order to account for differences in loan demand sensitivity that come with different characteristics using transformations of $B_{i,t}$ and $\mathbf{M}_t$:

$$\begin{aligned} B^{*}_{i,t} &= \left[\text{Size}_{i,t}, \text{Capital}_{i,t}, \text{Liquidity}_{i,t}\right] \otimes [1,1,1] \quad \text{and} \\ \mathbf{M}^{*}_{t} &= \left([1,1,1] \otimes [\Delta \text{ff}_t, \Delta\log(p_t), \Delta\log(y_t)]\right)' \end{aligned}$$

that is all the characteristics are interacted with a monetary policy indicator, and indicators of real and nominal aggregate factors. As is standard in the literature a time trend and seasonal dummies are included in the specification.

For testing how the phasing out of deposit rate regulation impacts on the lending channel the baseline specification (3.7) will have to be modified. First, the baseline specification (3.7) will be augmented by including a Regulation Q bindingness proxy (RegQ_t) in levels as in (3.8)

$$(3.7) \quad + \quad \sum_{k=0}^{4} \psi_k \cdot \mathrm{RegQ}_{t-k} + \sum_{k=0}^{4} \varphi_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \tag{3.8}$$

As in the lending-deposit growth regressions the Regulation Q proxy is also interacted with the individual bank level characteristics in order to the stability of the role of bank characteristics. This is to account for the possibility that smaller or less well-capitalized banks are affected by Regulation Q differently from larger or well-capitalized banks. This first augmented estimate will show how mean lending growth was affected by Regulation Q directly. Naturally, both measures of financial intermediation RegQ_t and RegQ_t^{Binary} are exogenous to each individual bank in the sample in the same way that macroeconomic controls like prices or real growth are exogenous to each bank level observation. Second, in order to explore changes in the *transmission of monetary policy* to individual bank lending interaction effect of deregulation are included in specification (3.9):

$$\begin{aligned} (3.7) \quad + & \quad \sum_{k=0}^{4} \chi_k \cdot \mathrm{RegQ}_{t-k} \cdot \Delta \mathrm{ff}_{t-k} \\ + & \quad \sum_{k=0}^{4} \omega_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \cdot \Delta \mathrm{ff}_{t-k} \end{aligned} \tag{3.9}$$

This estimation will show how lending growth is affected by monetary policy when Regulation Q was in place. Contrasting (3.9) and the baseline specification (3.7) will also illustrate how the direct coefficient estimates of the impact of monetary policy on equilibrium lending growth differ if Regulation Q proxies are introduced. Finally, both level and interaction effects are estimated in a single model (3.10) by combining (3.8) and (3.9):

$$\begin{aligned}
(3.7) \quad &+ \sum_{k=0}^{4} \psi_k \cdot \mathrm{RegQ}_{t-k} + \sum_{k=0}^{4} \chi_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \\
&+ \sum_{k=0}^{4} \chi_k \cdot \mathrm{RegQ}_{t-k} \cdot \Delta\mathrm{ff}_{t-k} \\
&+ \sum_{k=0}^{4} \omega_k \cdot B_{i,t-1} \cdot \mathrm{RegQ}_{t-k} \cdot \Delta\mathrm{ff}_{t-k}
\end{aligned} \tag{3.10}$$

Estimation results are reported and discussed for the baseline regression (3.7) and the three empirical models (3.8), (3.9) and (3.10) for two different proxies, one discrete and one continuous, for the phasing out of Regulation Q (RegQ_t^{Binary} and RegQ_t in section 3.4.2.

3.3.3 Bank Level Data

The source for all bank-level variables is the Call Reports of Condition and Income where all insured banks operating in the United States submit their reports on a quarterly basis to the Federal Reserve. The data are publicly available for download from the Federal Reserve Bank of Chicago. This study uses data spanning from 1976:1 - 2010:2. This contrast with the data panel for the first chapter that ended

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulation Q controls							
1.1. bindingness level	no	yes	no	no	no	yes	no
1.2. binary indicator level	no	no	yes	no	no	no	yes
2.1. bindingness interaction	no	no	no	yes	no	yes	no
2.2. binary indicator interaction	no	no	no	no	yes	no	yes
	Real Factors						
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta\log(y_{t-k})$	0.1614***	0.2017***	0.1494***	0.1896***	0.1254***	0.1920***	0.1271***
	(0.0094)	(0.0098)	(0.0094)	(0.0104)	(0.0097)	(0.0104)	(0.0097)
$\sum_{k=0}^{4} \text{Liquidity}_{i,t-1} \cdot \Delta\log(y_{t-k})$	0.1115***	0.1176***	0.1439***	0.1117***	0.1374***	0.1187***	0.1505***
	(0.0097)	(0.0098)	(0.0099)	(0.0103)	(0.0102)	(0.0104)	(0.0102)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta\log(y_{t-k})$	0.0174*	0.0282***	-0.0196*	0.0248***	-0.0149	0.0338***	-0.0144
	(0.0110)	(0.0113)	(0.0112)	(0.0118)	(0.0115)	(0.0118)	(0.0114)
	Nominal Factors						
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta\log(p_{t-k})$	-0.0593***	0.1507***	0.1410***	0.0990***	0.1761***	0.0920***	0.1627***
	(0.0085)	(0.0119)	(0.0170)	(0.0129)	(0.0177)	(0.0129)	(0.0176)
$\sum_{k=0}^{4} \text{Liquidity}_{i,t-1} \cdot \Delta\log(p_{t-k})$	0.1254***	0.0515***	-0.0348*	0.0743***	0.1038***	0.0916***	0.0708***
	(0.0106)	(0.0143)	(0.0192)	(0.0152)	(0.0198)	(0.0152)	(0.0197)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta\log(p_{t-k})$	0.0305***	0.1519***	0.3639***	0.1767***	0.2831***	0.1369***	0.2750***
	(0.0113)	(0.0155)	(0.0205)	(0.0169)	(0.0215)	(0.0168)	(0.0211)

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 3.3: Indicators for Non-Homogenous Demand Shifts

in 1999. As outlined earlier the main reasons for that are the comparability of the results with Ashcraft's (2006) original paper and the limitations imposed by the lag in the publication of the Greenbook.

The data were compiled based on the notes by Kashyap and Stein (2000) augmented by Den Haan, Sumner and Yamashiro (2002) in order to construct consistent bank characteristics time-series as the definition of variables collected varies through time. In particular, implausible negative and zero entries have been removed as well as banks that were involved in mergers one quarter before or after. The particular variables used in the estimates below are loans, size as measured by assets, liquidity as the sum of cash and securities on the balance sheet as a share of assets as well as capitalization as measured by the capital-asset ratio. A more detailed discussion of the data is given in section 2.3.4 on page 63 of chapter 2.

Table 3.5 on page 143 summarizes balance sheets for banks of different sizes as in Kashyap and Stein (2000). The two panels correspond to the start and end points of the sample. As in Kashyap and Stein (2000) data on seven different size categories is reported: all banks, banks below the 75th percentile by asset size, banks between the 75th and 90th percentile by asset size, bank between the 90th and 95th percentile, banks between the 95th and 98th percentile, banks between the 98th and 99th percentile, and banks above the 99th percentile. The table lists the number of banks in each size category, the mean and median assets within each size category and the fraction of assets that each size category contains. It then summarizes asset side items that are of particular importance: cash, securities, Federal Funds Lent, total loans and its subcomponents - real estate loans, commercial and industrial loans (unavailable for 2010:2) as well as individual household loans. The table also list major liability side items such as total deposits and its break-down into transaction deposits, non-transaction deposits including large (i.e. >US$100k) non-transaction deposits (term deposit as opposed to a cheque account). Finally, as a measure of portfolio risk the last row contains loan loss provisions which are unavailable for the smallest category of banks in the first quarter of the sample.

A number of patterns emerge. The number of banks has halved over the last decades from about 15,000 to around 7,400. This implies a considerable degree of consolidation. In 2010 the top one percent of banks control around three quarters of total assets whereas in 1976 they only controlled about one half. The top ten percent now control 91 percent of all assets (1976: 79 percent). These two cross-sectional snapshots mirror the time-series illustration in figure 3.1 on page 126 discussed in section 3.2.3 in the context of banking sector consolidation. On the investment (or asset) side larger banks hold larger amount of cash, but fewer securities. Overall, looking at securities and cash combined, smaller banks appear to have a more liquid balance sheet.

Table 3.4 on page 142 presents the correlation of the scaled and normalized bank characteristics for the full sample, the beginning, the end and the midpoint of sample. Note first how bank size and bank liquidity are negatively correlated indicating that larger banks hold less liquidity. This is also supported by table 3.5 in the cross-sectional as well as temporal dimension if one compares the first (1976:1) and the last quarter (2010:2) of the sample. The negative correlation between bank size and liquidity has become stronger over time with the increase coinciding with the phasing out of Regulation Q as illustrated by figure 3.2 on page 141 that plots three time-series of the within-quarter cross-sectional size-liquidity, size-capitalization and capitalization-liquidity correlation.[6] Second, while the size-liquidity correlation has become more negative over time the size-capitalization correlation has become less negative. So the fact that larger banks hold less liquid balance sheets has become more entrenched. Larger banks are still less likely to be well-capitalized, but this tendency has decline. From eye-balling the correlation time-series in figure 3.2 one could infer a mean gradual change in the correlation starting when Regulation Q was eventually phased out in 1982 until 1986. Since 1986 the correlations have (roughly) stabilized. While one cannot exclude the possibility that other factors like financial or legislative changes outside the commercial banking sector have caused these structural shifts, in terms of temporal coincidence, the only important nationwide *legislative* changes was the abolition of Regulation Q as was discussed earlier and illustrated in table 3.1 on page 122. Clearly, one danger is that Regulation Q may serve as a 'catch-all' for general structural changes that are independent of deposit interest rate deregulation. In order to avoid confounding such factors section 3.3.5 develops two different indicators of the bindingness of Regulation Q.

3.3.4 Macroeconomic Data

In order to control for bank level responses to changes in nominal and real macroeconomic conditions that may drive loan demand regression estimates include annualized contemporary and lagged output and price growth rates. The measure

[6]Shaded areas represent NBER recessions.

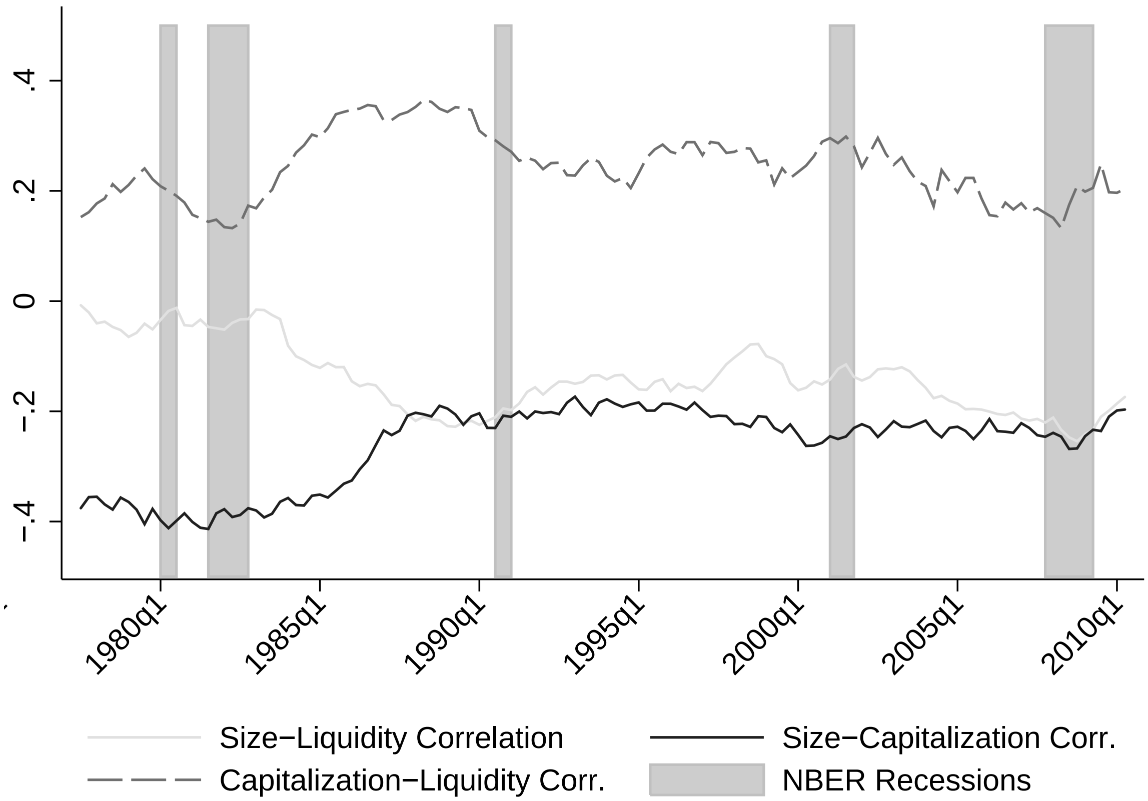


Figure 3.2: Bank Characteristics - Correlations Over Time

1977:1 - 2010:2	Observations: 1,296,659		
	Size	Liquidity	Capitalization
Size	1		
Liquidity	-0.1284	1	
Capitalization	-0.2524	0.1763	1

1977:1	Observations: 13,865		
	Size	Liquidity	Capitalization
Size	1		
Liquidity	-0.0075	1	
Capitalization	-0.3757	0.1525	1

1994:1	Observations: 9,829		
	Size	Liquidity	Capitalization
Size	1		
Liquidity	-0.1421	1	
Capitalization	-0.1782	0.2276	1

2010:2	Observations: 6,079		
	Size	Liquidity	Capitalization
Size	1		
Liquidity	-0.1739	1	
Capitalization	-0.1967	0.2037	1

Table 3.4: Bank Characteristics Correlations

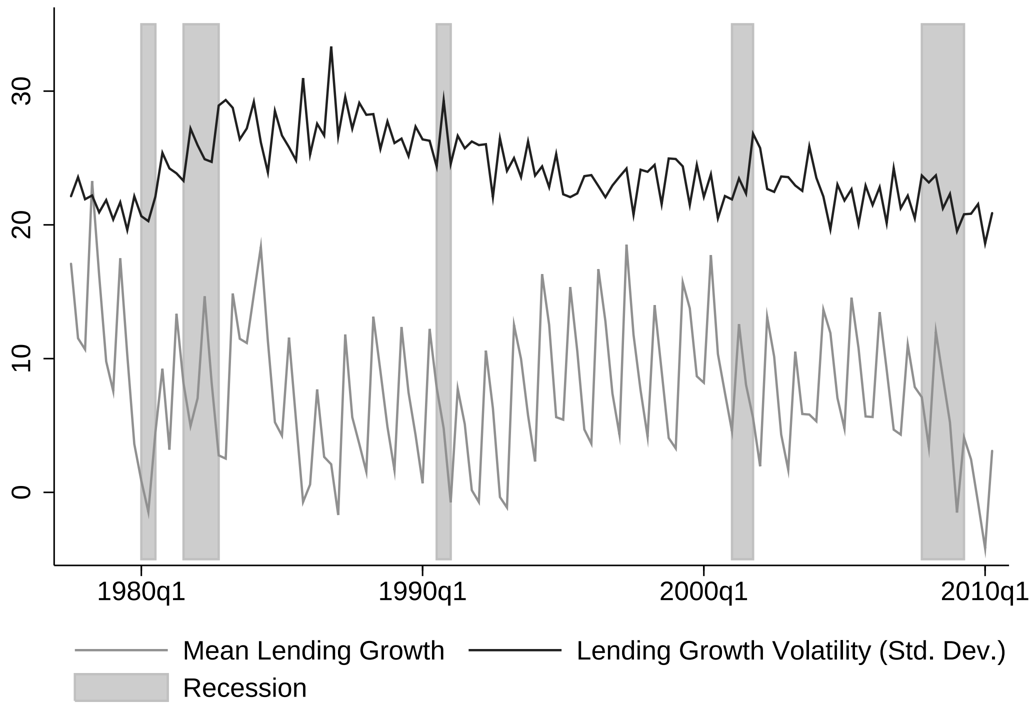
employed as the index of real activity is annualized quarterly real GDP growth ($\Delta\log(y_t) = 400 \cdot \Delta\log(GDP_t)$) from the St Louis FRED database (series: GDPC96). Nominal changes are proxied by annualized changes ($\Delta\log(p_t) = 400 \cdot \Delta\log(P_t)$) in the quarterly chain-type GDP deflator price index (St Louis FRED database series: GDPCTPI). Whilst in chapter 2 the choice of the macroeconomic controls other than the monetary policy was made to ensure comparability with Ashcraft (2006), this chapter also attempts to disentangle real and nominal effects by including real rather than nominal GDP growth in the lending regressions. Nothing of substance changes when either measures are used.

In order to assess the direct impact of monetary policy this chapter uses the end-of-quarter difference in the level of the federal funds rate. This follows the convention of the bank level data which reports the balance sheet variables at the end-of-quarter

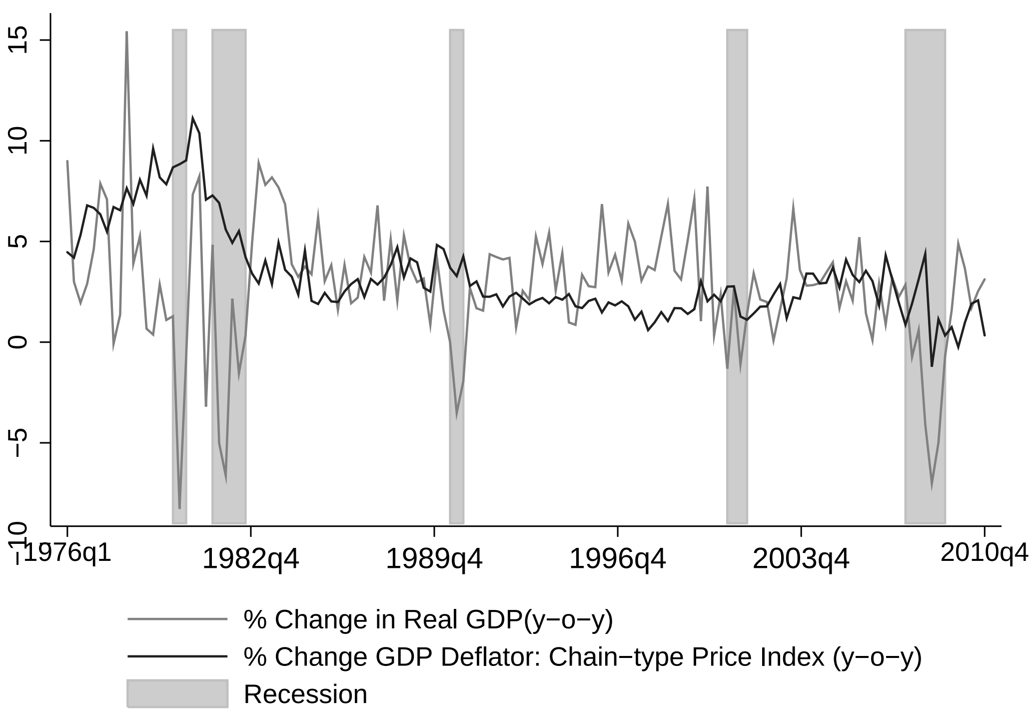
End-of-Quarter	1976:1						
Percentile	All banks	$< 75^{th}$	$75^{th} - 90^{th}$	$90^{th} - 95^{th}$	$96^{th} - 98^{th}$	99^{th}	100^{th}
Number of Banks	14,809	11,107	2,222	740	444	148	148
Mean Assets ($1,000,000s)	80.3	13.1	49.9	110.7	269.5	676.0	4,268.6
Median Assets ($1,000,000s)	15.8	11.2	47.2	105.6	246.8	671.9	1,705.2
Fraction of total system assets	100.00	12.19	9.33	6.89	10.06	8.41	53.12
Cash	9.33	9.30	8.83	9.68	10.11	9.73	14.59
Securities	32.75	33.42	32.10	30.63	28.54	26.42	21.92
Federal Funds Lent	4.90	5.23	3.97	3.69	4.17	3.85	3.51
Total Domestic Loans	50.28	49.46	52.02	52.92	53.65	56.91	56.02
· Real Estate Loans	16.16	15.76	18.36	18.08	15.00	12.72	10.28
· C&I Loans	10.50	9.61	12.60	14.25	13.89	12.31	14.72
· Individual Loans	14.07	14.06	15.44	13.31	12.44	9.25	7.89
Total Deposits	89.36	89.55	89.74	89.00	87.21	85.30	82.48
· Transaction Deposits	31.02	32.05	28.85	27.53	26.81	23.69	23.99
· Non-Transaction Deposits	58.26	57.49	60.89	61.47	60.34	60.98	51.13
· Time Deposits (>$100k)	7.09	6.07	9.16	11.39	12.02	9.97	12.58
Federal Funds Borrowed	0.72	0.34	0.96	1.85	3.56	5.18	7.20
Subordinated Debt	0.19	0.13	0.30	0.38	0.42	0.46	0.60
Other Liabilities	0.75	0.61	1.09	1.15	1.24	1.79	1.73
Equity	8.81	9.26	7.71	7.33	7.20	6.72	6.25
Loan Loss Provisions	0.07				0.07	0.07	0.09
End-of-Quarter	2010:2						
Percentile	All banks	$< 75^{th}$	$75^{th} - 90^{th}$	$90^{th} - 95^{th}$	$96^{th} - 98^{th}$	99^{th}	100^{th}
Number of Banks	7,399	5,550	1,110	370	222	74	73
Mean Assets ($1,000,000s)	2,040.8	126.7	544.2	1,298.6	4,196.9	13,999.1	155,400
Median Assets ($1,000,000s)	152.4	105.9	508.0	1,221.5	3,485.6	13,467.6	65,746
Fraction of total system assets	100.00	4.66	4.00	3.18	6.17	6.86	75.13
Cash	9.22	9.53	7.46	7.80	10.72	11.52	12.52
Securities	20.30	20.82	18.98	20.11	17.24	17.84	13.86
Federal Funds Lent	2.04	2.66	0.34	0.69	0.67	2.95	5.37
Total Domestic Loans	62.52	61.98	66.54	64.37	62.20	51.19	45.01
· Real Estate Loans	44.16	43.20	50.95	47.67	40.96	29.40	19.74
· Individual Loans	3.99	4.06	3.02	3.01	5.43	7.69	15.69
Total Deposits	82.03	82.78	81.63	79.99	75.56	66.36	62.99
· Transaction Deposits	19.48	22.27	11.73	8.98	8.86	5.97	5.64
· Non-Transaction Deposits	61.44	59.89	67.45	69.36	61.27	56.31	53.22
· Time Deposits (>$100k)	17.19	17.25	17.00	16.27	15.29	20.03	23.55
Federal Funds Borrowed	5.46	2.11	4.15	2.86	8.80	9.60	12.04
Subordinated Debt	0.04	0.01	0.08	0.08	0.15	0.41	1.47
Other Liabilities	0.91	0.85	0.76	1.31	1.65	3.97	2.43
Equity	11.90	12.31	10.31	10.48	11.14	12.84	13.62
Loan Loss Provisions	0.32	0.27	0.39	0.48	0.66	0.77	0.89

Source: Author's own calculations based on the Federal Reserve's Call Reports on Condition and Income.

Table 3.5: Balance Sheet by Size Class 1976:1 and 2010:2



(a) Lending Growth - Cross-Sectional Mean and Dispersion over Time



(b) Macroeconomic Controls - Real Growth and Price Level Changes

Figure 3.3: Lending Growth and Macroeconomic Controls

level. Considering the issue of the endogeneity of such measures of monetary policy was the independent contribution of chapter 2 and was discussed in much detail in section 2.2.3 on page 39.

3.3.5 Regulatory Data

The abolition of Regulation Q was part of the 1980 Depository Institutions Deregulation and Monetary Control Act (DIDMCA).[7] DIDMCA phased out government-imposed interest rate ceilings on banks and other institutions and removed competitive inequities among them. Prior to the passing of DIDMCA, Regulation Q limited the rate of interest that could be paid on time deposits by banks and savings and loans. The maximum rate allowed was 5.25 percent annually for banks and 5.0 percent annually for savings and loans.

In assessing the effects of deregulation the chapter employs two different measures of financial disintermediation. First, a binary dummy ($RegQ_t^{Binary}$) is constructed that is unity if Regulation Q was binding and zero otherwise. Second, in addition to this discrete measure of disintermediation a continuous variable ($RegQ_t$) measures the degree bindingness of Regulation Q. The value of this variable equals the quarterly average spread between the three-year Treasury rate and the rate ceiling on three-year small time deposits when the ceiling was binding, and zero otherwise (see Duca, 1998). Table 3.6 on page 146 shows time-series of these two measures. One can see that the continuous measure was particularly finding when inflation expectations took off in 1978.

[7]This section draws on the description of regulatory change in Allen and Wilhelm (1988) and Berger, Kashyap and Scalise (1995).

Quarter	$RegQ_t$	$RegQ_t^{Binary}$	Quarter	$RegQ_t$	$RegQ_t^{Binary}$
1975:1	0.40	1.00	1979:1	2.89	1.00
1975:2	0.94	1.00	1979:2	2.77	1.00
1975:3	1.56	1.00	1979:3	1.65	1.00
1975:4	1.07	1.00	1979:4	1.25	1.00
1976:1	0.56	1.00	1980:1	1.27	1.00
1976:2	0.64	1.00	1980:2	0.09	1.00
1976:3	0.38	1.00	1980:3	0.17	1.00
1976:4	0.00	0.00	1980:4	1.24	1.00
1977:1	0.00	0.00	1981:1	1.64	1.00
1977:2	0.02	1.00	1981:2	2.74	1.00
1977:3	0.21	1.00	1981:3	1.30	1.00
1977:4	0.74	1.00	1981:4	0.25	1.00
1978:1	1.16	1.00	1982:1	0.25	1.00
1978:2	1.57	1.00	1982:2	0.08	1.00
1978:3	1.93	1.00			
1978:4	2.50	1.00			

Table 3.6: Time-Series of the Regulation Q Indicator and Bindingness Variable

Not controlling for interest rate ceilings on deposits whilst using the full banking sample available may lead to estimating the pre-deregulation sensitivity of loan growth to monetary policy as too low and the post-deregulation as too high. Thus, full sample estimates may imply stronger response of lending to policy.

One may argue that one way of dealing with the issue is to leave out the relevant period from the sample. However, this may not necessarily be prudent for a number of reasons. First of all, there is a lot of variability at the bank and macroeconomic level in the earlier part of the sample. Second, it seems that the business cycle and hence the interest rate cycle has expanded ("Great Moderation") and indeed the most recent business and interest rate cycle were rather long inducing different estimates especially of lending dynamics. Third, given that the number of banks has literally halved over the last three and a half decades the impact of the earlier sample period is quantitatively more important its contribution to the estimation results and interpretation prominent previous studies on the lending channel such as Kashyap and Stein (2000), Kishan and Opiela (2000) and Ashcraft (2006). So correct estimates of the lending channel require an inclusion of the earlier period for comparability with previous studies.

Furthermore, this chapter estimates how the banking structure matters for the regulatory impacts. It also does not confine itself to just one characteristic and fully accounts for a differential regulatory impact depending on banking size, liquidity and capitalization. The importance of that in the light of non-homogenous loan demand shifts is illustrated in table 3.3 on page 137 and was discussed in detail below in section 3.2.1.

