Essays on Macroeconomics and Financial Intermediation

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Abstract

This dissertation examines the pivotal role of financial intermediaries in mediating the effects of monetary and macroprudential policies. In the first chapter, empirical evidence highlights that commercial banks curtail lending, whereas non-bank financial intermediaries (NBFIs) augment their loan offerings in response to monetary policy contractions. The subsequent empirical analysis illustrates the disparities in market power and leverage management between these entities, as evidenced by their divergent loan-rate-setting behaviors. Specifically, NBFIs, due to their lesser market concentration, are exposed to heightened interest-rate risks, predominantly via fixed-rate loans. As a strategic response to anticipated monetary tightening, firms transition from commercial bank financing to non-bank avenues.

The second chapter introduces a quantitative DSGE model, encapsulating banks and non-banks, each characterized by distinct market power and leverage management attributes. Utilizing Bayesian estimation methods on U.S. data spanning from 1987Q1 to 2008Q4, the model elucidates the "leakage" effect of monetary policy propagated through the non-bank sector. Counterfactual explorations reveal that an expansive non-bank sector attenuates monetary policy's impact on investments by 15%. Furthermore, a reduced market concentration for NBFIs undermines policy efficacy, particularly if accompanied by a contraction in their loan rate markup.

The final chapter delves into Basel III's application in a landscape influenced by non-banks. Post-Great Financial Crisis, Basel III pivoted to mandate heightened capital reserves for global systematically important banks (GSIBs) and introduced the counter-cyclical capital buffer (CCyB) to temper financial fluctuations. Yet, the U.S., with its prominent non-bank sector mirroring commercial banks, challenges Basel III's universality. This analysis assesses non-bank influence on the GSIB surcharge and the dynamics of CCyB within this context. Preliminary findings note a 1.14% increase in capital obligations due to the GSIB surcharge, with non-banks tempering cyclical financial effects. As non-bank presence grows, they moderate financial volatility by 20% but escalate credit leakage. The CCyB's deployment underscores a balance between credit volatility and leakage.

JEL Classifications: E43, E52, G21, G23, G28

Key Words: Monetary Policy, Financial Intermediaries, Commercial Banks, Non-Bank Financial Institutions

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Contents

Chapter 1

Monetary Policy Transmission Through Financial Intermediaries

1.1 Introduction

Previous studies of monetary policy's interaction with the financial sector predominantly focus on commercial banks (CBs) that collect deposits and extend loans. Nevertheless, despite the emphasis on commercial banks, non-bank financial intermediaries (NBFIs)—comprising mutual funds, asset-backed securities issuers, finance companies, real estate investment trusts, security brokers and dealers, holding companies, and funding corporations—have increasingly behaved like deposit-taking entities and significantly intermediated credit within the US since the 1980s. Data indicates that the NBFI contribution to the total loan portfolio surged from under 20% to over 40% between 1987 and 2008.[1]

In Figure (1.1), Xiao (2019) documents a trend where CBs decrease asset

[1]This categorization corresponds to the narrow measure in "Other Financial Institutions" from the annual reports of the Financial Stability Board as circulated by the Bank of International Settlements.

growth in response to monetary policy contraction, while NBFIs, represented by money market funds (MMFs), amplify their asset growth. Given the reliance of intermediaries on deposit inflows, decelerated deposit accumulation could hinder the expansion of CB balance sheets amid monetary policy tightening. Contrastingly, NBFIs augment their asset portfolios by channeling additional credit during monetary contractions, indicating a potential monetary policy leakage. This research elucidates how sector-specific financial structures mediate diverse monetary policy transmissions, particularly highlighting the loan market's pivotal role in these interactions.

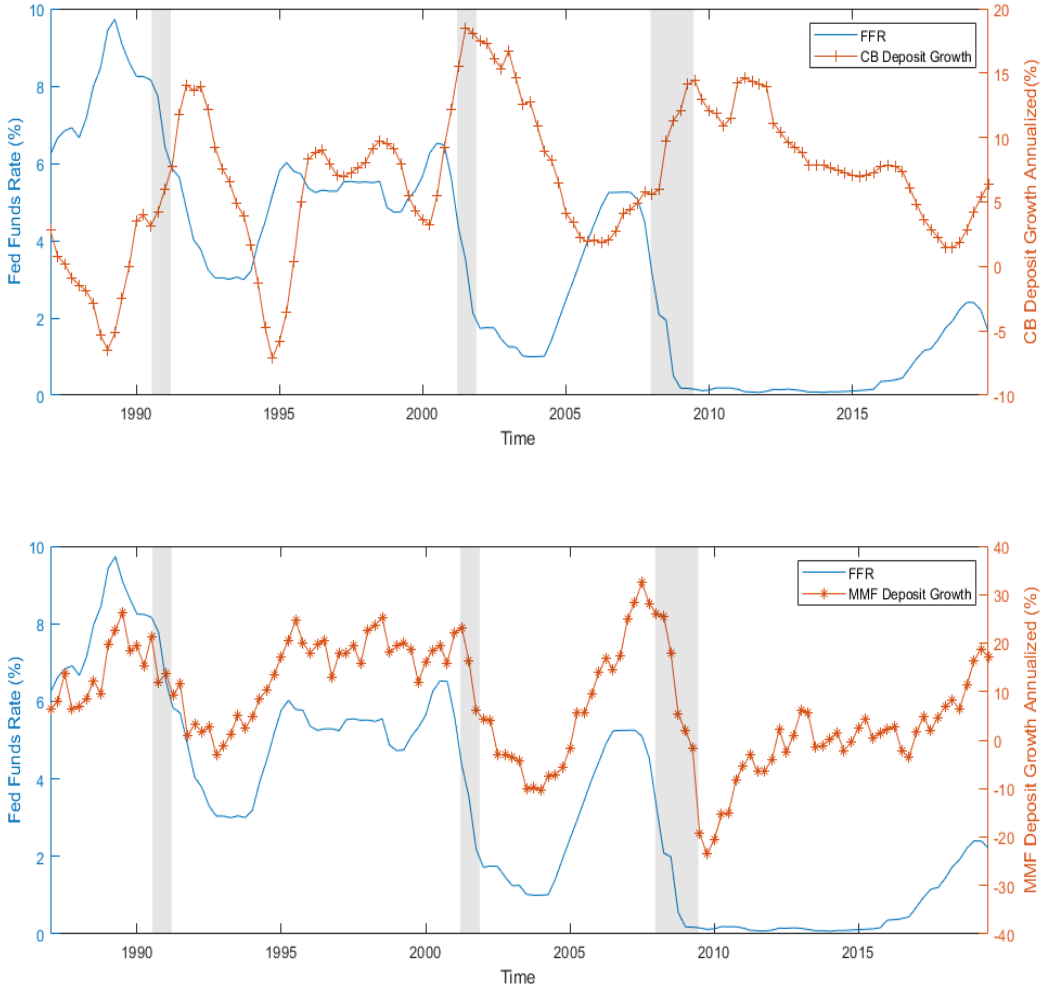

Figure 1.1: Relationship between the federal funds rate and commercial bank and non-bank deposit growths from 1987Q1 to 2019Q3. Non-bank deposit growth is plotted using the growth of money market funds as the proxy.

The critical mechanism for generating the opposite responses described above lies in the loan market. Compared with NBFIs, commercial banks prefer to issue floating-rate loans; when entrepreneurs expect monetary policy tightening, they find non-bank loans more attractive because they offer a fixed borrowing rate. If they borrow from commercial banks, they bear more interest-rate risk. Like households facing variable-rate versus fixed-rate mortgages, entrepreneurs restructure their debt when expecting a monetary tightening cycle. Existing entrepreneurs refinance with non-bank loans, and newly entered ones also find non-bank loans more appealing. When entrepreneurs redirect their borrowing to non-bank loans, the growth of non-bank balance sheets outpaces the growth of commercial bank balance sheets, which creates differing reactions on the asset side of intermediaries' balance sheets. The liability side follows the development on the asset side in the same direction, which generates contrasting responses for deposits. Hence the loan market mechanism from the credit supply explains the divergent responses and demonstrates the leakage of monetary policy to the non-bank financial sector.

The empirical study's findings from the structural VAR analysis of intermediaries' balance sheets distinctly showcase the varied reactions of commercial banks (CBs) and non-bank financial intermediaries (NBFIs) to monetary policy shifts. Before 1987, tightening monetary policy spurred an uptick in commercial bank asset growth with a minimal adjustment in non-bank asset growth. However, the landscape evolved post-1987: commercial banks curtailed their asset growth while NBFIs escalated theirs. This altered behavior can be traced back to enhanced regulatory oversight and the ensuing transformations in the banking sector. Delving deeper into CBs and NBFIs unveils two crucial divergences: market power and leverage management.

The 2020 Financial Stability Board report underscores the marked divergence in market concentration metrics between CBs and NBFIs. Within the domain of MMFs and fixed-income funds, the foremost five entities represent less than 20% of the aggregate assets. In stark juxtaposition, the prominent "Big Four" commercial banks[2] command nearly half of the entire asset pool, emphasizing the disparate concentration metrics. Comprehensive inquiries by Chernenko et al.

[2] JPMorgan Chase, Bank of America, Wells Fargo, and Citibank

(2022) into loan contract intricacies elucidate the inherent rigidity of non-bank loan rates. After adjusting for firm-specific determinants, lender type predominantly arbitrates the equilibrium between variable and fixed rates.

Regarding market power, CBs and NBFIs also display differentials in deposit and lending rates. Due to their substantial market clout, CBs intensify interest differences between deposit and loan rates. For instance, in an environment of escalating policy rates, while NBFIs transmit the entire increment to depositors, CBs implement only a fractional pass-through. Such differentials emanate from their respective market postures.

CBs, due to their regulatory mandates, operate with an externally defined target for their capital-to-assets ratio. This predetermined target is a tangible constraint on commercial banks' leverage spectrum. In stark contrast, NBFIs are governed by internal incentive-based constraints stemming from frictions amongst savers, accentuated by the lack of depositor insurance. This friction is suggestive of the information asymmetry between savers and non-banks. From an empirical lens, commercial banks' asset growth-leverage growth correlation stands neutral, signifying a structured leverage management approach. Conversely, NBFIs reveal a positive interplay between asset and leverage growth, underpinning their unique leverage decision-making matrix. To summarize, the variations in leverage resonate with the intrinsic financial frictions permeating both sectors, while the differential pass-through mechanisms are a testament to their respective market powers.

	Large Firm	Small Firm
Large Intermediary	Fixed-rate	Variable-rate
Small Intermediary	Fixed-rate	Fixed-rate

Table 1.1: Interaction of borrowers and intermediaries of different sizes.

Most importantly, this paper contributes to the understanding of the interplay between monetary policy and the industrial organization of financial institutions, introducing a unique distinction. Drechsler et al. (2017) underscores the deposits channel of monetary policy and the pivotal role of market power in its analysis. Additionally, this work deepens the empirical research concerning the interaction between monetary policy and NBFIs.[3]

While Xiao (2019) delves into the counter-cyclical assets growth of money market funds through a reduced-form analysis, concluding a causal relationship with monetary policy, Nelson et al. (2018) utilizes a structural VAR approach towards the same end. My research, however, diverges in two aspects. Firstly, it relies on a more expansive definition of NBFIs, aligned with FSB (2020), which encompasses mutual funds categories like fixed-income and credit hedge funds—major contributors to non-bank credit for corporations. Secondly, the observed responses in my study are transient, spanning a few quarters, unlike the persistent impact detailed in Nelson et al. (2018) or the point estimates of Xiao (2019).

Drawing from these empirical findings and juxtaposing them with existing literature, I've developed a monetary model within the New Keynesian model in the next chapter. Unlike Xiao, my approach incorporates this framework. Notably, I recognize and validate the "shadow banking channel" of monetary policy—a concept coined by Xiao. However, I attribute the contrasting reactions of CBs and

[3]NBFIs are also termed as "shadow banks." The adoption of "NBFIs" follows the guidance of FSB (2020) as the prior nomenclature is considered derogatory.

NBFIs to differences in institutional setups of intermediaries rather than depositor preferences, as Xiao suggests. He posits that deposit alterations directly influence loan shifts. In contrast, I argue for the reverse: loan changes can reciprocally affect deposits.

The subsequent sections of this paper are structured as follows: Section 2 provides empirical evidence elucidating intermediaries' responses to monetary policy and elaborates on the key distinctions across financial sectors. Section 3 offers concluding remarks.

1.2 Empirical Evidence

In this section, I first provide the structural VAR evidence of the responses of financial sectors to monetary policy. Then I highlight the key differences between CBs and NBFIs to motivate the modeling choices.

1.2.1 Structural VAR Analysis

I conduct VAR analysis on the asset side of intermediaries' balance sheets to further emphasize the contrasting changes. The distinct responses from commercial banks and aggregation of non-bank assets are less apparent than in Figure (1.1) because asset holdings are complicated. Commercial banks' liabilities include various forms of deposits, while assets include various debt securities. Aggregate non-bank assets vary considerably by the institution; therefore, the time series between federal funds rate (FFR) and NBFI asset growth is less clear-cut than in Figure (1.1). Nevertheless, a more rigorous econometric approach still identifies the opposite responses.

I set up the VAR with five variables and four lags. Five variables are in this order: FFR, real GDP growth, inflation, real asset growth for commercial banks, and real asset growth for NBFIs. All variables are in percentages. Cholesky's decomposition recursively identifies the monetary policy shock.

Figures (1.3) and (1.4) suggest that monetary policy has affected financial sectors and output differently since 1987. Before 1987, monetary tightening leads to an increase in commercial bank asset growth and an insignificant change in non-bank asset growth. Output decreases two quarters after the policy shock. After 1987, CBs lower asset growth, while NBFIs boost asset growth.[4] 90% confidence intervals do not include zero for both types of intermediaries, implying non-zero immediate responses. Moreover, output no longer drops when the policy rate strengthens, suggesting a decline in the effectiveness of the monetary policy. From the previous two results, monetary policy has a dampened impact on the real economy. Nelson et al. (2018) demonstrate the persistent and divergent responses. I present evidence on the short-term impact and argue there has been a structural change in how financial sectors respond to the Fed since the 1980s. My study differs in two key ways. First, I adopt a broader definition of NBFIs, in line with FSB (2020), which includes categories of mutual funds such as fixed-income and credit hedge funds—principal sources of non-bank credit for corporations. Second, the reactions noted in my research are short-lived, lasting only a few quarters, in contrast to the prolonged effects described in Nelson et al. (2018) or the specific findings of Xiao (2019).

[4] A possible explanation is that before 1987, CBs were not heavily regulated, so they do not have to follow the Fed's expectations from the *bank lending channel.* After Bernanke and many others pointed to credit channels through commercial banks, commercial banks faced greater regulatory pressure.

I then conduct several robustness checks to strengthen the results by reordering variables. Reordering FFR does not affect the opposite directions for balance sheets. After switching the ordering of balance sheets so that NBFIs' asset growth proceeds with CBs' asset growth, impulse responses are identical as displayed by Figures (1.5) and (1.6). This comparison rules out the possibility that non-banks expand as commercial banks conduct off-balance sheet activities. Using sign restriction, in Figure (1.7), mechanically restricting positive contemporaneous signs for output and inflation enables them to respond as expected by policymakers. However, the responses are also opposite from CBs and NBFIs. CBs shrink balance sheets with a high confidence level, while NBFIs' responses are not distinguishable from zero due to the wide confidence level.

1.2.2 Differences between CBs and NBFIs

I further discuss two key differences between CBs and NBFIs to incorporate into the model as summarized by Table (1.2).

	CBs	NBFIs
Market Power	Large	Small
Leverage Management	Regulatory Capital Requirement	Moral Hazard

Table 1.2: Comparing CBs vs. NBFIs

Market Power Market power difference explains how the market structure of financial intermediaries influences their business decisions in loan rate stickiness and interest rate pass-through. The presence of market power in the financial sector is well established in the empirical and theoretical studies, as portrayed in Gerali et al. (2010).[5] Relevant to this paper, the regulatory restrictions are

[5] Gerali et al. (2010) discuss the relevant literature and various reasons for the existence of

also potential sources of market power for CBs, as indicated by Demirgüç-Kunt et al. (2004). They show that tighter bank regulations on bank entry and activities boost banks' net interest margin: the regulatory environment enables a few powerful banks as regulations are barriers to competition. In contrast, the lack of regulations explains the less market power within NBFIs.[6] When identifying market power, Berger et al. (2004) suggests market concentration as an useful indicator.

As implied by comparing market concentrations, NBFIs are less competitive and set their deposit rates closer to the federal funds rate. Figure (1.2) displays that as monetary policy tightens, the pass-through from the policy rate to the CB deposit rate is much lower when compared to the pass-through from the policy rate to the NBFI deposit rate. During the sample period, CBs only pass through half of the rate hikes to depositors, while NBFIs pass through almost all the changes. The model's interest rate elasticities of deposit and loan demand measure the market power. Without incorporating loan riskiness, this paper calibrates a higher elasticity of loan demand for CBs so that the CB loan rate is lower than the NBFI loan rate in a steady state. Conditional on the identical quality of loans, CBs offer a higher borrowing rate due to greater market power. Xiao (2019) argues that although the FDIC does not insure NBFI deposits, the risk is not the primary factor for the spread between two deposit rates as in Figure (1.2).

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market power. Other potential sources of market power could be long-term customer relationships, switching costs, and asymmetric information within the banking sector.

[6]Commercial banks are under the supervision of FDIC, Fed, OCC, and state regulators, whereas NBFIs are mostly scrutinized by local regulators.

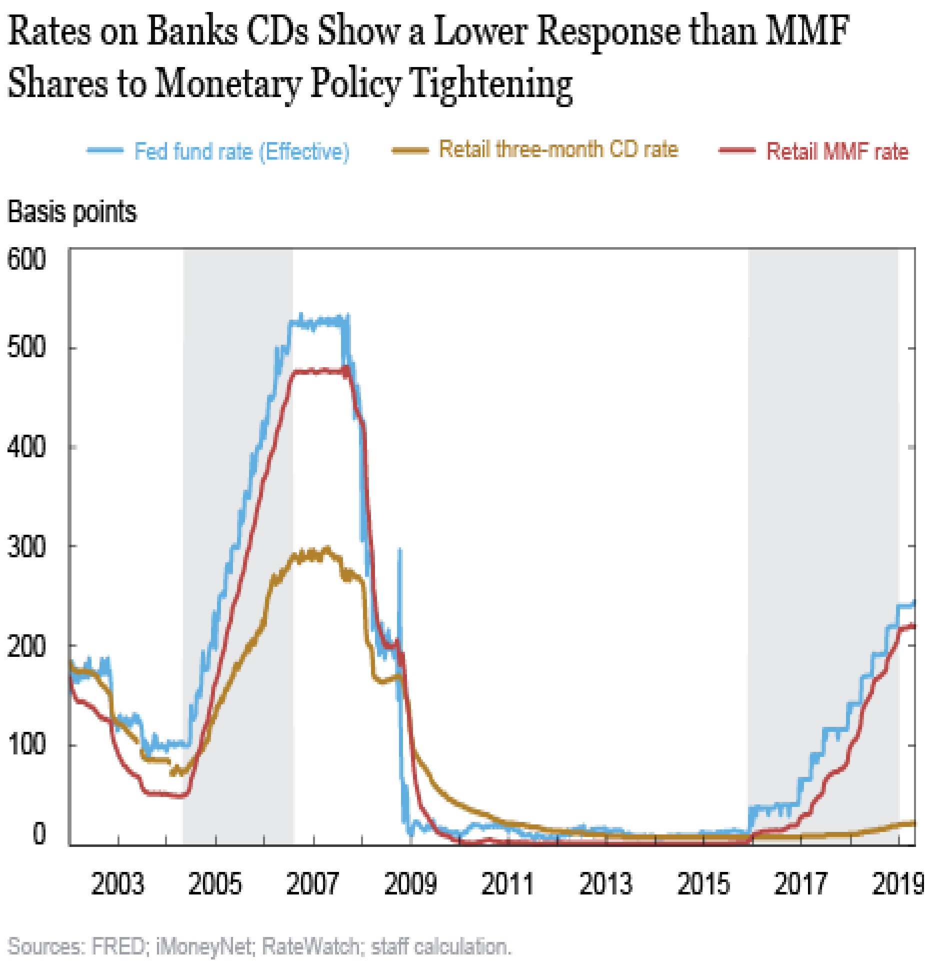

Figure 1.2: Time series of the federal funds rate, CB deposit rate, and NBFI deposit rate. Source: https://libertystreeteconomics.newyorkfed.org/2019/11/monetary-policy-transmission-and-the-size-of-the-money-market-fund-industry/

Leverage Management The distinction in leverage reflects the financial frictions behind their operations. Regulatory arbitrage is often attributed to the existence of NBFIs since they are considerably less regulated than CBs.[7] Specifically, commercial banks are subject to capital regulations. In contrast, NBFIs are bounded by endogenous leverage arising from a moral hazard problem between

[7] Adrian (2011), Pozsar et al. (2010), and others rationalize in detail the existence of shadow banks.

savers and non-banks. Endogenous leverage reflects various financial and informational frictions in the corporate finance literature (e.g., Hart and Moore (1998) and Holmstrom and Tirole (1997)).[8] In the model, I employ the same costly enforcement problem as in Gertler and Karadi (2011) for non-banks. The market conditions discipline their leverage instead of regulators. Moreover, Jiang et al. (2020) show NBFI capital structure choices are the result of regulations (i.e., no capital requirement) and subsidies (i.e., no FDIC insurance). The lack of FDIC insurance shows that this friction is non-trivial.