This section has justified the specific lending regression that is the core of the chapter and described the data. The subsequent section 3.4 presents and interprets the estimation results on bank level financial constraints and lending growth responses to monetary policy.

3.4 Empirical Models and Results

This section contains the core results of this chapter and is structured as follows. First, section 3.4.1 presents evidence of how the sensitivity of lending growth to cash flow has altered over the last decades illustrating the huge structural shifts in U.S. commercial banking. The section analyzes how balance sheet characteristics mitigate the sensitivity of lending growth to deposit growth providing evidence of the existence of a lending channel. It also explores the impact of deposit deregulation on the sensitivity of lending growth to deposit growth. Second, section 3.4.2 examines how changes in monetary policy as measured by the change in the federal funds rate impacts on lending growth again controlling for bank level characteristics that are commonly taken to proxy for bank level financial constraints. It analyzes how policy transmission through to lending at the individual bank level has changed due to the abolition of Regulation Q. Third, section 3.4.3 discusses the role of the individual bank level characteristics, in particular their role before and after deregulation. Finally, section 3.4.4 conducts a number of robustness exercises for the main results to ensure they are not driven by the choice of macroeconomic interactions, lag structures, or estimation method employed in the analysis.

3.4.1 Sensitivity of Investments to Cash Flow

Structural Change

Section 3.2 pointed to a number of financial, technological and regulatory changes in the U.S. banking system since 1976.[8] The aim here is to document changing financial constraints through time in order to motivate the subsequent more detailed analysis. Table 3.7 on page 150 provides coefficients and standard errors from OLS estimation of the sensitivity of lending growth with respect to deposit growth for different sub-periods of the sample. The specification is the one reported in model (3.2) on page 129 and is repeated for convenience at the top of table 3.7. The table lists estimates for (1) the full sample and three subperiods (2) 1976 to 1985, (3) 1986 to 1999 and (4) 2000 to 2010. Specifically, it reports the joint significance of the β_k and ϕ_k. As in all subsequent estimations standard errors are in brackets below the respective coefficient estimates. Standard errors have been corrected for heteroskedasticity and clustering at the individual bank level. Following Ashcraft (2006) each regression is initially estimated by OLS, and then the DFITS statistic described in Walsh and Kuh (1977) is used to identify and eliminate influential observations. DFITS is the scaled difference between the predicted values for the i^{th} observation when the regression is estimated with and without the i^{th} observation. This eliminates about 5% of observations depending on each specification. However, it does not significantly alter the estimation results.

The first row of table 3.7 reports the sensitivity of lending growth to contempo-

[8]For a detailed survey on the evolution of the U.S. commercial banking system until 1994 see Berger, Kashyap and Scalise (1995) or for a more recent, yet less technical survey see Hendrickson (2011, chapter 6).

$$\begin{aligned}\Delta\log(L_{i,t}) &= \alpha + \textstyle\sum_{k=1}^{4} \rho_k \cdot \Delta\log L_{i,t-k} + \sum_{k=0}^{4} \gamma_k \cdot \mathbf{M}_{t-k} \\ &+ \quad \upsilon \cdot B_{i,t-1} + \textstyle\sum_{k=0}^{4} \tau_k \cdot B^{*}_{i,t-1} \times \mathbf{M}^{*\prime}_{t-k} \\ &+ \quad \textstyle\sum_{k=0}^{4} \beta_k \cdot \Delta\log(\text{Deposits}_{i,t-k}) + \sum_{k=0}^{4} \phi_k \cdot B_{i,t-1} \cdot \Delta\log(\text{Deposits}_{i,t-k}) \\ &+ \quad \Theta \cdot time_t + \textstyle\sum_{j=1}^{3} \rho_j \cdot Quarter_j + \varepsilon_{i,t}\end{aligned}$$

$\Delta\log(L_{i,t})$	(1) Full Sample	(2) 1976:1 - 1985:4	(3) 1986:1 - 1999:4	(4) 2000:1 - 2010:2
$\sum_{k=0}^{4} \Delta\text{Deposits}_{i,t-k}$	0.4369***	0.5999***	0.4035***	0.3086***
	(0.0027)	(0.0045)	(0.0039)	(0.0054)
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta\text{Deposits}_{i,t-k}$	-0.0355***	0.0024	-0.0394***	-0.0253***
	(0.0021)	(0.0035)	(0.0030)	(0.0040)
$\sum_{k=0}^{4} \text{Liquidity}_{i,t-1} \cdot \Delta\text{Deposits}_{i,t-k}$	-0.0298***	-0.0566***	-0.0373***	-0.0374***
	(0.0020)	(0.0041)	(0.0029)	(0.0034)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta\text{Deposits}_{i,t-k}$	-0.0563***	-0.0405***	-0.0536***	-0.0239***
	(0.0021)	(0.0042)	(0.0029)	(0.0037)
R^2	0.2487	0.2146	0.2805	0.2792
Observations	1,134,548	367,456	515,833	250,258

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 3.7: Lending Growth and Deposit Growth - Structural Changes

raneous and four lags of deposit growth that is the joint coefficient for $\sum_{k=0}^{4}\beta_k$. A first glance at the first row illustrate quite well the changing nature of U.S. commercial banking, in particular, the evolution of its bank level financial constraints: They seem to ease over time at a declining rate as $\sum_{k=0}^{4}\beta_k$ declines within the sample.

When considering the lending growth responsiveness to deposit growth ($\sum_{k=0}^{4}\beta_k$) note that, in the absence of financial frictions and with uncorrelated liquidity shocks on the asset and liability side, investments on the assets side (lending growth) should be independent from the way individual banks fund themselves on the liability side (deposit growth). So if the Modigliani and Miller (1958) proposition were valid in this context the joint significance of the $\beta_k s$ would be zero. Yet, estimates are positive and highly significant. The coefficient estimates decline from 0.60 in the earlier period, to 0.40 in the second and 0.31 in the final sub-period. These results are in line with those reported by Ashcraft (2006). To summarize, given the model specification controls for common deposit and loan demand drivers the cross-sectional variation suggests banks are likely to have been financially constrained by their deposit growth but that this dependence has markedly decreased over the last decades.

Further examination of variations in the dependence of bank level loan growth on deposit growth due to bank specific characteristics that proxy for bank level financial constraints like size, liquidity or capitalization suggests that each of these three have mitigated the sensitivity of lending growth to deposit growth (ϕ_k). The second, third and fourth row report the joint significance of elements of the three-dimensional parameter vectors ϕ_k, that is the joint significance of the interaction of size, liquidity and capitalization with deposit growth for a bank that is one standard deviation above the mean for the respective characteristic. The second row reports $\sum_{k=0}^{4} \phi_k^{Assets}$, the third row $\sum_{k=0}^{4} \phi_k^{Liquidity}$ and the fourth row $\sum_{k=0}^{4} \phi_k^{Capitalization}$. These measure how each of the three bank characteristics (size, liquidity, capitalization) affect the impact of deposit growth on lending growth.

Consider two examples for illustration. For the full sample estimate, that is column (1) of table 3.7, a bank that is at the mean of all characteristics will expand its lending by 0.4369 percent in response to a one percent increase in deposits. In contrast, a representative bank that is otherwise exactly at the mean of all characteristics, yet one standard deviation above the mean in terms of its size, bank level lending growth will be 0.0355 less effected by a one percent change in deposits. This means its lending growth is only changing by 0.4014 percent in response to a one percent increase in deposits. As a further example, for the second sub-period (1986-1999) the lending growth of a bank that is one standard deviation above the mean in terms of its capitalization is 0.0536 less responsive to deposit growth than a comparable bank at the sample mean of the capitalization ratio. Given that a bank that is at the mean for all three characteristics has a lending growth to deposit growth sensitivity of 0.4035, a bank one standard deviation better capitalized but with a mean liquidity position and of mean size reduces its lending by one-eight less, that is by about 0.35 percent per one percent increase in deposits. This is significant evidence of bank level financial constraints.

Similar patterns emerge across all three characteristics and sample periods. In eleven out of twelve cases the larger the characteristic the less is the impact of deposit growth on lending growth. So there is evidence of shielding effects from these three proxies for bank level financial constraints. The only outlier is the bank characteristic size as measured by assets during the first sub-period (1976-1985). One interpretation of this is in terms of financial disintermediation due to deposit regulation. When deposits interest rate ceilings were regulated even small banks had a substantial degree of monopsony power over their depositors, potentially augmented by location restrictions, that slowly dissipated due to the market-based innovations that substituted for bank deposits.

To put this and the subsequent results tables in perspective it is worthwhile to note that mean lending growth at the individual bank level over the whole sample is 7.70 percent. The lending growth distribution is also skewed (25%-percentile: -4.60 percent, 50%-percentile (median): 6.95 percent, 75%-percentile: 19.19 percent).

One may argue that both, lending growth *and* deposit growth are determined by the same drivers and if one controlled for such omitted variables the strong correlation would disappear. First, regression specification (3.2) already includes the most important of these common drivers like real GDP growth and price changes.[9] Second, this specification also controls for non-homogenous loan demand shifts by interacting bank characteristics and real as well as nominal macroeconomic controls, taking into account systematic variations that are independent of deposit growth but potentially omitted in this specification. Third, it is the variation across the bank level financial constraints that matter most for the argument that the lending channel is operative. And all three bank level interactions between deposit growth and bank characteristics are highly significant and positive for all sample periods

[9]Controlling for the Federal Fund Rate does not significantly alter the results.

with the aforementioned single exception of size in the early period.

Regulation Q

The impact of the abolition of Regulation Q on the asset-liability dependencies of individual banks is estimated by a number of variations of regression (3.2) as discussed in section 3.3.1. The results are displayed in table 3.8 on page 155. The first column reiterates the full sample estimate from table 3.7 page 150 without controlling for regulatory changes as the baseline case. In order to evaluate the impact of financial disintermediation, first, the specification now includes the (continuous) degree of bindingness of Regulation Q as defined in section 3.2 and display in table 3.6 on page 146 in the second column (model 2). Second, the specification is augmented to include a binary indicator of whether or not regulation Q was binding (model 3). The empirical model 3.4 on page 131 is the basis for (2) and (3). Third, the model is specified with interactions between the continuous bindingness indicator with deposit growth (model 4) and the binary Regulation Q indicator (model 5), that is model 3.5 on page 132. Finally, empirical model 3.6 from page 132 is estimated. So the level *and* interactions of the continuous (model 6) and binary indicator (model 7) are included. These six models augmented by regulatory proxies may then be compared to the baseline model (1) without any regulatory controls.

The first point to note is that almost all previously estimated coefficients remain virtually unaltered from the benchmark specification. The one notable exception is the impact of the price level when a binary Regulation Q dummy RegQ_t^{Binary} is introduced in levels. This may be due to the higher degree of nominal uncertainty

$\Delta log(L_{i,t})$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulation Q Controls:							
1.1. Bindingness level	no	yes	no	no	no	yes	no
1.2. Binary indicator level	no	no	yes	no	no	no	yes
2.1. Bindingness interaction	no	no	no	yes	no	yes	no
2.2. Binary indicator interaction	no	no	no	no	yes	no	yes
$\sum_{k=0}^{4} \Delta \log(y_{t-k})$	0.9868***	0.9548***	1.0920***	0.9777***	1.0007***	0.9607***	1.0881***
	(0.0098)	(0.0111)	(0.0106)	(0.0101)	(0.0100)	(0.0114)	(0.0107)
$\sum_{k=0}^{4} \Delta \log(p_{t-k})$	0.3793***	0.6006***	0.2592***	0.4187***	0.3169***	0.5993***	0.2769***
	(0.0121)	(0.0168)	(0.0208)	(0.0129)	(0.0133)	(0.0170)	(0.0210)
$\sum_{k=0}^{4} \Delta \text{Deposits}_{i,t-k}$	0.4369***	0.4354***	0.4348***	0.4433***	0.4305***	0.4368***	0.4317***
	(0.0027)	(0.0028)	(0.0028)	(0.0030)	(0.0031)	(0.0030)	(0.0031)
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta \text{Deposits}_{i,t-k}$	-0.0355***	-0.0354***	-0.0354***	-0.0325***	-0.0349***	-0.0320***	-0.0348***
	(0.0021)	(0.0021)	(0.0021)	(0.0023)	(0.0024)	(0.0023)	0.0024
$\sum_{k=0}^{4} \text{Liquidity}_{i,t-1} \cdot \Delta \text{Deposits}_{i,t-k}$	-0.0298***	-0.0302***	-0.0313***	-0.0314***	-0.0361***	-0.0324***	-0.0360***
	(0.0020)	(0.0021)	(0.0021)	(0.0022)	(0.0022)	(0.0022)	(0.0022)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta \text{Deposits}_{i,t-k}$	-0.0563***	-0.0550***	-0.0565***	-0.0554***	-0.0588***	-0.0553***	-0.0576***
	(0.0021)	(0.0021)	(0.0021)	(0.0023)	(0.0023)	(0.0023)	(0.0023)
$\sum_{k=0}^{4} \text{RegQ}_{t-k}$		-0.7687***				-0.7595***	
		(0.0538)				(0.0584)	
$\sum_{k=0}^{4} \text{RegQ}_{t-k} \cdot \Delta \text{Deposits}_{i,t-k}$				-0.0326***		-0.0032	
				(0.0025)		(0.0027)	
$\sum_{k=0}^{4} \text{RegQ}_{t-k}^{Binary}$			1.0030***				0.6130***
			(0.1119)				(0.1213)
$\sum_{k=0}^{4} \text{RegQ}_{t-k}^{Binary} \cdot \Delta \text{Deposits}_{i,t-k}$					0.0570***		0.0327***
					(0.0047)		(0.0050)
R^2	0.2487	0.2524	0.2514	0.2447	0.2461	0.2476	0.2484
Observations	1,134,548	1,134,567	1,133,562	1,137,384	1,136,304	1,137,393	1,135,325

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).
Full specification as in equation 3.2 on page 129.

Table 3.8: Lending Growth Deposit Growth Regressions

in the earlier sample period as *nominal* lending growth is defined as the dependent variable. When Regulation Q proxies are included estimation results show that the more binding Regulation Q (i.e. RegQ_t is higher) the smaller was lending growth. For instance, if short-term rates were one percent above the legislated deposit rate maximum lending growth was about 0.75 percent lower than otherwise. The likely underlying cause is that when short-term interest rates rise above the legal maximum deposit rates, some depositors move out of deposits because of the higher opportunity cost in terms of other comparable asset classes. Deposit holders shifting into other non-deposit assets as markets paying higher returns than regulated deposits forced banks to aggressively seek funding alternatives for their investments (i.e. loans). All else being equal and with increasing marginal cost to external finance this will induce lending growth to be lower, the more binding the deposit rate regulation. Of course, there are always shifts in assets across categories accompanying any rise in short-term rates, but here the shift is more pronounced around the legally defined fix thresholds. On the other hand, the binary dummy RegQ_t^{Binary} indicates that lending growth was generally higher during the disintermediation period, potentially due to the higher degree of nominal uncertainty.[10]

Examining the binary interactions more closely note that consistently, when Regulation Q was binding, that is RegQ_t^{Binary} is unity, the responsiveness of lending to deposit growth was much greater than when there was no disintermediation. In fact, specification (5) suggests, as high as 0.4812 compared to a mean of 0.4305. This is an indication that during the period of deposit rate regulation dependencies of

[10]These results is robust to including other and fewer lags of the continuous RegQ_t and binary RegQ_t^{Binary} indicators.

banks' balance sheet assets on liabilities were more than ten percent stronger than today. This full sample estimate thus supports and complements the sub-sample estimates of table 3.7. So interaction estimates involving RegQ_t^{Binary} indicate that financial frictions were mitigated by either by deregulation or other concurrent factors potentially weakening the lending channel by at least one tenth according to this measure. Moreover, estimates of the level effects of RegQ_t indicate that deregulation did have an impact over and beyond concurrent factors that may cast doubt on the interpretation of coefficients on RegQ_t^{Binary}.

To summarize, the empirical findings above indicate that deposit interest rate deregulation may have eased bank level financial constraints by up to ten percent, thus identifying one potential driver of the substantial decline in lending growth sensitivity to deposit growth over time documented in table 3.7 at the beginning of this section. Having established that the two different measures of disintermediation have a significant impact upon individual banks' lending decisions and, potentially, the asset-liability side interactions the subsequent section 3.4.2 turns to quantitative estimates of the changing impact of monetary policy on lending growth due to Regulation Q and the role of individual bank characteristics in that process.

3.4.2 Lending Regressions

Evidence for changes in bank level financial frictions justifies a detailed analysis of the sensitivity of lending growth with respect to changes in the federal funds rate as a measure of monetary policy. As in the lending growth deposit regressions in the previous section this section estimates variations of the baseline lending regression

(3.7) by introducing the two Regulation Q proxies described in section 3.3.5 in levels and as interactions with the monetary policy indicator.

Table 3.9 on page 159 provides estimates of the effects of monetary policy on loan growth. The benchmark model in table column (1) regresses the annualized quarterly growth rate of total loans on four lags of itself, normalized bank characteristics, contemporaneous and four quarterly lags of macroeconomic controls, their interaction with the scaled bank characteristics as well as time and seasonal controls. This lending growth regression (3.7) was already described in detail in section 3.3.2 and exact specification is repeated below for convenience:

$$\begin{aligned}
\Delta\log(L_{i,t}) &= \alpha + \sum_{k=1}^{4}\rho_k \cdot \Delta\log(L_{i,t-k}) + \sum_{k=0}^{4}\gamma_k \cdot \mathbf{M}_{t-k} \\
&+ \upsilon \cdot B_{i,t-1} + \sum_{k=0}^{4}\tau_k \cdot B^{*}_{i,t-1} \times \mathbf{M}^{*'}_{t-k} \\
&+ \mu \cdot \text{time}_t + \sum_{k=1}^{3}\theta_k \cdot \text{Quarter}_{k,t} + \varepsilon_{i,t}
\end{aligned} \tag{3.7}$$

In the benchmark regression model (1) the joint significance of the coefficients γ_j and τ_k from regression (3.7) are reported. A one percent increase in real GDP increases lending growth by 1.07 percent and a one percent increase in the general price level measured by a percentage change in the GDP deflator increases lending growth by 0.88 percent. Monetary tightening as measured by a one percent increase in the federal funds rate in this empirical specification would decrease lending by about 1.77 percent. It is puzzling that in contrast to estimation results using the

$\Delta log(L_{i,t})$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulation Q Controls:							
1.1. Bindingness level	no	yes	no	no	no	yes	no
1.2. Binary indicator level	no	no	yes	no	no	no	yes
2.1. Bindingness interaction	no	no	no	yes	no	yes	no
2.2. Binary indicator interaction	no	no	no	no	yes	no	yes
$\sum_{k=0}^{4} \Delta\log(y_{t-k})$	1.0735***	1.0606***	1.1633***	0.9378***	0.9718***	0.9993***	1.0555***
	(0.0108)	(0.0127)	(0.0116)	(0.0118)	(0.0113)	(0.0136)	(0.0121)
$\sum_{k=0}^{4} \Delta\log(p_{t-k})$	0.8837***	0.9554***	0.5583***	1.1045***	1.0696***	1.0729***	0.6438***
	(0.0154)	(0.0187)	(0.0224)	(0.0208)	(0.0160)	(0.0223)	(0.0227)
$\sum_{k=0}^{4} \Delta r_{t-k}$	-1.7676***	-1.6448***	-1.8313***	-0.8645***	-0.4677***	-0.8028***	-0.5793***
	(0.0431)	(0.0470)	(0.0458)	(0.0519)	(0.0526)	(0.0529)	(0.0544)
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta r_{t-k}$	0.0312	0.1515***	0.1700***	0.2102***	0.3271***	0.2004***	0.3284***
	(0.0415)	(0.0420)	(0.0428)	(0.0472)	(0.0506)	(0.0475)	(0.0502)
$\sum_{k=0}^{4} \text{Liquidity}_{i,t-1} \cdot \Delta r_{t-k}$	-0.1749***	-0.2456***	-0.3065***	-0.0830*	0.0256	-0.0718	-0.0528
	(0.0446)	(0.0454)	(0.0461)	(0.0490)	(0.0510)	(0.0492)	(0.0510)
$\sum_{k=0}^{4} \text{Capitalization}_{i,t-1} \cdot \Delta r_{t-k}$	0.0758	0.1176***	0.3194***	-0.0177	0.0024	-0.0933*	-0.0070
	(0.0495)	(0.0503)	(0.0506)	(0.0535)	(0.0558)	(0.0536)	(0.0554)
$\sum_{k=0}^{4} \text{RegQ}_{t-k}$		-0.3794***				1.1678***	
		(0.0618)				(0.0709)	
$\sum_{k=0}^{4} \text{RegQ}_{t-k} \cdot \Delta r_{t-k}$				-1.6635***		-2.2647***	
				(0.0578)		(0.0628)	
$\sum_{k=0}^{4} \text{RegQ}_{t-k}^{Binary}$			2.0578***				3.1710***
			(0.1176)				(0.1217))
$\sum_{k=0}^{4} \text{RegQ}_{t-k}^{Binary} \cdot \Delta r_{t-k}$					-4.7063***		-4.9413***
					(0.0813)		(0.0843)
$\sum_{k=0}^{4} \left(\Delta r_{t-k} + \text{RegQ}_{t-k}^{Binary} \cdot \Delta r_{t-k}\right)$					-5.1740***		-5.5206***
					(0.0688)		(0.0735)
R^2	0.2026	0.2038	0.2051	0.2029	0.2043	0.2044	0.2066
Observations	1,131,336	1,131,875	1,130,793	1,132,672	1,131,954	1,132,862	1,131,405

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 3.9: Lending Growth Monetary Policy Regressions

methodology employed by Kashyap and Stein (2000) or Kishan and Opiela (2000) there are no significant loan supply shifts identifiable across the two bank characteristics size and capitalization, although the point estimate of the size-policy and capitalization-policy interaction is positive.[11] The specification employed here with interactions between bank characteristics and real and nominal macroeconomic controls implies that there is no differential response in lending growth for larger or better capitalized banks. Most strikingly, the liquidity of a bank balance sheet amplifies the effects of monetary policy once one controls for interactions with real and nominal macroeconomic controls, a feature noted earlier in chapter 2 on policy identification.

To measure the impact of Regulation Q a number of variations of regression (3.7) are estimated. Again, the impact of financial disintermediation is estimated, first, by including the (continuous) degree of bindingness of Regulation Q (RegQ_t) in levels as defined in section 3.2 and displayed in table 3.6 on page 146. This corresponds to model specification 3.8 on page 135. Estimation results can be found in the second column (model 2) of table 3.9. Second, the binary indicator (RegQ_t^{Binary}) of whether or not regulation Q was binding is introduced in levels (model 3). Third, the model is augmented by including the continuous bindingness indicator (model 4) and the binary indicator (model 5) interacted with monetary policy. The final set of specifications includes both the level and interaction effects of the continuous (model 6) and binary indicator (model 7).

[11]Using only bank characteristics monetary policy interactions without interacting bank characteristics with nominal and real loan demand drivers would yield significant estimates of shielding effects from the bank level characteristics employed here because such (mis)specifications assumes homogenous loan demand shifts at the bank level.

Consider first the changing impact of macroeconomic controls. The lending growth responsiveness to real macroeconomic factors ($\Delta\log(y_t)$) remains very stable, although it declines somewhat in specifications where the regulatory controls are interacted with monetary policy. The lending growth responsiveness to nominal macroeconomic factors ($\Delta\log(p_t)$) is reduced by up to 30 percent, possibly due to the higher nominal uncertainty during the Regulation Q sample period. A huge change in coefficient estimates can be observed in the direct lending growth response to changes in the federal funds rate, in particular when the federal funds rate is interacted with deregulation proxies in model (4) to (7). The estimated impact for the full sample period declines from a -1.77 percent decrease for any one percent increase in the federal funds rate to a -0.47 percent decrease. That is a decline by about three quarters. The last separate coefficient row indicates that in the period when Regulation Q was in place ($\text{RegQ}_t^{Binary} = 1$) the direct lending growth response was, depending on the precise specification, between -5.17 and -5.52 percent for a one percent monetary tightening of the federal funds rate. This is a more than tenfold increase in the direct effects on lending.

As the regressions estimated the impact of federal funds rate changes on observable *equilibrium* lending growth, rather than on loan supply, this tenfold increase is no clear-cut evidence of an increase loan supply sensitivity as the greater responsiveness of equilibrium lending growth in the earlier sample period when Regulation Q was binding may result from a higher interest rate sensitivity of *loan demand*. Figure 3.4 on page 163 illustrates that point graphically: Similarly sized shifts in loan supply (potentially policy induced e.g. through to the bank level financial frictions examined in section 3.4.1) induce much larger lending growth responses when faced with a loan demand curve that is more sensitive to interest rate changes. In the diagram a flatter loan demand schedule due to a higher interest rate sensitivity results in greater shifts in equilibrium lending when faced with similar size shifts in loan supply. Crucially, it is more likely that the loan demand sensitivity has increased rather than decreased since Regulation Q was abolished.

Indeed, Becketti and Morris (1992) argue that this is true: A contemporaneous rise in financial innovation means that the demand for loans becomes flatter because of a number of other available financing alternatives increases. Therefore, a contemporaneous rise in financial innovations makes it more likely that the interest rate sensitivity of loan demand for bank loans has become larger given the entry of a number of non-bank financial firms and the variety of financial products that has come to the market in recent decades. So the argument that loan demand was more sensitive to interest rates during Regulation Q when compared to the recent period seems implausible. Furthermore, the key argument of this chapter is that the legislative changes controlled for here most directly affected banks rather than households or firms and their finance requirements.

To summarize, whilst it is *possible* that other simultaneous, non-accounted for, events increased the interest rate sensitivity of loan demand until deposit interest rate deregulation was fully implemented and decreased it substantially during the 1980s, 1990s, and 2000s, it seems rather less *plausible*. This suggest that the impact of deregulation is primarily on the diminished ability of the Federal Reserve to directly shift loan supply schedules of individual banks implying that the lending channel is

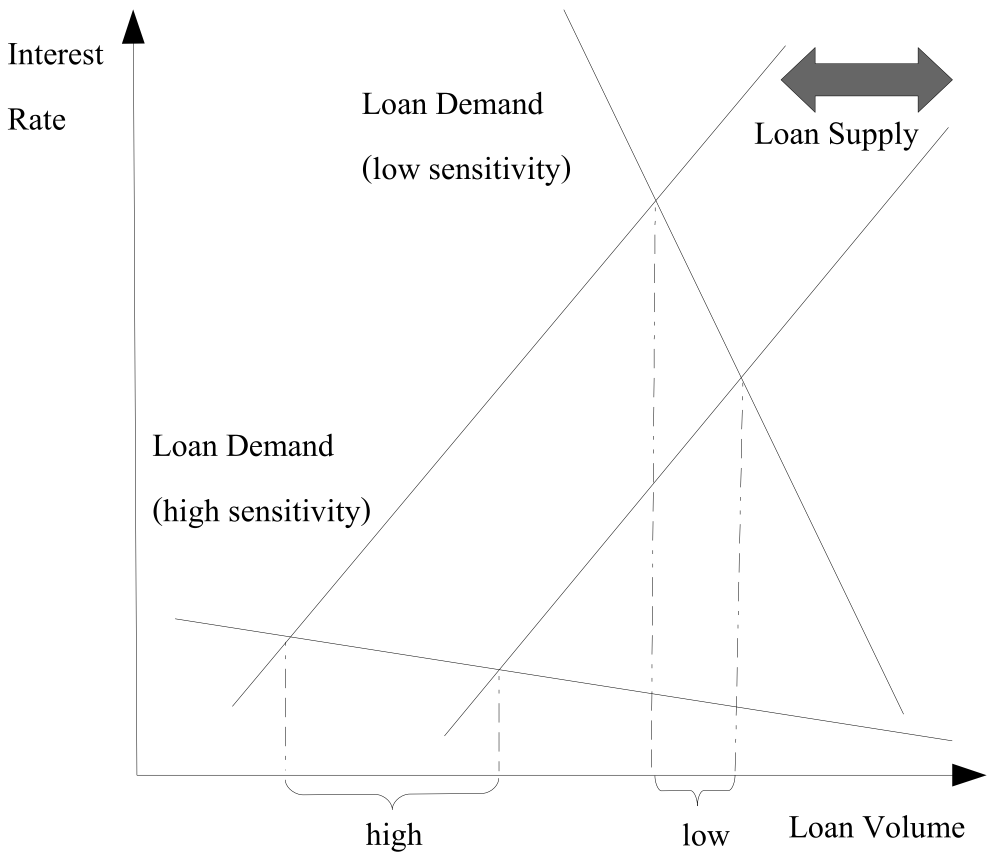


Figure 3.4: Structural Changes in Loan Demand Interest Rate Elasticities

much weaker overall if not defunct.