Empirically, we observe different leverage changes over time between the two financial sectors. In Adrian and Shin (2010), the commercial banks have a target leverage ratio by managing asset growth while keeping leverage relatively stable. They exhibit that brokers and dealers change leverage ratios when adjusting asset growth. Furthermore, they demonstrate that the five largest investment banks are raising leverage when growing their balance sheets before the Great Financial Crisis. Figure (1.8) shows that the correlation between asset and leverage growths is almost zero, suggesting CBs are actively maintaining target leverage. In Figure (1.10), the cluster of data points near zero leverage growths signifies that CBs have relatively stable leverage in this sample period. Compared with CBs, NBFIs in Figure (1.9) adjust leverage pro-cyclically to assets growth and do not demonstrate a target leverage ratio: the correlation between NBFI assets and leverage growths is 0.7.

[8] Brunnermeier et al. (2012) and Gertler and Kiyotaki (2010) provide a theoretical and empirical overview on financial frictions.

1.3 Conclusion

In examining the dynamics of financial intermediaries in response to monetary policy shifts, this study explains pronounced divergences in the behavior of commercial banks (CBs) and non-bank financial institutions (NBFIs). Post-1987 data reveals a retrenchment in asset growth by CBs concurrent with an expansion by NBFIs under monetary tightening—a phenomenon potentially anchored in regulatory evolutions and inherent institutional disparities. CBs, buttressed by considerable market power and nestled within a robust regulatory framework, display a tendency toward consistent leverage ratios. In contrast, NBFIs, characterized by their relative operational latitude yet grappling with moral hazard issues, exhibit more cyclical leverage adjustments. This research accentuates the imperative of nuanced institutional differentiation in analyzing the financial sector's monetary policy feedback mechanisms.

1.4 Appendix

1.4.1 VAR Results

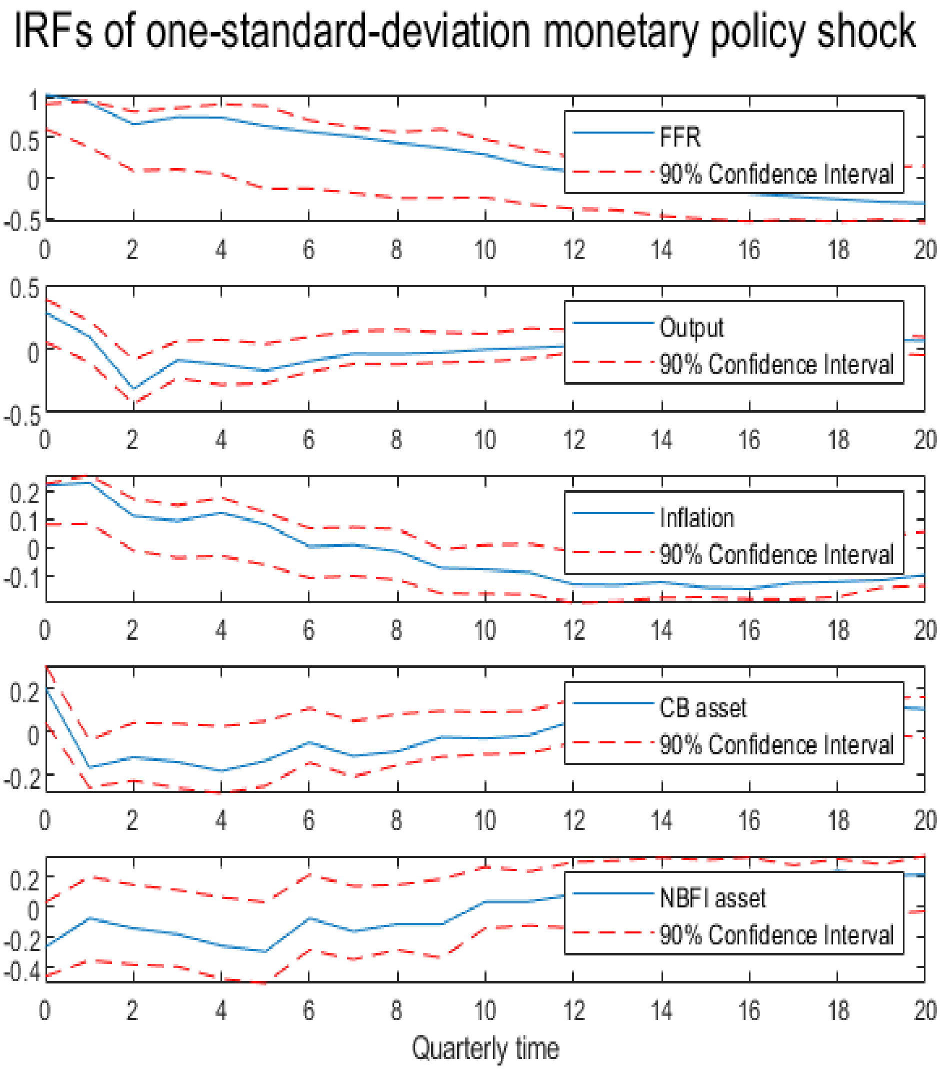

Figure 1.3: Impulse response functions of monetary policy shock using data from 1973Q2 to 1986Q4. Dashed red lines are 90% confidence interval. The federal funds rate is the first variable.

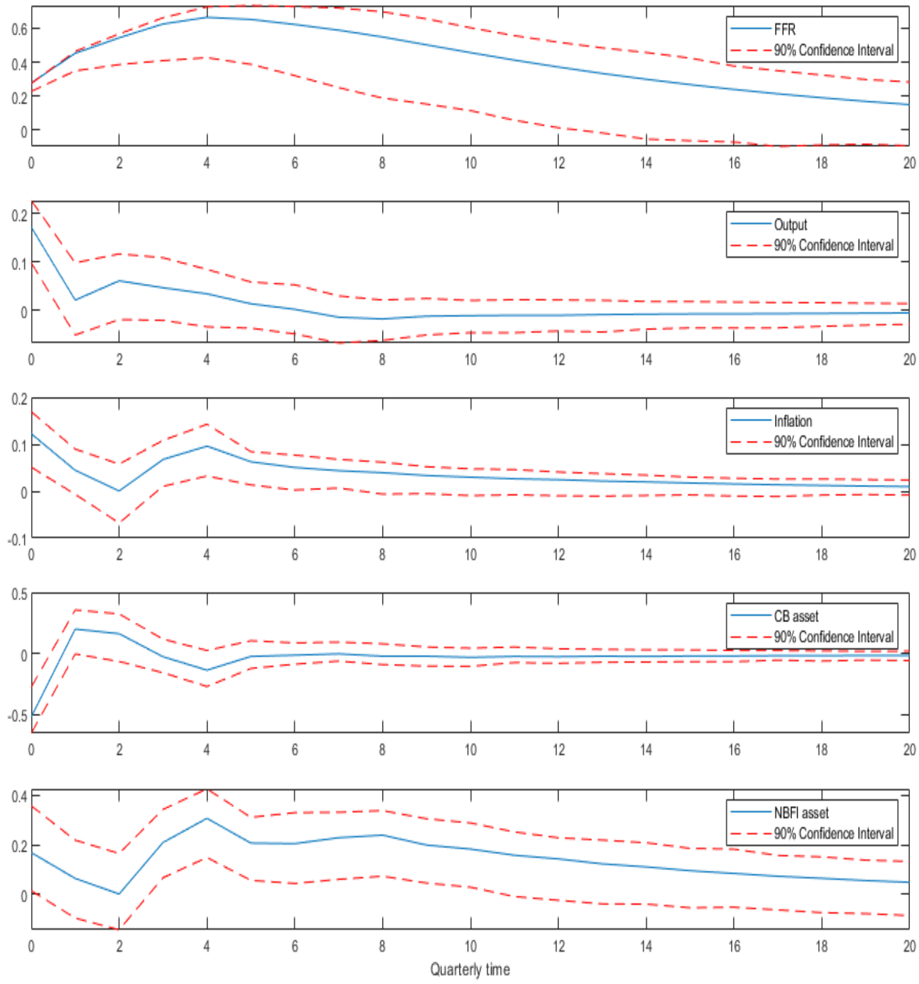

Figure 1.4: Impulse response functions of monetary policy shock using data from 1987Q1 to 2019Q4. Dashed red lines are 90% confidence interval. The federal funds rate is the first variable.

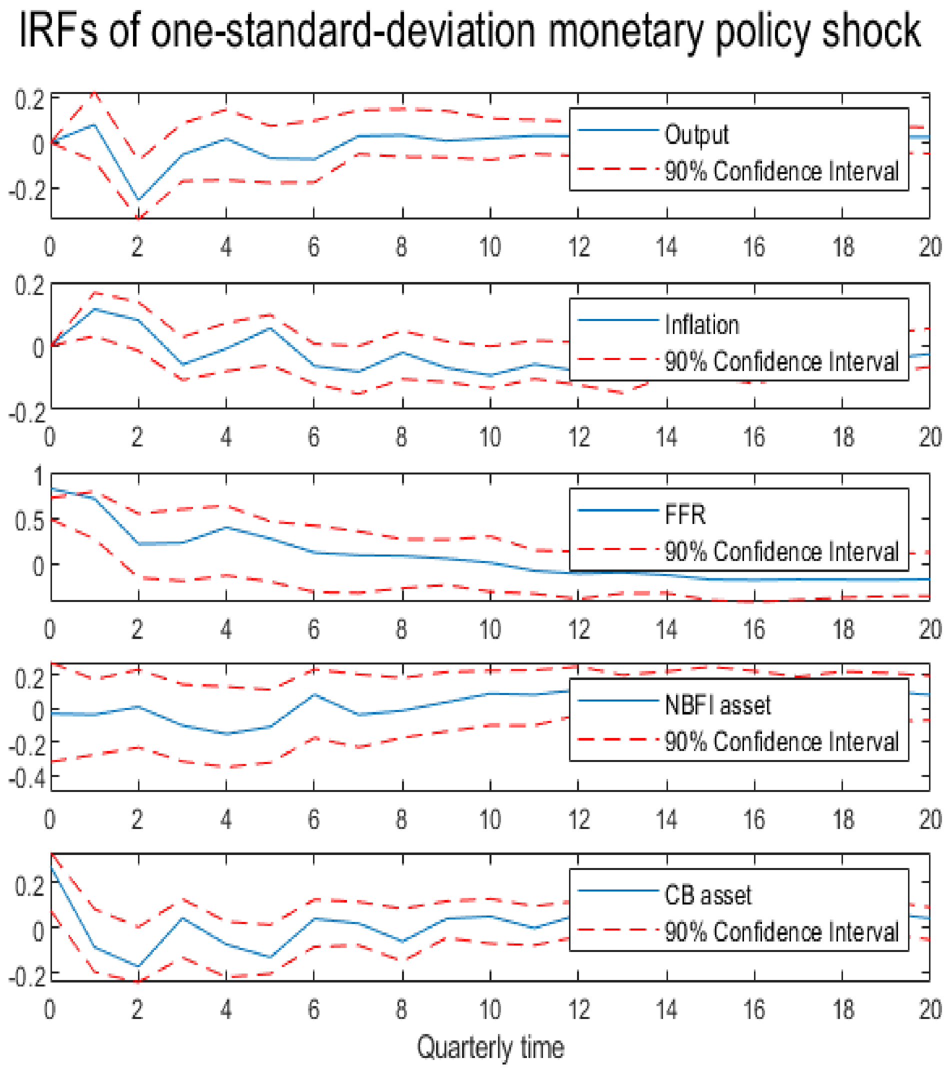

Figure 1.5: Impulse response functions of monetary policy shock using data from 1973Q2 to 1986Q4. Dashed red lines are 90% confidence interval. NBFI asset growth is the first variable.

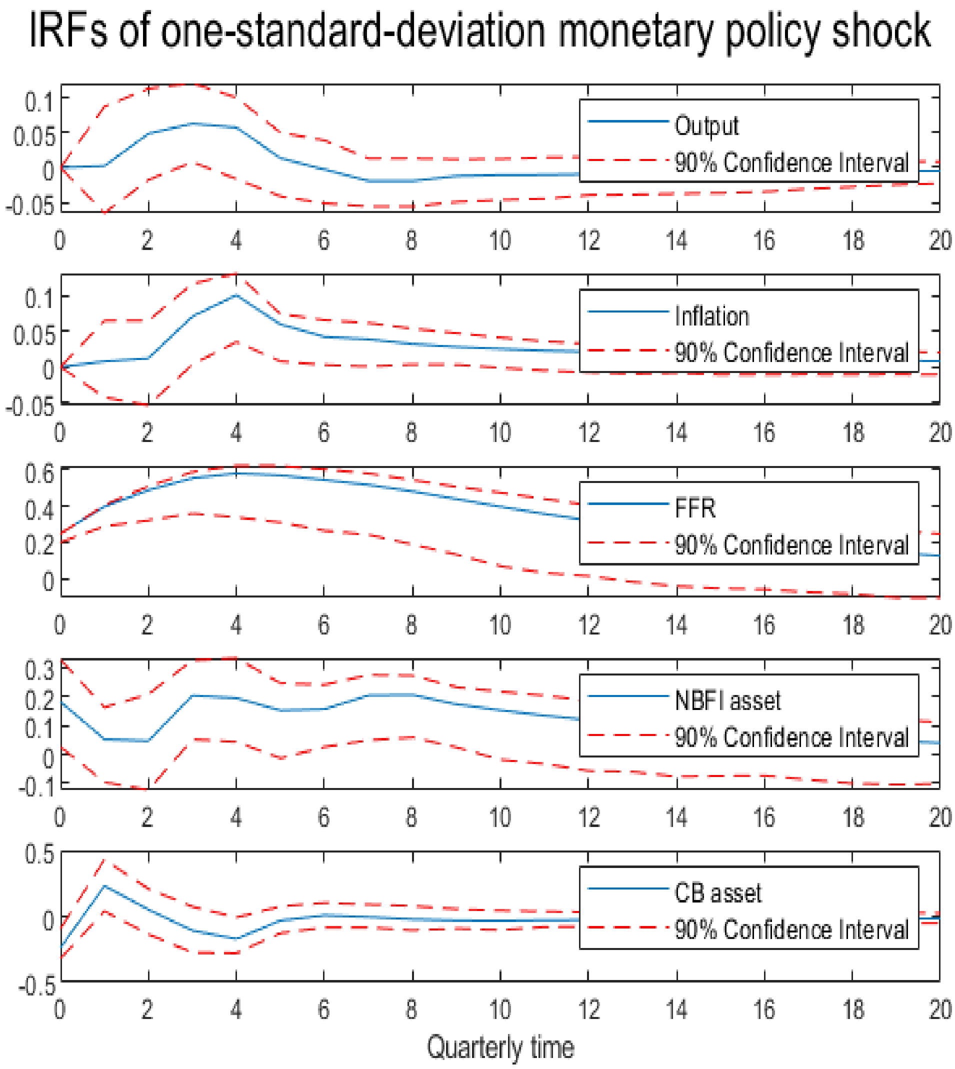

Figure 1.6: Impulse response functions of monetary policy shock using data from 1987Q1 to 2019Q4. Dashed red lines are 90% confidence interval. NBFI asset growth is the first variable.

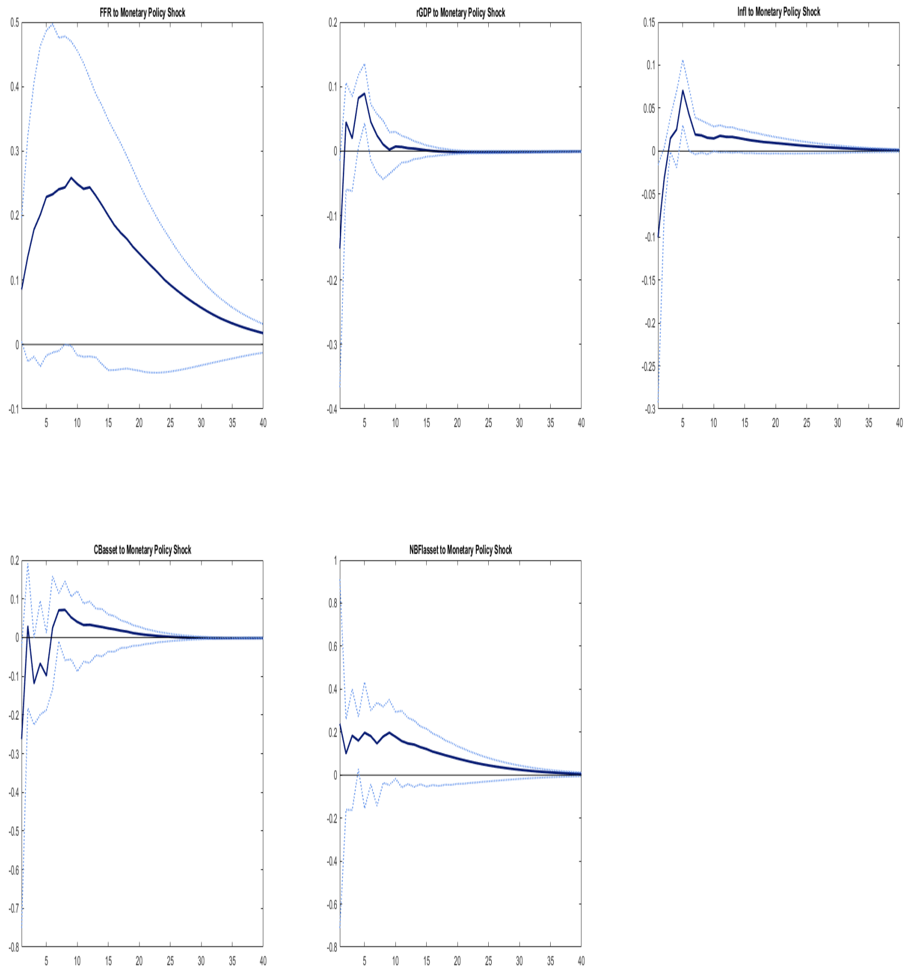

Figure 1.7: Impulse response functions of monetary policy shock using data from 1987Q1 to 2019Q4 using sign restrictions: GDP has to respond positively to policy rate while inflation has to respond negatively. Dashed blue lines are 90% confidence interval.