Further examination of table 3.9 regarding the introduction of the binary Regulation Q variables in levels into the specifications in models (3) and (7) shows that when Regulation Q was binding lending growth was generally higher by about 2 to 3 percent likely attributable as argued earlier to the greater nominal uncertainty in that period. This is quite sizable give that mean lending growth at the individual bank level over the whole sample is 7.70 percent (see sections 3.3.3 and 3.4.1). Column (2) indicates that the more binding Regulation Q was the less was lending growth during that period.

The degree of bindingness of Regulation Q as proxied by the variable RegQ also alters the transmission mechanism of monetary policy. If one considers models (4) and (6) the interaction terms are significantly negative with -1.6635 and -2.2647 respectively. This means that if the short-term interest rates where one percent above the legal deposit rate ceiling the impact of a one percent increase in the federal funds rate was not just -0.8645 (model 4) or -0.8028 (model 6), but -2.5280 (model 4) or -3.0675 (model 6). If short-term rates were two percent above the legal ceiling the policy impact on a bank at the mean of all bank characteristics would have been -4.1915 and -4.5294 percent respectively. Notice the strong non-linear impact of monetary policy on lending in the period of financial disintermediation.

Consider next the role of bank characteristics and the associate coefficients, i.e. elements of τ_k in model (3.7) and its variations. Regarding shielding effects from bank size turn out to be significant in those specifications that do control for financial deregulation (2) to (7), but insignificant in baseline model (1). The other characteristics are largely insignificant or feature surprising amplifying effects in the case of liquidity. Clearly not controlling for financial disintermediation may lead to different inferences about the role of bank level characteristics in shielding lending from the effects of monetary policy in the full available banking sample.

So the main finding is that the inclusion of binary and continuous proxies for deposit interest rate ceilings in levels and interactions into the baseline specification (3.7) significantly alters the direct impact of federal funds rate changes on equilibrium lending growth of individual commercial banks. It was very likely caused by the now reduced ability of the central banks to shift individual banks loan supply schedules. This is likely due to changes in the credit channel of monetary transmission rather than through classical interest rate channels. Overall, this may lead to a weaker transmission mechanism if other monetary transmission channels remain mostly unaltered requiring the Federal Reserve to respond more aggressively to monetary shocks or shocks stemming from the financial sector.

The next section 3.4.3 will analyze in more detail the variation in regulatory impact and lending growth across different bank characteristics that proxy for bank level financial constraints.

3.4.3 Bank Characteristics

Most studies on the lending channel use a standard set of proxies for bank level financial constraints: bank size, liquidity and capitalization. It is of particular interest to examine coefficients estimates of level and interaction effects of each of these bank level controls and the two proxies for financial disintermediation on bank level lending growth. In such a way one may assess whether the impact of deregulation is primarily on larger, more liquid or better capitalized banks and how the transmission mechanism for each group has changed due to deregulation. This is important because there were huge structural changes in the banking industry as discussed in section 3.2 and illustrated in figure 3.1 (page 126) and figure 3.2 (page 141). This section does not estimate additional empirical models. Rather, it analyzes in further detail the previous specifications (1) to (7) from table 3.9 (page 159) by turning attention to a set of coefficient estimates that were not the primary focus of the previous section 3.4.2, and hence were not explicitly reported in the core results table 3.9.

It is noteworthy, that most bank level studies do not control for all these characteristics simultaneously or interact them with the macroeconomic controls such as real GDP growth or price changes. In case they do they rarely discuss the estimated coefficients and, in particular, their stability across different specifications. Here, we provide an analysis in turn of individual bank size as measured by assets, liquidity and capitalization and how each of these bank level characteristics affect monetary transmission and, in particular, how the deregulation of deposit interest rate ceilings altered their importance for lending growth and the lending channel.

The rows of the subsequent three summary tables on size (table 3.10, page 167), liquidity (table 3.11, page 168) and capitalization (table 3.12, page 169) include (1) direct effects from monetary policy as measured by changes in the federal funds rate that are reiterated to ease the discussion, (2) the level effects of the individual bank characteristics, the interaction effects between bank characteristics and (3) monetary

$\Delta log(L_{i,t})$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulation Q Controls:							
1.1. Bindingness level	no	yes	no	no	no	yes	no
1.2. Binary indicator level	no	no	yes	no	no	no	yes
2.1. Bindingness interaction	no	no	no	yes	no	yes	no
2.2. Binary indicator interaction	no	no	no	no	yes	no	yes
$\sum_{k=0}^{4} \Delta r_{t-k}$	-1.7676***	-1.6448***	-1.8313***	-0.8645***	-0.4677***	-0.8028***	-0.5793***
	(0.0431)	(0.0470)	(0.0458)	(0.0519)	(0.0526)	(0.0529)	(0.0544)
$\text{Assets}_{i,t-1}$	-0.0031	-0.6225***	-0.4463***	-0.4529***	-0.4385***	-0.4452***	-0.4144***
	(0.0523)	(0.0590)	(0.0625)	(0.0610)	(0.0632)	(0.0613)	(0.0633)
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta r_{t-k}$	0.0312	0.1515***	0.1700***	0.2102***	0.3271***	0.2004***	0.3284***
	(0.0415)	(0.0420)	(0.0428)	0.0472)	(0.0506)	(0.0475)	(0.0502)
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta\text{log}(y_{t-k})$	0.1614***	0.2017***	0.1494***	0.1896***	0.1254***	0.1920***	0.1271***
	(0.0094)	(0.0098)	(0.0094)	(0.0104)	(0.0097)	(0.0104)	(0.0097)
$\sum_{k=0}^{4} \text{Assets}_{i,t-1} \cdot \Delta\text{log}(p_{t-k})$	-0.0593***	0.1507***	0.1410***	0.0990***	0.1761***	0.0920***	0.1627***
	(0.0085)	(0.0119)	(0.0170)	(0.0129)	(0.0177)	(0.0129)	(0.0176)
$\text{RegQ}_t \cdot \text{Assets}_{i,t-1}$		-1.0074***		0.1802*		0.2665***	
		(0.0378)		(0.0937)		(0.0931)	
$\text{RegQ}_t^{Binary} \cdot \text{Assets}_{i,t-1}$			-1.4552***		-1.6737***		-1.5183***
			(0.1037)		(0.1074)		(0.1057)
$\sum_{k=0}^{4} \text{RegQ}_t \cdot \text{Assets}_{i,t-1} \cdot \Delta r_{t-k}$				-1.2252***		-1.3042***	
				(0.1029)		(0.1027)	
$\sum_{k=0}^{4} \text{RegQ}_t^{Binary} \cdot \text{Assets}_{i,t-1} \cdot \Delta r_{t-k}$					-0.4308***		-0.4619***
					(0.0791)		(0.0788)
$\text{Assets}_{i,t-1} + \text{RegQ}_t^{Binary} \cdot \text{Assets}_{i,t-1}$			-1.9015***		-2.1122***		-1.9326***
			(0.1472)		(0.1508)		(0.1493)
$\sum_{k=0}^{4} \left(\text{Assets}_{i,t-1} \cdot \Delta r_{t-k} + \text{RegQ}_t^{Binary} \cdot \text{Assets}_{i,t-1} \cdot \Delta r_{t-k}\right)$					-0.1036		-0.1335*
					(0.0683)		(0.0684)
R^2	0.2026	0.2038	0.2051	0.2029	0.2043	0.2044	0.2066
Observations	1,131,336	1,131,875	1,130,793	1,132,672	1,131,954	1,132,862	1,131,405

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 3.10: Bank Size, Deregulation and Lending Dynamics

$\Delta\log(L_{i,t})$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulation Q Controls:							
1.1. Bindingness level	no	yes	no	no	no	yes	no
1.2. Binary indicator level	no	no	yes	no	no	no	yes
2.1. Bindingness interaction	no	no	no	yes	no	yes	no
2.2. Binary indicator interaction	no	no	no	no	yes	no	yes
$\sum_{k=0}^{4} \Delta r_{t-k}$	-1.7676***	-1.6448***	-1.8313***	-0.8645***	-0.4677***	-0.8028***	-0.5793***
	(0.0431)	(0.0470)	(0.0458)	(0.0519)	(0.0526)	(0.0529)	(0.0544)
$\text{Liquid}_{i,t-1}$	0.5948***	0.7487***	0.9156***	0.6977***	0.5648***	0.6504***	0.6440***
	(0.0560)	(0.0614)	(0.0657)	(0.0632)	(0.0661)	(0.0633)	(0.0667)
$\sum_{k=0}^{4} \text{Liquid}_{i,t-1} \cdot \Delta r_{t-k}$	-0.1749***	-0.2456***	-0.3065***	-0.0830*	0.0256	-0.0718	-0.0528
	(0.0446)	(0.0454)	(0.0461)	(0.0490)	(0.0510)	(0.0492)	(0.0510)
$\sum_{k=0}^{4} \text{Liquid}_{i,t-1} \cdot \Delta\log(y_{t-k})$	0.1115***	0.1176***	0.1439***	0.1117***	0.1374***	0.1187***	0.1505***
	(0.0097)	(0.0098)	(0.0099)	(0.0103)	(0.0102)	(0.0104)	(0.0102)
$\sum_{k=0}^{4} \text{Liquid}_{i,t-1} \cdot \Delta\log(p_{t-k})$	0.1254***	0.0515***	-0.0348*	0.0743***	0.1038***	0.0916***	0.0708***
	(0.0106)	(0.0143)	(0.0192)	(0.0152)	(0.0198)	(0.0152)	(0.0197)
$\text{RegQ}_t \cdot \text{Liquid}_{i,t-1}$		0.4303***		0.8767***		0.5602***	
		(0.0479)		(0.1190)		(0.1191)	
$\text{RegQ}_t^{Binary} \cdot \text{Liquid}_{i,t-1}$			1.1957***		0.7563***		0.7978***
			(0.1187)		(0.1217)		(0.1215)
$\sum_{k=0}^{4} \text{RegQ}_t \cdot \text{Liquid}_{i,t-1} \cdot \Delta r_{t-k}$				-0.5354***		-0.2364*	
				(0.1317)		(0.1318)	
$\sum_{k=0}^{4} \text{RegQ}_t^{Binary} \cdot \text{Liquid}_{i,t-1} \cdot \Delta r_{t-k}$					-0.9427***		-0.8172***
					(0.0933)		(0.0938)
$\text{Liquid}_{i,t-1} + \text{RegQ}_t^{Binary} \cdot \text{Liquid}_{i,t-1}$			2.1113***		1.3211***		1.4419***
			(0.1627)		(0.1658)		(0.1663)
$\sum_{k=0}^{4} \left(\text{Liquid}_{i,t-1} \cdot \Delta r_{t-k} + \text{RegQ}_t^{Binary} \cdot \text{Liquid}_{i,t-1} \cdot \Delta r_{t-k}\right)$					-0.9171***		-0.8701***
					(0.0855)		(0.0858)
R^2	0.2026	0.2038	0.2051	0.2029	0.2043	0.2044	0.2066
Observations	1,131,336	1,131,875	1,130,793	1,132,672	1,131,954	1,132,862	1,131,405

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 3.11: Bank Liquidity, Deregulation and Lending Dynamics

$\Delta\log(L_{i,t})$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Regulation Q Controls:							
1.1. Bindingness level	no	yes	no	no	no	yes	no
1.2. Binary indicator level	no	no	yes	no	no	no	yes
2.1. Bindingness interaction	no	no	no	yes	no	yes	no
2.2. Binary indicator interaction	no	no	no	no	yes	no	yes
$\sum_{k=0}^{4} \Delta r_{t-k}$	-1.7676***	-1.6448***	-1.8313***	-0.8645***	-0.4677***	-0.8028***	-0.5793***
	(0.0431)	(0.0470)	(0.0458)	(0.0519)	(0.0526)	(0.0529)	(0.0544)
$\text{Capital}_{i,t-1}$	-0.1009*	-0.4051***	-0.8180***	-0.4196***	-0.5782***	-0.3746***	-0.6256***
	(0.0590)	(0.0658)	(0.0694)	(0.0685)	(0.0704)	(0.0683)	(0.0703)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta r_{t-k}$	0.0758	0.1176***	0.3194***	-0.0177	0.0024	-0.0933*	-0.0070
	(0.0495)	(0.0503)	(0.0506)	(0.0535)	(0.0558)	(0.0536)	(0.0554)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta\log(y_{t-k})$	0.0174	0.0282***	-0.0196*	0.0248**	-0.0149	0.0338***	-0.0144
	(0.0110)	(0.0113)	(0.0112)	(0.0118)	(0.0115)	(0.0118)	(0.0114)
$\sum_{k=0}^{4} \text{Capital}_{i,t-1} \cdot \Delta\log(p_{t-k})$	0.0305***	0.1519***	0.3639***	0.1767***	0.2831***	0.1369***	0.2750***
	(0.0113)	(0.0155)	(0.0205)	(0.0169)	(0.0215)	(0.0168)	(0.0211)
$\text{RegQ}_t \cdot \text{Capital}_{i,t-1}$		-0.6663***		-1.6152***		-1.0747***	
		(0.0553)		(0.1400)		(0.1392)	
$\text{RegQ}_t^{Binary} \cdot \text{Capital}_{i,t-1}$			-2.5398***		-2.4983***		-2.0031***
			(0.1299)		(0.1401)		(0.1365)
$\sum_{k=0}^{4} \text{RegQ}_t \cdot \text{Capital}_{i,t-1} \cdot \Delta r_{t-k}$				1.0421***		0.6153***	
				(0.1546)		(0.1539)	
$\sum_{k=0}^{4} \text{RegQ}_t^{Binary} \cdot \text{Capital}_{i,t-1} \cdot \Delta r_{t-k}$					0.3003***		0.1272
					(0.1072)		(0.1083)
$\text{Capital}_{i,t-1} + \text{RegQ}_t^{Binary} \cdot \text{Capital}_{i,t-1}$			-3.3579***		-3.0765***		-2.6287***
			(0.1752)		(0.1859)		(0.1819)
$\sum_{k=0}^{4} \left(\text{Capital}_{i,t-1} \cdot \Delta r_{t-k} + \text{RegQ}_t^{Binary} \cdot \text{Capital}_{i,t-1} \cdot \Delta r_{t-k}\right)$					0.3027***		0.1201
					(0.1003)		(0.1014)
R^2	0.2026	0.2038	0.2051	0.2029	0.2043	0.2044	0.2066
Observations	1,131,336	1,131,875	1,130,793	1,132,672	1,131,954	1,132,862	1,131,405

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 3.12: Bank Capitalization, Deregulation and Lending Dynamics

policy, (4) real macroeconomic factors, (5) nominal macroeconomic factors. In order to analyse the effects of Regulation Q and its bindingness the table also contains coefficient estimates of the interaction between the level of the bank characteristics and (6) the degree of bindingness of Regulation Q (RegQ_t), (7) the binary indicator for Regulation Q $\left(\mathrm{RegQ}_t^{Binary}\right)$ and these two double interactions combined with monetary policy (rows 8 and 9). Finally, in order to examine the presence of structural shifts combine (2) and (7) in row (10) in order to check for *level* shifts in lending growth across the bank characteristic due to deregulation as well as (3) and (9) in row (11) in order to check how the *transmission of policy* due to loan supply shifts implied by differential lending growth responses to monetary policy across the different bank level financial constraints has been affected by deregulation.

Bank Size

First, effects of size as measured by assets are displayed in table 3.10 on page 167. The level effect of individual bank size on equilibrium lending growth is significantly negative for all but the baseline specification (1) that does not control for disintermediation effects. That is larger banks' mean lending growth is smaller. Rows 4 and 5 indicate that larger banks hold more cyclically sensitive loan portfolios.

Regarding the level impact of RegQ_t and RegQ_t^{Binary} it is noteworthy that when Regulation Q was binding (that is $\mathrm{RegQ}_t^{Binary} = 1$) a representative bank that is one standard deviation above the sample mean in terms of its size lent significantly less, by about three to four times less than over the whole sample period: In model (3) -0.4463 percent less in the full sample and -1.9015 during the period of financial disintermediation, in model (5) -0.4385 in the full sample and -2.1122 during the period of financial disintermediation and in model (7) -0.4144 in the full sample and -1.9326 during the period of financial disintermediation.

Structural breaks regarding the role of bank size in *transmission* from monetary policy to lending growth, rather than structural breaks in the *level* of lending growth, that is models (4) to (7), suggest that the more binding Regulation Q was the stronger was the transmission effect of bank size from monetary policy to mean lending growth. For instance in model (6) when short-term rates were one percent above the legal ceiling lending for a bank one standard deviation above the mean would contract lending by 1.3042 percent more in response to a one percent increase in the federal funds rate than a bank at the mean of all characteristics. Larger banks were more responsive to monetary policy and this effect was stronger the more binding deposit rate ceilings. This may be due to that fact that larger banks were better able to attract (or were early innovators of) alternative unregulated non-deposit sources of funding such as small-saver certificates (SSCs) and money market certificates (MMCs).

Bank Liquidity

The next table 3.11 on page 168 provides details of estimated coefficients for bank liquidity. The second row indicates that more liquid banks have a larger mean lending growth. Furthermore, this effect is more pronounced when Regulation Q was binding and the stronger the degree of bindingness. Interaction effects with real GDP growth and prices indicate more pro-cyclical lending growth in more liquid banks. Interestingly interaction effects in row 3 between the bank level liquidity position and federal funds rate changes in regressions that do not control for interaction effects between policy and regulation, that is models (1) to (3), indicate that banks with more liquid balance sheet are significantly *more* responsive to monetary policy. Controlling for deregulation in the interaction effects in models (4) to (7) somewhat mitigates this puzzling effect, but none of the specifications suggests a positive interaction effect that would indicate shielding effects of a bank's liquidity position for monetary policy transmission through credit.

Analysing the effect of deregulation on the *level* effects of financial deregulation in rows 7 and 8 suggest that lending growth was higher for more liquid banks when Regulation Q was binding. Row 7 indicates that the more binding Regulation Q was the stronger this effect. One interpretation is that more liquid banks were better able to cope with the outflow of deposits into alternative non-deposit assets induced by interest rate rises over and beyond the regulated interest rate ceilings on the liability side by selling off these liquid assets rather than shrinking their loan portfolio immediately by less than less liquid banks.

Considering the effect of deregulation on the *transmission* effects of financial deregulation in rows 9 and 10 one can discover strong amplifying effects from liquidity the more binding interest rate ceilings (i.e. RegQ_t more positive) were in models (4) and (6). The puzzling result that liquidity amplifies the lending responses is even more pronounce during the period of disintermediation.

Bank Capitalization

Finally, the third prominent bank level characteristic in the empirical literature on the lending channel is capitalization. Table 3.12 on page 169 reports findings on capitalization, bank lending and deregulation. First, mean lending is smaller for better capitalized banks (row 2) and this effect is even more pronounced in the period of financial disintermediation (row 7). Row 6 indicates that the more binding the interest rate ceilings the smaller was lending growth.

If one considers the shielding effect of capitalization from monetary contraction this very much depends on the specification. There are not shielding effects in the baseline specification (1). Whilst shielding effects are present when one controls for deregulation in level in models (2) and (3). They also appear to be present in the "interaction" models (4) to (7) but are primarily restricted to the regulated period. The full sample interaction between capitalization and monetary policy in row 3 of table 3.12 are either insignificant or, in one case, significantly positive implying amplifying effects from capitalization. So the data and estimation in this chapter provides no evidence for shielding effects from capitalization after the period when Regulation Q was binding.

To summarize, the analysis of the impact of deregulation on the role of individual bank characteristics for identifying bank level loan supply shifts due to monetary policy lead to the conclusion that only bank size as measured by total assets appears to be a bank level proxy for identifying policy induced loan supply shifts over the whole sample period. However, these differential size effects are only present when one controls for the abolition of deposit interest rate ceilings. Differential lending responses across different levels of capitalization only occurred when Regulation Q was binding and does not seem to be a permanent feature of the data up to the present day. A puzzling finding is that the liquidity position of bank seems to generally amplify their lending growth responses to policy in samples extending to 2010. During the period of financial disintermediation there were substantial shielding effects for more liquid banks in levels, potentially driven by their ability to respond more flexible to the decline in deposits when the interest rate ceiling were more binding. Overall, it seems crucial to take account for regulatory changes when estimating differential shifts in lending growth sensitivities to interest rate changes across different bank characteristics.

The section now concludes with some stability exercises on the lending growth sensitivity to monetary policy in next section 3.4.4.

3.4.4 Robustness Checks

This section briefly describes two robustness checks on the stability of the main lending results reported above in table 3.9. Specifically, the section considers different lag structures and bank holding company dummies as in Ashcraft (2006).

Coefficient estimates for these robustness checks can be found in table 3.13 on page 177. The two columns (1) and (2) displays the benchmark estimates from the the full specification (6) and (7) from table 3.9 on page 159 as a benchmark for comparison.

Column (3) and (4) in table 3.13 reports results after altering the lag structure of characteristics equation (3.7). In equation (3.7) each of the bank characteristics interacted with the macroeconomic controls was dated $t-1$, even when the macroeconomic control is dated earlier, for instance $t-4$. This follows the convention in the literature. However, bank characteristics may themselves be bank level choices in response to earlier (and potentially expected future) macroeconomic or monetary policy developments. Hence, this robustness check addresses potential objections to such specifications by lagging the bank level characteristic correspondingly.[12]. The dating of bank characteristics is hence lagged *relative* to the macroeconomic controls including the measure of monetary policy. Specification (3.11) makes this alteration of (3.7) explicit (in bold letters):

$$\begin{aligned}
\Delta\log(L_{i,t}) &= \alpha + \sum_{k=1}^{4}\rho_k \cdot \Delta\log(L_{i,t-k}) + \sum_{k=0}^{4}\gamma_k \cdot \mathbf{M}_{t-k} \\
&+ \upsilon \cdot B_{i,t-1} + \sum_{k=0}^{4}\tau_k \cdot B^{*}_{i,\mathbf{t\text{-}1}} \times \mathbf{M}^{*'}_{t-k} \qquad (3.7)\\
&+ \mu \cdot \text{time}_t + \sum_{k=1}^{3}\theta_k \cdot \text{Quarter}_{k,t} + \varepsilon_{i,t}
\end{aligned}$$

$$\begin{aligned}
\Delta\log(L_{i,t}) &= \alpha + \sum_{k=1}^{4}\rho_k \cdot \Delta\log(L_{i,t-k}) + \sum_{k=0}^{4}\gamma_k \cdot \mathbf{M}_{t-k} \\
&+ \upsilon \cdot B_{i,t-1} + \sum_{k=0}^{4}\tau_k \cdot B^{*}_{i,\mathbf{t\text{-}k\text{-}1}} \times \mathbf{M}^{*'}_{t-k} \qquad (3.11)\\
&+ \mu \cdot \text{time}_t + \sum_{k=1}^{3}\theta_k \cdot \text{Quarter}_{k,t} + \varepsilon_{i,t}
\end{aligned}$$

[12]If one was to fully include the critique of Sims (1980) one method in the bank level lending regression context would be to introduced global vector autoregressions to address the endogeneity of bank characteristics.

Note how the lag structure does impact upon inferences based on bank characteristics. In particular, neither bank liquidity nor capitalization exert any shielding effects which is puzzling in the context to the findings of Kashyap and Stein (2000) and Kishan and Opiela (2000). The main results of this chapter, however, the changing equilibrium lending growth response to monetary policy that is likely to be driven by changing sensitivities in loan supply responses to monetary policy remains intact. It even appears amplified in this setting with lending growth responses to policy during the period of financial disintermediation (-4.9579) being about ten times stronger than the standard responses (-0.4901).

Finally, columns (5) and (6) examines include the contribution of Ashcraft (2006) showing how bank holding companies are a source-of-strength for their subsidaries. One can see that most of the important results remain intact. When Regulation Q was binding Lending growth (RegQ: -3.2781, RegQ^{Binary}: -5.4845) is again up to ten times more sensitive to changes in the federal funds rate then after the period of disintermedation (RegQ: -0.9799, RegQ^{Binary}:-0.5384). Other robustness test, e.g. including controlling for Basel II implementation and Long Term Capital Management failure, yield similar results.