1.4.2 Leverage Growths

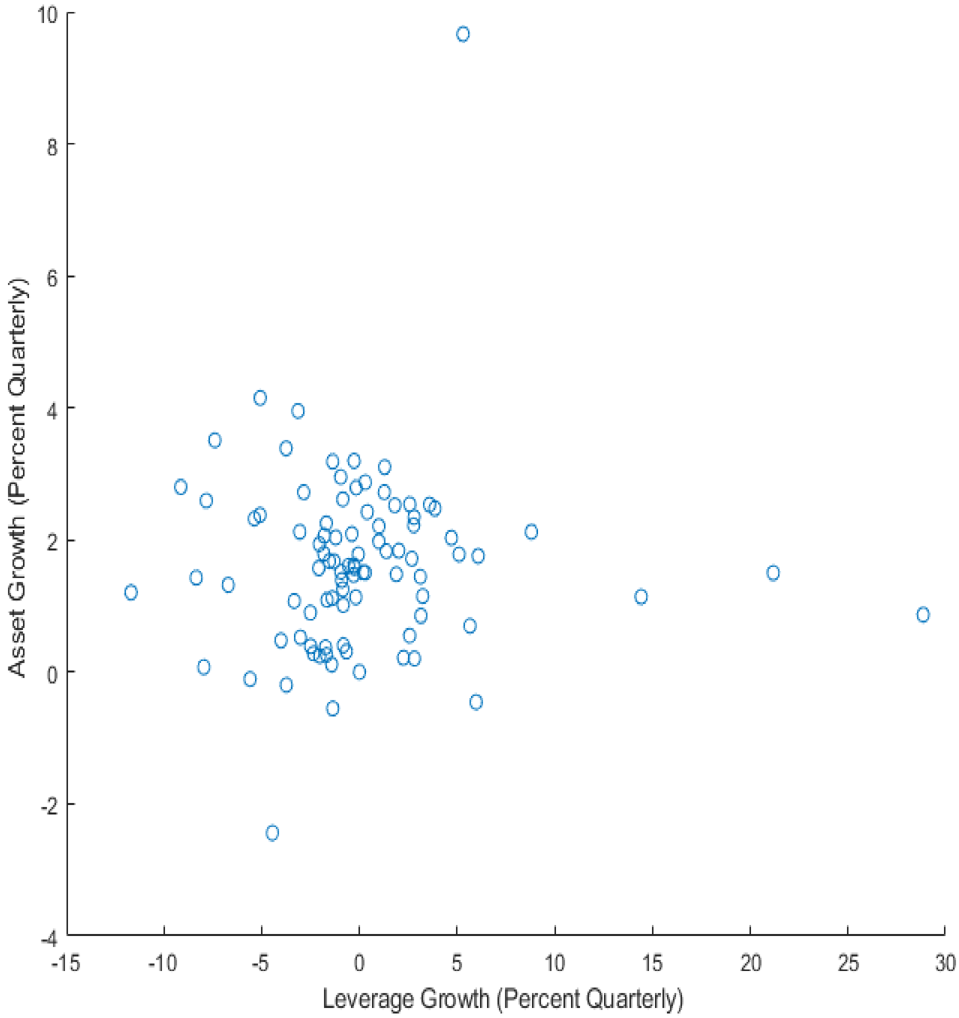

Figure 1.8: Leverage and assets growth of commercial banks from 1987Q1-2008Q4.

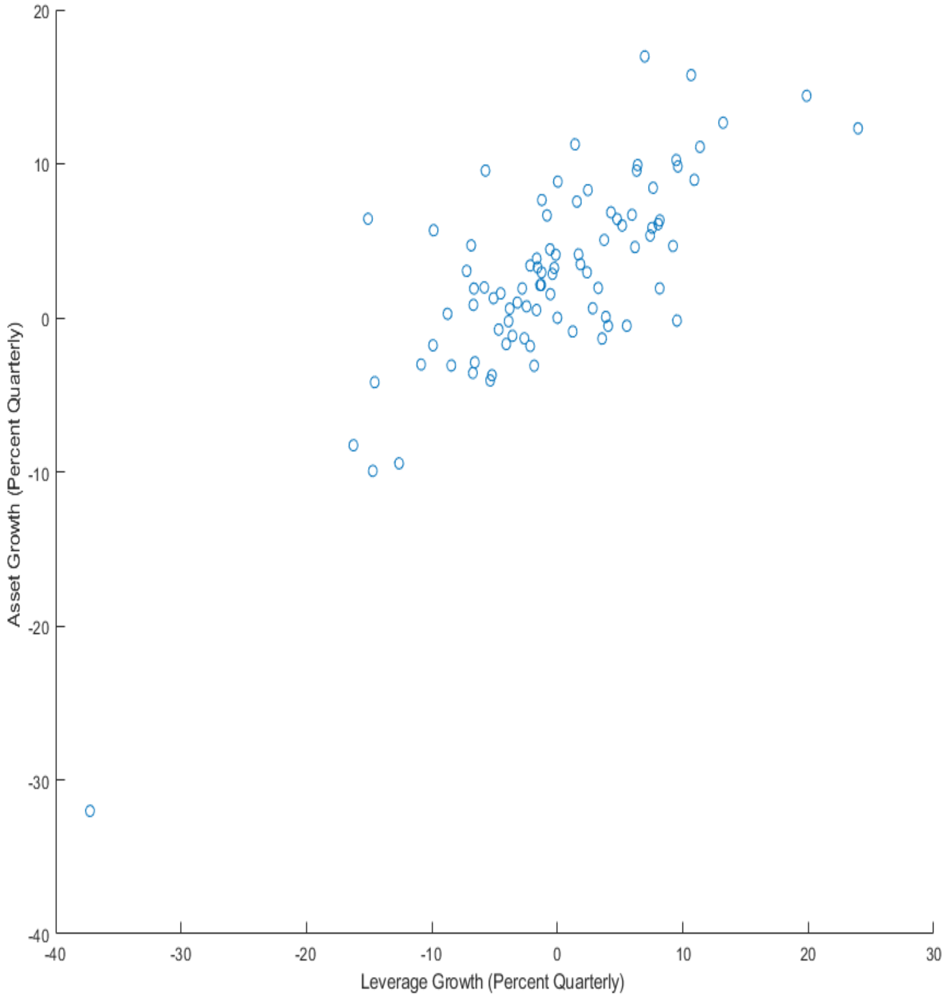

Figure 1.9: Leverage and assets growth of security brokers and dealers from 1987Q1-2008Q4.

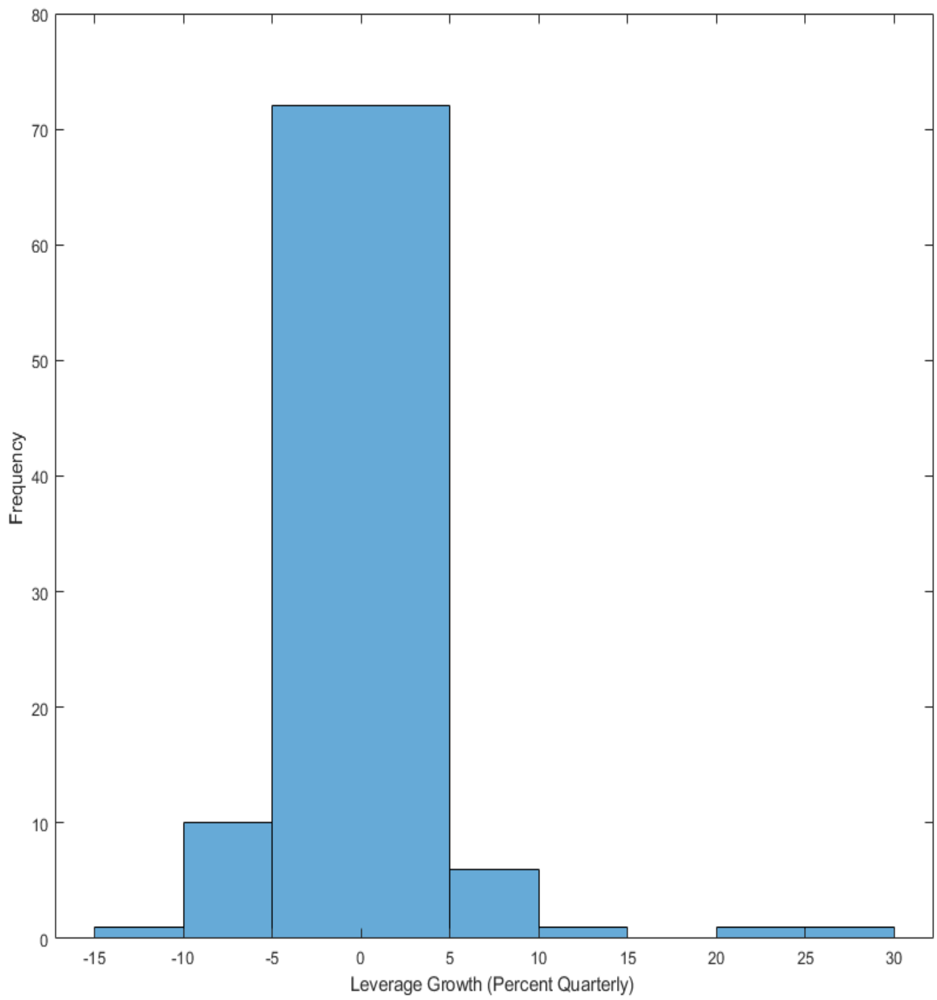

Figure 1.10: Frequency of leverage growth of commercial banks from 1987Q1-2008Q4.

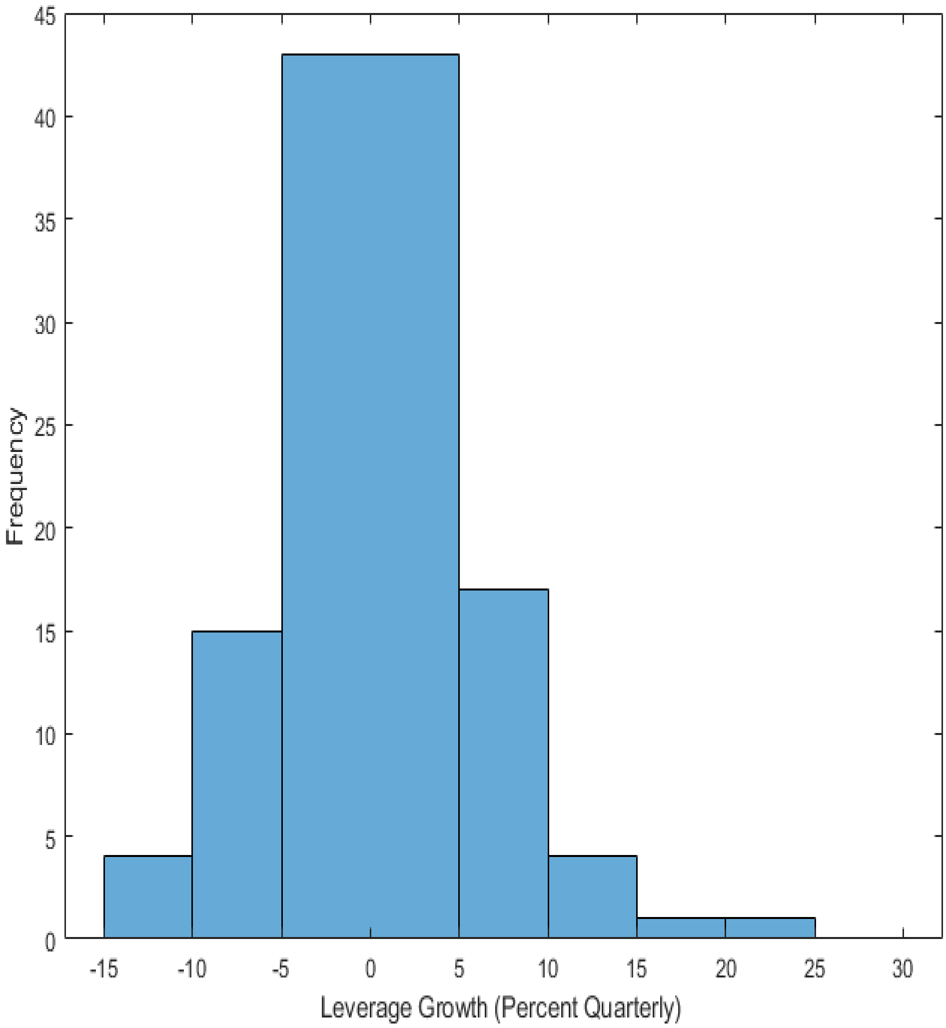

Figure 1.11: Frequency of leverage growth of brokers and dealers from 1987Q1-2008Q4.

Chapter 2

A Structural Framework of Banks and Non-banks

2.1 Introduction

The structural VAR analysis from the initial chapter reveals contrasting responses of Commercial Banks (CBs) and Non-Bank Financial Intermediaries (NBFIs) to monetary policy shifts. In this chapter, I delve deeper, integrating a structural framework to simulate these distinct reactions. The core structure remains consistent with conventional central bank models after incorporating nuances like market power disparities and unique leverage management styles.

Within this structure, patient households, constrained by budget, make their consumption decisions based on habits, leisure, and savings. They face a choice: to save in either CBs or NBFIs. Entrepreneurs, on the other hand, are less patient than households. They engage in the production of goods using constant returns to scale technology, acquire physical capital at prevailing market rates, and access loans from both CBs and NBFIs, using future capital as collateral. Each financial entity enforces its distinct borrowing constraint on these entrepreneurs. Meanwhile, capital producers are engaged in making decisions around investment, taking into account adjustment costs and capital utilization rates, which subsequently inform the capital goods pricing.

Retail firms, facing price stickiness and inflation indexing, are tasked with converting intermediate goods into the final product. On the macro level, the Central Bank, governed by the Taylor rule, is responsible for deciding the nominal interest rate. Once calibrated with structural parameters, the model parameters are evaluated through Bayesian estimation using US data from 1987Q1 to 2008Q4. The results align: they fittingly replicate the market shares of the two financial sectors and their respective saving and lending rates.

Upon tightening monetary policy, the model elucidates a discernible leakage towards the non-bank sector through the described mechanism. The asymmetry in leverage management doesn't directly influence monetary policy. However, it plays a pivotal role in the financial stability sphere. The palpable friction between savers and NBFIs curtails the deposit influx into NBFIs, making a compelling case for policymakers to address these frictions to fortify the health of NBFIs.

This research pivots around the nuanced ripple effects of a monetary policy shock when NBFIs are in the equation. A tightening of monetary policy results in deposit rates swiftly converging with the policy rate. CBs, tapping into their market power, adjust deposit rates less aggressively than NBFIs. This discrepancy triggers a noticeable surge in bank borrowing rates, given the relative rigidity of NBFI rates. This dynamic prompts entrepreneurs to pivot away from bank loans. The findings from Vector Auto Regression (VAR) analysis buttress these observations, emphasizing the fleeting nature of these asymmetric responses.

Moreover, a noteworthy "leakage" in monetary policy emerges, characterized by NBFIs augmenting their lending endeavors and bolstering their deposit base. CBs strategically maneuver their rates to recalibrate leverage ratios, expanding their interest margins by juxtaposing lending against deposit rates. Contrarily, NBFIs, while in the throes of deleverage, grapple with delayed borrowing rate adjustments, culminating in a negative credit spread. This study's pivotal observation underscores the importance of loan rate stickiness in NBFI responses to monetary policy transitions. By eliminating information asymmetry between the banking sectors, there's potential to amplify monetary policy efficiency by 2%. The study concludes with a recommendation for policy strategists: with NBFIs steadily cementing their influence, there's an escalating need for a proactive approach, continually assessing and recalibrating monetary policy tools to uphold their efficacy.

The study's implications, especially from a policy perspective, are twofold. Firstly, the Federal Reserve should remain attuned to the growth trajectory of the non-bank sector. A dominant yet unchecked, non-bank sector can diminish the potency of monetary policy. In a hypothetical scenario where NBFIs intermediate a third more of total credit, the repercussions could be significant, potentially diluting monetary policy influence by 15% on investment and 10% on consumption. Secondly, the Fed must be diligent in its assessment of concentration levels within both financial sectors. Intensifying concentrations in CBs and NBFIs have ramifications for interest margins, potentially escalating loan rates or driving down deposit rates. Notably, the policy analysis spotlights that the post-2008 stagnation in deposit rates hasn't dented the efficacy of policy rates. In the realm of non-bank loan markups, if non-banks consolidate more leisurely than banks, the repercussions could be diminished markup, potentially undermining policy efficiency.

The discourse on financial intermediation in macroeconomic models has significantly expanded, especially following the Great Financial Crisis (GFC) reverberations. Central to this discourse, Woodford (2010) underscores the necessity of incorporating financial intermediaries in macroeconomic models, highlighting their unique institutional attributes. This perspective echoes in the works of researchers like Gertler and Kiyotaki (2010), Cúrdia and Woodford (2011), Gerali et al. (2010), and Gertler and Karadi (2011), who offer insightful examinations into the roles of financial intermediaries in the aftermath of the GFC.[1] Within this rich tapestry of research, this chapter seeks to provide a supplementary layer by considering the differences in leverage management and market power. Taking cues from the model by Gertler and Karadi, which revolves around an aggregate financial sector, I introduce a variation by considering a second banking sector. This inclusion, while building on the foundational insights of Gerali et al., acknowledges the divergences in leverage management practices arising from distinct financial frictions that different intermediaries confront.

Further nuances emerge when market power is scrutinized. Although Gebauer and Mazelis (2019) have ventured into frameworks considering heterogeneous fi-

[1] A dive into earlier literature brings us to influential works by Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Bernanke et al. (1999), and Iacoviello (2005). These scholars have rigorously explored the interplay between monetary policy and financial frictions, bringing concepts like borrowers' financial accelerator and borrowing constraints to the forefront.

nancial sectors, there remains a space for further exploration into the intricacies of market power, given its potential implications for monetary policy transmission. In addressing this, the current model integrates market power to delineate between deposit and loan rates across these sectors. It ventures into the dynamics of imperfect competition, specifically examining the trade-offs between fixed and flexible loan rates. This facet of the study complements and draws contrasts to the approach of Wang et al. (2018). While they, too, navigate the contours of market power and financial frictions vis-à-vis monetary policy, the mechanism proposed in this chapter adds another layer of understanding, especially in the context of the NBFIs and their offering of varied loan options to borrowers.

Theoretically, this paper emphasizes the traditional functions of intermediaries. Most papers, such as Gertler et al. (2016), Moreira and Savov (2017), and Ordoñez (2018) and Pozsar et al. (2010) model the connections between retail and wholesale banks, whereas I model them as separate entities to highlight the conventional functions of intermediaries. Since government-sponsored enterprises focus on originate-to-distribute mortgages instead of deposit-to-loan credit, I move away from them to emphasize how NBFIs compete with CBs in the non-financial corporate borrowing market. Loutskina and Strahan (2009) empirically show that shadow banks' activities weaken monetary policy. Nevertheless, they focus on liquidity transformation (i.e., securitization) instead of credit intermediation.

The rest of the paper is organized as follows. Section 2 lays out the model. Section 3 describes the data handling, calibration, and Bayesian estimation strategy. Section 4 presents the main results and the impact of modeling choices, and Section 5 discusses policy implications. Section 6 concludes.

2.2 Model

The model is a medium-scale New Keynesian model with heterogeneities within the financial sector. The economy has six types of agents: households, entrepreneurs, commercial bankers, non-bank financial intermediaries, capital-goods producers, and final-goods retailers. The two banking sectors build upon Gertler and Karadi (2011) and Gerali et al. (2010).

Households consume, work, and decide between CB and NBFI deposits. They earn interest payments on deposits determined from the previous period. Entrepreneurs produce intermediate goods, hire labor, consume, hold capital, and borrow from CBs and NBFIs with capital as collateral. They face a borrowing constraint *à la* Iacoviello (2005) from each banking sector and borrow against the expected value of capital holdings. Entrepreneurs are less patient than households and are the sole borrowers in this economy. Patient households are the net savers in the model.

Figure (2.1) represents a simplified US financial system. Both types of financial intermediaries, owned by households, conduct businesses by taking in deposits and lending out loans. Four one-period financial instruments are available in this economy: deposits and loans from CBs and NBFIs. All the instruments are indexed to the current inflation.[2] Financial intermediaries are forward-looking when setting the quantities and prices of deposits and loans. Each banking sector has three separate branches: one wholesale branch and two retail branches.

[2] I simplify the nominal-debt channel from Gerali et al. (2010) to stress the role of financial intermediaries in monetary policy transmission. Their results are qualitatively similar by comparing my main results and the QNK model in their paper.

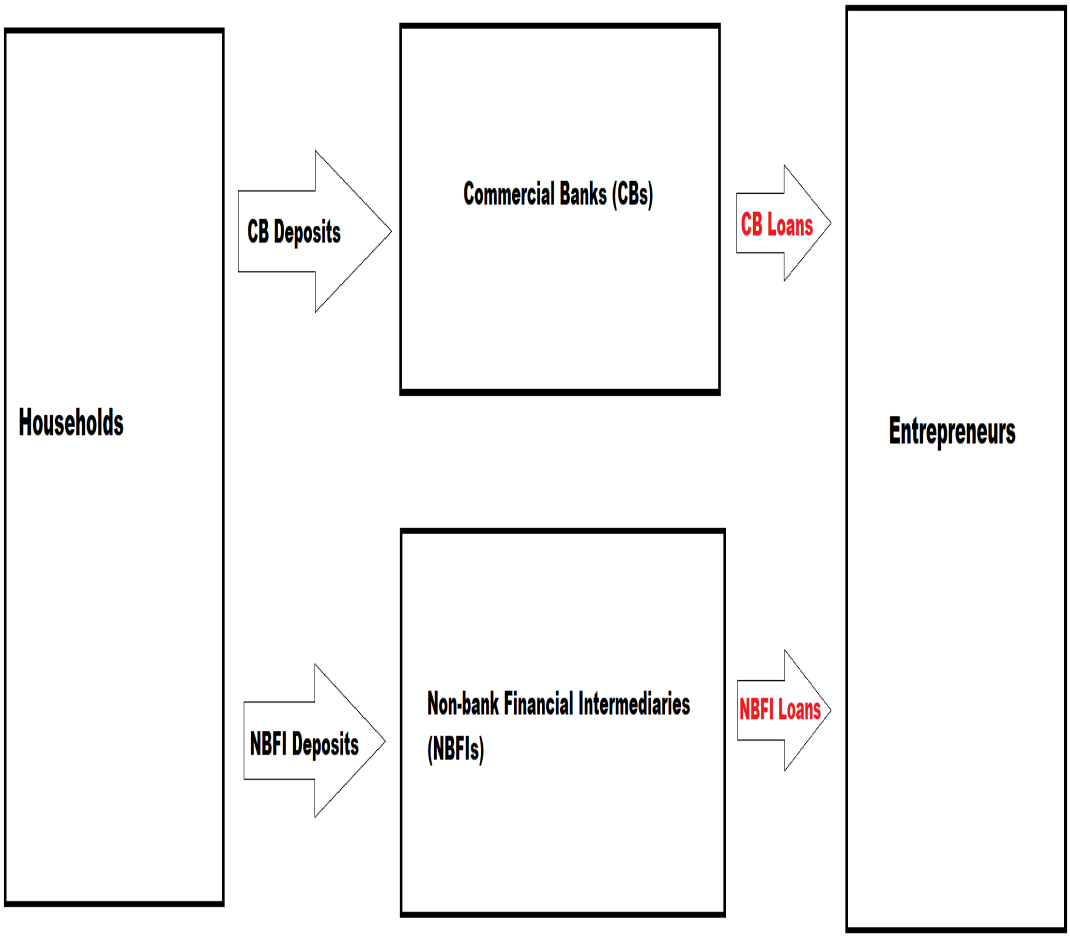

Figure 2.1: A simplified US financial system.

The wholesale branch oversees the capital position as it solves expected lifetime cash flows. The retail deposit (loan) branches exert market power over households (entrepreneurs). For example, CBs exercise greater market power over households by offering lower saving rates. Retail branches are separate to introduce market power over depositors and borrowers so that the deposit (loan) rate is marked down (up) over the policy rate.[3]

[3]By combining three branches, the model produces equivalent results; however, this setup singles out the bank capital management role better as bank capital only appears in the wholesale branch. After combining all the branches, there are several changes. First, only one credit spread is left: the difference between borrowing and deposit rates. The expression is similar

CBs are very similar to banks in Gerali et al. (2010). The wholesale branches determine optimum leverage ratios subject to a quadratic adjustment cost. The target could be regulatory constraints or trade-offs in commercial banks' decision-making processes. The quadratic form of this cost implies symmetric changes to leverage, which the data in Figure (1.10) accurately reflect. Their balance sheets are simple: total loans equal the sum of deposits and bank capital. They keep all the retained earnings to accumulate bank capital. The capital of commercial banks incurs managing costs to keep it stationary. Bank leverage affects banks' interest margins as they are inversely related. If banks increase leverage by deviating from the target, the spread between borrowing and saving rates will increase.

NBFI wholesale branches are similar to banks in Gertler and Karadi (2011) since they face a costly enforcement problem that limits leverage. Because NBFIs can divert funds, an incentive constraint determines the leverage. Since NBFIs face much less regulatory attention than CBs, the financial market conditions discipline their corporate strategies. As explained in the empirical section, the loan rate in the retail loan branches incurs a quadratic adjustment cost since it is more sluggish. I introduce sticky loan rates by assuming NBFIs face quadratic adjustment costs. The micro-foundation of this choice is untouched in the paper, but quadratic adjustment costs are prevalent in macroeconomics, such as in price stickiness from Rotemberg (1982). Even though the paper abstracts from the term structure, the NBFI loan rate is sticky regarding outstanding loans for existing and incoming borrowers.[4]

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to the wholesale branch spread. Second, the borrowing rate is a markup over the deposit rate, and the deposit rate is a markdown on borrowing rates. Third, recalibrating bank parameters such as adjustment costs and demand elasticities produces identical results as if there are three branches.

[4]In the sample from their paper, the loan maturity is similar, regardless of issuers of loans,

Capital goods producers introduce the price of capital into the framework. Retailers purchase intermediate goods from entrepreneurs, differentiate them, and package them into final goods. Finally, the monetary authority sets the policy rate via a smoothed Taylor rule. Many bells and whistles in a full-blown Bayesian macroeconomic model in the spirit of Smets and Wouters (2007) are intentionally left out to focus on financial intermediaries. In an exercise not attached here, results are qualitatively the same if debt-deflation channel, impatient households, housing consumption, and wage stickiness are in the current framework.

2.2.1 Households

The representative household i solves for consumption $\{C_t^H(i)\}$, labor supply $\{L_t^H(i)\}$, CB deposits $\{D_t^C(i)\}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^{H^t} [(1-a^H) log(C_t^H(i) - a^H C_{t-1}^H) - \frac{L_t^H(i)^{1+\phi^H}}{1+\phi^H}] \tag{2.1}$$

subject to the following budget constraint in real terms

$$C_t^H(i) + D_t^C(i) + D_t^N(i) \leq W_t L_t^H(i) + (1+r_{t-1}^{D,C}) D_{t-1}^C(i) + (1+r_{t-1}^{D,N}) D_{t-1}^N(i) + T_t(i) \tag{2.2}$$

with $0 < \beta^H < 1$, $0 < a^H < 1$ and $\phi^H > 0$. Habit persistence captures the hump-shaped consumption dynamics. W_t is the real wage, and $T_t(i)$ includes profits and transfers from financial and non-financial firms. $(1 + r_{t-1}^{D,C}) D_{t-1}^C(i) + (1 + r_{t-1}^{D,N}) D_{t-1}^N(i)$ are gross total deposit holdings. Deposits are non-negative as households are the net savers in this economy. I assume the demand for non-bank

when controlling for firm characteristics.

deposits is perfectly elastic, so households will supply as many deposits as needed by NBFIs.[5]

Given their similarity to CB deposits, this paper treats household investments in NBFIs as deposits. Sunderam (2014) reveals that some shadow banks' claims, such as asset-backed commercial paper (ABCP) and repurchase agreements (repos), are similar to bank deposits as they are money-like claims. Jiang et al. (2020) also conclude the similarity in the deposit functions as both institutions rely primarily on short-term debt.

2.2.2 Entrepreneurs

Entrepreneurs use capital from capital goods producers to produce intermediate goods and are the only credit demanders in this economy. They decide on consumption with habit $\{C_t^E(i)\}$, labor inputs for households $\{L_t^H(i)\}$, physical capital $\{K_t^E(i)\}$, loans from CB $\{B_t^C(i)\}$ and from NBFI $\{B_t^N(i)\}$ to maximize

$$E_0 \sum_{t=0}^{\infty} {\beta^E}^t log(C_t^E(i) - a^E C_{t-1}^E) \tag{2.3}$$

subject to

$$\begin{aligned} C_t^E(i) + W_t L_t^H(i) + (1 + r_{t-1}^{B,C}) B_{t-1}^C(i) + (1 + r_{t-1}^{B,N}) B_{t-1}^N(i) + Q_t K_t^E(i) \\ \leq \frac{Y_t^E(i)}{X_t} + B_t^C(i) + B_t^N(i) + Q_t(1 - \delta^K) K_{t-1}^E(i) \end{aligned} \tag{2.4}$$

δ^K is the depreciation rate, and Q_t is the price of unit physical capital in terms of consumption. $\frac{1}{X_t}$ is the relative price of the wholesale good, so X_t is the markup

[5]This simplification assumption avoids the complexity of the household portfolio choice problem. Otherwise, both deposit rates are the same from the Euler equations in the log-linearized equilibrium. I will discuss the impact of this assumption later.

of retail goods over wholesale goods.

The borrowing constraints are

$$(1 + r_t^{B,C})B_t^C(i) \leq m_t^C E_t[Q_{t+1}(1 - \delta^K)K_t^E(i)] \tag{2.5}$$

$$(1 + r_t^{B,N})B_t^N(i) \leq (1 - m_t^C)E_t[Q_{t+1}(1 - \delta^K)K_t^E(i)] \tag{2.6}$$

m^C is the supervisory loan-to-value (LTV) limit for CBs. $(1 - m^C)$ limits the borrowing from NBFIs. Following Iacoviello (2005), the borrowing constraints are binding around the steady state by assuming "sufficiently small" shocks. When both constraints are binding, $\frac{m^C}{1-m^C}$ approximately determines the relative size of two banking sectors in the equilibrium as net deposit rates are close to zero.

Entrepreneurs have a standard CRS production technology

$$Y_t^E(i) = A_t^E K_{t-1}^E(i)^\alpha L_t^E(i)^{1-\alpha} \tag{2.7}$$

with $L_t^E = L_t^H$ in equilibrium as only households provide labor. A_t^E is a stochastic productivity process.

2.2.3 Commercial Banks

Each commercial banker j is composed of retail and management branches. The retail branches raise differentiated deposits and distribute differentiated loans monopolistically while the management unit fixates the capital position.

Wholesale Branch The perfectly competitive wholesale branches utilize bank capital and deposits to issue loans. They collect deposits at rate $r_t^{W,D,C}$ from retail deposit branches and pass the loans to retail loan branches at $r_t^{W,B,C}$. A commercial banker accumulates net worth via retained earnings:

$$K_t^C = (1-\delta^C)K_{t-1}^C + J_{t-1}^C \tag{2.8}$$

where J_t^C are the aggregate profits from three branches. δ^C is the proportional management cost for the branch. Taking wholesale interest rates as given, it chooses loans $\{B_t^C\}$ and deposits $\{D_t^C\}$ to maximize the discounted sum of cash flows:

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^H [(1+r_t^{W,B,C})B_t^C - B_{t+1}^C + D_{t+1}^C - (1+r_t^{W,D,C})D_t^C + K_{t+1}^C - K_t^C - \frac{\kappa_{K^C}}{2}(\frac{K_t^C}{B_t^C} - \nu^C)^2 K_t^C] \tag{2.9}$$

subject to

$$B_t^C = D_t^C + K_t^C. \tag{2.10}$$

$\Lambda_{0,t}^H$ is the stochastic discount factor for households, the ultimate owners of intermediaries. $0 < \nu^C < 1$ is the target capital-to-asset ratio. $\kappa_{K^C} > 0$ is the parameter controlling the size of adjustment cost that is proportional to bank capital. This cost is positive if the capital-to-assets ratio deviates from the target value.[6]

After substituting the balance sheet constraints at t and $t+1$ into the objective

[6] Holding assets constant, increasing capital incurs a nonlinear increase in the bank's cost. This cost exists because the capital markets are more skeptical of higher capital needs from the bank. Holding bank capital constant and reducing assets creates a downward spiral cost for the bank due to fire sales. Both situations explain the nonlinear increase in cost if the capital-to-assets ratio falls. The nonlinear increase in cost when having unwanted regulatory attention could explain the capital-to-assets ratio increases if the bank increases the leverage.

function, the problem simplifies to

$$\max_{B_t^C, D_t^C} r_t^{W,B,C} B_t^C - r_t^{W,D,C} D_t^C - \frac{\kappa_{K^C}}{2} (\frac{K_t^C}{B_t^C} - \nu^C)^2 K_t^C. \tag{2.11}$$

Combining the first-order conditions yields

$$r_t^{W,B,C} - r_t^{W,D,C} = -\kappa_{K^C} (\frac{K_t^C}{B_t^C} - \nu^C) \left(\frac{K_t^C}{B_t^C} \right)^2. \tag{2.12}$$

I assume CBs have outside funding options besides raising deposits: since the Fed is the lender of last resort, CBs could borrow from the Fed at the policy rate. By arbitrage between these two funding options, the wholesale deposit rate $r_t^{W,D,C}$ is equal to the policy rate r_t, and the wholesale credit spread, denoting $S_t^{W,C}$, becomes

$$S_t^{W,C} = r_t^{W,B,C} - r_t = -\kappa_{K^C} (\frac{K_t^C}{B_t^C} - \nu^C) (\frac{K_t^C}{B_t^C})^2. \tag{2.13}$$

This equation displays that the marginal benefit from increasing lending (by increasing loans) and the marginal cost from doing so (the deviating cost from a set target) are equal. If commercial banks are less capitalized, the interest margin becomes wider as the wholesale spread is inversely related to the leverage ratio. This equation serves as the supply curve for CB loans.

Retail Deposit Branch Households' demand for financial products follows a Dixit-Stiglitz form. Deposits are a composite constant elasticity of substitution basket of slightly differentiated products, each supplied by bank j, with elasticity equal to $\epsilon_t^{D,C}$. This elasticity is stochastic as I want to investigate how exogenous shocks on intermediaries affect monetary policy. Innovation to any markup or markdown is independent of monetary policy.

Demand for CB deposits of household i is solved by choosing $D_t^C(i,j)$ to maximize total savings $\int_0^1 r_t^{D,C}(j)D_t^C(i,j)dj$ from a continuum of banks j, subject to

$$\int_0^1 D_t(i,j)^{(\epsilon_t^{D,C}-1)/\epsilon^{D,C}}dj]^{\epsilon_t^{D,C}/(\epsilon_t^{D,C}-1)} \leq \bar{D_t^C}(i). \tag{2.14}$$

$\bar{D_t^C}(i)$ is the savings goal for household i in CBs. Combining the first-order conditions for all households and then imposing symmetry, the aggregate households' deposit demand at bank j, $D_t^C(j)$, is

$$D_t^C(j) = \left(\frac{r_t^{D,C}(j)}{r_t^{D,C}}\right)^{-\epsilon_t^{D,C}} D_t^C. \tag{2.15}$$

D_t^C is the aggregate CB deposits and $r_t^{D,C} = [\int_0^1 r_t^{D,C}(j)^{1-\epsilon_t^{D,C}}dj]^{\frac{1}{1-\epsilon_t^{D,C}}}$ is the deposit rate index. The demand at bank j depends on the total volumes and j's deposit rate relative to the average deposit rate. The elasticity $\epsilon_t^{D,C}$ determines the spreads between CB deposits and policy rates.

The retail branch of bank j receives deposits from households and passes the savings to the management unit at rate $r_t^{W,D,C} = r_t$. It chooses $\{r_t^{D,C}(j)\}$ and $\{D_t^C(j)\}$to solve

$$\max E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^H [r_t D_t^C(j) - r_t^{D,C}(j) D_t^C(j)] \tag{2.16}$$

subject to demand (2.15). After imposing symmetry, the first-order condition is

$$-1 + \epsilon_t^{D,C} - \epsilon_t^{D,C}\frac{r_t}{r_t^{D,C}} = 0. \tag{2.17}$$

Rearranging, $r_t^{D,C} = \frac{\epsilon_t^{D,C}}{\epsilon_t^{D,C}-1} r_t$, a markdown over the policy rate. The markup size signals the degree of deposit market power for commercial banks.

Retail Loan Branch The loan branch of CB j receives loans from the wholesale branch at the rate $r_t^{W,B,C}$ and differentiates and resells them to entrepreneurs at a markup. For the same reasoning as the retail deposit, demand for CB j's retail loan is

$$B_t^C(j) = (\frac{r_t^{B,C}(j)}{r_t^{B,C}})^{-\epsilon_t^{B,C}} B_t^C. \tag{2.18}$$

$\epsilon_t^{B,C}$ is the elasticity of loan demand. It chooses $\{r_t^{B,C}(j)\}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^H [r_t^{B,C}(j) B_t^C(j) - r_t^{W,B,C} B_t^C(j)] \tag{2.19}$$

subject to demand (2.18). Solving for the first-order condition and imposing symmetric equilibrium,

$$-1 + \epsilon_t^{B,C} - \epsilon_t^{B,C} \frac{r_t^{W,B,C}}{r_t^{B,C}} = 0. \tag{2.20}$$

The loan rate is a markup over the cost paid to wholesale branches. The CB borrowing rate for entrepreneurs is

$$r_t^{B,C} = \frac{\epsilon_t^{B,C}}{\epsilon_t^{B,C} - 1} S_t^{W,C} + \frac{\epsilon_t^{B,C}}{\epsilon_t^{B,C} - 1} r_t. \tag{2.21}$$

The loan rate is increasing in the policy rate and the degree of monopolistic competition and depends on the wholesale spread from the capital position problem. A higher market power decreases the elasticity of substitution $\epsilon_t^{B,C}$ and widens the spread between borrowing and policy rates.