3.5 Conclusion

This chapter used bank level data to explore the question of how financial deregulation affected the monetary transmission mechanism. Using bank level rather than aggregate or sectoral data this chapter thus contributed to two previously disparate streams in the literature. First, it contributed to empirical research of the lending

$\Delta log(L_{i,t})$	(1) · benchmark RegQ	(2) · benchmark RegQ^{Binary}	(3) · lag structure RegQ	(4) · lag structure RegQ^{Binary}	(5) · BHC RegQ	(6) · BHC RegQ^{Binary}
$\sum_{k=0}^{4} \Delta\log(y_{t-k})$	0.9993***	1.055***5	0.9630***	1.0214***	1.0037***	1.0591***
	(0.0136)	(0.0121)	(0.0136)	(0.0121)	(0.0136)	(0.0121)
$\sum_{k=0}^{4} \Delta\log(p_{t-k})$	1.0729***	0.6438***	1.0049***	0.5760***	1.0657***	0.6356***
	(0.0223)	(0.0227)	(0.0222)	(0.0240)	(0.0226)	(0.0227)
$\sum_{k=0}^{4} \Delta r_{t-k}$	-0.8028***	-0.5793	-0.7540	-0.4901	-0.9799	-0.5384
	(0.0529)	(0.0544)	(0.0532)	(0.0543)	(0.0682)	(0.0717)
$\sum_{k=0}^{4} \text{Assets}_{i,t(-k)-1} \cdot \Delta r_{t-k}$	0.2004***	0.3284***	0.0836*	0.1054**	0.1741***	0.3205***
	(0.0475)	(0.050)2	(0.0468)	(0.0498)	(0.0476)	(0.0504)
$\sum_{k=0}^{4} \text{Liquid}_{i,t(-k)-1} \cdot \Delta r_{t-k}$	-0.0718	-0.0528	-0.2104***	-0.0111	-0.0519	-0.0666
	(0.0492)	(0.0510)	(0.0442)	(0.0475)	(0.0494)	(0.0512)
$\sum_{k=0}^{4} \text{Capitalization}_{i,t(-k)-1} \cdot \Delta r_{t-k}$	-0.0933*	-0.0070	-0.0827*	-0.0859*	-0.0759	-0.0140
	(0.0536)	(0.0554)	(0.0486)	(0.0511)	(0.0538)	(0.0556)
$\sum_{k=0}^{4} \text{RegQ}_{t-k}$	1.1678***		1.3766***		1.2704***	
	(0.0709)		(0.0705)		(0.0715)	
$\sum_{k=0}^{4} \text{RegQ}_{t-k} \cdot \Delta r_{t-k}$	-2.2647***		-2.4886***		-2.2982***	
	(0.0628)		(0.0622)		(0.0640)	
$\sum_{k=0}^{4} \Delta r_{t-k} + \text{RegQ}_{t-k} \cdot \Delta r_{t-k}$	-3.0675***		-3.2426***		-3.2781***	
	(0.0661)		(0.0658)		(0.0727)	
$\sum_{k=0}^{4} \text{RegQ}^{Binary}_{t-k}$		3.1710***		2.8032***		3.1560***
		(0.1217)		(0.1312)		(0.1226)
$\sum_{k=0}^{4} \text{RegQ}^{Binary}_{t-k} \cdot \Delta r_{t-k}$		-4.9413***		-4.4678***		-4.9461***
		(0.0843)		(0.0833)		(0.0895)
$\sum_{k=0}^{4} \Delta r_{t-k} + \text{RegQ}^{Binary}_{t-k} \cdot \Delta r_{t-k}$		-5.5206***		-4.9579***		-5.4845***
		(0.0735)		(0.0725)		(0.0752)
$\sum_{k=0}^{4} \text{BHC}_{t-1} \cdot \Delta r_{t-k}$					0.2494***	-0.0580
					(0.0638)	(0.0633)
$\sum_{k=0}^{4} \Delta r_{t-k} + \text{BHC}_{t-1} \cdot \Delta r_{t-k}$					-0.7305***	-0.5964***
					(0.0567)	(0.0569)
R^2	0.2044	0.2066	0.2070	0.2101	0.2051	0.2070
Observations	1,132,862	1,131,405	1,109,488	1,107,794	1,132,633	1,131,283

Table 3.13: Robustness Checks

channel and, second, to the analysis on deregulation. The empirical analysis revealed that structural changes in the lending channel stemming from the deregulation of deposit interest rate ceilings known as Regulation Q implemented through the *Depository Institutions Deregulation and Monetary Control Act of 1980* were crucial in reducing the direct causal effect of monetary policy on individual bank level lending.

Specifically, the analysis showed that deposit ceilings increased the strength of the lending channel by a factor of up to ten. Other non-policy lending regression parameters remained remarkably stable. This is particularly true for real macroeconomic factors driving loan demand shifts. So these large differences in the direct effects of monetary policy are likely driven by changes in the loan supply response to policy. In contrast to a number of studies, this chapter also controls for non-homogenous loan demand shifts along different bank characteristics. The chapter pointed out that lending growth of larger and more liquid banks is generally more cyclically sensitive and that controlling for these different loan demand drivers is important, especially when it is argued that the lending channel is identified by differential responses to policy by different size, liquidity or capitalization classes.

The findings of this chapter are important for practical purposes as well. Bernanke, Gertler and Watson (1997) note that U.S. post-oil price hike recessions might be caused by exogenous oil price hikes themselves but also, to a significant extent, by contractionary monetary responses to those oil prices hikes. The findings imply that more muted responses would have been desirable in the 1970s whereas now shocks are less likely to emerge from monetary policy responses to exogenous oil price rises. The findings further imply that, for credit channels, greater instrument variability is necessary in order to offset macroeconomic shocks. The aggressive quantitative easing policies currently pursued by the Federal Reserve may be part of that story.

Finally, one may consider potential macroeconomic implications of the findings of this chapter. Most advanced economies have experienced a striking decline in the volatility of aggregate economic activity since the early 1980s. Volatility reductions are evident for output and employment at the aggregate level and across most industrial sectors and expenditure categories. Inflation and inflation volatility have also declined dramatically. Whilst the sources of the "Great Moderation" (Bernanke, 2004) are still debated, surveys like Stock and Watson (2002) put forward three nonexclusive explanations for "the long and large decline in US output volatility" (Blanchard and Simon, 2001). One interpretation of the Great Moderation is to consider it as a marked reduction in the variance of exogenous structural shocks ("good luck"). A second set of explanations focusses on structural changes in the economy like innovations in financial market that facilitate intertemporal smoothing of consumption and investment (Blanchard and Simon, 2001), better inventory management through information technology (McConnell and Perez-Quiros, 2000; Kahn, McConnell and Perez-Quiros, 2001) and the marked shift in output from goods to services (Burns, 1960; Moore and Zarnowitz, 1987). The third and final set of explanation centers around improved policy ("good policy") and, in particular, monetary policy (Taylor, 1999; Cogley and Sargent, 2001).

By introducing a measure of deposit rate ceilings in bank level lending regressions, this chapter's focus was on monetary transmission during the period when the "Great Moderation" commenced. Previous aggregate sector studies like Dynan, Elmendorf and Sichel (2006) find evidence that financial deregulation like the abolition of deposit ceilings (Regulation Q) might be part of the story explaining the “Great Moderation”. They accurately note that feedback relationships among sectors of the economy make it difficult to separate impulse from propagation. Clearly this is true for aggregate data, where short-term or long-term cross-equation restrictions have to be assumed. Yet this chapter uses individual bank level data where the feedback from any individual bank back to regulation, aggregate shocks, structural changes in transmission or policy is negligible and thus improves on Dynan, Elmendorf and Sichel (2006).

The results of this chapter suggest that the propagation of monetary shocks, as least through bank loans, has been diminished pointing to changes in shock *propagation* driven by deregulation. This structural change in transmission would be supportive of Giannone, Lenza and Reichlin (2008) who identify changes in the transmission mechanism rather than shocks as a source of the “Great Moderation”. It is interesting in the context of competing explanations for the change in transmission to notice that unlike the gradual phasing out of branching restrictions over the 1980ies, the phasing out of Regulation Q coincides with what Stock and Watson (2002) identify as the break point between the “Great Inflation” and the “Great Moderation”:

> “Both univariate and multivariate estimates of the break date center on 1984. When we analyze 168 series for breaks in their conditional variance, approximately 40 percent have significant breaks in their conditional variance in 1983 to 1985. Our 67 percent confidence interval for the break

> date in the conditional variance of four-quarter GDP growth (given past values of GDP growth) is 1982:4 to 1985:3, consistent with Kim and Nelson's (1999) and McConnell and Perez-Quiros's (2000) estimate of 1984:1." (Stock and Watson, 2002, p. 161)

This bank level finding is in line with a number of other recent empirical papers using aggregate data. Galí and Gambetti (2009) point to a shrinking contribution of non-technology shocks to output volatility. Herrera and Pesavento (2009) employing VAR techniques find

> "regarding the role of the systematic monetary policy response, it appears to have dampened fluctuations in economic activity during the 1970s, but to have had virtually no effect after the "Great Moderation" (...) Both the impulse responses and the variance decomposition suggests that, after the "Great Moderation," the role of monetary policy in mitigating the effect of an oil price shock is considerably smaller."

In an even broader context the findings of this chapter cast doubt on whether "good policy" maybe characterized by simple stabilizing policy rules as in Taylor (1993), or whether the rules should be made more conditional on the underlying (time-varying) transmission mechanism.

3.A Depository Institutions Deregulation and Monetary Control Act of 1980[13]

DIDMCA began as the Monetary Control Act of 1979 (H.R. 3864), and three different Senate bills. Deliberations on these bills began in early 1979. On February 26, 1979, G. William Miller (then Chairman of the FRS Board of Governors) commented at length on two of the Senate Bills. H.R.7 was the only bill ever passed by either House in that year. In early February of 1980, FRS Chairman Paul Volcker spoke to the Senate about the seriousness of the declining FRS membership problem. In early March, a House and Senate Conference Committee agreed to phase out interest rate ceilings and to require uniform reserve requirements for for all depository institutions. The exact form of the act was still not set at this time. On March 28,1980, the Wall Street Journal reported House approval of a compromise measure that was to become DIDMCA. Senate approval was reported the next trading day (March 31, 1980). President Carter signed the bill into law on that date.

Federal law, enacted in 1980, deregulating deposit interest rates and expanding access to the Federal Reserve Discount Window in the first major reform of the U.S. Banking system since the 1930s. The act has two main sections: Title 1, the Monetary Control Act, which extends Reserve Requirements to all U.S. Banking institutions and also deals with the banking services furnished by the Federal Reserve System; and Title 2, the Depository Institutions Deregulation Act of 1980, phasing out Federal Reserve Regulation Q deposit interest rate ceilings.

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[13] This appendix draws on the description in Allen and Wilhelm (1988) and table 3.14 is adopted from Gilbert (1986, p. 31).

The following are highlights of the act:

1. mandatory reserve requirements that banks keep in noninterest earning accounts at Federal Reserve Banks were lowered. State chartered banks that are not members of the Federal Reserve System, as well as thrift institutions, were required to maintain reserve account balances. Mandatory reserves for all depository institutions were phased in over an eight-year period ending in 1988.

2. Federal Reserve Banks were required to begin charging banks for clearing checks through the Federal Reserve System, and pricing reserve bank services at levels competitive with private sector pricing.

3. a five-member committee, the Depository Institutions Deregulation Committee was created to phase out federal interest rate ceilings on deposit accounts over a six-year period ending in 1986.

4. nationwide Negotiable Order of Withdrawal (NOW) accounts were authorized.

5. federal deposit insurance coverage was raised from \$40,000 to \$100,000 per insured account.

6. all depository institutions, including savings and loans and other thrift institutions, were given access to the Federal Reserve Discount Window for credit advances.

7. savings and loan associations were authorized to make consumer loans, including auto loans and credit card loans, up to 20% of total assets.

8. savings and loans were authorized to offer Trust accounts.

9. state Usury laws limiting rates lenders could charge on residential mortgage loans were pre-empted.

10. state chartered, federally insured banks were allowed to charge the same interest rates on bank loans as national banks.

11. Federal Reserve Regulation Z implementing the consumer credit protections in the Truth in Lending Act, was simplified.

12. authorized federal credit unions to originate residential mortgages.

Effective Date of Change	Nature of Change
1 June 1978	MMCs established, with minimum denomination of $10,000 and maturities of 26 weeks. The floating ceiling rates for each week were set at the discount yield an six-month Treasury hills at S&Ls and MSBs. 25 basis paints less at CBs.
1 November 1978	CBs authorized to offer ATS accounts, allowing funds to be transferred automatically from savings to checking accounts as needed to avoid overdrafts. The ceiling rate on ATS accounts was set at 5.25 percent, the same as the ceiling rate on regular savings accounts at CBs.
1 July 1979	SSCs established with no minimum denomination, maturity of 30 months or more and floating ceiling rates based on the yield on 2 1/2-year Treasury securities, but 25 basis points higher at S&Ls and MSBs. Maximums of 11.75 percent at CBs and 11 percent at S&Ls and MSBs.
2 June 1980	The floating ceiling rates on MMCs raised 50 basis points relative to the yield on 2 1/2-year Treasury securities at S&Ls and MSBs and at CBs. The maximum ceiling rates set in June 1979 were retained.
5 June 1980	New floating ceiling rates on MMCs. All depository institutions may pay the discount yield on 6-month Treasury bills plus 25 basis points when the bill rate is 8.75 percent or higher. The ceiling rate will be no lower than 7.75 percent. A rate differential of up to 25 basis points favors S&Ls and MSBs if the bill rate is between 7.75 percent and 8.75 percent.
31 December 1980	Now accounts permitted nationwide at all depository institutions. Ceiling rates on NOW and ATS accounts set at 5.25 percent.
1 August 1981	Caps on SSCs of 11.75 percent at CBs and 12 percent at S&Ls and MSBs eliminated. Ceiling rates float with the yield on 2 1/2-year Treasury securities.
1 October 1981	Adopted rules for the All Savers Certificates specified in the Economic Recovery Act of 1981.
1 November 1981	Floating ceiling rates on MMCs each week changed to the higher of the 6-month Treasury bill rate in the previous week or the average over the previous four weeks.
1 December 1981	New category of IRA/Keogh accounts created with minimum maturity of 1-1/2 years, no regulated interest rate ceiling and no minimum denomination.
1 May 1982	New time deposit created with no interest rate ceiling, no minimum denomination and an initial minimum maturity of 3-1/2 years. New short-term deposit instrument created with $7,500 minimum denomination and 91-day maturity. The floating ceiling rate is equal to the discount yield on 91-day Treasury bills for S&Ls and MSBs, 25 basis points less for CBs. Maturity range of SSCs adjusted to 30-42 months.
1 September 1982	New deposit account created with a minimum denominatino of $20,000 and maturity of 7 to 31 days. The floating ceiling rate is equal to the discount yield on 91-day Treasury bills for S&Ls and MSBs, 25 basis points less for CBs. These ceiling rates are suspended if the 91-day Treasury bill rate falls below 9 percent for four consecutive Treasury bill auctions.
14 December 1982	MMDAs authorized with minimum balance of not less than $2,500, no interest ceiling, no minimum maturity, up to six transfers per month (no more than three by draft), and unlimited withdrawals by mail, messenger or in person
5 January 1983	Super NOW accounts authorized with same features as the MMDAs, except that unlimited transfers are permitted. Interest rate ceiling eliminated and minimum denomination reduced to $2,500 on 7- and 31-day accounts. Minimum denomination reduced to $2,500 on 91-day accounts and MMCs of less than $100,000.
1 April 1983	Minimum maturity of SSCs reduced to 18 months.
1 October 1983	All interest rate ceilings eliminated except those on passbook savings and regular NOW accounts. Minimum denominations of $2,500 established for time deposits with maturities of 31 days or less (below this minimum, passbook savings rates apply.
1 January 1984	Rate differential between commercial banks and thrifts on passbook savings accounts and 7- to 31-day time deposits of less than $2,500 eliminated. All depository institutions may pay a maximum of 5.50 percent.
1 January 1985	Minimum denominations on MMDAs, Super NOWs and 7-to 31-day ceiling free time deposits reduced to $1,000.
1 January 1986	Minimum denominations on MMDAs, Super NOWs and 7-to 31-day ceiling free time deposits eliminated.
31 March 1986	All interest rate ceilings eliminated, except or the requirement that no interest he paid on demand deposits.

Table 3.14: Steps in the Phase-Out of Regulation Q

Chapter 4

Econometric Analysis of Euro Area Bank Lending: Monetary Policy Identification and Non-Linearities

Chapter Abstract

Empirical results on the lending channel in the euro area remain ambiguous as to whether or not an aggregate bank lending channel exists. This chapter contributes to this literature by asking two questions: Do different ways of identifying monetary policy yield different results in euro area bank lending regressions? And are there important non-linearities in the response of individual bank lending to different measures of monetary policy shocks and what are their sources? The chapter seeks to answer the first question by generating two measures of exogenous and two measures of unanticipated monetary policy shocks. It estimates lending responses of an annual panel of euro area commercial banks to these four annualized shock measures and contrasts the responses with the standard endogenous change in the nominal policy rate. In order to explore non-linearities in lending responses this chapter introduces an aggregate market-based index of financial conditions and discusses non-linearities in monetary transmission related to this index. We find, first, that - unlike in the US - standard measures of bank level financial constraints like size, capitalization or liquidity *do not* suggest the existence of a distinct lending channel in the euro area. This finding is robust to the different exogenous and unanticipated measure of monetary policy. However, empirical estimates of responsiveness of individual lending growth to deposit growth yield indirect evidence for a lending channel. Second, bank level lending responses to all different indicators of monetary policy are highly non-linear. A market-based indicator of financial conditions is an important determinant of individual bank level lending responses and it is also the source of interesting non-linearities in lending responses to monetary shocks. In periods of tight aggregate financial conditions individual bank lending is very responsive to monetary policy. In periods of light financial conditions it is less responsive.

Keywords: Monetary Transmission, Identification, Lending Channel, Financial Conditions

JEL Codes: G21, E52, E58

Contents

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4.1 Introduction

Whilst chapters 2 and 3 used U.S. banking data, this chapter studies the monetary transmission mechanism in the euro area. It considers a potentially important element of the monetary transmission channel related to the response of bank lending to monetary policy. When the central bank reduces bank reserves through monetary tightening this may reduce the supply of loans unless commercial banks' can easily alter the decomposition of their liabilities and substitute away from liabilities (deposits in particular) that are subject to reserve requirements. Such substitutes may come from money markets in the form of Certificates of Deposits or interbank loans or it may come from financial markets through the issuance of (covered) bonds or new equity. If such substitution does not happen without frictions and the supply of loans is reduced, then a monetary contraction may affect the real economy if non-financial firms cannot substitute bonds or commercial paper for bank loans. Such monetary transmission through a "credit" channel (Bernanke and Gertler, 1995) works on the supply side and may amplify the traditional "price" or "money" channel that works through the demand effect of a monetary contraction by modifying borrowing conditions that effect marginal inter-temporal spending decisions.

Problems arising from the use of macroeconomic time-series due to disentangling the "credit" channel from the classical "money" channel (Bernanke and Blinder, 1992) motivated the analysis of microeconomic data. Microeconomic bank level panel data enables a more clear-cut identification of loan supply shifts by analysing the differential lending growth response along bank characteristics that capture bank level financial constraints. For the U.S. there is evidence for differential lending growth responses along (inverse) proxies for bank level financial constraints such as bank size (by assets) and liquidity (Kashyap and Stein, 2000), capitalization (Kishan and Opiela, 2000) and affiliation with a bank holding company (Ashcraft, 2006). The absence of bank level financial constraints seems to mitigate the impact of monetary policy on lending. Other bank characteristics that have been suggested to identify loan supply shifts in the U.S. banking system include securitization (Loutskina, 2005), international exposure (Cetorelli and Goldberg, 2008) and proximity to the efficiency frontier (Jonas and King, 2008). The methodologies have ranged from panel estimations (Kishan and Opiela, 2000; Ashcraft, 2006) to two-stage regressions (Kashyap and Stein, 2000).

In contrast, empirical results on the existence of a bank lending channel in the euro area remain inconclusive as summarized in a survey by Ehrmann et al. (2003). Several papers claim that the lending channel should be at least as effective in the euro area as in the US given financial markets are less developed in Europe (Cecchetti, 1999; Kashyap and Stein, 1997). King (2002) and De Bondt (1999) and find evidence in favour of a euro area lending channel though some of their evidence (e.g. on France and Italy) is contradictory. Altunbas, Fazylov and Molyneux (2002) find that undercapitalized banks tend to respond more to monetary policy in the euro area, though in single country studies they only find evidence for that in Italy and Spain. An event study by Favero, Giavazzi and Flabbi (2001) focussing on the monetary tightening of 1992 does not find evidence of a significant response of bank loans to the monetary tightening.

Whilst all U.S. and euro area studies focus on different measures of bank level financial constraints and different econometric methodologies, they all employ the *endogenous* change in short-term interest rates as a measure of the monetary policy stance. This may be problematic if the same factors that drive the change in the nominal policy rate also drive loan supply of commercial banks or loan demand by households and firms. If, for instance, expectations of output move up then commercial banks may be more prone to take risks, reduce their excess reserves and expand loans by shifting their individual credit supply. At the same time the policy rate may move up in response to higher growth expectations in order to curb inflationary pressure arising from such expectations. This means that, even if there is no “money” channel operative and equilibrium lending growth rises solely in response to loan supply effects due to expectations, the estimated response to endogenous monetary policy may be attenuated. This is also true if there were no loan supply shifts and only expectations induced loan demand shifts as only equilibrium lending growth is observable. Thus a policy measure that purges some of the endogeneity of the policy rate may give a less biased estimates of the equilibrium loan growth responses to monetary policy via a combination credit and money channels.

Assuming homogenous loan demand movements across bank level financial constraints such as size, capitalization, or liquidity, the identification of a separate lending channel requires heterogeneity in lending responses along the aforementioned proxies for bank level financial constraints. Similar endogeneity issues arise when estimating such heterogenous lending responses. The estimated heterogeneity in lending outcomes across a number of such characteristics may be a consequence of the endogenous component of policy rate changes. If, for example, larger, better capitalized or more liquid banks are less risk-averse and more willing to pick up loan requests driven by output growth expectations then contractionary endogenous policy that is reactive to such expectations might appear (in panel estimates) to affect such banks to a lesser extent. Therefore, evidence for a lending channel based on such bank level financial constraints may be spurious if an endogenous policy measure is used because it is not loan supply shifts but heterogenous responses to drivers of policy causing these estimates. The contribution of this chapter is to address this endogeneity issue by contrasting bank lending responses in the euro area to two series of exogenous components of policy as well as unanticipated movements in the short-term money market rates with the lending responses to endogenous movements in the policy rate. In this way it builds on the arguments of chapter 2 that extended the Romer and Romer (2004) approach to generate exogenous monetary policy shocks to estimate the response of U.S. commercial banks' lending growth to this newly identified monetary policy measure.

The findings in chapter 2 were consistent with a distinct lending channel of monetary policy in the U.S. In particular, it was noted that monetary policy shocks identified by orthogonalizing against real-time Greenbook forecasts gave rise to bank level lending responses of larger magnitudes and with different dynamics. The responses to identified exogenous policy changes were both faster and stronger than lending responses to endogenous changes in the federal funds rate. Furthermore, the structure of the banking industry was more important in the determination of lending responses to exogenous monetary policy shocks in the sense that larger, better capitalized banks and banks within a bank holding company structure were more sheltered from contractionary monetary policy.

The first main contribution in this chapter is to examine a different range of possible identification schemes for policy shocks than in chapter 2. First, we estimate a simple quarterly Taylor (1993) rule as in its original formulation for the euro area and the residual component of this quarterly estimate is summed within the year to yield an annual measure of exogenous monetary policy. This exogenous policy measure is then employed in annual bank lending regressions.

Second, in an open economy setting the exchange rate might respond contemporaneously to changes in the nominal policy rate. Therefore, we derive exogenous quarterly monetary shocks from an open economy vector autoregression following the open specification suggested by Peersman and Smets (2003). Again the quarterly series of exogenous, orthogonal VAR shocks is summed within years and employed in annual bank lending regressions. The bank lending growth regressions using these two policy measures, that were purged of some of their endogenous movements, are contrasted with the standard measure of policy, the purely endogenous change in the nominal ECB Main Refinancing Rate.

Furthermore, two series of unanticipated nominal interest rate shocks are generated. They are identified by two high-frequency data series. We extract interest rate surprises from 1 month Euribor and 1 month Eurepo around the 170 monetary policy meetings of the ECB Council. We sum these shocks within years to generate two annual series of unanticipated nominal interest shocks. Like the exogenous monetary policy measures the bank level lending responses to these unanticipated money-market based measures of interest rate shocks will be contrasted with responses the to change in the average annual ECB Main Refinancing Rate.

Using these five different measures of monetary shocks we find that - unlike in the U.S. - standard measures of bank level financial constraints in lending regressions like bank size, capitalization or liquidity *do not* support the existence of a distinct lending channel in the euro area. This apparent irrelevance of bank level financial constraints is robust to the measure of policy used. Whilst this finding is in line with findings by Favero, Giavazzi and Flabbi (2001) and Ehrmann et al. (2003) it stands in contrast to findings by De Bondt (1999) and Altunbas, Gambacorta and Marques-Ibanez (2009*a*). We discuss these differences in terms of regression specifications as well as the endogeneity of the policy measures used in these studies.

The second major contribution of this chapter is to introduce a stock market based index of financial conditions into bank lending regressions. This indicator is computed as the annual average of the monthly ratio of an index of banking stocks and a stock market index. We compare estimates that include the financial conditions index with results from standard lending regressions. The aggregate financial conditions proxy turns out to be an important determinant of individual bank level lending responses. Its inclusion reduces the explanatory power of country level real output growth. As this market-based index can be interpreted as a proxy for aggregate financial conditions as well as expectations of the path of future output its significance in lending regressions underpin the importance of controlling for forward looking elements. It is these forward looking elements that are also likely to drive both the loan supply and demand schedules as well as the policy measure used in standard lending growth regressions (such as Kashyap and Stein, 2000, Kishan and

Opiela , 2000, and Ashcraft, 2006, for the U.S. or Ehrmann et al. 2003, and Altunbas et al. 2009*a* for the euro area).

In a second step, the financial conditions index is interacted with the generated monetary policy shocks in order to test for non-linearities. Interestingly, the financial conditions index is the source of non-linearities in lending responses to monetary shocks. In fact, the index reverses the direct impact of policy for all types of policy shocks. For the benchmark policy measure, in periods of tight aggregate financial conditions individual bank lending is very responsive to the endogenous policy measure whilst in periods of light financial conditions contractionary policy does not result in lending growth contractions in response to policy contraction.

The second major finding suggest that research on bank lending should take into account aggregate measures of financial conditions and consider seriously proxies for expectations about the future paths of real output and inflation which are both drivers of equilibrium lending. Whilst there have been studies incorporating sectoral uncertainty (Baum, Caglayan and Ozkan, 2003) or uncertainty relating to an individual banks (Altunbas, Gambacorta and Marques-Ibanez, 2009*a*), the findings in this chapter point to non-linearities due to aggregate financial conditions as perceived by financial markets. These non-linearities are present irrespective of the identification scheme employed. The importance of financial conditions found in the chapter suggests that forward-looking omitted variables driving policy as well as credit supply and demand may have biased previous empirical studies of the bank lending channel in the euro area in favour of finding effects of bank level financial constraints that help identify loan supply shifts. This second finding underlines the need to analyse lending responses to exogenous policy measures.

Whilst the evidence based on heterogeneity in lending outcomes along bank level financial constraints does not support the existence of a lending channel this chapter alternatively offers an indirect finding in support of the existence of a lending channel: Regressions of lending growth on deposit growth conditioning on bank level financial constraints result in a positive sensitivity of individual bank loan growth to deposit growth that is robust to a number of specifications.

The chapter is structured as follows: Section 4.2 discusses empirical estimates of bank lending and why the distinction between endogenous and exogenous monetary policy measures as well as anticipated and unanticipated changes in the nominal interest rate is relevant. Section 4.3 describes the macroeconomic and banking data used for the bank lending regressions and section 4.4 presents the empirical model and discusses the estimation results and section 4.5 concludes.

4.2 Bank Lending Responses and Monetary Policy Shocks

Bank loans are the important link between banks and non-financial firms or households. Whilst bank loans might be replaced by altering the level of inventories or adjusting the net trade credit position, smaller borrowers will generally have greater difficulties to access external sources of finance other than bank loans. Empirical evidence suggests that changes in the nominal interest rate impact the demand for credit via classical "price" channels that affect consumption and investment demand. It is difficult, however, to clearly disentangle differences in policy induced loan supply shifts from differences due to the price effect of monetary policy. Whilst there have been attempts to test for a bank lending channel using aggregate data (Driscoll, 2004), panel data estimates on commercial bank data have been a very promising and active area of empirical research in particular for the U.S. where quarterly bank level data is publicly available.

For the U.S. there is abundant evidence for differential lending growth responses along bank level financial constraints such as bank size and liquidity (Kashyap and Stein, 2000), capitalization (Kishan and Opiela, 2000) and affiliation with a bank holding company (Ashcraft, 2006). For the euro area results are more mixed. Altunbas, Fazylov and Molyneux (2002) present evidence that lending growth of under-capitalized banks respond more strongly to monetary policy than lending growth of adequately or overcapitalized banks independent of their size. They take the monetary policy shock to be the change in the country-specific short-term interest rate and their data set is restricted to annual data from 1991 to 1999. Looking at a similar time period, but using an event study approach Favero, Giavazzi and Flabbi (2001) do not find evidence of a significant response of bank loans to the monetary tightening.

There is also mixed evidence from studies based on national data sets. Much of the research related to that was conducted by the Eurosystem Monetary Transmission Network (MTN) on the transmission of monetary policy in the euro area and is summarized in Angeloni, Kashyap and Mojon (2003). For Germany, Worms (2001) shows that banks reduce their lending more sharply in response to contractionary monetary policy the lower their ratio of short-term interbank deposits to total assets (i.e. the lower their liquidity). Ehrmann and Worms (2001) explain the weak evidence for a lending channel in Germany by the fact that many smaller German banks may - despite their size - access liquidity through their head institutions. For Italy, Gambacorta (2001) analyses a bank panel from 1986 to 1998. He finds that size does not affect the banks' reaction to a monetary policy and explains this in terms of a closer customer relationship, which provides an incentive for smaller banks, which are more liquid on average, to smooth the effects of a tightening on loan supply. For Spain, Hernando and Pagès (2001) use a natural experiment, a one-off tax-induced switch from deposits to mutual funds that should leave loan demand unaffected, in order to test for the existence of a lending channel in Spain. They found no evidence that the sizeable reduction in deposits due to the shifts towards mutual fund shares affected the ability of even the smaller, less liquid and less capitalised banks to satisfy loan demand.

Most of the papers that employ a panel approach to test for the credit channel focus on isolating bank characteristics that help identify loan supply shifts, however, none of the papers have considered controlling for aggregate financial conditions nor have they considered the implications of the endogenous nature of their measure of monetary policy shocks.[1] The two contributions of this chapter to the literature are to consider a range of exogenous and unanticipated monetary policy shocks on an up-to date annual bank panel from 1999 to 2008 that spans the whole episode of the common currency as well as including a measure of aggregate financial conditions.

In order to consider the importance of the endogeneity of the policy measure

[1]However, Altunbas, Fazylov and Molyneux (2002) in their discussion of lending regression results for the euro area mention that "[g]reater attention perhaps also needs to be paid to (...) the use of a wider array of monetary stance indicators." and Baum, Caglayan and Ozkan (2003) employ a VAR based shock measure in their tests.

consider the following regression specification that is standard in annual bank lending regressions of the euro area:

$$\begin{aligned}
\Delta\log\left(L_{i,t}\right) &= \alpha_0 + \rho\cdot\Delta\log\left(L_{i,t-1}\right) + \alpha_1\cdot x_{i,t-1} \\
&+ \beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log\left(Y_t\right) + \beta_3\cdot\pi_t \\
&+ \gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \gamma_2\cdot\Delta\log\left(Y_t\right)\cdot x_{i,t-1} \\
&+ \gamma_3\cdot\pi_t\cdot x_{i,t-1} + \mu\cdot\mathrm{time}_t + \varepsilon_{i,t}
\end{aligned} \tag{4.1}$$

where i and t are indices of banks and time in years, $\Delta\log\left(L_{i,t}\right)$ denotes the change (t minus $t-1$) in the natural logarithm of total nominal loans, Δr_t is a monetary policy measure, $\Delta\log\left(Y_t\right)$ is annual real GDP growth, π_t is annual inflation, $x_{i,t}$ is a vector of bank-specific characteristics, and $\varepsilon_{i,t}$ is a mean-zero error term. All other Greek letters denote parameters.

First, most of the variation in monetary policy instrument Δr_t is accounted for by systematic, reactive responses of policy to the state of the economy. For the US, the real-time identification in chapter 2 purged about half of the endogenous variation in the federal funds rate. Sections 2.2.3 and 2.2.4 in chapter 2 discuss the endogeneity of monetary policy and its implications in some detail. This paragraph recapitulates some of the main points. Consider endogenous variations in Δr_t e.g. in response to the output gap, expectations of future inflation or output growth that also drive loan demand by households and firms. Then an endogenous increase in the interest rate which is taken to be indicative of contractionary monetary policy in the studies on euro area bank lending surveyed above coincides with a demand driven rise in equilibrium lending and the estimated response β_1 is attenuated. The same argument is true of changes in credit supply that are responsive to drivers of the endogenous nominal interest rate. For instance, banks' risk-taking behaviour may be affected and loan supply thus expands. Furthermore, the endogeneity of the nominal interest rate might affect estimates of the cross-effects γ_1 in (4.1). This is crucial in so far as these cross-effects are taken as evidence of loan supply shifts. If either loan demand or loan supply vary systematically with the state of the economy (that the policy rate is endogenous to) along one of the bank level characteristics proxying for bank level financial constraints discussed earlier, like size, capitalization or liquidity, then the estimates of heterogeneity in bank level lending responses may over- or understate the true effects.[2] Before making inferences about heterogeneity in bank lending, one ought to take into account such biases and - at least comparatively - consider responses to measures of policy that are largely exogenous to the state of the economy. Estimation of the effects of monetary policy on equilibrium lending using the endogenous change in the policy instrument, the short-term interest rate, may confound effects from the state of the economy with direct effects from monetary policy.

The subsequent subsections present the five different measures of monetary policy shocks that are employed in the euro area bank lending regressions. Section 4.2.1 discusses the benchmark endogenous policy measure used in the aforementioned empirical studies of the lending channel in the euro area. A measure of the monetary policy stance based on a simple "stylized" Taylor (1993) rule is discussed in sec-

[2]See section 2.4 in the first chapter for a more detailled discussion.

tion 4.2.2. Thirdly, we present the derivation of (Choleski orthogonalized) monetary policy shocks from an open economy SVAR in section 4.2.3. Finally, section 4.2.4 discusses monetary policy shocks based on changes in high-frequency data around ECB monetary policy meetings. Table 4.3 summarizes and compares the annualized shock measures.

4.2.1 Standard Monetary Policy Identification

The standard in the bank lending literature is to measure monetary policy as changes in the nominal target policy rate. When the policy rate rises policy is considered "tight", when the policy rate falls monetary policy is "loose". Figure 4.5 on page 225 displays the Bundesbank and ECB main refinancing rate from the first quarter of 1970 to the first quarter of 2010. The vertical lines in the figure bracket the time period of the commercial bank level sample analysed in this chapter. The figure gives a visual illustration of the quarterly time path of conventional monetary policy measures in bank lending regression, namely, the end-of-quarter change in the policy rate. Since the inception of the single currency monetary policy was initially loose, then contractionary up to 2001, expansionary during and after 2001, neutral in 2004/2005 and contractionary in 2006/2007. In subsequent bank lending regressions this measure of policy will be used as a benchmark (referred to as "ECB" or "Δ ECB Main Refinancing Rate" in the subsequent tables). Column (1) of table 4.3 on page 214 lists the average annual level of the ECB Main Refinancing Rate and column (2) gives the first difference.

4.2.2 Taylor Rule Identification

Another way to look at monetary policy measures is to disentangle their endogenous and exogenous components using a parsimonious single equation model. Similarly, one could impose familiar short-run restrictions on a vector autoregression that includes the nominal interest rate and recursively estimated and extract the shocks from the nominal interest rate equation that can be considered the policy rule in a simultaneous equation setting. We look at an open economy simultaneous equation identification in the next subsection. Here, we estimate the following simple Taylor (1993) type rule for the period from the first quarter of 1999 to the last quarter of 2008:

$$stn_t = \alpha + \beta \cdot \pi_t + \gamma \cdot \hat{y}_t + \varepsilon_t \tag{4.2}$$

where t indexes the quarter, stn_t is the quarterly average short term nominal interest rate in the euro area, π_t is the rate of annual inflation measured by the seasonally adjusted Harmonised Index of Consumer Prices (HICP) and $\hat{y}_t$ is the percent deviation of quarterly real GDP from a target averaged over the year.[3] The target GDP Y^* is obtained from a quarterly Hodrick-Prescott (1997) filter. The residuals of (4.2) from using different lag lengths on the inflation measure are highly correlated with the residuals from the specific regression presented here. Table 4.1 displays the estimates and figure 4.2 illustrates the actual and fitted quarterly values and the

[3] $\pi_t = 100 \cdot \left(\frac{\text{HICP}_t - \text{HICP}_{t-1}}{\text{HICP}_{t-1}} + \frac{\text{HICP}_{t-1} - \text{HICP}_{t-2}}{\text{HICP}_{t-2}} + \frac{\text{HICP}_{t-2} - \text{HICP}_{t-3}}{\text{HICP}_{t-3}} + \frac{\text{HICP}_{t-3} - \text{HICP}_{t-4}}{\text{HICP}_{t-4}} \right)$
$\hat{y}_t = 100 \cdot \frac{Y - Y^*}{Y^*}$ where Y is constant price, real GDP and Y^* is trend real GDP.

i_t	Taylor rule (1999q1-2008q4)
π_t	0.1557
	(0.1363)
$\hat{y}_t$	0.2863***
	(0.0258)
N	40
R^2	0.8129

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.1: Taylor Rule Estimate

residuals. About 81 percent of the variation in the policy rate is explained by this model. Clearly, other modified Taylor rule specifications, for instance with a degree of interest rate smoothing, forward-looking or open economy elements, are possible and will yield different time-series of residuals. Given the variety of modeling options, like in the subsequent section on VAR identification we choose an established benchmark in order to separate out systematic, reactive policy from autonomous shocks. So we estimate a simple Taylor rule as in (4.2) over the sample period for which we have banking data available (1999:1 to 2008:4).[4]

Given that the frequency of the bank panel is annual we construct quarterly exogenous components to policy via a simple Taylor Rule and sum them within the year. The macroeconomic data for the euro area, the quarterly series of real output and the Harmonized Index of Consumer Prices (HICP), is from the European Central Bank. Table 4.1 reports the estimation results and figure 4.2 displays the actual and fitted values as well as the estimated residuals. We note that according to this simple model policy has been tight in late 2000 and excessively easy during 2004/2005. Column (3) of table 4.3 on page 214 summarizes the annualized exogenous policy shock derived from the Taylor rule identification.

4.2.3 Open Economy Vector Autoregression Identification

Whilst dynamic variants of the Taylor Rule identification can be derived from a VAR under the assumption that the short-term interest rate is the most exogenous component in the sense that output and prices are assumed to respond with a lag,

[4]The HP filter used to obtain the output gap contains data points beyond the estimation sample.

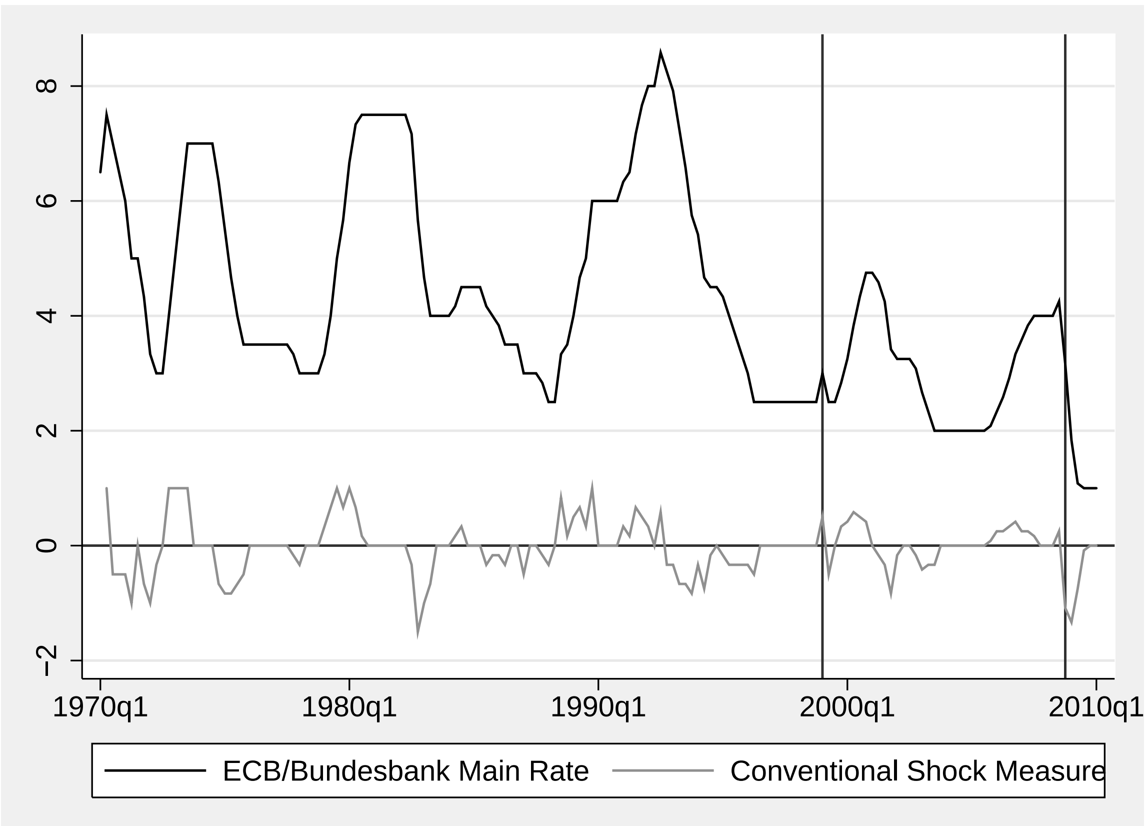

Figure 4.1: Standard Measure of Monetary Policy- End-of-Quarter Changes in the Policy Rate

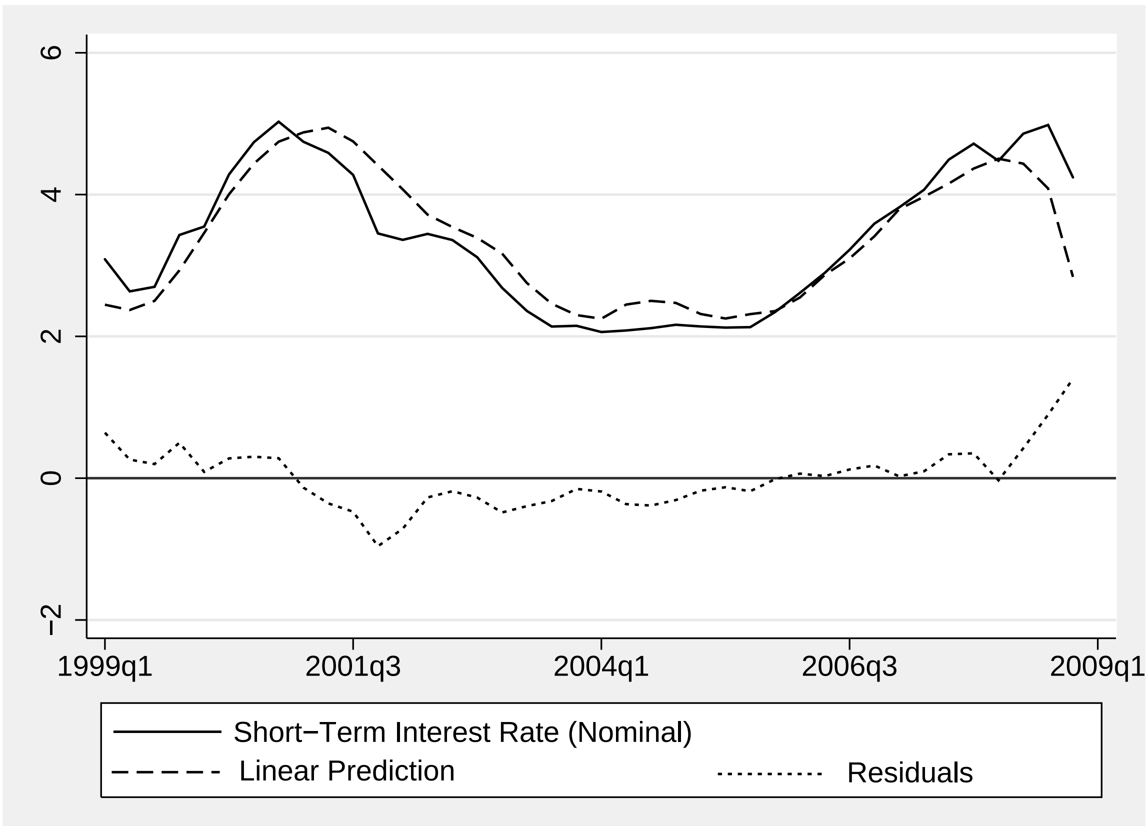

Figure 4.2: Simple Taylor Rule - Residuals, Fitted and Actual Values.

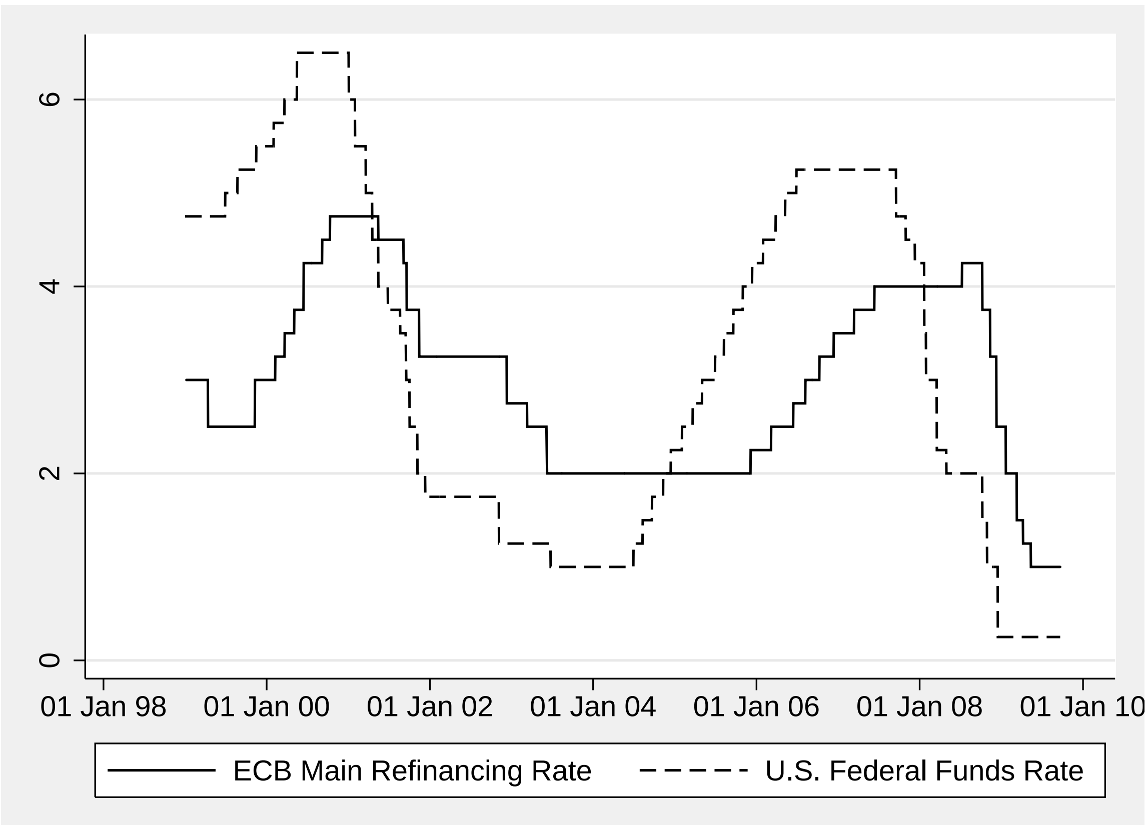

Figure 4.3: European and US Monetary Policy (1999-2010)

such arguments are different in an open economy setting. In contrast to the U.S. this is particularly relevant for the euro area. Figure 4.3 on page 209 plots the target Federal Funds Rate and the ECB Main Refinancing Facility. If both economies are subject to similar shocks casual observation suggest that monetary policy of the Federal Reserve is more activist (likely to be due to different macroeconomic structures, preferences and shocks) and also leads ECB policy. This motivates extending the single equation identifying framework to an open economy vector autoregression. We estimate an open economy VAR specification similar to Peersman and Smets (2003). Consider a quarterly VAR with the following representation:

$$Y_t = A(L)Y_{t-1} + B(L)X_t + \mu_t \tag{4.3}$$

where Y_t is the vector of endogenous euro area variables and X_t is a vector of exogenous foreign variables. In the following specification we assume that the vector of exogenous variables consists of a commodity price index com_t, US real GDP y_t^{US} and the US short-term nominal interest rate stn_t^{US}:

$$X_t' = \begin{bmatrix} com_t & y_t^{US} & stn_t^{US} \end{bmatrix} \tag{4.4}$$

The endogenous euro area variables are real output y_t, prices as measured by the GDP deflator p_t, the real effective exchange rate x_t and the short-term nominal interest rate stn_t:

$$Y_t' = [y_t \quad p_t \quad stn_t \quad x_t] \tag{4.5}$$

Orthogonalized Monetary Policy VAR Residuals

Quarterly Correlations		$[y_t \quad p_t \quad i_t \quad x_t]$		$[y_t \quad p_t \quad x_t \quad i_t]$	
Ordering	Sample starting...	1999q1	1980q1	1999q1	1980q1
$[y_t \quad p_t \quad stn_t \quad x_t]$	1999q1	1.0000			
$[y_t \quad p_t \quad stn_t \quad x_t]$	1980q1	0.4354	1.0000		
$[y_t \quad p_t \quad x_t \quad stn_t]$	1999q1	0.9611	0.4911	1.0000	
$[y_t \quad p_t \quad x_t \quad stn_t]$	1980q1	0.4533	0.9801	0.4716	1.0000
Annual Correlations		$[y_t \quad p_t \quad i_t \quad x_t]$		$[y_t \quad p_t \quad x_t \quad i_t]$	
Ordering	Sample starting...	1999q1	1980q1	1999q1	1980q1
$[y_t \quad p_t \quad stn_t \quad x_t]$	1999q1	1.0000			
$[y_t \quad p_t \quad stn_t \quad x_t]$	1980q1	0.6240	1.0000		
$[y_t \quad p_t \quad x_t \quad stn_t]$	1999q1	0.9652	0.6153	1.0000	
$[y_t \quad p_t \quad x_t \quad stn_t]$	1980q1	0.5407	0.9703	0.4937	1.0000

Table 4.2: Correlations of Orthogonalized Residuals of Different VAR Specifications

We estimate the VAR in (4.3) using quarterly data from the European Central Bank on real GDP growth, the GDP deflator, and an index of commodity prices and the real exchange rate as well as US data on quarterly constant price GDP and the monthly average federal funds rate, that is then converted into quarterly values by averaging within quarters, taken from the FRED economic database of the Federal Reserve of St. Louis (series GDPC96 and FEDFUNDS respectively). The estimation period is confined by the availability of the bank level data and covers the period 1999:1 to 2008:4. One popular identifying short-term restriction in structural VAR studies of the monetary transmission mechanism is that the monetary policy shock does not affect prices and output contemporaneously. This corresponds to ordering the monetary policy after output and prices in a Choleski decomposition. This assumption is attractive since the monetary shock can then be identified without having to take a stand on any of the other shocks in the economy: the identification of the monetary shock is the same, no matter how the other shocks are identified. Here, we follow Peersman and Smets (2003) and order the exchange rate last.

As a robustness check we estimate different orderings (the interest rate last and exchange rate last) and subsamples (1980:1 to 2008:4 and 1999:1 to 2008:4) of the open economy VAR in (4.3). Table 4.2 on page 211 presents correlations of the quarterly residual series of monetary policy from such alterations as well as their annualized equivalents that will be used in the bank lending growth regressions. There is very little change in the quarterly shock measures when the ordering between the exchange rate and the interest rate is reversed (>96 percent correlation). There is less correlation when we compare estimations across different subsamples, although quarterly monetary policy residuals are still significantly positively correlated (>43 percent). The lowest annualized correlation for the monetary policy shock measures that are relevant for the annual bank lending regression is around 50 percent between the sample starting in 1980 with the interest rate ordered last and the sample starting in 1999 with the exchange rate ordered last. The bank lending regressions use the residuals from Peersman and Smets' (2003) specification during the subperiod starting in 1999.

Column (4) in table 4.3 on page 214 summarizes the annualized exogenous policy shock derived from the open economy VAR identification. According to this annualized measure policy has been easy in the years 1999 - 2001 and tight to varying degrees afterwards.[5]

4.2.4 High-Frequency Identification

Another approach to identify monetary policy shocks is to analyse market-based high-frequency asset prices around monetary policy decisions. One critique from identifying monetary policy shocks from either structural VARs and single equation Taylor rule relates to the omitted variables problem and the time-varying parameters problem. The omitted variables problem in estimated policy rules is that such identification schemes might omit important variables that the monetary policy authority watches when making its policy decision (like expectations or asset prices). Indeed, one objective of "simple" Taylor (1993) type policy rules is their parsimony. Simple single equation policy rules typically feature inflation and a measure of the output gap, however, there are a number of times when the monetary authority reacts to different factors. One instance might be exchange rate considerations (see e.g. Clarida, Galí and Gertler, 2001), another example are clearly trouble in the financial markets and the banking sector e.g. in early 1987 or during the financial crisis of 2007/2008.

[5] We are mindful of the critique of Rudebusch (1998) regarding the validity of monetary shocks derived from various vector autoregressive estimations that interpret the interest rate equation as a policy rule and its orthogonalized residuals as monetary shocks. This is why this particular exogenous monetary policy shock identification is presented alongside with the simple Taylor (1993) rule identification and other unanticipated shocks as well as the actual endogenous change in the policy rate. For a critique of Rudebusch (1998) see Sims (1998).

Annual Monetary Policy Measures

	(1)	(2)	(3)	(4)	(5)	(6)
Year	ECB Main Ref. Rate	Δ ECB Main Ref. Rate	Taylor Rule	Open SVAR	Euribor (1 month)	Eurepo (1 month)
1999	2.715		1.602	0.221	-0.515	-0.172
2000	3.987	1.272	0.953	-0.142	-0.033	-0.183
2001	4.307	0.320	-1.919	-0.200	-0.254	-0.008
2002	3.222	-1.084	-1.440	0.188	0.141	0.167
2003	2.270	-0.952	-1.350	-0.197	0.173	0.199
2004	2.000	-0.270	-1.246	0.276	0.006	0.047
2005	2.017	0.017	-0.500	-0.251	-0.033	-0.027
2006	2.756	0.739	0.396	0.165	-0.070	-0.079
2007	3.836	1.080	0.812	-0.107	-0.081	0.076
2008	3.893	0.057	2.692	0.046	-0.319	-0.005
2009	1.287	-2.605			-0.257	-0.149
2010	1.000	-0.287			-0.010	-0.003

Annual Correlation	Δ ECB Main Ref. Rate	Taylor Rule	Open SVAR	Euribor (1 month)	Eurepo (1 month)
Δ ECB MR Rate	1.000				
Taylor Rule	0.535	1.000			
Open SVAR	-0.233	0.174	1.000		
Euribor (1 month)	-0.024	-0.606	-0.193	1.000	
Eurepo (1 month)	-0.155	-0.556	-0.087	0.676	1.000

Table 4.3: Monetary Policy Shock Measures and Correlations (Annualized)

In times of financial market turbulence monetary policy was accommodating over and beyond what would have been justified by inflation or (even forward-looking) output gap measures. The other problem, for instance with a VAR identification, is the time-varying parameters problem. Both the structure of the economy as well as the preferences of the policy makers or the variance of shocks hitting the economy may have changed over time which is not captured by fixed parameters of standard VARs. So endogenous monetary policy movements to due different time-varying preferences over output and inflation or changes in the transmission mechanism and hence different policy responses might be classified as "exogenous" in a recursive vector autoregression despite being systematic. Rudebusch (1998) suggests the use of market-based high-frequency asset prices in order to identify measures of unanticipated monetary policy as alternatives to shocks identified by VARs. Market expectations summarize real-time information surmounting the omitted-variables or time-variant parameters problems that may occur with identification schemes outlined in 4.2.2 and 4.2.3. Kuttner (2001) and Rudebusch (1998) extract unanticipated monetary policy shocks from daily data on federal funds futures. Cochrane and Piazzesi (2002) suggest defining a monetary policy shock for the US as the change in the one-month Eurodollar rate just before to just after a target rate change. We follow this approach and slightly modify it though we do not restrict ourselves only to the ECB's 31 target changes. We also look at changes in one-month rate changes around policy meeting where no change in the target was announced because money market participants might have expected a change that then did not happen. This is as much a "surprise" as an actual target rate adjustment that happened unexpectedly or to a larger or smaller degree than expected. Changes in both one-month Euribor, the unsecured money market rate, as well as one-month Eurepo rates, the secured money market rates, around ECB monetary policy meetings are generated. Annual measures are constructed by summing these shocks for each year in the sample.