To close commercial banks' problem, banks earn profits equal to the difference in interest earnings minus the adjustment costs AC_t^C from all three branches:

$$J_t^C = r_t^{B,C} B_t^C - r_t^{D,C} D_t^C - AC_t^C. \tag{2.22}$$

2.2.4 NBFIs

Wholesale branch The wholesale branch of non-bank financial intermediary j at the end of period t has a net worth $K_{j,t}^N$. It obtains savings $D_t^N(j)$ from the retail deposit branch and passes quantity $B_t^N(j)$ to the retail loan branch. The balance sheet for an NBFI j is

$$B_t^N(j) = D_t^N(j) + K_t^N(j) \tag{2.23}$$

The next period's net worth is the difference between assets returns and liability payouts:

$$K_{t+1}^N(j) = (1+r_t^{W,B,N})B_t^N(j) - (1+r_t^{W,D,N})D_t^N(j) = (r_t^{W,B,N} - r_t^{D,N})B_t^N + (1+r_t^{D,N})K_t^N(j), \tag{2.24}$$

where the second equality holds by plugging in the balance sheet. I assume NBFIs have no outside funding options, so the wholesale deposit rate equals the retail deposit rate. The wholesale loan rate is assumed to be equal to the policy rate in equilibrium.[7] Non-bank j has the expectation not to fund assets if his expected

[7]Theoretically, the wholesale loan rate could be wholesale deposit rate plus x basis points as long as wholesale deposit rate $<$ wholesale loan rate $<$ retail loan rate. Without loss of generality, I choose an x such that wholesale deposit rate $+ x =$ policy rate.

discounted premium is less than 0:

$$E_0\Lambda^H_{0,t}(r_{0,t} - r^{D,N}_{0,t}) \geq 0 \tag{2.25}$$

Under perfect capital markets, the expected discounted premium is zero. NBFI maximizes expected terminal wealth given by

$$V^N_t(j) = maxE_0\sum_{t=0}^{\infty}(1-\theta)\theta^t\Lambda^H_{0,t}(K^N_t(j)), \tag{2.26}$$

where θ is the survival rate of non-banker j. $(1-\theta)\theta^t$ is the probability non-banker j exits the economy at period t. A moral hazard problem prevents him from expanding assets indefinitely if the risk premium is positive: banker j can divert a fraction λ^N of available funds and transfer them back to households (think of large dividend payments). In return, depositors will force them into bankruptcy and seize the remaining assets $(1-\lambda^N)B^N_t(j)$ without additional costs. Thus, investors supply funds to the non-banker as long as he will not divert:

$$V^N_t(j) \geq \lambda^N B^N_t(j) \tag{2.27}$$

As long as NBFIs value future wealth more than the profit from diverting, they will operate normally. Solving this problem gives the NBFI credit supply curve.

Using the method of undetermined coefficients, $V^N_t(j)$ is equal to[8]

$$V^N_t(j) = \nu^N_t B^N_t(j) + \eta^N_t K^N_t(j) \tag{2.28}$$

[8]Gertler and Kiyotaki (2010) shows the detailed steps in their paper.

with ν_t^N as

$$\nu_t^N = E_t[(1-\theta)\Lambda_{t,t+1}^H(r_t^{W,B,N} - r_t^{D,N}) + \Lambda_{t,t+1}^H\theta\chi_{t,t+1}^N\nu_{t+1}^N] \tag{2.29}$$

where $\chi_{t,t+1}^N = B_{t+1}^N(j)/B_t^N(j)$ is the assets growth rate from t to $t+1$. ν_t^N captures a unit's expected discounted marginal gain of expanding assets, holding net worth constant. Alternatively, η_t^N expresses as

$$\eta_t^N = E_t[1-\theta+\Lambda_{t,t+1}^H\theta z_{t,t+1}^N\eta_{t+1}^N] \tag{2.30}$$

where $z_{t,t+1}^N = K_{t+1}^N(j)/K_t^N(j)$ is the net worth growth rate. η_t^N is the expected discounted marginal gain of expanding net worth by a unit, holding assets constant. Substituting (2.28) into the binding incentive constraint, we get

$$\nu_t^N B_t^N(j) + \eta_t^N K_t^N(j) = \lambda^N B_t^N(j) \tag{2.31}$$

Rearranging, we get a relationship between assets and equity for non-banker j:

$$B_t^N(j) = \frac{\eta_t^N}{\lambda^N - \nu_t^N} K_t^N(j) = \phi_t^N K_t^N(j) \tag{2.32}$$

where ϕ_t^N is the leverage. When this equality holds, the punishment discourages non-bankers from diverting. Therefore, the agency problem is an endogenous leverage constraint on the NBFI: holding net worth constant, the banker j chooses assets holdings depending on the severity of financial frictions. Note that this model focuses on the region such that $0 < \nu_t^N < \lambda^N$ as in Gertler and Karadi

(2011). Plugging (2.32) into (2.24), the evolution of net worth is

$$K_{t+1}^{N}(j) = [(r_t^{W,B,N} - r_t^{D,N})\phi_t^N + (1 + r_t^{D,N})]K_{j,t}^N. \tag{2.33}$$

Rearranging, growth rates for equity and assets are

$$z_{t,t+1}^N = K_{t+1}^N(j)/K_t^N(j) = (r_t^{W,B,N} - r_t^{D,N})\phi_t^N + (1 + r_t^{D,N}) \tag{2.34}$$

and

$$\chi_{t,t+1}^N = B_{t+1}^N(j)/B_t^N(j) = \frac{\phi_{t+1}^N}{\phi_t^N} z_{t,t+1}^N. \tag{2.35}$$

The aggregate NBFI balance sheet is

$$B_t^N = K_t^N + D_t^N. \tag{2.36}$$

Since demand for non-bank deposits is perfectly elastic, NBFI's problem determines the equilibrium level of D_t^N.

The aggregate net worth is a combination of existing bankers' net worth ($K_{e,t}^N$) and new bankers' net worth ($K_{n,t}^N$):

$$K_t^N = K_{e,t}^N + K_{n,t}^N \tag{2.37}$$

where

$$K_{e,t}^N = \theta^N K_t^N = \theta^N z_{t-1,t} K_{t-1}^N \tag{2.38}$$

since θ^N non-bankers survive from $t-1$ to t. $K_{n,t}^N$ is equal to

$$K_{n,t}^N = \omega^N B_{t-1}^N \tag{2.39}$$

as newly entered NBFIs get $\omega^N/(1-\theta^N)$ fraction of all the exiting NBFIs' net worth $(1-\theta^N)B_{t-1}^N$. $0 < \omega^N < 1$ and θ jointly determine the size of assets from exiting banks to new bankers as start-up funds.

Retail Deposit Branch Similar to CB deposit demand, NBFI deposit demand at bank j, $D_t^N(j)$, is

$$D_t^N(j) = \left(\frac{r_t^{D,N}(j)}{r_t^{D,N}}\right)^{-\epsilon_t^{D,N}} D_t^N. \tag{2.40}$$

The first-order condition for the deposit branch is

$$-1 + \epsilon_t^{D,N} - \epsilon_t^{D,N}\frac{r_t}{r_t^{D,N}} = 0 \tag{2.41}$$

With fully flexible deposit rates, $r_t^{D,N} = \frac{\epsilon_t^{D,N}}{\epsilon_t^{D,N}-1} r_t$, a markdown over the policy rate. The calibrated elasticities of deposit demands ensure $r^{D,N} > r^{D,C}$ in the steady state.

Retail Loan Branch Similarly, loan demand for non-bank j is

$$B_t^N(j) = (\frac{r_t^{B,N}(j)}{r_t^{B,N}})^{-\epsilon_t^{B,N}} B_t^N. \tag{2.42}$$

It chooses $\{r_t^{B,N}(j)\}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^H [r_t^{B,N}(j) B_t^N(j) - r_t^{W,B,N} B_t^N(j) - \frac{\kappa^{B,N}}{2} (\frac{r_t^{B,N}(j)}{r_{t-1}^{B,N}(j)} - 1)^2 r_t^{B,N} B_t^N \quad (2.43)$$

subject to demand (2.42). $\kappa^{B,N} > 0$ controls the NBFI loan rate stickiness. Solving for the first-order condition and imposing symmetric equilibrium,

$$\begin{aligned} -1 + \epsilon_t^{B,N} - \epsilon_t^{B,N} \frac{r_t^{W,B,N}}{r_t^{B,N}} - \kappa^{B,N} \left(\frac{r_t^{B,N}}{r_{t-1}^{B,N}} - 1 \right) \frac{r_t^{B,N}}{r_{t-1}^{B,N}} \\ + \beta^H E_t [\frac{\lambda_{t+1}^H}{\lambda_t^H} \kappa^{B,N} (\frac{r_{t+1}^{B,N}}{r_t^{B,N}} - 1)(\frac{r_{t+1}^{B,N}}{r_t^{B,N}})^2 \frac{B_{t+1}^N}{B_t^N}] = 0. \end{aligned} \quad (2.44)$$

Because of the adjustment costs, the current loan rate depends on future loan rates.

2.2.5 Capital and Final Goods Producers

Perfectly competitive capital goods producers purchase capital from entrepreneurs and then purchase final goods I_t from final goods producers. Effective capital $\bar{K}_t = u_t K_t$ accumulate as

$$\bar{K}_{t+1} = \bar{K}_t + [1 - \frac{\kappa_i}{2} (\frac{I_t}{I_{t-1}} - 1)^2] I_t. \quad (2.45)$$

I_t is the investment, and κ_i controls the adjustment costs to investment. Capital producers choose I_t to maximize expected profits

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^E (Q_t^K (\bar{K}_{t+1} - \bar{K}_t) - I_t) \quad (2.46)$$

subject to (2.45). The first-order condition gives a "Q" relation for the real price of physical capital. This equation creates the financial amplification effect for shocks. The adjustment cost for capacity utilization is $\psi(u_t) = \xi_1(u_t - 1) + \frac{\xi_2}{2}(u_t - 1)^2$ as in Schmitt-Grohe and Uribe (2007).

Retailers buy intermediate goods at P_t^W, differentiate at zero cost, and price them in a monopolistic competitive setting as in Bernanke et al. (1999). The prices are sticky as in Rotemberg (1982). Retailers facing a quadratic cost of price adjustment choose $\{P_t(j)\}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^H [P_t(j)Y_t(j) - P_t^W Y_t(j) - \frac{\kappa_p}{2}(\frac{P_t(j)}{P_{t-1}(j)} - \pi_{t-1}^{\iota}\pi^{1-\iota})^2 P_t Y_t \tag{2.47}$$

subject to downward sloping demand $Y_t(i) = (\frac{P_t(j)}{P_t})^{-\epsilon_t^y} Y_t$. ι controls the relative weight of the past inflation index. κ_p parameterizes the degree of adjustment cost if the price changes greater than the level of indexation. Households own retailers and receive monopolistic profits. $\frac{1}{X_t} = \frac{P_t^W}{P_t}$ holds in equilibrium.

2.2.6 Monetary Policy and Market Clearing

A smoothed Taylor rule characterizes the monetary policy and influences the interest rate in the wholesale branches:

$$(1 + r_t) = (1 + r)^{1-\phi_r}(1 + r_{t-1})^{\phi_r}(\frac{\pi_t}{\pi})^{\phi_\pi(1-\phi_r)}(\frac{y_t}{y_{t-1}})^{\phi_y(1-\phi_r)}\epsilon_t^r. \tag{2.48}$$

r is the steady-state policy rate, and ϵ_t^r is the white noise to monetary policy with standard deviation σ_r. ϕ_π and ϕ_y are the weights assigned to inflation and output stabilization. ϕ_r is the weight of the steady-state policy rate.

The aggregate resource constraint is

$$Y_t = C_t + Q_t^K(K_t - (1-\delta^K)K_{t-1}) + \delta^C K_t^C + AC_t. \tag{2.49}$$

Aggregate consumption equals $C_t = C_t^H + C_t^E$, and AC_t includes all adjustment costs.

2.3 Estimation

I first discuss the data handling process and explain the calibration methodology and prior distributions selection. Then, I report the posterior distributions and conduct robustness checks.

2.3.1 Data

I use eight observables for the US: real output, CB real loans, NBFI real loans, NBFI real deposits, inflation, CB borrowing rate, CB deposit rate, and policy rate. The details of data handling are in the appendix. Figure (2.2) displays all the transformed data. The sample period is 1987Q1-2008Q4. When processing data, real variables are demeaned log differences. Interest and inflation are quarterly net rates in absolute deviations from the sample mean. The borrowing rate is the prime loan rate, the interest rate for lenders with good credit.[9] The deposit rate is the weighted average of deposits with different maturities.

[9]NBFIs commonly use London Interbank Offered Rate (LIBOR) and prime loan rate as the target in the contracts.

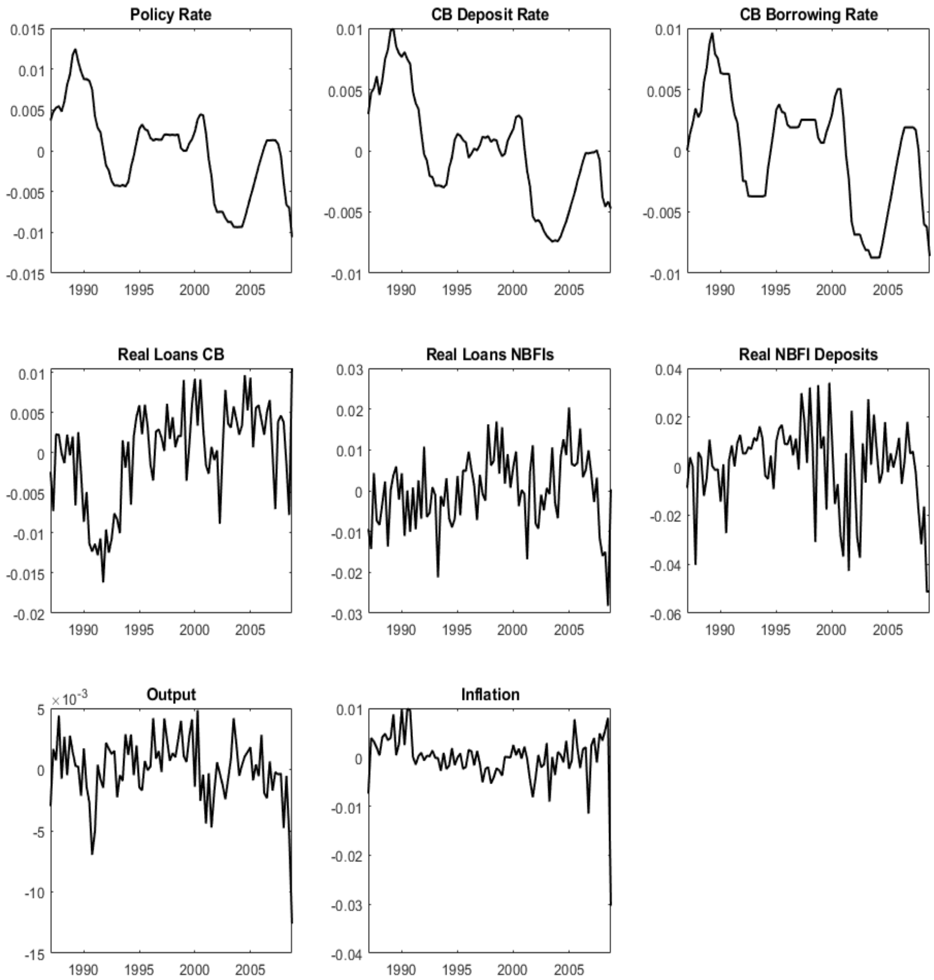

Figure 2.2: US Observable Time Series Used in Estimation

2.3.2 Calibration

Table (2.1) reports all the calibrated structural parameters. For the households' discount factor, I set it to 0.9916 to match the CB deposit rate, as the average CB deposit rate is 3.35% annually in the sample. Entrepreneurs' discount factor is 0.975 as in Iacoviello (2005). From Gerali et al. (2010), the capital share is at 0.25, and the depreciation rate of capital is 0.025; the inverse of Frisch elasticity and final foods elasticity are 1 and 6, respectively. Final goods price has 20%

markup over intermediate goods price.

The calibration process seeks to match CBs and NBFIs' leverage, credit volume, and credit spreads in the US. Equation (2.17) shows that the markup only depends on elasticity in equilibrium, so I can use elasticity to estimate the credit spread. Since the spread between the bank prime loan rate and the policy rate is 283 basis points annualized,[10] $\epsilon^{B,C}$ equals 2.18; Equivalently, the CB borrowing rate is 184% of the policy rate. From Chernenko et al. (2022), CB loans charge 190 basis points lower than NBFI loans, so the average NBFI loan rate is 808 basis points and $\epsilon^{B,C}$ is set at 1.72. The elasticity of substitution for deposits is estimated using policy and deposit rates. CB's elasticity is estimated at -3.79 in the sample period, reflecting that the CB deposit rate is about 80% of the policy rate on average. From Marco et al. (2019) and using the retail money market funds yield, the NBFI deposit rate is roughly 91% of the policy rate, equating to the elasticity of -10.1.

The LTV ratio for CBs reflects the relative size of the two banking sectors. The CB LTV ratio of 2/3 is from Gerali et al. (2010), the average proportion of credit intermediated by CBs.[11] Chernenko et al. (2022) also notice that non-banks issue about one-third of all loans using micro-level data. Moreover, they show that asset managers and insurance companies are less likely to require collateral than banks: overall, NBFI loans are 51 percentage points less likely to be secured by collateral. Capital utilization parameters are calculated as in Schmitt-Grohe and Uribe (2007).

[10] The average loan rate and policy rate in my sample period are 618 and 335 basis points, respectively.

[11] This is an upper bound measure: if I consider assets instead of loans, CBs intermediate 60% of total loans. By further considering GSEs as NBFIs, NBFIs intermediate more credit than CBs.

The target leverage ratio for CBs is 8%, as the Basel II framework requires, reflecting a leverage of 12.5. Basel III increases the minimum requirement to 10.5% by mandating a conservation buffer. I will return to the Basel III requirement in the policy analysis. Accordingly, the bank management cost rate is 0.1498 to ensure a leverage of 12.5. The NBFI leverage is much harder to calibrate as it varies wildly by institution. Households own all shares of MMFs and fixed-income funds, so they operate without leverage. REITs have a leverage of 3.66. Security brokers and dealers, and finance companies have higher leverage at 7 and 9, respectively. Conservatively, I use a ratio of 4, as in Gertler and Karadi (2011), reflecting much lower leverage for NBFIs than CBs. This choice is consistent with empirical findings from Jiang et al. (2020). Parameters related to the moral hazard are estimated to ensure a leverage of four and a specific credit spread between NBFI wholesale and retail deposit rates. The survival rate suggests NBFIs live approximately sixteen quarters on average, which is smaller than in Gertler and Karadi. The enforcement problem is less severe as the proportion of diverted fraction is also smaller.

Calibrated Parameters		
Parameters	Value	Description
Households		
β^H	0.9916	Discount rate
ϕ^H	1.0	Inverse Frisch elasticity of labor supply
Entrepreneurs		
β^E	0.975	Discount rate
m^c	2/3	Loan-to-value ratio for CBs
ξ_1	0.0442	Parameter for capacity utilization
ξ_2	0.0044	Parameter for capacity utilization
Commercial banks		
$\epsilon^{D,C}$	-3.79	Elasticity of substitution CB deposits
$\epsilon^{B,C}$	2.18	Elasticity of substitution CB loans
ν^C	0.08	Target leverage ratio
δ^C	0.1498	Bank management cost rate
NBFIs		
$\epsilon^{D,N}$	-10.1	Elasticity of substitution NBFI deposits
$\epsilon^{B,N}$	1.72	Elasticity of substitution NBFI loans
λ^N	0.2687	Possible diverted fraction for NBFIs
ω^N	0.0148	Transfer to entering NBFIs
θ^N	0.9284	Survival rate of NBFIs
Intermediate goods firms		
α	0.25	Capital share
Capital producing firms		
δ^K	0.025	Depreciation rate
Retail firms		
ϵ^y	6	Elasticity of substitution for final goods

Table 2.1: Calibrated parameters in the model.

2.3.3 Prior distributions

The prior distributions for structural parameters are either consistent with the literature or relatively uninformative. The prior distributions' persistence and standard deviation for all the shocks are relatively uninformative. The coefficients for NBFI loan adjustment cost and CB capital adjustment cost are hard to pin down, so I assume they have a prior mean of 10, the same as in Gerali et al. (2010). The Taylor rule coefficient on output changes to a gamma distribution to ensure strict positiveness.

All shocks except monetary policy follow smoothed AR(1) processes. There are five financial shocks. The shocks to the LTV ratio capture an exogenous change in the relative size of two banking sectors as it affects CB credit availability. The higher the LTV ratio, the more credit CBs intermediate. The shocks to demand elasticities of loans and deposits simulate exogenous fluctuations in loan and deposit rates. These shocks to interest rates reflect fluctuations in the price and risk absent from the model and help match observables from intermediaries. Five observables from financial intermediaries jointly estimate parameters for financial shocks. Besides financial shocks, the remaining shocks estimate a three-equation New Keynesian model with output, inflation, and policy rate.

2.3.4 Posterior distributions

Prior and posterior distributions							
		Prior distributions			Posterior distributions		
	Parameter	distributions	Mean	Std. Dev.	Mean	5%	95%
Structural							
κ_p	Price stickiness	Gamma	50	20	54.399	51.876	57.396
κ_i	Invest adj. cost	Gamma	2.5	0.5	3.032	2.961	3.123
$\kappa^{B,N}$	NBFI loan AC	Gamma	10	2.5	15.404	14.900	15.968
$\kappa^{K,C}$	CB capital AC	Gamma	10	2.5	1.134	1.119	1.154
ϕ_π	TR coeff. on π	Gamma	2	0.5	2.097	1.964	2.199
ϕ_y	TR coeff. on y	Gamma	0.1	0.05	0.176	0.166	0.185
ι_p	Price indexation	Beta	0.5	0.15	0.376	0.362	0.389
ϕ_R	TR coeff. on R	Beta	0.75	0.10	0.917	0.905	0.929
a^H	Habit coefficient	Beta	0.5	0.1	0.478	0.473	0.480
AR Coefficients							
$\rho_{M,C}$	CB LTV	Beta	0.8	0.1	0.979	0.964	0.995
$\rho_{D,C}$	CB dep markdown	Beta	0.8	0.1	0.874	0.859	0.889
$\rho_{D,N}$	NB dep markdown	Beta	0.8	0.1	0.594	0.579	0.613
$\rho_{B,C}$	CB loan markup	Beta	0.8	0.1	0.835	0.828	0.843
$\rho_{B,N}$	NB loan markup	Beta	0.8	0.1	0.964	0.942	0.987
ρ_A	Technology	Beta	0.8	0.1	0.843	0.826	0.861
ρ_y	Price markup	Beta	0.8	0.1	0.718	0.703	0.734
Standard Deviations							
$\sigma_{M,C}$	CB LTV	Inv. Gamma	0.01	0.05	0.0012	0.0012	0.0013
$\sigma_{D,C}$	CB dep markdown	Inv. Gamma	0.01	0.05	0.0012	0.0012	0.0013
$\sigma_{D,N}$	NB dep markdown	Inv. Gamma	0.01	0.05	0.0226	0.0202	0.0251
$\sigma_{B,C}$	CB loan markup	Inv. Gamma	0.01	0.05	0.0193	0.0164	0.0222
$\sigma_{B,C}$	NB loan markup	Inv. Gamma	0.01	0.05	0.0133	0.0109	0.0154
σ_A	Technology	Inv. Gamma	0.01	0.05	0.0289	0.0252	0.0330
σ_y	Price markup	Inv. Gamma	0.01	0.05	0.0543	0.0467	0.0628
σ_r	Monetary policy	Inv. Gamma	0.01	0.05	0.0013	0.0012	0.0014

Table 2.2: Prior and Posterior distributions: results based on five chains, each with 200,000 draws from the Metropolis-Hastings algorithm. TR stands for Taylor rule, while AC stands for adjustment costs.

Table (2.2) reports the summary statistics for the posterior distributions, including mean and 90% confidence intervals. Results are from the Metropolis algorithm. I ran five chains, each of 200,000 draws. Posterior distributions are graphed in Figure (2.9) to (2.11). All posterior distributions have different shapes from the priors, suggesting relatively strong identification.

All shocks are persistent, with CB loan markup being very persistent; these estimations are similar in Gerali et al. (2010). Posterior inflation indexation indicates a moderate dependence of current inflation on past inflation. Habit persistence is lower than Smets and Wouters (2007) posterior mean and is close to the prior mean. Habit consumption is not captured in the estimation since consumption is absent from Figure (2.2). The Taylor coefficients for output and inflation are slightly higher than in Smets and Wouters (2007). The inflation indexation is closer to wage indexation than price indexation compared to Smets and Wouters (2007). Compared to prior, $\kappa^{K,C}$ is estimated to be small. Bank capital adjustment cost is much smaller than the EU estimate from Gerali et al., which suggests that US commercial banks have a looser capital constraint. This estimation suggests that the US commercial banks are more like the US NBFIs than European banks, as the capital requirement is lax.

2.3.5 Robustness

I employ different prior distributions to demonstrate their robustness. Two key parameters $\kappa^{B,N}$ and $\kappa^{K,C}$ use different mean values to test their robustness. The posterior distributions are robust to different prior settings from Figure (2.12). Shifting the prior distributions left does not affect the posterior distributions. $\kappa^{B,N}$'s mean is greater than ten even after shifting the mean from 10 to 5.[12]The mean of $\kappa^{K,C}$ is consistently much more petite than the prior mean. The importance of financial shocks is checked by examining their impact on the model's

[12]My main results still hold even if this parameter is 1. The sensitivity test shows that the non-bank rate only needs some stickiness.

fit. When I replace five financial shocks with i.i.d. measurement errors to financial observables, the marginal data density decreases from 1126 (log) points to 955. Moreover, without financial shocks, the model has difficulty explaining the dynamics of financial quantities and movements in bank rates.

2.4 Results

This section studies how the transmission of monetary policy shock is affected by the presence of NBFIs using calibrated and estimated parameters. When monetary policy tightens, deposit and lending rates are affected differently. Deposit rates move with the policy rate as they are flexible. Due to greater market power, CBs increase deposit rates less than NBFIs. From Figure (2.3), the bank borrowing rate increases more than the non-bank borrowing rate due to stickiness in the latter. Entrepreneurs respond to the borrowing rate changes by contracting bank loans. Figure (2.13) demonstrates the changes in interest margin. NBFIs decrease the interest margin as the loan rate is sticky. On the other hand, CBs increase their interest margin since the pass-through to deposit rate is incomplete and to loan rate is greater than one-to-one. After four quarters, the bank borrowing rate responds similarly to the NBFI borrowing rate, causing loans to co-move together. Consistent with VAR analysis, the asymmetric responses are short-term because loan differences only last several quarters. The leakage of monetary policy is present as NBFIs increase lending activities and take in more deposits.

Commercial banks adjust bank rates to return the leverage ratio to the desired level from the equilibrium condition (2.12). They deleverage relative to the target ratio as capital constraints are less binding than NBFIs. In response, they widen the interest margin between lending and deposit rates. NBFIs deleverage but with a much smaller scale. As a result, the NBFI credit spread becomes negative since the borrowing rate slowly adjusts. In the subsequent periods, loans increase due to the valuation effects of the physical capital. Initially, the price decreases significantly, then overshoots above the steady-state level after three quarters; bank and non-bank loans stay positive longer. However, once the capital price falls back to normal, loans decline in both sectors.

For commercial banks, loans, deposits, and bank leverage have the same responses as in Gerali et al. (2010). However, CBs increase their leverage much more than NBFIs since NBFI deposits are greater than CB deposit changes. Bank leverage peaks in the third quarter, as loans rise above normal and deposits stay negative. The same reasoning applies to non-bank leverage, but deposit inflows help against the deleveraging cycle. CBs and NBFIs build up more capital as interest margins widen, but NBFIs build capital at a slower pace as the borrowing rate stays fixed. Loan dynamics drive deposit dynamics, as I abstract from the household portfolio choice problem. An increase in loan provision leads to an increase in deposits as non-banks balance their assets and liabilities. With household portfolio choice, more deposits will flow into non-banks because households search for higher yields. Therefore, a higher deposit inflow will increase non-bank loans as well. Compared with Figure (2.3), the gap between deposits and loans from the two sectors is wider.

An increase in loan rate negatively impacts the real variables as a lower borrowing capacity limits entrepreneurs' consumption through higher interest payments and slower capital accumulation. Due to a slowdown in consumption and investment, output declines initially, and graduates return to the steady-state level. Aggregate consumption is not hump-shaped: household consumption is hump-shaped, but entrepreneur consumption dominates the overall shape.

Impulse responses from monetary policy shock

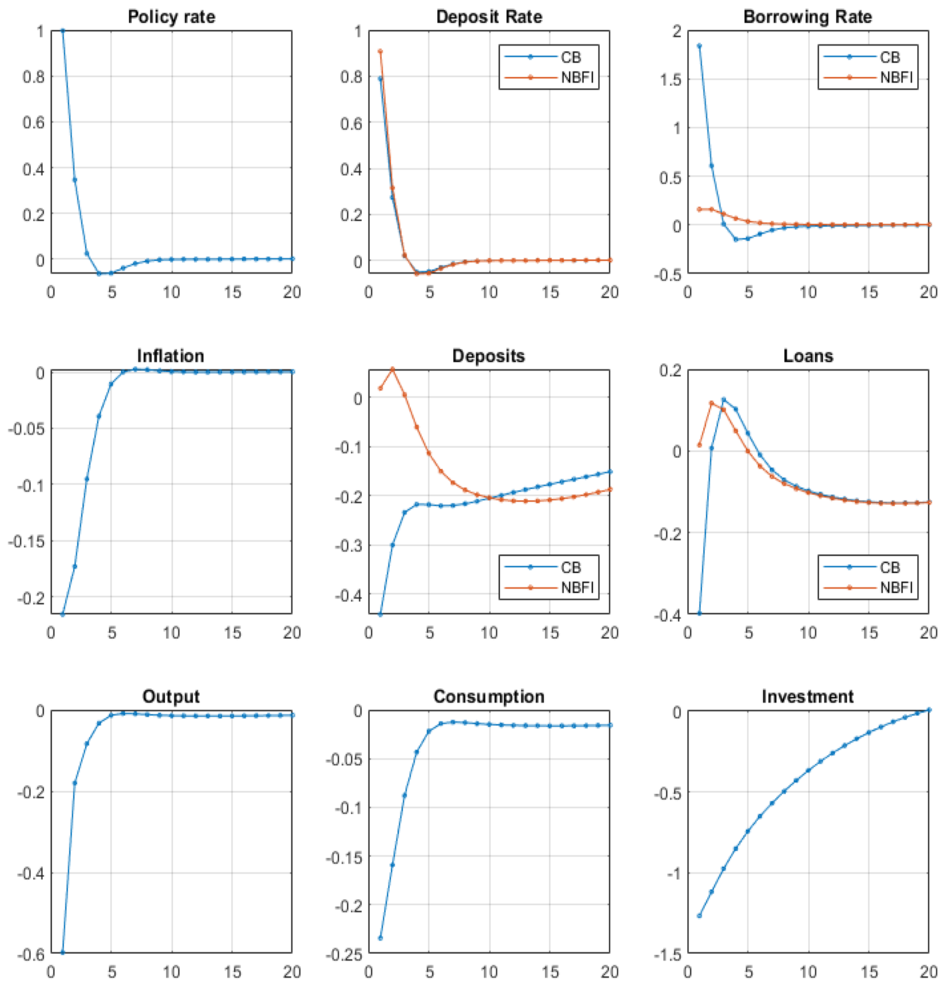

Figure 2.3: Impulse response functions to one standard deviation monetary policy shock. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state.

2.4.1 Modeling Assumptions

This section examines the impact of modeling assumptions on loan rate stickiness and asymmetric information.

Modeling Assumptions: Loan Rate Stickiness

After shutting down loan rate stickiness, $\kappa^{B,N}$ becomes zero. As shown in Figure (2.4), monetary policy significantly impacts all real variables. Having flexible non-bank loan rates increases the effectiveness of the monetary policy as NBFI loans co-move with CB loans: investment responds stronger by more than 20% while consumption responds stronger by 17%. The impact on inflation is minimal. In the flexible case, non-bank loans fall below bank loans. Since the loan difference between the two sectors is slightly positive, CBs issue relatively more loans, contradicting the empirical findings. Thus, the NBFI loan rate stickiness is crucial to generating divergent responses.

Impulse responses from monetary policy shock

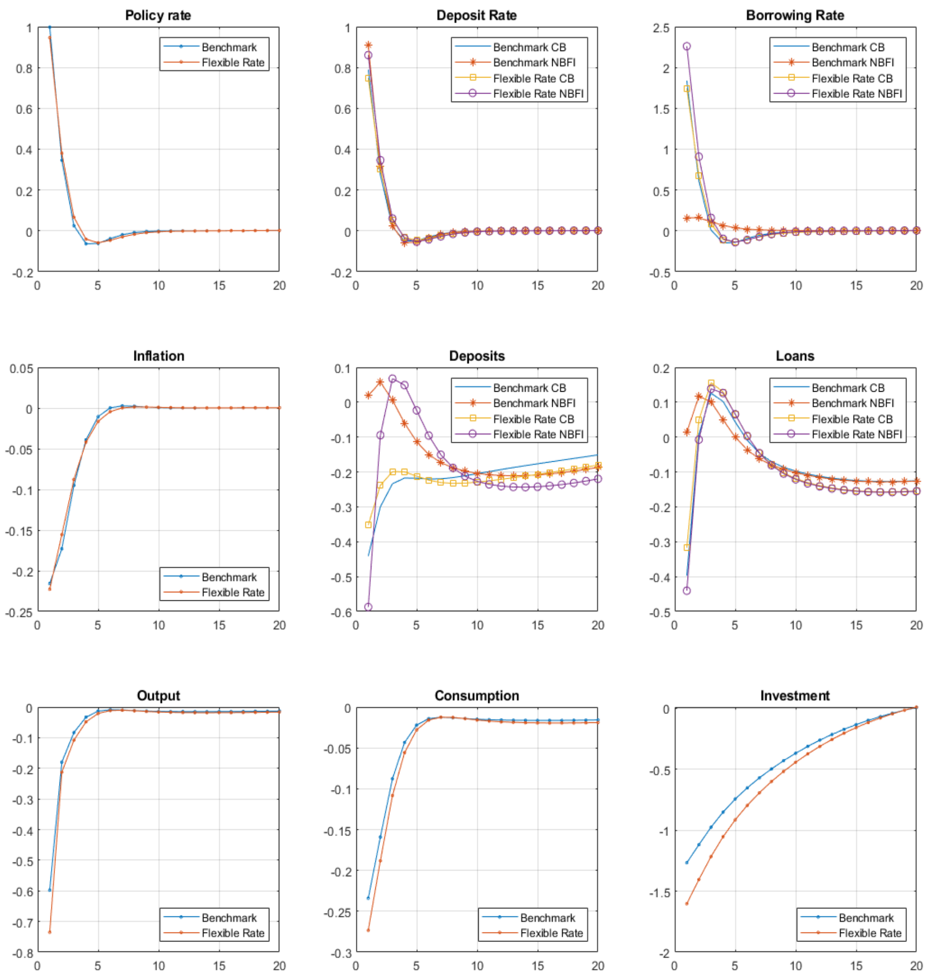

Figure 2.4: Impulse response functions to one standard deviation monetary policy shock with flexible loan rates. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. “Benchmark” refers to the main results from estimation. “Flexible Rate” refers to responses by assuming a flexible NBFI loan rate.

Asymmetric Information I then explore the consequences of eliminating information costs by assuming the two banking sectors are identical as both have target leverage ratios. In Figure (2.5), the real variables are identical since the loan market is the driving force instead of the deposit market: Monetary policy is 2% more effective when two financial sectors are symmetric. However, the financial stability of non-banks is improved: Eliminating moral hazard is ideal because of greater deposit inflows into non-banks. As a result, non-bank leverage fluctuates less without impacting the effectiveness of the monetary policy. This finding demonstrates the benefits of reducing moral hazards between savers and non-banks.

Impulse responses from monetary policy shock

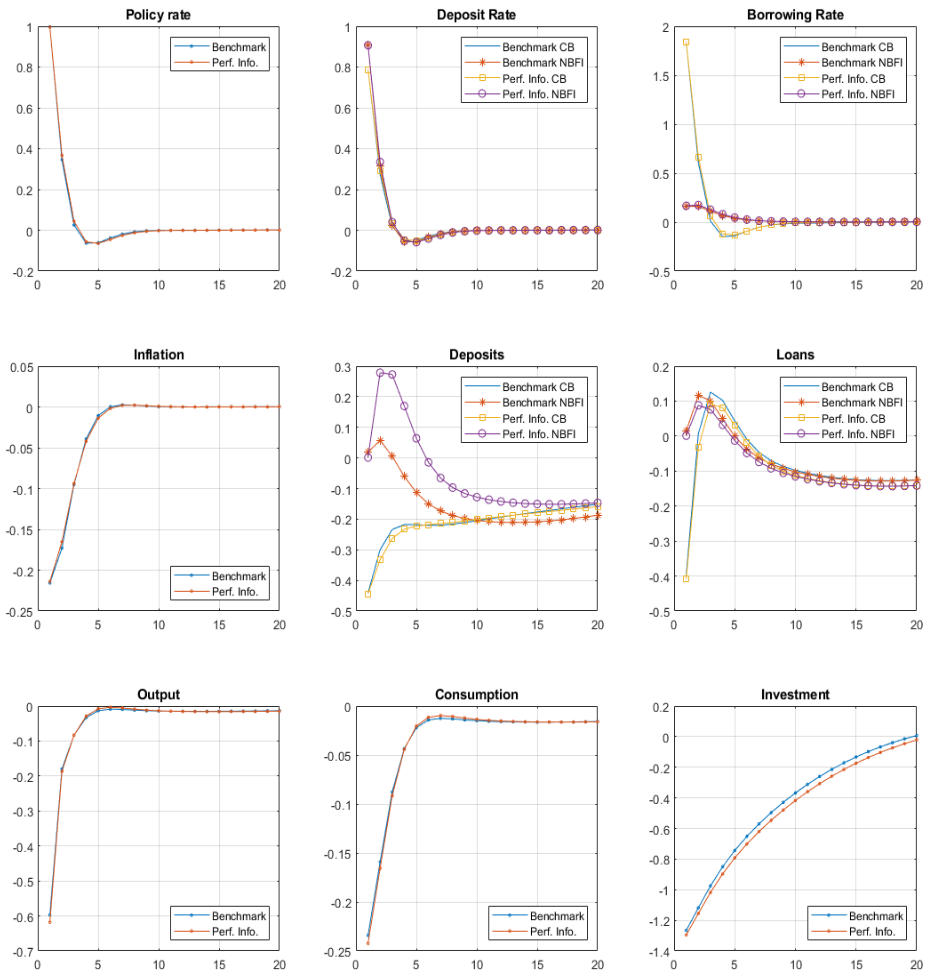

Figure 2.5: Impulse response functions to one standard deviation monetary policy shock with symmetric financial sectors. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. The Benchmark model refers to the model presented in this paper. "Perf. Info. " label is for the hypothetical model with perfect information.

2.5 Policy Analysis

After estimating and understanding the fundamental ingredients of the model, I take the model to study the implications of two changes within the financial sector: the increasing size of non-banks and the increase in concentrations in both sectors.