Table 4.15 on page 256 lists all the ECB General Council meetings and the corresponding nominal interest rate decisions. Between March 1999 and March 2010 there have been 170 ECB General Council meetings concerned with monetary policy that decided on 31 changes in the ECB Main Refinancing Facility. Figure 4.4 on page 224 gives a summary of these rate changes. Whilst the sample is rather small there is a notable asymmetry in that rate rises are more gradual (usually by 25 b.p.) whereas policy rate reductions are more rapid (the mode here is 50 b.p.).

The target nominal monetary policy rate like the ECB Main Refinancing Facility as well as its changes are endogenous to developments in the real economy in particular with respect to current and future output in relation to its natural level as well as inflation and inflation expectations. Clearly, many changes of the target policy rate are then anticipated by market participants aware of the drives of policy and well-know to banks that are active in the money markets and act as borrowers but also to depositors and lenders.

In order to generate unanticipated policy surprises we compute changes in short-term interest rates around ECB monetary policy meetings. There are a number of high-frequency data sources that are available on a daily basis and can be used to identify unanticipated monetary policy shocks. In particular, we look at two different money market interest rates. Given the ECB meetings are a month apart the change in the one-month interest rate will reflect the surprises from this particular meeting only. First, the Euro Interbank Offered Rate (Euribor), the euro area equivalent of Libor, is the rate at which euro interbank term deposits are being offered by one prime bank to another within the EMU zone. It is computed as an average of all rates for a number of maturities in the interbank market reported by prime banks.[6] It is available since the inception of the single currency on 1 January 1999. Euribor is available for a whole range of maturities: 1 week, 2 weeks, 3 weeks, and 1 - 12 months. Euribor is the *unsecured* lending rates in the euro area (for details on Euribor see `http://www.euribor.org`). As a second rate we use Eurepo, the *secured* lending rate between banks. It is the rate at which one prime bank offers funds in euro to another prime bank if in exchange the former receives from the latter "Eurepo General Collateral" (GC) as collateral (see `http://www.eurepo.org`).[7]

The rates for 1 month Euribor and 1 month Eurepo are aggregated from a panel of prime banks in the euro area at 11:00 (CET) each business day. The decisions on the key interest rates for the euro area are announced in a press release issued at 13:45 (CET) on the day of the Governing Council's first meeting of the month. Shortly afterwards, at 14:30 (CET), the decisions are explained in a press conference.

If the maturity date of a trade falls on a non-business day, the maturity date is

[6]The sample of banks consists of ABN AMRO Amsterdam, Banca Intesa Milan, Barclays Capital London, BBVA Madrid, BNP Paribas Paris, BSCH Madrid, Calyon Paris, NATIXIS, Citibank New York, Commerzbank Frankfurt, CSFB Zurich, Deutsche Bank Frankfurt, Dresdner Bank Frankfurt, DZ Bank Frankfurt, Fortis Bank Brussels, HSBC France, JP Morgan New York, KBC Brussels, Rabobank Utrecht, RBS London, Societe Generale Paris, UBS Zurich, West LB Dusseldorf.

[7]General collateral is a set of specific government guaranteed bonds and bills. The four interest rate Eonia interest rate swaps are available only from 2005 onwards (for definitions see `http://www.eoniaswap.org`).

moved to the next business day except in the case of "end-end" quotes where the value date of the trade falls at month-end. If the corresponding maturity date falls on a non-business day, the maturity date is brought back to the last business day of that month. For instance the 1 month Euribor quote for 28 February each year is 31 March and not 28 March assuming both are business days. Using this convention of business day counting we can think of the 1 month Euribor as the sum of overnight rates for the coming month starting at date t and ending precisely one month latter according to the above definition:

$$\text{Euribor}_t^{1month} = \frac{1}{d_t} E_t \left[\sum_{k=0}^{d_t} r_{t+k}^{on} \mid \Omega_t \right] \tag{4.6}$$

where r_{t+k}^{on} is the overnight rate spot value on an Actual/360 Day count convention and d_t is the number of business days from day t onwards until the reference day according to the definition above and Ω_t denotes the information set at time t.[8] Ω_t denotes the information set just before the meeting but after the submission of the Euribor and Eurepo rates of the panel banks. Correspondingly, the 1 month Euribor rate at $t+1$ can be thought of as

$$\text{Euribor}_{t+1}^{1month} = \frac{1}{d_{t+1}} E_{t+1} \left[\sum_{k=0}^{d_{t+1}} r_{t+1+k}^{on} \mid \Omega_{t+1} \right] \tag{4.7}$$

Note that in money markets, in contrast to bond markets, there is no cumulative interest accounting such that a simple sum of notional overnight rates suffices. So if

[8] Under the Actual/360 Day count convention each month is treated normally with its actual day count and the year is assumed to be 360 days. For example, in a period from 1 February 2005 to 1 April 2005, the factor is 59 days divided by 360 days.

we assume that the overnight rate r_t^{on} is a constant premium over the actual policy rate or that liquidity shock induces movements of this premium even out over the month then

$$\begin{aligned} \text{Euribor}_t^{1month} &= E_t\left[\bar{r}_m^{on} \mid \Omega_t\right] \\ \text{Euribor}_{t+1}^{1month} &= E_{t+1}\left[\bar{r}_m^{on} \mid \Omega_{t+1}\right] \end{aligned}$$

Now, if there was no change in policy at the ECB meeting day t, this was fully anticipated by money market participants and there were no liquidity shocks driving the premium on this very day, then it should be true that

$$\begin{aligned} \text{Euribor}_{t+1}^{1month} - \text{Euribor}_t^{1month} &= \frac{1}{d_{t+1}} E_{t+1}\left[\sum_{k=0}^{d_{t+1}} r_{t+1+k}^{on} \mid \Omega_{t+1}\right] - \frac{1}{d_t} E_t\left[\sum_{k=0}^{d_t} r_{t+k}^{on} \mid \Omega_t\right] \\ &= 0 \\ \text{i.e. } \Omega_t \cap \Omega_{t+1} = \Omega_t &= \Omega_{t+1} \\ \text{or } \left(\Omega_t \cap \Omega_{t+1}\right)^C &= \emptyset \end{aligned}$$

Let $\bar{r}_m^{on}$ denote the average overnight lending rate for the coming month. Then we are interested in obtaining a meetings-based interest rate surprise measure $\varepsilon_t^{1mEuribor}$ as

$$\varepsilon_t^{1mEuribor} = E_{t+1}\left[\bar{r}_m^{on} \mid \Omega_{t+1}\right] - E_t\left[\bar{r}_m^{on} \mid \Omega_t\right]$$

that is we are interested in the unanticipated component of policy rate changes. In order to compute these meetings based unanticipated interest rate shocks we note that

$$\begin{aligned}
\Delta\text{Euribor}_t^{1month} &\equiv \text{Euribor}_{t+1}^{1month} - \text{Euribor}_t^{1month} \\
\Delta\text{Euribor}_t^{1month} &= \frac{1}{d_{t+1}} E_{t+1}\left[\sum_{k=0}^{d_{t+1}} r_{t+1+k}^{on} \mid \Omega_{t+1}\right] - \frac{1}{d_t} E_t\left[r_t^{on} + \sum_{k=1}^{d_t} r_{t+k}^{on} \mid \Omega_t\right] \\
&= \frac{1}{d_{t+1}} E_{t+1}\left[\sum_{k=0}^{d_{t+1}} r_{t+1+k}^{on} \mid \Omega_{t+1}\right] - \frac{1}{d_t} E_t\left[r_t^{on} + \sum_{k=0}^{d_t} r_{t+1+k}^{on} \mid \Omega_t\right] \\
&= \frac{1}{d_{t+1}} E_{t+1}\left[d_{t+1} \cdot \bar{r}_m^{on} \mid \Omega_{t+1}\right] - \frac{1}{d_t} E_t\left[r_t^{on} + (d_t - 1) \cdot \bar{r}_m^{on} \mid \Omega_t\right] \\
&= E_{t+1}\left[\bar{r}_m^{on} \mid \Omega_{t+1}\right] - \frac{1}{d_t} E_t\left[r_t^{on} \mid \Omega_t\right] - \frac{d_t - 1}{d_t} E_t\left[\bar{r}_m^{on} \mid \Omega_t\right]
\end{aligned}$$

So

$$E_t\left[\bar{r}_m^{on} \mid \Omega_t\right] = \frac{d_t}{d_t - 1} \cdot \left(\text{Euribor}_t^{1month} - \frac{1}{d_t} E_t\left[r_t^{on} \mid \Omega_t\right]\right)$$

Therefore, the meetings-based interest rate surprise measure $\varepsilon_t^{1mEuribor}$ can be written as

$$\begin{aligned}
\varepsilon_m^{1mEuribor} &= E_{t+1}\left[\bar{r}_m^{on} \mid \Omega_{t+1}\right] - E_t\left[\bar{r}_m^{on} \mid \Omega_t\right] \\
&= \text{Euribor}_{t+1}^{1month} - \frac{d_t}{d_t - 1} \cdot \left(\text{Euribor}_t^{1month} - \frac{1}{d_t} E_t\left[r_t^{on} \mid \Omega_t\right]\right)
\end{aligned}$$

If we set $E_t\left[r_t^{on} \mid \Omega_t\right]$ equal to its realization Eonia_t then

$$\varepsilon_t^{1mEuribor} = \text{Euribor}_{t+1}^{1month} - \frac{d_t}{d_t - 1} \cdot \left(\text{Euribor}_t^{1month} - \frac{1}{d_t}\text{Eonia}_t\right) \quad (4.8)$$

$$\Delta\text{yield}_{m,t} = \alpha_m + \beta_m \cdot \Delta Eonia_t$$
$$\Delta\text{yield}_{m,t} = \alpha_m + \beta_m \cdot \varepsilon_t^{1mEuribor}$$
$$\Delta\text{yield}_{m,t} = \alpha_m + \beta_m \cdot \varepsilon_t^{1mEurepo}$$

where t indexes the ECB meetings and m indexes maturity

Change in Yield with Maturity ...	β_m 1 month	β_m 2 month	β_m 1 year	β_m 3 years	β_m 5 years	β_m 10 years
(1) Eonia	0.1252***	0.1155***	0.0994**	0.0873*	0.0570	0.0156
	(0.0217)	(0.0180)	(0.0336)	(0.0379)	(0.0355)	(0.0302)
N	170	170	169	169	169	169
R^2	0.1648	0.1971	0.0497	0.0307	0.0152	0.0016
(2) Euribor		0.7604***	0.5783***	0.4161***	0.2684*	-0.0017
(1 month)		(0.0250)	(0.1000)	(0.1181)	(0.1116)	(0.0960)
N		170	169	169	169	169
R^2		0.8462	0.1669	0.0692	0.0335	0.0000
(3) Eurepo		0.6875***	0.6613***	0.4649**	0.3072*	0.0008
(1 month)		(0.0446)	(0.1187)	(0.1409)	(0.1328)	(0.1129)
N		162	161	161	161	161
R^2		0.5973	0.1634	0.0640	0.0326	0.0000

The dependent variable is the change in yields from a day before the ECB meeting to one day after the meeting. The independent variables are changes in Eonia, and unanticipated changes derived from Euribor, and Eurepo.
Standard errors are in parentheses. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 4.4: High-Frequency Identification and Yield Responses

The meetings based Eurepo shocks are similarly computed as

$$\varepsilon_t^{1mEurepo} = \text{Eurepo}_{t+1}^{1month} - \frac{d_t}{d_t - 1} \cdot \left(\text{Eurepo}_t^{1month} - \frac{1}{d_t} \text{Eonia}_t \right) \qquad (4.9)$$

where t is the date of the ECB General Council meeting. Table 4.5 on page 223 presents summary statistics of the shocks. It is noteworthy that shocks to Euribor and Eurepo are highly correlated. The differences between these is that Euribor is unsecured and Eurepo is secured. As the financial crisis 2007/2008 is part of the banking sample we include both measures. Figure 4.6 on page 226 plots the spread between both money market rates with the financial crisis and the corresponding rise in uncollateralised interbank rate. Generally, Eurepo will be less subject to influences emanating from the banking sector and will hence give a purer measure of the true interest rate surprise.

In order check the informational content of the shocks $\varepsilon_t^{1mEuribor}$ and $\varepsilon_t^{1mEurepo}$ we regress changes in yields of the maturities 1 and 2 months, 1, 3, 5 and 10 years around ECB meeting (i.e. $t+1$ minus the yield at t) on the change in Eonia and the newly constructed unanticipated shocks to 1 month Euribor and Eurepo.

$$\begin{aligned}
\Delta\text{yield}_{m,t} &= \alpha_m + \beta_m \cdot \Delta Eonia_t \\
\Delta\text{yield}_{m,t} &= \alpha_m + \beta_m \cdot \varepsilon_t^{1mEuribor} \\
\Delta\text{yield}_{m,t} &= \alpha_m + \beta_m \cdot \varepsilon_t^{1mEurepo}
\end{aligned}$$

Table 4.4 on page 221 shows that unanticipated changes in 1 month Euribor and Eurepo have a very strong effect on changes in yields between 2 months and 5 years, suggesting some real informational content is contained in these shocks. In particular, the relation between interest rates and unexpected changes is clearly much stronger and more consistent than the relation between interest rates and changes in Eonia around meeting dates.

In order to obtain annualized shocks to be used in the annual banking panel the meeting based ε's are summed within years. These annualized shock series and their correlations with annualized endogenous and exogenous policy measures are summarized in columns (5) and (6) of table 4.3 on page 214.

Correlation (obs=162)	Eonia[a]	Euribor (1 month)	Eurepo (1 month)
Eonia[a]	1.0000		
Euribor	0.3548	1.0000	
Eurepo	0.3348	0.8534	1.0000
Observations	170	170	162
Mean	-0.0207	-0.0074	-0.0008
Std. Dev.	0.1798	0.0566	0.0498
Variance	0.0323	0.0032	0.0025
Skewness	0.0073	-2.8005	-3.1483
Kurtosis	11.0339	22.7830	28.7755

[a] Difference between three business day average Eonia before and after the ECB meeting.

Table 4.5: Descriptive Statistics: Meeting Based High-Frequency Policy Shocks

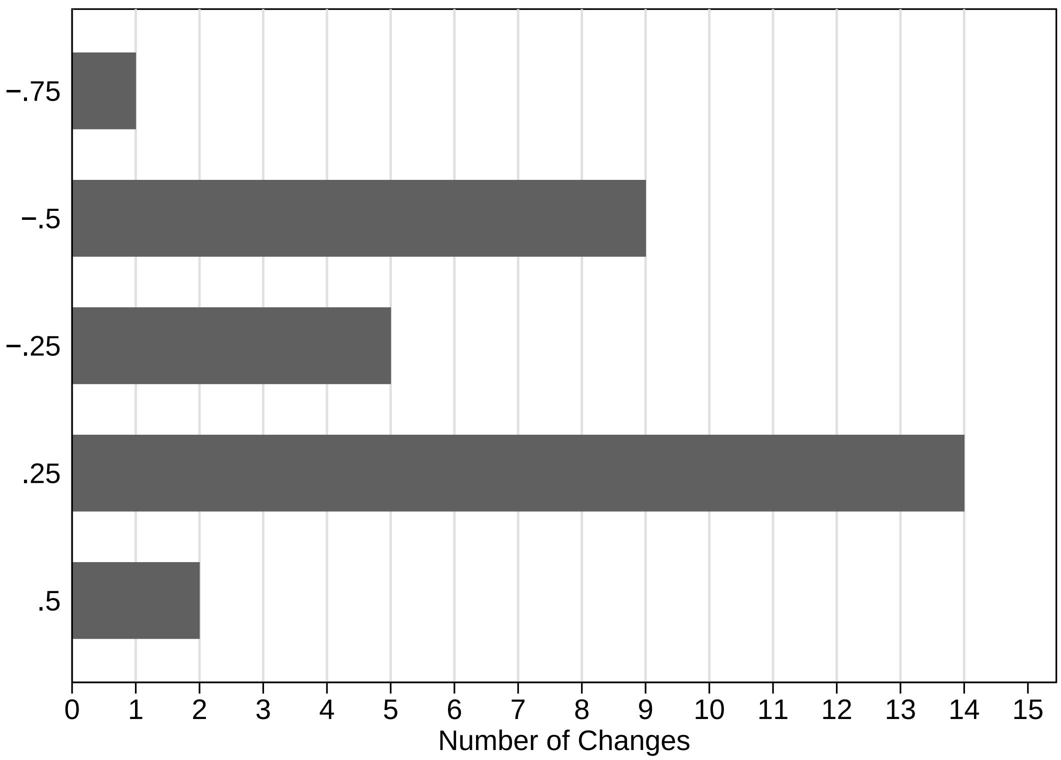

Figure 4.4: Frequency of Nominal Interest Rate Changes

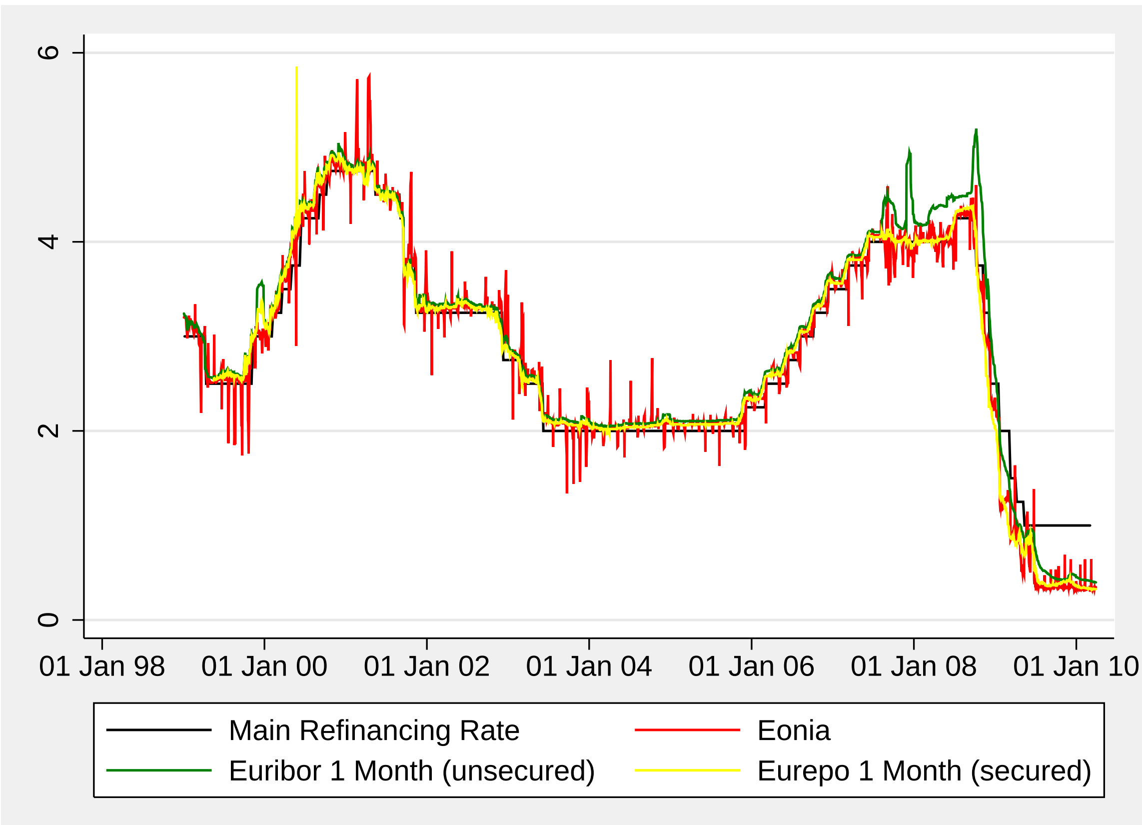

Figure 4.5: ECB Main Refinancing Facility, Eonia, Euribor, Eurepo (1999-2010)

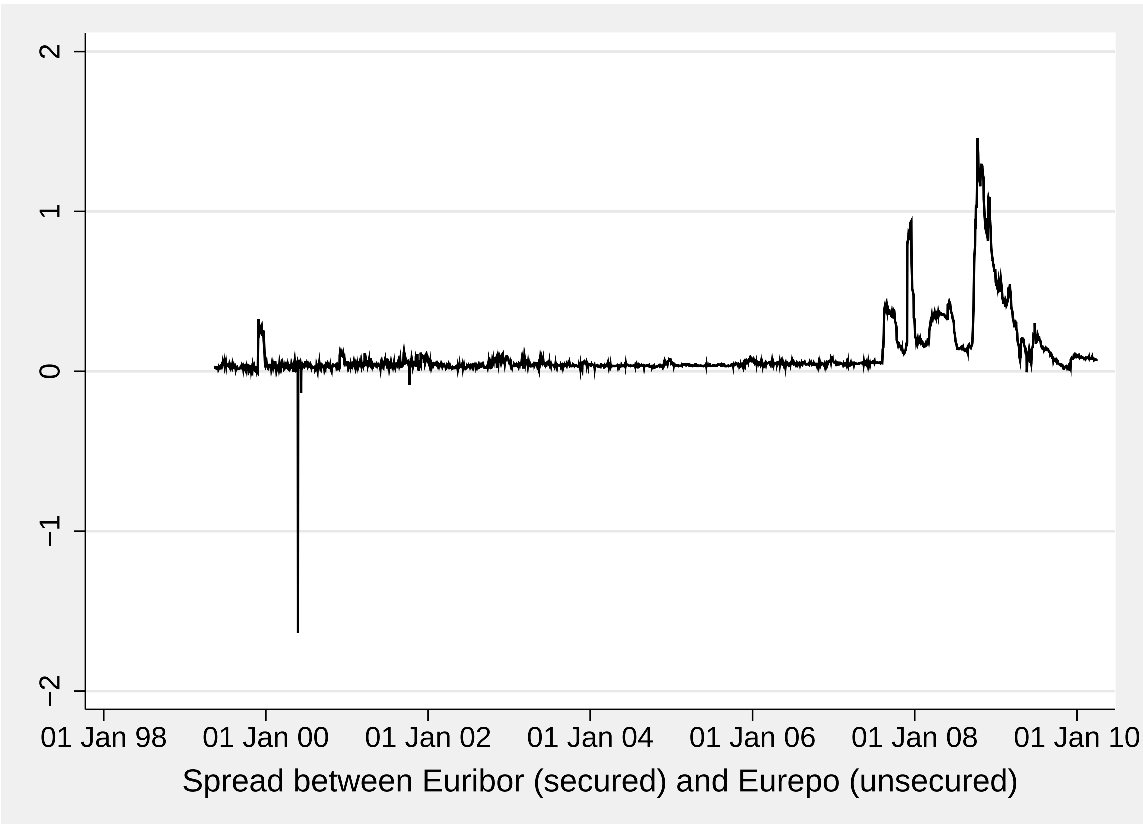

Figure 4.6: One Month Euribor-Eurepo-Spread (1999-2010)

4.3 Data

Recall that the annual bank lending growth regressions in this chapter take the form

$$
\begin{aligned}
\Delta\log\left(L_{i,t}\right) &= \alpha_0 + \rho\cdot\Delta\log\left(L_{i,t-1}\right) + \alpha_1\cdot x_{i,t-1} \\
&+ \beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log\left(Y_t\right) + \beta_3\cdot\pi_t \\
&+ \gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \gamma_2\cdot\Delta\log\left(Y_t\right)\cdot x_{i,t-1} \\
&+ \gamma_3\cdot\pi_t\cdot x_{i,t-1} + \mu\cdot\mathrm{time}_t + \varepsilon_{i,t}
\end{aligned}
$$

4.3.1 Macroeconomic Data

Individual country level macroeconomic data used in the bank lending regressions on constant price output growth $\log\left(Y_t\right)$ and the CPI index π_t is from the Electronic Data Sharing Service (EDSS) of the International Monetary Fund.[9] We estimate lending growth responses to the standard monetary policy measure Δr_t defined as the year-to-year difference in the day weighted average ECB Main Refinancing Rate. We also estimate bank level credit growth responses to the four different monetary policy shocks that will then be denoted by Δr_t in the respective regressions. These different series of monetary shocks have been generated as discussed in section 4.2. Five different measures of monetary policy shocks will be employed in the subsequent bank lending regressions. Table 4.3 on page 214 lists all five monetary policy shock measures on an annualized basis and their correlations.

[9]In the bank lending regression we control for the GDP growth and CPI inflation of the country that the bank is incorporated in whilst for policy identification purposes euro area aggregates are being used. The sources of the macroeconomic data for the Taylor Rule and open economy VAR identification have been discussed in sections 4.2.3 and 4.2.2.

4.3.2 Bank Level Data

The bank level data is obtained from Bureau Van Dijk's BankScope database. The BankScope database contains data on 9,187 financial institutions in the euro area.[10] We restrict the sample to only include institutions with consolidated statements so as to not count any institution twice i.e. a bank with an unconsolidated statement that is then part of a larger bank's consolidated statement (according to the BankScope definition C1, "Consolidated Statement with no Unconsolidated Companion", and C2, "Consolidated Statement with an Unconsolidated Companion"). It worthwhile pointing out that only a small proportion of these institutions have annual (or even quarterly) statements recorded in BankScope for the full period from 1999 - 2009. The average time an institution remains in the estimation sample is 3.65 years, about one third of the full sample, the range is between 1 and 10 years. Singleton observations in differences were eliminated.

The sample only includes what has been classified by BankScope as "commercial banks", "cooperative banks", "savings banks" and "bank holding companies". For 2009 hardly any data is available. For an analysis of loan growth first differences are required which eliminates further observations. Also, for some banks the full set of variables required for the analysis is unavailable at different points in time. This reduces the number of potential observations down to around 2,700 for a dynamic model with a first order autoregressive term down to around 2,200 observations. Table 4.6 on page 229 gives a summary of the available observations over time for the

[10]For the purposes of this chapter the euro area is defined by: Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain.

Year	Euro Area	France	Germany	Italy	Spain	Other[a]
2000	148	38	30	11	4	65
2001	151	50	30	10	4	57
2002	139	43	30	4	3	59
2003	138	39	31	1	2	65
2004	148	39	35	2	1	71
2005	142	36	37	0	0	69
2006	378	76	45	54	53	150
2007	440	95	48	58	73	166
2008	451	101	52	57	72	169
$\sum$	2,135	517	338	197	212	871

[a] includes Austria, Belgium, Cyprus, Finland, Greece, Ireland, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia

Table 4.6: Observations by Year and Country

Correlation Matrix	Loan Growth	Size (by Assets)	Capital-ization	Liquidity
Loan Growth	1.0000			
Size (by Assets)	0.0174	1.0000		
Capitalization	-0.0825	-0.4330	1.0000	
Liquidity	-0.0646	-0.1146	0.0843	1.0000
Mean[a]	0.1193	$6.51bn	0.0978	0.2385
Std. Dev.	0.4629	0.1291	0.1184	0.1955

[a] For interpretability individual characteristics are de-meaned and standardized in the lending regressions below.

Table 4.7: Descriptive Statistics: Bank Lending and Characteristics.

euro area as a whole, the four countries with the largest number of banks (France, Germany, Spain, Italy) and the rest of the euro area combined (Austria, Belgium, Cyprus, Finland, Greece, Ireland, Luxembourg, Netherlands, Malta, Portugal, Slovenia, and Slovakia). The panel is strongly unbalanced with the largest number of observations between 2004 and 2008. Furthermore, the four largest countries France, Germany, Italy and Spain account for about 60 percent of all observations.

Bank level lending is extracted from BankScope as total nominal loans. Bank deposits are total deposits. We also include three standard characteristics in the bank lending regressions. First, size as measured by total assets, second, capitalization as measured by equity capital over total assets and, third, liquidity as measured by liquid assets over total assets. Table 4.7 contains summary statistics for and correlations of bank characteristics used in the lending regressions as well as bank level lending growth. Nominal loan growth averages around 11.9 percent, liquid assets are around 23.8 percent of total assets and the mean capital ratio is 9.8 percent. According to table 4.7 on page 230 larger banks seem to be less capitalized and less liquid. Better capitalized banks tend to be more liquid. Lending growth correlates negatively with capitalization and liquidity and (slightly) positively with bank size.

4.3.3 Financial Market Data

In order to measure financial market conditions the regressions later include the ratio of the Euro Stoxx Banking Index and the Euro Stoxx Index. The Euro Stoxx Index is a broad yet liquid subset of the Stoxx Europe 600 Index. With a variable number of components, the index represents large, mid and small capitalisation companies of 12 Eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. The Euro Stoxx Banking Index contains all banks included in the Euro Stoxx Index. Both series were downloaded from Datastream (code $S2ESB2E$ for Euro Stoxx Banks and code $DJEURST$ for the Euro Stoxx) and the daily data was averaged by month and by year. Table 4.7 displays a time series of this ratio.

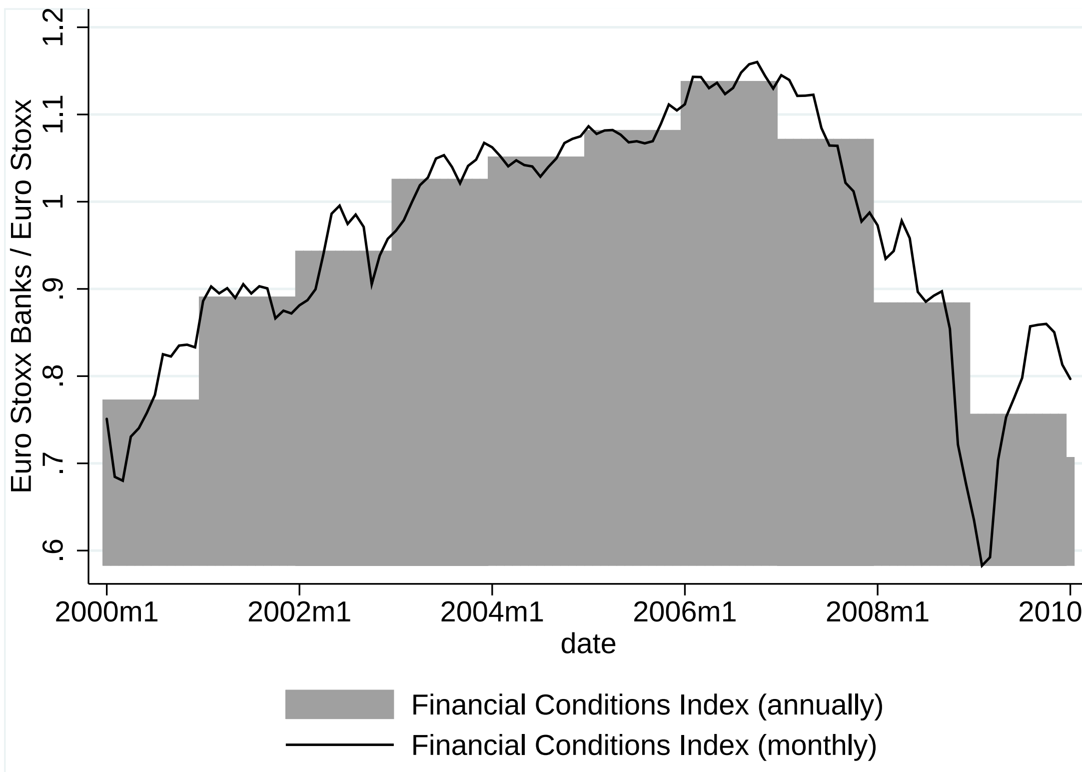

Figure 4.7: Annualized Financial Conditions Index (2000-2009)

4.4 Empirical Results

This section presents and discusses the estimation results. Section 4.4.1 presents evidence suggesting that at the individual bank level financial constraints play a part in determining lending growth. Section 4.4.2 discusses bank level lending responses to the five different measures of monetary policy shocks. Section 4.4.3 reports findings from an inclusion of a market-based financial conditions index into standard lending regressions. Finally, section 4.4.4 reports some robustness exercises.

4.4.1 Bank Level Lending Frictions

The theoretical literature on the bank lending channel argues that it is difficult for commercial banks to substitute one source of funding, the outflows of deposits, for another, say money market borrowing, capital or bond issuance following a policy contraction and hence lending for the bank concerned will have to to contract. One first indicator of whether or not financial frictions do influence equilibrium lending outcomes is to look at the responsiveness of lending growth to deposit growth. This follows the lead of the investment literature where the sensitivity of firm level investment to cash flow is measured (Fazzari, Hubbard and Petersen, 1988).

In order to test for bank level financial constraints we regress bank level lending growth on deposit growth as in (4.10):

$$\begin{aligned} \Delta\log\left(L_{i,t}\right) &= \alpha + \beta \cdot \Delta\log\left(D_{i,t}\right) + \gamma \cdot x_{i,t-1} \\ &+ \delta \cdot x_{i,t-1} \cdot \Delta\log\left(D_{i,t}\right) + \varepsilon_{i,t} \end{aligned} \tag{4.10}$$

where i denotes the bank and t denotes the time period in years, $\Delta\log(L_{i,t})$ is bank level nominal lending growth, $\Delta\log(D_{i,t})$ is bank level deposit growth, $x_{i,t-1}$ is a vector of bank characteristics that proxy for bank level financial constraints. In particular, we include bank size, capitalization and bank liquidity as bank level characteristics individually and combined. The idea is that larger banks, better capitalized banks and more liquid banks have easier access to financial and money markets and can substitute a drain on deposits more easily. So if bank level financial constraints do exist and these bank characteristics proxy for them well we would find the elements of the vector δ to be significantly negative. Under the admittedly extreme assumption of uncorrelated liquidity shocks on the borrowing (debtors to banks) and lending side (depositors) as well as frictionless markets the correlation between deposit growth and lending growth should be zero and the estimated effect of deposits on lending β should be zero. Banks could perfectly substitute the drain in deposits by tabbing financial and money markets.

Table 4.8 on page 236 presents the results from estimating (4.10). The estimated impact β of deposit growth ($\Delta\log(D_{i,t})$) on lending growth ($\Delta\log(L_{i,t})$) is significant and about 0.67, even controlling for a number of bank level co-variates individually and combined. That is a one percent outflow of deposits reduces bank level lending by about 0.67 percent. Clearly, there may be omitted variables that drive both deposit growth as well as lending growth. As a robustness check we test whether the inclusion of obvious macroeconomic controls like country level output growth or inflation alter the results. With country level output and CPI inflation included the highly significant estimates are still between 0.64 and 0.66. Similarly, the introduction of an autoregressive term $\Delta\log\left(L_{i,t-1}\right)$ led to a range of significant estimates ranging from 0.64 to 0.67. Introducing both, macroeconomic controls and autoregressive dynamic yields a sensitivity between 0.59 and 0.67. In the later two modifications size significantly shields lending growth from deposit growth, capitalization amplifies the sensitivity.

So like in the firm level literature on investment it seems that the availability of funding matters and financial frictions do exist and drive lending decisions in the euro area. Furthermore, model (5) in table 4.8 suggests that the better capitalized a bank is the smaller the impact of a change in deposits on a lending growth. For an otherwise average bank that is capitalized one standard deviation above the sample mean in terms of capitalization this implies 0.04 percent less of a reduction in lending growth. In other words, a bank one standard deviation above the sample mean will reduce lending growth only by about 0.64 percent in response to a one percent drop in deposit growth. Point estimates of the liquidity ratio interaction with deposit growth are negative, though insignificantly so.

4.4.2 Bank Level Lending Responses to Monetary Policy Shocks

Having examined the bank level lending response to deposit growth we now turn to the response of lending growth to the different measures of monetary policy. This subsection presents bank lending regression results for all five measures of monetary policy. Like in Angeloni et al. (2003) the bank lending regression model is specified

$$\Delta\log\left(L_{i,t}\right) = \alpha + \beta \cdot \Delta\log\left(D_{i,t}\right) + \gamma \cdot x_{i,t-1} + \delta \cdot x_{i,t-1} \cdot \Delta\log\left(D_{i,t}\right) + \varepsilon_{i,t}$$

where $\Delta\log\left(L_{i,t}\right)$ loan growth, $\Delta\log\left(D_{i,t}\right)$ deposit growth and $x_{i,t-1}$ bank characteristics.

$\Delta\log\left(L_{i,t}\right)$	(1) Simple	(2) Size	(3) Capitalization	(4) Liquidity	(5) All Controls
$\Delta\log\left(D_{i,t}\right)$	0.6757***	0.6719***	0.6795***	0.6783***	0.6752***
	(0.0225)	(0.0214)	(0.0228)	(0.0231)	(0.0208)
$\text{Size}_{i,t-1} \times \Delta\log\left(D_{i,t}\right)$		0.0303			0.0048
		(0.0188)			(0.0192)
$\text{Cap}_{i,t-1} \times \Delta\log\left(D_{i,t}\right)$			-0.0301		-0.0359*
			(0.0167)		(0.0173)
$\text{Liq}_{i,t-1} \times \Delta\log\left(D_{i,t}\right)$				-0.0274	-0.0176
				(0.0190)	(0.0171)
N	2691	2688	2697	2685	2691
R^2	0.4550	0.4239	0.4344	0.4302	0.4204

Robust standard errors after clustering at bank level in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: Includes time controls, a constant and the respective bank characteristic(s) in levels (not reported).

Table 4.8: Lending Growth and Deposit Growth

as in (4.11):

$$\begin{aligned}
\Delta\log\left(L_{i,t}\right) &= \alpha_0 + \rho\cdot\Delta\log\left(L_{i,t-1}\right) + \alpha_1\cdot x_{i,t-1} \\
&+ \beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log\left(Y_t\right) + \beta_3\cdot\pi_t \\
&+ \gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \gamma_2\cdot\Delta\log\left(Y_t\right)\cdot x_{i,t-1} \\
&+ \gamma_3\cdot\pi_t\cdot x_{i,t-1} + \mu\cdot\text{time}_t + \varepsilon_{i,t}
\end{aligned} \tag{4.11}$$

where t and i index time (in years) and the individual bank respectively. $\Delta\log\left(L_{i,t}\right)$ is lending growth, Δr_t represents the different measures of monetary policy, $\Delta\log\left(Y_t\right)$ and π_t represent real output growth and CPI inflation in the country where the bank i is based, and $x_{i,t-1}$ represents a vector of bank characteristics that proxy for bank level financial constraints. As is standard in the literature these include size, as measured by asset size (Kashyap and Stein, 1995), liquidity (Kashyap and Stein, 2000) and capitalization (Kishan and Opiela, 2000). The characteristics are de-meaned and normalized by their standard deviation for ease of interpretation of the interaction terms such that

$$\begin{aligned}
\text{Size}_{i,t} &= \frac{1}{\sigma_A}\left[log(A_{i,t}) - \left(\frac{1}{N_t}\sum_i \log(A_{i,t})\right)\right] \\
\text{Capital}_{i,t} &= \frac{1}{\sigma_C}\left[\frac{C_{i,t}}{A_{i,t}} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i\frac{C_{i,t}}{A_{i,t}}\right)\right] \\
\text{Liquidity}_{i,t} &= \frac{1}{\sigma_L}\left[\frac{L_{i,t}}{A_{i,t}} - \frac{1}{T}\sum_t\left(\frac{1}{N_t}\sum_i\frac{L_{i,t}}{A_{i,t}})\right)\right]
\end{aligned}$$

where σ_A, σ_C, σ_L are the standard deviations of (log) assets, the capital ratio and the liquidity ratio, $A_{i,t}$ is total assets, $C_{i,t}$ is equity capital and $L_{i,t}$ is total liquid assets, and N_t denotes the number of observations within a year and T the total number of years. Such normalization enables us to interpret the direct lending response as the response of a hypothetical bank that is at the mean of all characteristics. Also, it gives interaction terms an interpretation that is normalized by the variation in the individual characteristic (e.g. computing the marginal lending response of a bank whose capitalization is one standard deviation above the sample).

In (4.11) we include real GDP growth rates to control for country-specific loan demand shifts. Good economic conditions increase the number of potentially profitable projects thus increasing the firm's demand for credit (Kashyap, Stein and Wilcox, 1993). This control should capture some country-specific cyclical macroeconomic movements. The econometric specification also includes interactions between changes in the interest rate, real GDP growth, and inflation with the bank-specific characteristics (see Ehrmann et al., 2003; Ashcraft, 2006). As is standard in the literature individual bank characteristics are lagged by one year so that they are predetermined with respect to the monetary policy measure and the macroeconomic controls.

Table 4.9 on page 243 presents the results for all five policy measures discussed above for the full specification that includes all three bank level characteristics interacted with the policy measure, real output growth and inflation. The results presented in the main summary tables 4.9, 4.10 and 4.11 are generally not contradicted by the other specifications that include single bank characteristics or combinations of different bank characteristics. Observations for which the absolute $DFITS$ statistic (the scaled difference between the fitted values for the n^{th} observation when the regression is fitted with and without the n^{th} observation) exceeds the threshold $2 \cdot \sqrt{\text{slope coefficients/sample size}}$ as defined in Walsh and Kuh (1977) are dropped as outliers (around 4 percent of observations varying with the model specification). The standard errors reported are robust after clustering at the bank level.

The coefficient on the autoregressive term ρ is significantly different from zero and ranges between 0.0551 (Eurepo) and 0.0864 (SVAR). Table 4.9 reports short run coefficients. Given the autoregressive term long-run coefficients are between 5.5 and 9.8 percent larger. The direct lending response to changes in β_1 the coefficient on the different measures of monetary policy shocks Δr_t is insignificantly negative for the benchmark measure ECB (-0.0038) and significantly negative for the first exogenous policy measure identified by the Taylor rule (-0.0544). These are relatively minor magnitudes as an exogenous shock to the Taylor rule identification of 100 b.p. would only reduce lending growth by 0.05 percent. The SVAR identification and the two high-frequency identification yield positive significant lending responses to contractionary monetary policy shocks.

The estimated coefficient β_2 on the country specific real growth $\Delta \log (Y_t)$ for the country that the bank is registered in is positive for all monetary policy shocks apart. A one percent increase in GDP raises lending growth by between 1.07 (Euribor) and 3.03 (ECB) percent and is significant for all but one policy shock. Whilst at first sight lending growth responses to real output growth appear large it is worthwhile bearing in mind that annual nominal lending growth averaged around 11.9 percent during the sample period as shown in table 4.7. The coefficient β_3 on the inflation term π_t is also positive for all policy shock rate although insignificant for the Eurepo identification and the standard endogenous change in the ECB Main Refinancing Rate. It may be that the endogenous component of the ECB rate that correlates with contemporary inflation attenuates the estimates of the impact of nominal price rises in model (1) of table 4.9. If that is the case this underscores the need for othogonalizing measures of policy with respect to drivers of equilibrium lending.

Finally, we note that most of the $\gamma_{1,k}$ coefficients are not significantly different from zero. However, point estimates for size and capitalization are positive in the case of the endogenous change in the ECB policy rate in model (1). Three papers that suggest the existence of a lending channel in the euro area like De Bondt (1999) or the more recent papers looking at securitization (Altunbas, Gambacorta and Marques-Ibanez, 2009*a*) and bank level risk (Altunbas, Gambacorta and Marques-Ibanez, 2009*b*) claim to find evidence for a lending channel in the euro area by estimating a regression that modifies (4.11) such that

$$\begin{aligned}\Delta\log\left(L_{i,t}\right) &= \alpha_0 + \rho\cdot\Delta\log\left(L_{i,t-1}\right) + \alpha_1\cdot x_{i,t-1} \\ &+ \beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log\left(Y_t\right) + \beta_3\cdot\pi_t \\ &+ \gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \mu\cdot\mathrm{time}_t + \varepsilon_{i,t}\end{aligned} \tag{4.12}$$

So in contrast to (4.11) model (4.12) does not interact output growth $\Delta\log\left(Y_t\right)$ and inflation π_t with individual bank characteristics and, hence, claim to find evidence supportive of a bank lending channel. However, other lending estimates such as

Ehrmann et al. (2003) and Ashcraft (2006) correctly interact the bank level financial constraints with the monetary policy measures as well as output growth and inflation as in (4.11). This suggests that some of the findings in De Bondt (1999), Altunbas, Gambacorta and Marques-Ibanez (2009*a*) and Altunbas, Gambacorta and Marques-Ibanez (2009*b*) are likely driven by such missing interactions. This may suggest that an exogenous policy measure might have been more robust for inferences about the existence of a lending channel in potentially misspecified models where the interpretation of interaction terms is crucial. Using the two exogenous policy shocks measures yields quantitatively different results. The marginal effects of size and capitalization are significantly negative. There are also negative marginal effects for the two unanticipated policy measures. Whilst the interaction effects with monetary policy reported in the table are either insignificant or negative, the levels effects of size, capitalization and liquidity ratio is positive in all specifications (coefficients not reported). This means that everything else being equal larger banks, better capitalized and more liquid banks have higher rates of lending growth.

The finding of insignificant $\gamma_{1,k}$'s is in stark contrast to the findings on U.S. banking behaviour examined in chapter 2. This might be due to a number of factors. First, there is a difference in the time periods. The time period used in the euro area analysis is constrained both by data availability as well as by the introduction of the single currency in 1999. The real time identification from chapter 2 relies on real-time forecasts from the Greenbook that are only available with a considerable lag, so the sample ends in 1999. Second, there are differences in the data frequency, which is annual here. We noted that most of the lending growth response to policy is within two to three quarters which is about half the sample frequency of the euro area banking sample. Third, as Angeloni et al. (2003) point out, there may be different structures in the European banking industry that do no make the characteristics size, capitalization and liquidity relevant proxies for bank level financial constraints. For instance, it is unlikely that deposits at smaller or less capitalized banks are riskier in countries where there is an extensive degree of effective deposit insurance like Italy or Germany. Moreover, in contrast to the U.S. there have been very few bank failures in the euro area and there is generally a more active role for the state in Europe, potentially inducing banks with weaker characteristics to "gamble for resurrection" by asset substitution, that is by extending their loan portfolio despite of associated risk increases. Because of such implicit government guarantees informational asymmetries may be less pronounced and lending to banks in the euro area involves relatively little risk. The role of banking networks (especially for cooperatives and saving banks) could also be important for the different findings. Ehrmann and Worms (2001) show that in Germany smaller banks receive cash injections from their head institution. Also, relationship lending might imply a degree of insurance and risk sharing. If such implicit risk-sharing agreements are particularly important for smaller banks they might need to expand their lending volumes and respond less strongly to monetary policy. In order to further explore the role of the different monetary policy shocks the next section we will consider the inclusion of a financial conditions index and its implications for the estimation of responses to monetary policy.

$$\Delta\log(L_{i,t}) = \alpha_0 + \rho\cdot\Delta\log(L_{i,t-1}) + \alpha_1\cdot x_{i,t-1} + \beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log(Y_t) + \beta_3\cdot\pi_t + \gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \gamma_2\cdot\Delta\log(Y_t)\cdot x_{i,t-1} + \gamma_3\cdot\pi_t\cdot x_{i,t-1} + \mu\cdot\text{time}_t + \varepsilon_{i,t}$$

$\Delta\log(L_{i,t})$	(1) ECB	(2) Taylor	(3) SVAR	(4) Euribor	(5) Eurepo
$\Delta\log(L_{i,t-1})$	0.0696***	0.0861***	0.0864***	0.0725***	0.0551***
	(0.0151)	(0.0191)	(0.0186)	(0.0165)	(0.0157)
Δr_t	-0.0038	-0.0544***	0.1858***	0.5816***	0.5609***
	(0.0099)	(0.0041)	(0.0241)	(0.0403)	(0.0541)
$\Delta\log(Y_t)$	3.0270***	1.6461**	2.5740***	1.0729	4.0304***
	(0.7495)	(0.5377)	(0.6327)	(0.6474)	(0.6922)
π_t	0.6045	1.4001***	0.8769*	1.6193***	0.4202
	(0.4279)	(0.3875)	(0.4235)	(0.4055)	(0.4101)
$\text{Size}_{i,t-1}\times\Delta r_t$	0.0028	-0.0075*	-0.1029***	-0.0148	-0.1506**
	(0.0094)	(0.0034)	(0.0267)	(0.0337)	(0.0516)
$\text{Capital}_{i,t-1}\times\Delta r_t$	0.0216	-0.0158*	-0.1332*	-0.1341	-0.2761*
	(0.0217)	(0.0077)	(0.0621)	(0.0953)	(0.1231)
$\text{Liquidity}_{i,t-1}\times\Delta r_t$	-0.0077	0.0031	-0.0641*	-0.0275	0.0561
	(0.0101)	(0.0035)	(0.0304)	(0.0331)	(0.0578)
N	2125	2123	2129	2120	2128
R^2	0.1096	0.1762	0.1336	0.2371	0.1753

Robust standard errors after clustering at bank level in parentheses

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

Table 4.9: Bank Lending Regressions - Benchmark

4.4.3 Financial Sector Conditions

In order to measure financial market conditions the regressions later include the ratio of the Euro Stoxx Banking Index and the Euro Stoxx Index. The Euro Stoxx Index is a broad yet liquid subset of the Stoxx Europe 600 Index. With a variable number of components, the index represents large, mid and small capitalisation companies of 12 Eurozone countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. The Euro Stoxx Banking Index contains all banks included in the Euro Stoxx Index. Both series were downloaded from Datastream (code $S2ESB2E$ for Euro Stoxx Banks and code $DJEURST$ for the Euro Stoxx) and the daily data was averaged by month and by year. Table 4.7 displays a time series of this ratio.

The previous section has cast some doubt the existence of a direct lending channel. This section makes two additions to regression (4.11). First the direct impact of a financial conditions index that is formed by taking the ratio between a monthly index of banking stocks of the euro area (Euro Stoxx Banking Index, Datastream code $S2ESB2E$) and the leading stock market index (Euro Stoxx Index, Datastream code $DJEURST$) for the euro area:

$$FCI_t = \frac{\text{Euro Stoxx Banking Index}}{\text{Euro Stoxx Index}} \tag{4.13}$$

Figure 4.7 illustrates both the monthly ratio as well as the annual average used in the bank lending regressions. Whilst the index is affected by overall lending behaviour, i.e. banks' aggregate investments in assets in the form of interest bearing loans, as well as expected economic conditions, that the likely return to these interest bearing assets, it is exogenous to the lending behaviour of any individual bank in the sample. We can see in figure 4.7 an increase up until 2006 and then a rapid decrease of the performance of banking stocks relative to the overall stock market in 2007 to 2010 owing largely to write-downs on mortgage backed securities.

First, we just include this indicator in equation (4.11) and re-estimate the regressions. Estimation results from estimating (4.14):

$$\begin{aligned}
\Delta\log\left(L_{i,t}\right) &= \alpha_0 + \rho\cdot\Delta\log\left(L_{i,t-1}\right) + \alpha_1\cdot x_{i,t-1} \\
&+ \beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log\left(Y_t\right) + \beta_3\cdot\pi_t \\
&+ \gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \gamma_2\cdot\Delta\log\left(Y_t\right)\cdot x_{i,t-1} \qquad (4.14) \\
&+ \gamma_3\cdot\pi_t\cdot x_{i,t-1} + \delta_1\cdot FCI_t + \mu\cdot\text{time}_t + \varepsilon_{i,t} \\
&= (4.11) + \delta_1\cdot FCI_t
\end{aligned}$$

where FCI_t is the annual financial conditions index that is annual average of monthly financial conditions can be found in table 4.10 on page 249.

The inclusion of the financial conditions indicator first cuts the estimated significant coefficients β_2 on real output growth $\Delta\log\left(Y_t\right)$ and reduces its significance substantially especially in the case of the Taylor identification. This suggests that the new indicator proxies for expectations of future output or other factors which may drive lending growth through loan demand or loans supply shifts. Similarly, its inclusion increases the coefficients β_3 on inflation π_t as well as their significance levels. The estimated coefficient δ_1 on the financial conditions index FCI_t enters the lending regression with a significant positive sign. The response to a change in the index say from 0.77 in 2000 to 0.89 in 2001 would result in an estimated lending growth increase of between $((0.8909 - 0.7729) \cdot 0.2868 = 0.0338 \simeq)$ 3.4 percent (Euribor identification) and $((0.8909 - 0.7729) \cdot 0.8475 = 0.1000 \simeq)$ 10 percent (Taylor identification). The coefficients on the cross-effects $(\gamma_{1,k})$ are largely unchanged through this alteration. Similarly, interacting the new measure of financial conditions with the three proxies for bank level financial constraints does not yield significant coefficients (results not reported).

Second, in order to explore the direct lending responses further, the financial conditions index is interacted with the five different measures of monetary shocks. The bank lending regression is estimated as (4.15):

$$\begin{aligned}
\Delta\log(L_{i,t}) &= \alpha_0 + \rho \cdot \Delta\log(L_{i,t-1}) + \alpha_1 \cdot x_{i,t-1} \\
&+ \beta_1 \cdot \Delta r_t + \beta_2 \cdot \Delta\log(Y_t) + \beta_3 \cdot \pi_t \\
&+ \gamma_1 \cdot \Delta r_t \cdot x_{i,t-1} + \gamma_2 \cdot \Delta\log(Y_t) \cdot x_{i,t-1} \qquad (4.15) \\
&+ \gamma_3 \cdot \pi_t \cdot x_{i,t-1} + \delta_1 \cdot FCI_t + \delta_2 \cdot FCI_t \cdot \Delta r_t + \mu \cdot \mathrm{time}_t + \varepsilon_{i,t} \\
&= (4.14) + \delta_2 \cdot FCI_t \cdot \Delta r_t \\
&= (4.11) + \delta_1 \cdot FCI_t + \delta_2 \cdot FCI_t \cdot \Delta r_t
\end{aligned}$$

where $FCI_t \cdot \Delta r_t$ is the average annual financial conditions index of year t interacted with the respective monetary policy shock measure. The estimation results are presented in table 4.11 on page 250.