2.5.1 Increase in Relative Size of NBFIs

Impulse responses from monetary policy shock

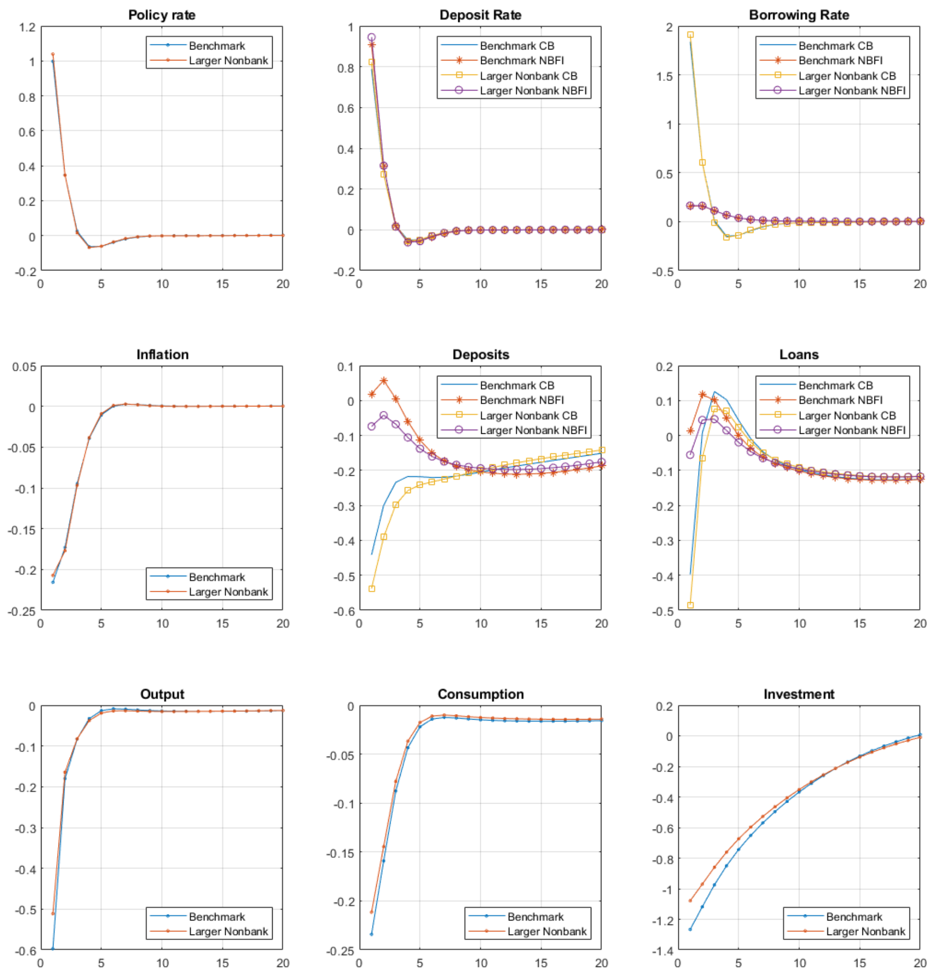

Figure 2.6: Impulse response functions to one standard deviation monetary policy shock. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. “Larger non-bank” means assuming the NBFIs now intermediate 2/3 of total credit.

Non-bank financial intermediaries raise concerns about the effectiveness of monetary policy as loans are driven into the unregulated financial sector. They undermine monetary policy as non-bank credit moves against bank credit. With their rapid growth, this section performs an exercise where NBFIs intermediate 2/3 of total credit by lowering the commercial bank loan-to-value ratio from 2/3 to 1/3. The one-third increase in relative size is close to the actual change from the 1980s to today since aggregate non-bank balance sheets outpace the growth of bank balance sheets. From the results in Figure (2.6), monetary policy is 14% less effective on output as non-banks become more prominent in the financial sector. In other words, when the Fed attempts to contract aggregate demand, it has to increase the policy rate by a larger hike if non-banks intermediate more credit. Therefore, policymakers need to monitor the growth of the non-bank sector as the growth enlarges the leakage, making conventional policy less effective.

2.5.2 Increase in Concentration of NBFIs and CBs

There have been increases in the concentration of banks and non-banks. Since the 1980s, the number of commercial banks has been declining sharply. Figure (2.14) demonstrates that consolidation has been nonstop even though the Great Financial Crisis raised caution on financial sectors. The number of MMFs declined from 601 in October 2012 to 304 in September 2022. Over the same period, the number of commercial banks decreased from 6072 to 4418, a 30% drop.

Looking at the monetary tightening periods after the GFC in Figure (1.2), commercial banks exert market power mostly in the deposit market as they barely increase savings rates to match money market funds yields when the federal funds rate increases. From 2015Q4 to 2018Q4, the pass-through from the policy rate to the bank deposit rate is near zero. For loan markup, Gödl-Hanisch (2022) offers empirical evidence of increased cross-county loan rates for US commercial banks due to higher market concentration. Since both sectors can widen interest margins by lowering deposit rates or pushing up loan rates, I want to explore the consequences of a lower deposit rate pass-through and a higher loan rate pass-through for NBFIs. Without loss of generality, I consider the following two scenarios on changes to deposit and loan elasticities when non-banks are relatively less concentrated.

Decrease in Relative Deposit Markdown Deposit rates are lower if intermediaries exert market power in the deposit market. Suppose non-banks offer a higher deposit rate as they concentrate relatively slower: Non-bank demand elasticity of deposits is -101 instead of -10.1. This ten-fold increase implies that the non-bank deposit rate is essentially the policy rate — a zero markdown. As shown in Figure (2.7), deposit market power has a negligible impact on monetary policy as central frictions lie within the loan market even though the non-bank deposit rate increases more than in the benchmark case. Note that there is a small increase in non-bank deposits: A portfolio shift increases the holdings of non-bank deposits since they are more attractive to households. In this framework, adjusting deposit rate markdown has a limited impact on monetary policy transmission.

Impulse responses from monetary policy shock

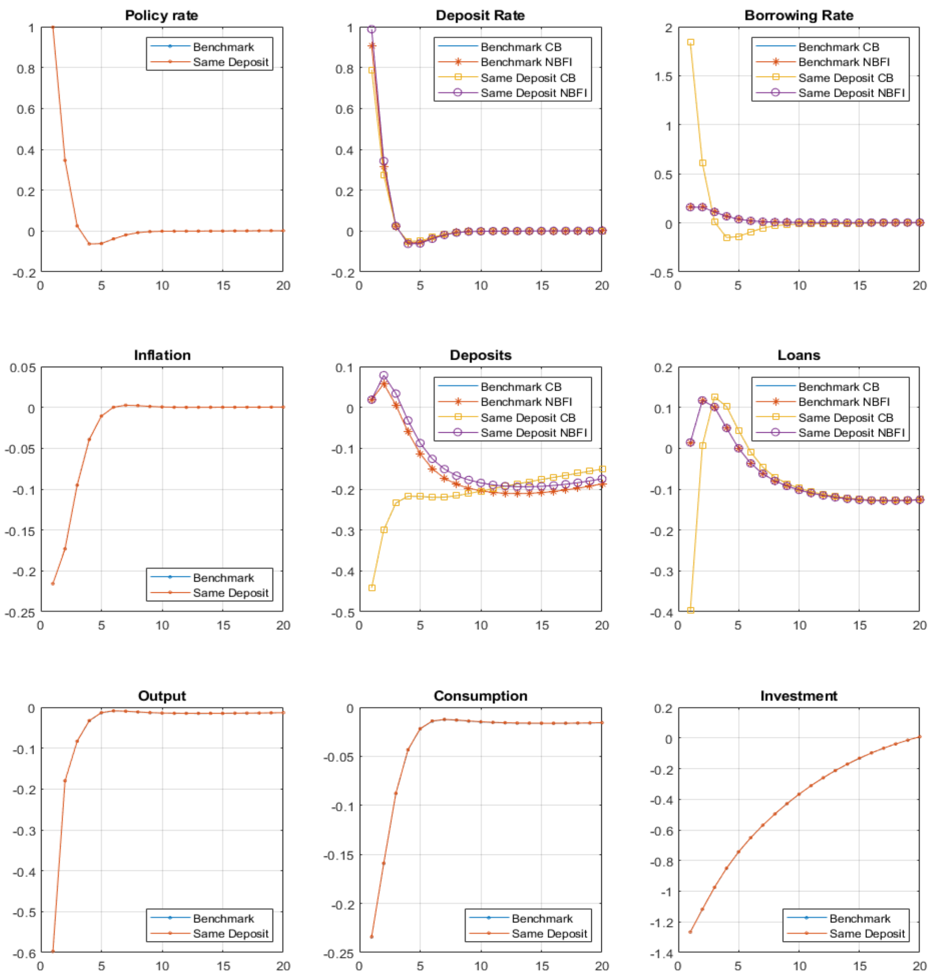

Figure 2.7: Impulse response functions to one standard deviation monetary policy shock. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. The Benchmark model refers to the model presented in this paper. "Lower Con." means NBFIs have lower relative concentrations when compared to CBs.

Decrease in Relative Loan Markup When intermediaries exert market power over borrowers, loan rates are higher. Suppose the non-bank elasticity of loan demand equals 1.72, the same elasticity for commercial banks. This experiment implies that non-banks offer a more competitive loan rate by decreasing loan markup over the policy rate. From the simulated results in Figure (2.8), monetary policy is less effective: investment response is weaker by 3% as commercial bank loans shrink less while non-bank loans expand less. In other words, a relatively weaker consolidation in the non-bank sector weakens the intent of the monetary policy. In conclusion, the Fed needs to monitor the market concentration in both sectors since any changes quantitatively influence monetary policy.

Impulse responses from monetary policy shock

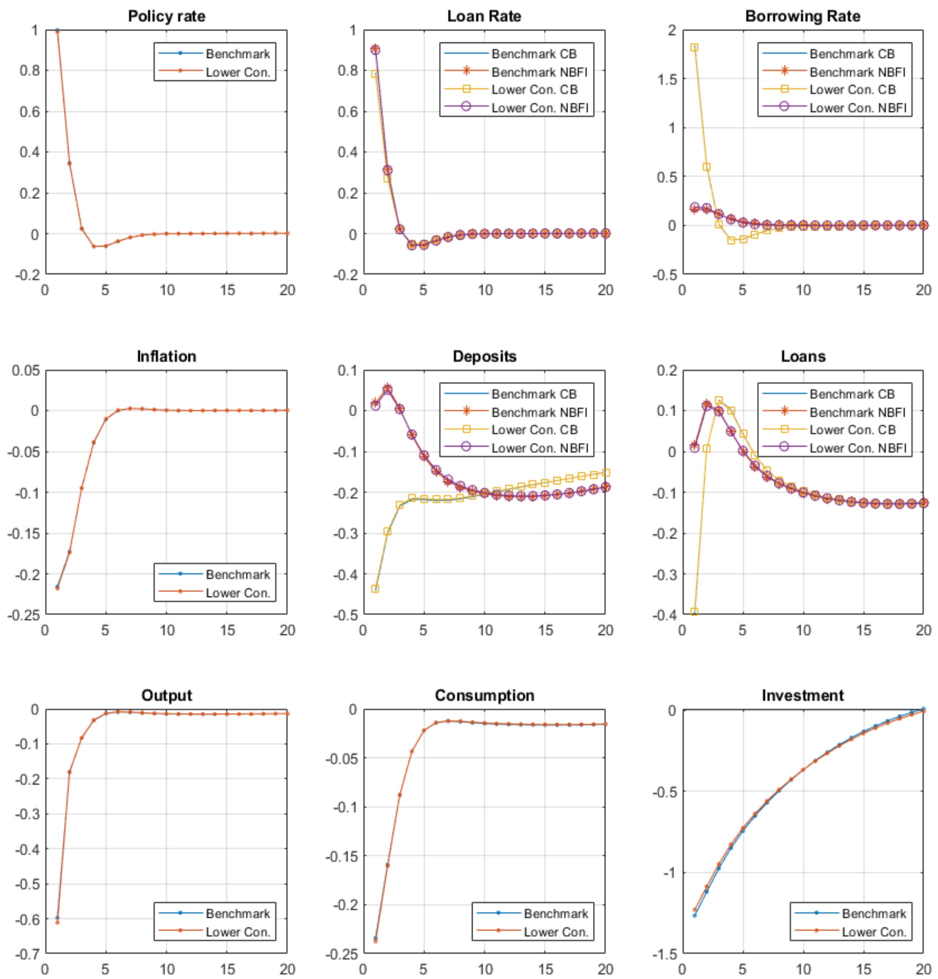

Figure 2.8: Impulse response functions to one standard deviation monetary policy shock. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. The Benchmark model refers to the model presented in this paper. "Lower Con." means NBFIs have lower relative concentrations than CBs.

2.6 Conclusion

Compared with commercial banks, this paper explains why non-banks take in more deposits and create more loans when monetary policy tightens. The reason lies in the loan market: Entrepreneurs shift from bank loans to non-bank loans because the latter are fixed-rate and offer more stable income expenditures to their cash flow if they anticipate monetary tightening cycles. The increase in non-bank loans expands the asset side of their balance sheets and encourages them to take in more deposits on the liability side to balance the two sides, which explains the empirical finding. Banks issue variable-rate instead of fixed-rate loans because they have more market power over borrowers than non-banks. In summary, the distinct market concentration affects monetary policy transmissions differently for CBs and NBFIs.

Two policy implications arise from the mechanism and framework I propose. First, the growth of the non-bank financial sector contributes to a non-negligible dampening effect on monetary policy. Second, when commercial banks consolidate faster than non-banks, deposit markdown changes do not impact policy outcomes. Conversely, a decline in the loan markup of non-bank loan rates weakens monetary policy.

There are three possible extensions of this paper. First, theoretically, firms' and intermediaries' bargaining determines the fixed-rate decision. The micro-foundation could be further investigated based on Figure (1.1) in a static setting to provide a conceptually tractable explanation. The framework can also be extended in the loan market in two dimensions. Empirically, market power cannot explain CB and NBFI borrowing rates alone. Hence, future research should include two types of entrepreneurs that differ in the riskiness of projects. As Chernenko et al. (2022) have shown, cash-flow loans are more popular for NBFIs. Thus, seeing how a cash-flow constraint (instead of a collateral constraint) alters my analysis would be interesting. Incorporating both the supply and demand sides of the loan market enables discussion of potential trade-offs between monetary policy and financial stability. Lastly, this paper abstracts from deposit demand to focus on the role of supply. Solving the household portfolio problem opens up the supply side of the deposit market and the deposits channel of monetary policy. Quantitatively examining the deposit shift from the depositors' portfolio choice would shed light on the importance of different explanations for the gear-switching evidence of bank and non-bank loan growth.

2.7 Appendix 2

2.7.1 Data Description

Real variables are demeaned log differences. Interest and inflation are quarterly net rates in absolute deviations from sample means.

Real consumption: Real Personal Consumption Expenditures, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate.

Real investment: Real Gross Private Domestic Investment, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate.

Real output: Real Gross Domestic Product, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate.

Real commercial bank loans: U.S.-Chartered Depository Institutions; Loans; Asset, Level, Millions of Dollars, Quarterly, Not Seasonally Adjusted. Deflated using CPI.

Real NBFI loans: Aggregation of loans from mutual funds, Issuers of asset-backed securities, finance companies, real estate investment trusts, security brokers and dealers, holding companies, and other financial businesses. Deflated using CPI.

Real NBFI deposits: Aggregation of debt securities from mutual funds, Issuers of asset-backed securities, finance companies, real estate investment trusts, security brokers and dealers, holding companies, and other financial businesses. Deflated using CPI.

Inflation: Consumer Price Index for All Urban Consumers: All Items in the US. City Average, Index 1982-1984=100, Quarterly, Seasonally Adjusted.

Policy rate: Federal Funds Effective Rate, Percent, Quarterly, Not Seasonally Adjusted.

Interest rate on loans: Bank Prime Loan Rate, Percent, Quarterly, Not Seasonally Adjusted.

Commercial bank deposit rate: Weighted average of checking, savings, and 6-month CD rates.

2.7.2 Equilibrium Conditions

This section lists all the equilibrium conditions from the model. The model is log-linearized around the steady state. All the borrowing constraints are always binding—wholesale quantities equal to retail quantities in equilibrium. Non-bank wholesale interest rates are set to policy rates as they do not face adjustment costs for the capital position. Intermediaries and households have the same discount factor since households own them. Entrepreneurs have the same consumption habits as households: $a^H = a^E$. Households receive transfers from retailers as they profit from NBFIs, and a fraction of NBFIs exit every period.

All shocks smooth around steady-state values. Steady-state inflation π and production technology A equal 1. m^C equals 2/3. Shocks to interest rates $\epsilon^{D,C}$, $\epsilon^{B,C}$, $\epsilon^{D,N}$, and $\epsilon^{B,N}$ calibrates the steady state credit spreads between bank rates and policy rate.

Households

$$\frac{1-a^H}{C_t^H - a^H C_{t-1}^H} = \lambda_t^H \qquad \text{(FOC for consumption)}$$

$$\lambda_t^H = \beta^H E_t[\lambda_{t+1}^H (1 + r_t^{D,C})] \qquad \text{(FOC for CB deposits)}$$

$$L_t^{H\phi} = \lambda_t^H W_t \qquad \text{(FOC for labor demand)}$$

$$C_t^H + D_t^C + D_t^N = W_t L_t^H + (1 + r_{t-1}^{D,C}) D_{t-1}^C + (1 + r_{t-1}^{D,N}) D_{t-1}^N + T_t^H$$

(Budget constraint)

$$T_t^H = T_t^R + T_t^N \qquad \text{(Total Transfers)}$$

Entrepreneurs

$$\frac{1-a^H}{C_t^E - a^H C_{t-1}^E} = \lambda_t^E \qquad \text{(FOC for consumption)}$$

$$E_t[(\lambda_t^{E,C} m_t^C + \lambda_t^{E,N}(1-m_t^C))Q_{t+1}(1-\delta^K) + \beta^E \lambda_{t+1}^E (Q_{t+1}(1-\delta^K) + \alpha \frac{Y_{t+1}^E}{K_t^E X_t}] = \lambda_t^E Q_t$$

(FOC for capital)

$$W_t = (1-\alpha)\frac{Y_t^E}{L_t^H X_t} \qquad \text{(FOC for labor)}$$

$$\lambda_t^E - \lambda_t^{E,C}(1+r_t^{B,C}) = \beta^E E_t[\lambda_{t+1}^E(1+r_t^{B,C})] \qquad \text{(FOC for CB loans)}$$

$$\lambda_t^E - \lambda_t^{E,N}(1+r_t^{B,N}) = \beta^E E_t[\lambda_{t+1}^E(1+r_t^{B,N})] \qquad \text{(FOC for NBFI loans)}$$

$$\begin{aligned} C_t^E + W_t L_t^H + (1+r_{t-1}^{B,C})B_{t-1}^C + (1+r_{t-1}^{B,N})B_{t-1}^N + Q_t K_t^E \\ = \frac{Y_t^E}{X_t} + B_t^C + B_t^N + Q_t(1-\delta^K)K_{t-1}^E \end{aligned} \qquad \text{(Budget constraint)}$$

$$Y_t^E = A_t^E {K_{t-1}^E}^{\alpha} {L_t^H}^{1-\alpha} \qquad \text{(Production technology)}$$

$$(1+r_t^{B,C})B_t^C = m_t^C E_t[Q_{t+1}(1-\delta^K)K_t^E] \qquad \text{(CB borrowing constraint)}$$

$$(1+r_t^{B,N})B_t^N = (1-m_t^C)E_t[Q_{t+1}(1-\delta^K)K_t^E] \qquad \text{(NBFI borrowing constraint)}$$

$$r_t^K = \alpha\frac{Y_t^E}{K_{t-1}^E} \qquad \text{(Returns of capital)}$$

Commercial Banks

$$K_t^C = (1-\delta^C)K_{t-1}^C + J_{t-1}^C \qquad \text{(Accumulation of bank capital)}$$

$$J_t^C = r_t^{B,C} B_t^C - r_t^{D,C} D_t^C - \frac{\kappa^{D,C}}{2} \left(\frac{r_t^{D,C}}{r_{t-1}^{D,C}} - 1 \right)^2 r_t^{D,C} D_t^C$$
$$- \frac{\kappa^{B,C}}{2} \left(\frac{r_t^{B,C}}{r_{t-1}^{B,C}} - 1 \right)^2 r_t^{B,C} B_t^C - \frac{\kappa_{K^C}}{2} \left(\frac{K_t^C}{B_t^C} - \nu^C \right)^2 K_t^C \quad \text{(Bank profit)}$$

$$B_t^C = D_t^C + K_t^C \quad \text{(Balance Sheet)}$$

$$r_t^{W,B,C} = -\kappa_{K^C} \left(\frac{K_t^C}{B_t^C} - \nu^C \right) \left(\frac{K_t^C}{B_t^C} \right)^2 + r_t \quad \text{(FOC wholesale branch)}$$

$$-1 + \epsilon_t^{D,C} - \epsilon_t^{D,C} \frac{r_t}{r_t^{D,C}} = 0 \quad \text{(FOC deposit branch)}$$

$$-1 + \epsilon_t^{B,C} - \epsilon_t^{B,C} \frac{r_t}{r_t^{B,C}} = 0 \quad \text{(FOC loans branch)}$$