The inclusion of the interaction term alters the estimated coefficients on the policy measures β_1. This suggests strongly non-linear effects of monetary policy where the non-linearity if primarily driven by the conditions of the financial sector. When the market perceives the banking sector to do well relative to the rest of the publicly listed companies (that is when the ratio FCI_t is high), policy tightening has very different effects than when the banking sector is doing relatively badly (and FCI_t is low). Table 4.12 on page 251 summarizes formal tests of these non-linearities.

The top third of the table summarizes responses at the sample mean of the annual financial conditions index. When financial conditions are normal, i.e. at the sample mean, the overall effect of all policy shocks is comparable to the results in table 4.9. That is the third row of table 4.12 is roughly equivalent to the second row of table 4.9. Ignoring the contribution from the financial conditions index interaction (i.e. counterfactually assuming the measure $FCI_t = 0$) (1), (2), and (5) yield contractionary bank lending responses to policy shocks of the order -0.6376 (ECB), -0.2851 (Taylor) and -1.0364 (Eurepo identification). These are then mitigate by the financial conditions interactions to the extend that only the impact of the change in the ECB rate yields a contractionary lending response overall.

When financial conditions are good ("light", as in the year 2006 i.e. $FCI_{2006} = 1.1381$), however, only the unanticipated increase in the unsecured 1 month interbank lending rate Euribor yields overall contractionary lending responses. As a visual comparison of 4.6 on page 226 and 4.7 on page 232 illustrates the spread between Euribor and Eurepo is inversely related to the downturn in 2007/2008 and the annual financial conditions index FCI_t. This suggests that some of the information from unanticipated changes in Euribor (unsecured) as compared to Eurepo (secured) around the ECB dates meeting is already captured by the financial conditions index and might thus explain this differences in the estimated coefficients. The insignificant point estimates of the coefficient δ_1 (0.0297) in table 4.11 on the level of the FCI_t could be signs of that for Euribor.

Under "tight" financial conditions the endogenous policy measure, the change in the annual average ECB base rate, shows a contractionary effects of around -0.14, the Taylor rule identified exogenous change in policy is estimated to have an effect of around -0.04. The overall effect from the remaining policy identifications is positive. The key finding is that both the qualitative as well as the quantitative response of lending growth to various measures of monetary policy is contingent upon financial conditions as proxied by the ratio of an index of euro area banking stocks to a more broad liquid index of euro area stocks.

4.4.4 Robustness

This section briefly mentions four robustness tests that have been conducted to check the stability of the results. First, given the low average duration of a bank within the estimation annual bank panel of 3.65 years a fixed-effects (within groups) estimator will be subject to Nickell (1981) bias. This is why all the reported regressions for the all specifications are estimated using ordinary least squares with standard error that are robust after clustering at the bank level. We also tested all the specifications reported in the chapter using a Hausman test as to whether the efficient random effects estimator are the same as the ones estimated by the consistent fixed effects estimator. For every single regression specification Hausman test p-value is

$$\begin{aligned}\Delta\log(L_{i,t}) = \alpha_0 + \rho\cdot\Delta\log(L_{i,t-1}) + \alpha_1\cdot x_{i,t-1} \\ +\beta_1\cdot\Delta r_t + \beta_2\cdot\Delta\log(Y_t) + \beta_3\cdot\pi_t \\ +\gamma_1\cdot\Delta r_t\cdot x_{i,t-1} + \gamma_2\cdot\Delta\log(Y_t)\cdot x_{i,t-1} \\ +\gamma_3\cdot\pi_t\cdot x_{i,t-1} + \delta_1\cdot FCI_t + \mu\cdot\text{time}_t + \varepsilon_{i,t}\end{aligned}$$

$\Delta log(L_{i,t})$	(1) ECB	(2) Taylor	(3) SVAR	(4) Euribor	(5) Eurepo
$\Delta\log(L_{i,t-1})$	0.0813***	0.0963***	0.0894***	0.0748***	0.0743***
	(0.0174)	(0.0205)	(0.0199)	(0.0151)	(0.0172)
Δr_t	0.0047	0.0167	0.1214***	0.4119***	0.3702***
	(0.0091)	(0.0089)	(0.0252)	(0.0480)	(0.0568)
$\Delta\log(Y_t)$	0.1640	-0.8310	-0.1711	0.2116	1.6743*
	(0.7740)	(0.5897)	(0.5584)	(0.5870)	(0.7075)
π_t	1.7210***	2.2448***	1.9404***	2.0485***	1.1763**
	(0.4184)	(0.3678)	(0.3842)	(0.3600)	(0.3955)
FCI_t	0.6957***	0.8475***	0.6787***	0.2868***	0.5662***
	(0.0432)	(0.0904)	(0.0435)	(0.0549)	(0.0472)
$\text{Size}_{i,t-1}\times\Delta r_t$	-0.0032	-0.0055	-0.1181***	-0.0180	-0.1400**
	(0.0087)	(0.0032)	(0.0264)	(0.0331)	(0.0499)
$\text{Capital}_{i,t-1}\times\Delta r_t$	-0.0055	-0.0126	-0.1630**	-0.1157	-0.2031
	(0.0205)	(0.0071)	(0.0594)	(0.0982)	(0.1217)
$\text{Liquidity}_{i,t-1}\times\Delta r_t$	0.0010	0.0015	-0.0618*	-0.0187	0.0798
	(0.0093)	(0.0036)	(0.0308)	(0.0331)	(0.0566)
N	2125	2126	2132	2122	2131
R^2	0.2058	0.2137	0.2190	0.2407	0.2281

Robust standard errors after clustering at bank level in parentheses

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

Table 4.10: Bank Lending Regressions - Financial Conditions

$$\begin{aligned}\Delta\log(L_{i,t}) = {} & \alpha_0 + \rho \cdot \Delta\log(L_{i,t-1}) + \alpha_1 \cdot x_{i,t-1} + \beta_1 \cdot \Delta r_t \\ & +\beta_2 \cdot \Delta\log(Y_t) + \beta_3 \cdot \pi_t + \gamma_1 \cdot \Delta r_t \cdot x_{i,t-1} \\ & +\gamma_2 \cdot \Delta\log(Y_t) \cdot x_{i,t-1} + \gamma_3 \cdot \pi_t \cdot x_{i,t-1} \\ & +\delta_1 \cdot FCI_t + \delta_2 \cdot FCI_t \cdot \Delta r_t + \mu \cdot \text{time}_t + \varepsilon_{i,t}\end{aligned}$$

$\Delta\log(L_{i,t})$	(1) ECB	(2) Taylor	(3) SVAR	(4) Euribor	(5) Eurepo
$\Delta\log(L_{i,t-1})$	0.0823***	0.1015***	0.0888***	0.0785***	0.0702***
	(0.0190)	(0.0225)	(0.0203)	(0.0162)	(0.0165)
Δr_t	-0.6376***	-0.2851***	0.8992*	3.4861***	-1.0364*
	(0.0947)	(0.0484)	(0.3820)	(0.7191)	(0.5136)
$\Delta\log(Y_t)$	1.1615	-0.8740	-0.0162	-0.6986	1.2143
	(0.7568)	(0.6114)	(0.5974)	(0.6645)	(0.7584)
π_t	1.0393**	2.0094***	1.9368***	2.2297***	1.2044**
	(0.3980)	(0.4074)	(0.3819)	(0.3764)	(0.4112)
FCI_t	0.2949***	0.6694***	0.6843***	0.0297	0.6651***
	(0.0738)	(0.0924)	(0.0439)	(0.0790)	(0.0646)
$FCI_t \times \Delta r_t$	0.6613***	0.3246***	-0.7553*	-3.2882***	1.4116**
	(0.0972)	(0.0523)	(0.3621)	(0.7624)	(0.5052)
$\text{Size}_{i,t-1} \times \Delta r_t$	-0.0005	-0.0067*	-0.1248***	-0.0099	-0.1466**
	(0.0087)	(0.0034)	(0.0252)	(0.0335)	(0.0513)
$\text{Capital}_{i,t-1} \times \Delta r_t$	0.0149	-0.0173*	-0.1665*	-0.1337	-0.2462
	(0.0218)	(0.0077)	(0.0652)	(0.1064)	(0.1260)
$\text{Liquidity}_{i,t-1} \times \Delta r_t$	0.0001	-0.0000	-0.0717*	-0.0127	0.0995
	(0.0093)	(0.0037)	(0.0310)	(0.0334)	(0.0592)
N	2129	2124	2135	2122	2133
R^2	0.2175	0.2361	0.2195	0.2456	0.2294

Robust standard errors after clustering at bank level in parentheses

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

Table 4.11: Bank Lending Regressions - Financial Conditions and Interaction

	(1) ECB	(2) Taylor	(3) SVAR	(4) Euribor	(5) Eurepo
	Normal Financial Conditions ($FCI_{ø} = 0.9120$)				
Δr_t $(= \beta_1)$	-0.6376***	-0.2851***	0.8992**	3.4861***	-1.0364**
	(0.0947)	(0.0484)	(0.3820)	(0.7191)	(0.5136)
$FCI_t \times \Delta r_t$ $(= \delta_2)$	0.6031***	0.2960***	-0.6889**	-2.9989***	1.2874***
	(0.0886)	(0.0477)	(0.3303)	(0.6953)	(0.4608)
$\beta_1 + \delta_2 \times FCI_{ø}$	-0.0344***	0.0109	0.2103***	0.4871***	0.2510***
	(0.0107)	(0.0089)	(0.0570)	(0.0540)	(0.0753)
	"Light" Financial Conditions ($FCI_{2006} = 1.1381$)				
Δr_t $(= \beta_1)$	-0.6376***	-0.2851***	0.8992**	3.4861***	-1.0364**
	(0.0947)	(0.0484)	(0.3820)	(0.7191)	(0.5136)
$FCI_t \times \Delta r_t$ $(= \delta_2)$	0.7526***	0.3694***	-0.8596**	-3.7424***	1.6066***
	(0.1106)	(0.0596)	(0.4121)	(0.8677)	(0.5750)
$\beta_1 + \delta_2 \times FCI_{2006}$	0.1151***	0.0843***	0.0396	-0.2563	0.5701***
	(0.0187)	(0.0149)	(0.0401)	(0.1582)	(0.0859)
	"Tight" Financial Conditions ($FCI_{2009} = 0.7566$)				
Δr_t $(= \beta_1)$	-0.6376***	-0.2851***	0.8992**	3.4861***	-1.0364**
	(0.0947)	(0.0484)	(0.3820)	(0.7191)	(0.5136)
$FCI_t \times \Delta r_t$ $(= \delta_2)$	0.5003***	0.2456***	-0.5715**	-2.4878***	1.0680***
	(0.0735)	(0.0396)	(0.2740)	(0.5768)	(0.3822)
$\beta_1 + \delta_2 \times FCI_{2009}$	-0.1372***	-0.0395***	0.3278***	0.9983***	0.0316
	(0.0226)	(0.0120)	(0.1102)	(0.1490)	(0.1402)
N	2129	2124	2135	2122	2133
R^2	0.2175	0.2361	0.2195	0.2456	0.2294

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

Table 4.12: Nonlinear Lending Responses Under Good and Bad Financial Conditions

insignificant (Probability > χ^2 larger than 0.05).

Second, the findings are robust to lagging the aggregate financial indicator and its interaction. The lagged indicator in levels gives even stronger results at the expense of contemporaneous output, whereas the interactions with the policy measures are slightly weaker in such specifications.

Third, we estimated a number of open economy VAR specifications in order to check the robustness of our findings with respect to this exogenous policy measure. As illustrated earlier in table 4.2 the monetary policy shocks extracted from these VARs are reasonably highly correlated across different orderings and estimation samples both on an annual as well as on a quarterly frequency. The estimation results are robust across VAR orderings as well as subsamples. However, a sample starting in 1980 yield slightly weaker estimates.

Fourth, different combinations of bank level characteristics may yield significantly different estimation results. Table 4.13 on page 253 and table 4.14 on page 254 report a variety of lending regression specifications for both the endogenous change in the ECB rate as well as the exogenous monetary policy shocks identified from the open economy VAR. Model (4) in table 4.13 and 4.14 are the same that are reported in model (1) and (3) in the lending regression table 4.9 on page 243. As we can see the results are very stable across different model specifications.

$\Delta\log(L_{i,t})$	(1) Size	(2) Cap	(3) Liq	(4) Size, Cap, Liq	(5) Size, Liq
$\Delta\log(L_{i,t-1})$	0.0561**	0.0776***	0.0726***	0.0696***	0.0700***
	(0.0174)	(0.0208)	(0.0163)	(0.0151)	(0.0168)
Δr_t	-0.0044	-0.0017	-0.0050	-0.0038	-0.0074
	(0.0085)	(0.0094)	(0.0088)	(0.0099)	(0.0090)
$\Delta\log(Y_t)$	1.4362**	2.3212***	1.6714**	3.0270***	1.8278**
	(0.5356)	(0.6564)	(0.5402)	(0.7495)	(0.6064)
π_t	1.6026***	0.8603*	1.5172***	0.6045	1.4375***
	(0.3281)	(0.3764)	(0.3292)	(0.4279)	(0.3798)
$\text{Size}_{i,t-1} \times \Delta r_t$	-0.0019			0.0028	-0.0120
	(0.0083)			(0.0094)	(0.0084)
$\text{Capital}_{i,t-1} \times \Delta r_t$		0.0156		0.0216	
		(0.0186)		(0.0217)	
$\text{Liquidity}_{i,t-1} \times \Delta r_t$			-0.0084	-0.0077	0.0007
			(0.0086)	(0.0101)	(0.0096)
$\text{Liq}_{i,t-1} \times \text{Cap}_{i,t-1} \times \Delta r_t$					0.0311***
					(0.0093)
N	2139	2138	2130	2125	2126
R^2	0.0960	0.0899	0.1055	0.1096	0.1037

Robust standard errors after clustering at bank level in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.13: Different Lending Regression Specifications (ECB)

$\Delta\log(L_{i,t})$	(1) Size	(2) Cap	(3) Liq	(4) Size, Cap, Liq	(5) Size, Liq
$\Delta\log(L_{i,t-1})$	0.0743***	0.0964***	0.0863***	0.0864***	0.0903***
	(0.0184)	(0.0225)	(0.0186)	(0.0186)	(0.0195)
Δr_t	0.1840***	0.1651***	0.1962***	0.1858***	0.2102***
	(0.0242)	(0.0267)	(0.0241)	(0.0241)	(0.0240)
$\Delta\log(Y_t)$	1.4283**	2.1429***	1.7019***	2.5740***	1.5854**
	(0.4497)	(0.5679)	(0.4415)	(0.6327)	(0.5061)
π_t	1.5695***	0.9334**	1.4056***	0.8769*	1.4192***
	(0.3016)	(0.3540)	(0.3018)	(0.4235)	(0.3612)
$\text{Size}_{i,t-1} \times \Delta r_t$	-0.0674**			-0.1029***	-0.0632*
	(0.0253)			(0.0267)	(0.0250)
$\text{Capital}_{i,t-1} \times \Delta r_t$		-0.0734		-0.1332*	
		(0.0558)		(0.0621)	
$\text{Liquidity}_{i,t-1} \times \Delta r_t$			-0.0685*	-0.0641*	-0.0742*
			(0.0280)	(0.0304)	(0.0295)
$\text{Liq}_{i,t-1} \times \text{Cap}_{i,t-1} \times \Delta r_t$					0.0147
					(0.0304)
					(0.0093)
N	2141	2139	2127	2129	2126
R^2	0.1154	0.1042	0.1269	0.1336	0.1247

Robust standard errors after clustering at bank level in parentheses.

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

Table 4.14: Different Lending Regression Specifications (VAR)

4.5 Conclusion

This chapter examined the lending responses of euro area banks to different measures of monetary policy shocks. It generated two series on unanticipated monetary shocks based on changes in high-frequency data around monetary policy meetings of the ECB Governing Council and two annualized series of exogenous monetary policy shocks based on stylized identification schemes: The first exogenous monetary shock measure is based on a quarterly parsimonious Taylor (1993) rule, the second based on a quarterly open economy SVAR following Peersman and Smets (2003). Further, two unanticipated shocks from high-frequency data are considered. The chapter also introduced a market-based measure of financial conditions and focussed on its interaction effects with the set of policy measures.

The evidence presented in this chapter suggests that the classic bank level characteristics and their interaction with monetary policy shocks used to identify loan supply shifts do not support the existence of monetary policy induced loan supply shifts at the euro area level. This negative finding might be due to the frequency and limited availability of bank level data, but within this annual framework it is robust against all different measures of monetary policy shocks. The second major finding is that bank level lending responses to all different indicators of monetary policy are highly non-linear with respect to aggregate financial conditions as proxied by the ratio between a banks based stock market index and the overall stock market in the euro area. There is also indirect evidence for cash-flow effects running from deposits to lending growth.

These findings suggest that financial conditions or output growth expectations that likely correlate with them are an important driver of both lending growth as well as of the effect monetary policy exerts on lending growth regardless of whether these effects come from classic price channels or credit channel. This further underlines the need to control for forward looking determinant in panel lending growth regressions. The stronger lending growth responses estimated from the two exogenous components of interest rate changes suggests that addressing the monetary policy measure is important for quantitative inferences. This finding is in line with the finding from chapter 2.

A limitation of this chapter is that, by concentrating on banks, we can only study the first link in the chain of monetary transmission through the credit channel. One extension would be to investigate the response of European firms and households to a similar monetary tightening and the financial conditions. Furthermore, if higher quality or a greater frequency of bank level data becomes available, revisiting the regressions from this chapter may be interesting in a couple of years.

4.A Supplementary Tables

Table 4.15: ECB Council Meetings and Decisions.

Meeting	Change	(New) Rate	Date Effective
04/03/99		3.00	
18/03/99		3.00	
08/04/99	-0.50	2.50	14/04/99
22/04/99		2.50	
06/05/99		2.50	
20/05/99		2.50	
02/06/99		2.50	

Meeting	Change	(New) Rate	Date Effective
08/05/03		2.50	
05/06/03	-0.50	2.00	09/06/03
10/07/03		2.00	
31/07/03		2.00	
04/09/03		2.00	
02/10/03		2.00	
06/11/03		2.00	

Meeting	Change	(New) Rate	Date Effective
17/06/99		2.50	
01/07/99		2.50	
15/07/99		2.50	
29/07/99		2.50	
26/08/99		2.50	
09/09/99		2.50	
23/09/99		2.50	
07/10/99		2.50	
21/10/99		2.50	
04/11/99	0.50	3.00	10/11/99
18/11/99		3.00	
02/12/99		3.00	
15/12/99		3.00	
05/01/00		3.00	
20/01/00		3.00	
03/02/00	0.25	3.25	09/02/00
17/02/00		3.25	
02/03/00		3.25	
16/03/00	0.25	3.50	22/03/00
30/03/00		3.50	
13/04/00		3.50	
27/04/00	0.25	3.75	04/05/00
11/05/00		3.75	
25/05/00		3.75	
08/06/00	0.50	4.25	15(21)/06/2000
21/06/00		4.25	
06/07/00		4.25	
20/07/00		4.25	
03/08/00		4.25	
31/08/00	0.25	4.50	06/09/00
14/09/00		4.50	
05/10/00	0.25	4.75	11/10/00
19/10/00		4.75	
02/11/00		4.75	
16/11/00		4.75	
30/11/00		4.75	
14/12/00		4.75	
04/01/01		4.75	
18/01/01		4.75	

Meeting	Change	(New) Rate	Date Effective
04/12/03		2.00	
08/01/04		2.00	
05/02/04		2.00	
04/03/04		2.00	
01/04/04		2.00	
06/05/04		2.00	
03/06/04		2.00	
01/07/04		2.00	
05/08/04		2.00	
02/09/04		2.00	
07/10/04		2.00	
04/11/04		2.00	
02/12/04		2.00	
13/01/05		2.00	
03/02/05		2.00	
03/03/05		2.00	
07/04/05		2.00	
04/05/05		2.00	
02/06/05		2.00	
07/07/05		2.00	
04/08/05		2.00	
01/09/05		2.00	
06/10/05		2.00	
03/11/05		2.00	
01/12/05	0.25	2.25	06/12/05
12/01/06		2.25	
02/02/06		2.25	
02/03/06	0.25	2.50	08/03/06
06/04/06		2.50	
04/05/06		2.50	
08/06/06	0.25	2.75	15/06/06
06/07/06		2.75	
03/08/06	0.25	3.00	08/08/06
31/08/06		3.00	
05/10/06	0.25	3.25	10/10/06
02/11/06		3.25	
07/12/06	0.25	3.50	13/12/06

Meeting	Change	(New) Rate	Date Effective
01/02/01		4.75	
15/02/01		4.75	
01/03/01		4.75	
15/03/01		4.75	
29/03/01		4.75	
11/04/01		4.75	
26/04/01		4.75	
10/05/01	-0.25	4.50	15/05/01
23/05/01		4.50	
07/06/01		4.50	
21/06/01		4.50	
05/07/01		4.50	
19/07/01		4.50	
02/08/01		4.50	
30/08/01	-0.25	4.25	05/09/01
13/09/01		4.25	
17/09/01	-0.50	3.75	19/09/01
27/09/01		3.75	
11/10/01		3.75	
25/10/01		3.75	
08/11/01	-0.50	3.25	14/11/01
06/12/01		3.25	
03/01/02		3.25	
07/02/02		3.25	
07/03/02		3.25	
04/04/02		3.25	
02/05/02		3.25	
06/06/02		3.25	
04/07/02		3.25	
01/08/02		3.25	
12/09/02		3.25	
10/10/02		3.25	
07/11/02		3.25	
05/12/02	-0.50	2.75	11/12/02
09/01/03		2.75	
06/02/03		2.75	
06/03/03	-0.25	2.50	12/03/03
03/04/03		2.50	

Meeting	Change	(New) Rate	Date Effective
11/01/07		3.50	
08/02/07		3.50	
08/03/07	0.25	3.75	14/03/07
12/04/07		3.75	
10/05/07		3.75	
06/06/07	0.25	4.00	13/06/07
05/07/07		4.00	
02/08/07		4.00	
06/09/07		4.00	
04/10/07		4.00	
08/11/07		4.00	
06/12/07		4.00	
10/01/08		4.00	
07/02/08		4.00	
06/03/08		4.00	
10/04/08		4.00	
08/05/08		4.00	
05/06/08		4.00	
03/07/08	0.25	4.25	09/07/08
07/08/08		4.25	
04/09/08		4.25	
02/10/08		4.25	
08/10/08	-0.50	3.75	09/10/08
06/11/08	-0.50	3.25	12/11/08
04/12/08	-0.75	2.50	10/12/08
15/01/09	-0.50	2.00	21/01/09
05/02/09		2.00	
05/03/09	-0.50	1.50	11/03/09
02/04/09	-0.25	1.25	08/04/09
07/05/09	-0.25	1.00	13/05/09
04/06/09		1.00	
02/07/09		1.00	
06/08/09		1.00	
03/09/09		1.00	
08/10/09		1.00	
05/11/09		1.00	
03/12/09		1.00	

Meeting	**Change**	**(New) Rate**	**Date Effective**	**Meeting**	**Change**	**(New) Rate**	**Date Effective**

Chapter 5

Conclusion

In the 1980s attempts to identify an independent credit channel that was operative over and beyond the classical "price" channels in aggregate data were largely ambiguous. Bernanke (1986) finds that evidence of the credit channel is typically sensitive to choice of specification and to the identifying assumptions. Bernanke and Blinder (1992), however, show that aggregate bank lending declines in response to monetary tightening. Kashyap, Stein and Wilcox (1993) looking at the composition of external finance of firms find that the issue of commercial paper, a more costly non-bank substitute for bank loans, increases following monetary tightening. This substitution in combination with the decline in bank lending found by Bernanke and Blinder (1992) suggests the existence of a distinct bank lending channel, since the changing composition in external finance implies constraints on bank loan supply rather than merely a decline in loan demand that would be indicative of solely "price" channel effects.

Over the last decade considerable progress has been made in identifying the features of the banking industry that matter for monetary transmission, especially following the creation of a large database on the activities of insured banks in the United States in work by Kashyap and Stein (2000). Individual bank level empirical models of the lending channel in the U.S. and the euro area have customarily employed the change in the short-term policy rate as a measure of monetary policy and have assumed parameter constancy over time. The key point emphasized in the second chapter of this thesis is that such a policy measure is endogenous to expected future macroeconomic conditions, which are likely to exert quite separate effects on both the loan demand and the loan supply of each individual bank. The second chapter thus attempted to improve estimates of the strength of the lending channel by constructing an endogenous measure of monetary policy shocks. It purged the endogenous movements in the federal funds rate previously used in most bank level lending channel studies of its endogenous component, that is its systematic responses to forecasts embodied in the Greenbook forecasts prepared by Federal Reserve staff. The comparison of lending responses to the endogenous component and the exogenous parts in the movement of the federal funds rate reveals different lending dynamics and a very different picture of the heterogeneity in lending. Lending contracts faster and stronger in response to the exogenous compared to the endogenous federal funds rate.

Turning to parameter constancy, the thesis then moved on to examine the impact of the deregulation of deposit rate ceilings on the lending channel in the third chapter. It introduced a new measure of bindingness of interest rate ceilings commonly known as Regulation Q into standard tests of bank level financial constraints as well as standard lending regressions. It found that when short-term interest rates moved above the legally fixed deposit ceiling imposed by Regulation Q lending responses to monetary policy were much stronger than after the abolition of Regulation Q. Further, the asset-liability frictions that are important for an independent lending channel were larger during the period when Regulation Q was in place. This implies that the lending channel has structurally changed due to the phasing out of deposit rate ceilings and this fact may have been insufficiently emphasized in the previous empirical literature on the individual bank level responses to policy. The chapter on deregulation also emphasizes potential macroeconomic implications of this finding.

Finally, the thesis examined the lending channel in the euro area using an annual panel of banks. It focussed on the implications of different ways of constructing exogenous and unanticipated policy shocks and contrasted their impact on the equilibrium lending decisions of euro area banks. The first finding is that independent of the measure of policy used (endogenous, exogenous and unanticipated interest rate changes) there is no evidence of a lending channel due to significantly different responses across bank level characteristics that proxy for bank level financial constraints. The chapter further examined the implications of aggregate financial conditions on bank lending by a proxy that is the ratio between a broad euro area *banking* stock index and a broad euro area stock index. The inclusion of a financial conditions index leads to a reversal of the direct impact of policy independent for all the constructed monetary policy measures employed in the estimation.

To summarize this thesis showed that individual bank level estimates of the lending channel are improved by a thorough consideration of the monetary policy measure employed in empirical models, a careful discussion of institutional properties that may have altered important coefficient estimates over time. It also showed that there are significant differences in the bank level evidence with respect the existence and strength of the lending channel in the U.S. and the euro area. Finally, it showed that including proxies for aggregate financial conditions improves estimates of bank lending responses to policy and yields important non-linearities. Qualitatively, this finding is robust across a range of policy measures.

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