NBFIs

$$\nu_t^N = E_t[(1-\theta)\beta^H \frac{\lambda_{t+1}^H}{\lambda_t^H} (r_t^{W,B,N} - r_t^{D,N}) + \beta^H \frac{\lambda_{t+1}^H}{\lambda_t^H} \theta \chi_{t,t+1}^N \nu_{t+1}^N] \quad \text{(Bank capital value)}$$

$$\eta_t^N = 1 - \theta + \beta^H \theta E_t[\frac{\lambda_{t+1}^H}{\lambda_t^H} z_{t,t+1}^N \eta_{t+1}^N] \quad \text{(Bank net worth value)}$$

$$\frac{\eta_t^N}{\lambda^N - \nu_t^N} = \phi_t^N \quad \text{(Endogenous Leverage)}$$

$$z_{t-1,t}^N = (r_{t-1}^{W,B,N} - r_{t-1}^{D,N}) \phi_{t-1}^N + (1 + r_{t-1}^{D,N}) \quad \text{(Bank capital growth)}$$

$$\chi_{t-1,t}^N = \frac{\phi_t^N}{\phi_{t-1}^N} z_{t-1,t}^N \quad \text{(Bank net worth growth)}$$

$$B_t^N = D_t^N + K_t^N \quad \text{(Balance sheet)}$$

$$K_t^N = K_{e,t}^N + K_{n,t}^N \quad \text{(NBFI net worth)}$$

$$K_{e,t}^N = \theta^N z_{t-1,t}^N K_{t-1}^N \quad \text{(Net worth accumulation)}$$

$$K_{n,t}^{N} = \omega^{N} B_{t-1}^{N} \qquad \text{(New bank's net worth)}$$

$$-1 + \epsilon_t^{D,N} - \epsilon_t^{D,N} \frac{r_t}{r_t^{D,N}} = 0 \qquad \text{(FOC deposit branch)}$$

$$\begin{aligned} -1 + \epsilon_t^{B,N} - \epsilon_t^{B,N} \frac{r_t^{W,B,N}}{r_t^{B,N}} - \kappa^{B,N} \left(\frac{r_t^{B,N}}{r_{t-1}^{B,N}} - 1 \right) \frac{r_t^{B,N}}{r_{t-1}^{B,N}} \\ + \beta^H E_t [\frac{\lambda_{t+1}^H}{\lambda_t^H} \kappa^{B,N} (\frac{r_{t+1}^{B,N}}{r_t^{B,N}} - 1) (\frac{r_{t+1}^{B,N}}{r_t^{B,N}})^2 \frac{B_{t+1}^N}{B_t^N}] = 0 \end{aligned} \qquad \text{(FOR loans branch)}$$

$$r_t^{W,B,N} = r_t \qquad \text{(Wholesale borrowing rate)}$$

$$T_t^N = (1 - \omega^N - \theta) B_{t-1}^N \qquad \text{(Transfer to Households)}$$

Capital Producers

$$K_t^E = (1 - \delta^K) K_{t-1}^E + [1 - \frac{\kappa_i}{2} (\frac{I_t}{I_{t-1}} - 1)^2] I_t \qquad \text{(Capital Flow)}$$

$$\begin{aligned} 1 = Q_t [1 - \frac{\kappa_i}{2} (\frac{I_t}{I_{t-1}} - 1)^2 - \kappa_i (\frac{I_t}{I_{t-1}} - 1) \frac{I_t}{I_{t-1}}] \\ + \beta^E E_t [\frac{\lambda_{t+1}^H}{\lambda_t^H} Q_{t+1} \kappa_i (\frac{I_{t+1}}{I_t} - 1) (\frac{I_{t+1}}{I_t})^2] \end{aligned} \qquad \text{(Capital Price)}$$

Retailers

$$T_t^R = Y_t^E [1 - \frac{1}{X_t} - \frac{\kappa_p}{2} (\pi_t - \pi_{t-1}^{\iota} \pi^{1-\iota})^2] \qquad \text{(Retail profits)}$$

$$1 - \epsilon_t^y + \frac{\epsilon_t^y}{X_t} - \kappa_p (\pi_t - \pi_{t-1}^{\iota} \pi^{1-\iota}) \pi_t + \beta^H E_t [\frac{\lambda_{t+1}^E}{\lambda_t^E} \kappa_p (\pi_{t+1} - \pi_t^{\iota} \pi^{1-\iota}) \pi_{t+1} \frac{Y_{t+1}^E}{Y_t^E}] = 0$$

(New Keynesian Phillips Curve)

Aggregation

$$Y_t = C_t + Q_t(K_t^E - (1-\delta^K)K_{t-1}^E) + \delta_K^C K_{t-1}^C + AC_t \qquad \text{(Aggregate Resources)}$$

$$C_t = C_t^H + C_t^E \qquad \text{(Consumption)}$$

$$B_t = B_t^C + B_t^N \qquad \text{(Loans)}$$

$$D_t = D_t^C + D_t^N \qquad \text{(Deposits)}$$

$$AC_t = \frac{\kappa_p}{2}(\pi_t - \pi_{t-1}^{\iota}\pi^{1-\iota})^2 Y_t^E + \frac{\kappa^{B,N}}{2}\left(\frac{r_t^{B,N}}{r_{t-1}^{B,N}} - 1\right)^2 r_t^{B,N} B_t^N$$

(Adjustment Costs)

Monetary Policy

$$1 + r_t = (1+r)^{1-\phi_r}(1+r_{t-1})^{\phi_r}(\frac{\pi_t}{\pi})^{\phi_\pi(1-\phi_r)}(\frac{Y_t}{Y_{t-1}})^{\phi_y(1-\phi_r)}\epsilon_t^r \qquad \text{(Taylor Rule)}$$

Exogenous Processes

$$A_t^E = (1-\rho_{A^E})A + \rho_{A^E}A_{t-1}^E + \epsilon_{A^E t} \qquad \text{(Production)}$$

$$\epsilon_t^y = (1-\rho_{\epsilon^y})\epsilon^y + \rho_{\epsilon^y}\epsilon_{t-1}^y + \epsilon_{\epsilon^y t} \qquad \text{(Price markup)}$$

$$m_t^C = (1-\rho_{m^C})m^C + \rho_{m^C}m_{t-1}^C + \epsilon_{m^C t} \qquad \text{(CB LTV)}$$

$$\epsilon_t^{D,C} = (1-\rho_{\epsilon^{D,C}})\epsilon^{D,C} + \rho_{\epsilon^{D,C}}\epsilon_{t-1}^{D,C} + \epsilon_{\epsilon^{D,C} t} \qquad \text{(CB deposit markdown)}$$

$$\epsilon_t^{B,C} = (1-\rho_{\epsilon^{B,C}})\epsilon^{B,C} + \rho_{\epsilon^{B,C}}\epsilon_{t-1}^{B,C} + \epsilon_{\epsilon^{B,C} t} \qquad \text{(CB loan markup)}$$

$$\epsilon_t^{D,N} = (1-\rho_{\epsilon^{D,N}})\epsilon^{D,N} + \rho_{\epsilon^{D,N}}\epsilon_{t-1}^{D,N} + \epsilon_{\epsilon^{D,N} t} \qquad \text{(NBFI deposit markdown)}$$

$$\epsilon_t^{B,N} = (1-\rho_{\epsilon^{B,N}})\epsilon^{B,N} + \rho_{\epsilon^{B,N}}\epsilon_{t-1}^{B,N} + \epsilon_{\epsilon^{B,N} t} \qquad \text{(NBFI loan markup)}$$

2.7.3 Prior and Posterior Distributions

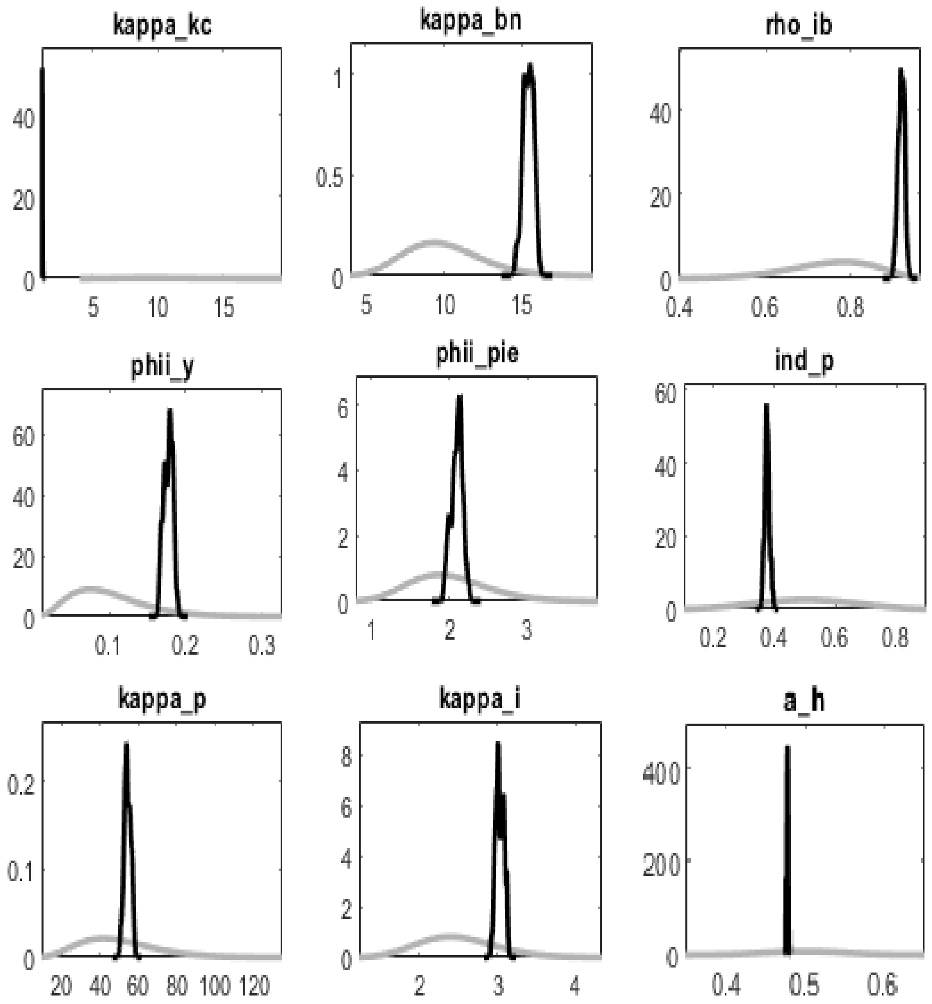

Figure 2.9: Prior and posterior distributions from estimation. Table (2.2) reports all the statistics. Grey and black lines are prior and posterior density distributions, respectively.

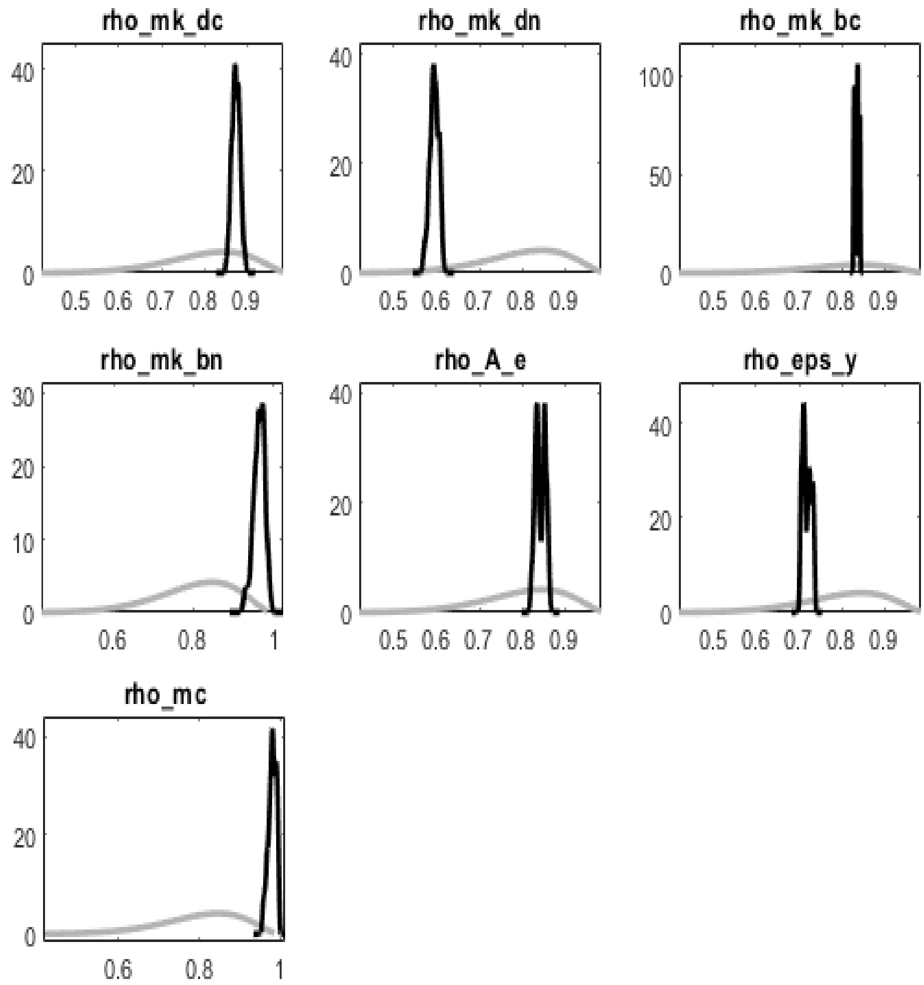

Figure 2.10: Prior and posterior distributions from estimation. Table (2.2) reports all the statistics. Grey and black lines are prior and posterior density distributions, respectively.

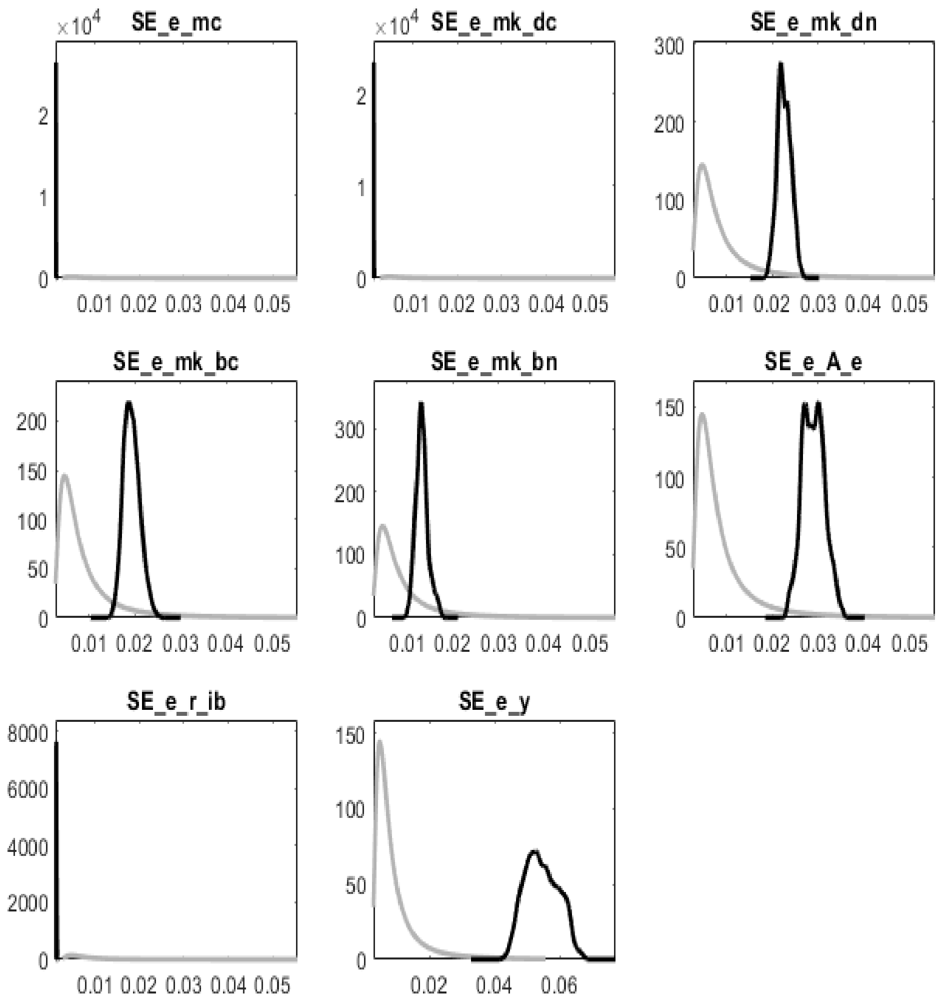

Figure 2.11: Prior and posterior distributions from estimation. Table (2.2) reports all the statistics. Grey and black lines are prior and posterior density distributions, respectively.

2.7.4 Robustness Checks for $\kappa^{K,C}$ and $\kappa^{B,N}$

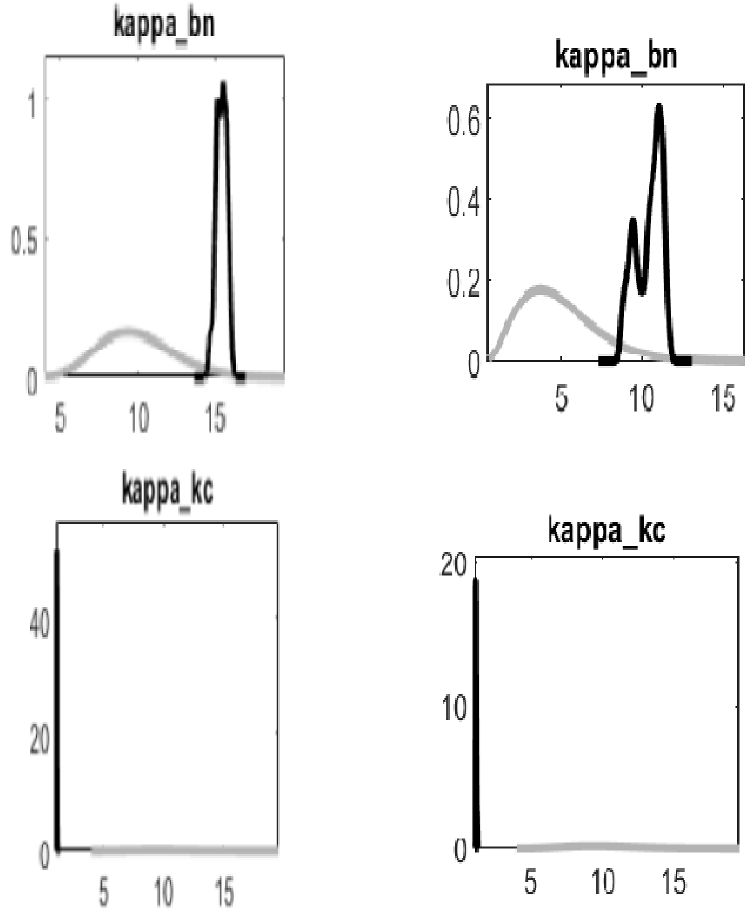

Figure 2.12: Robustness check for $\kappa^{K,C}$ and $\kappa^{B,N}$. The original prior and posterior distributions from Figure (2.9) are on the left. On the right, the mean cuts by half from 10 to 5, fixing everything else the same. Grey and black lines are prior and posterior density distributions, respectively.

2.7.5 Main results figure 2

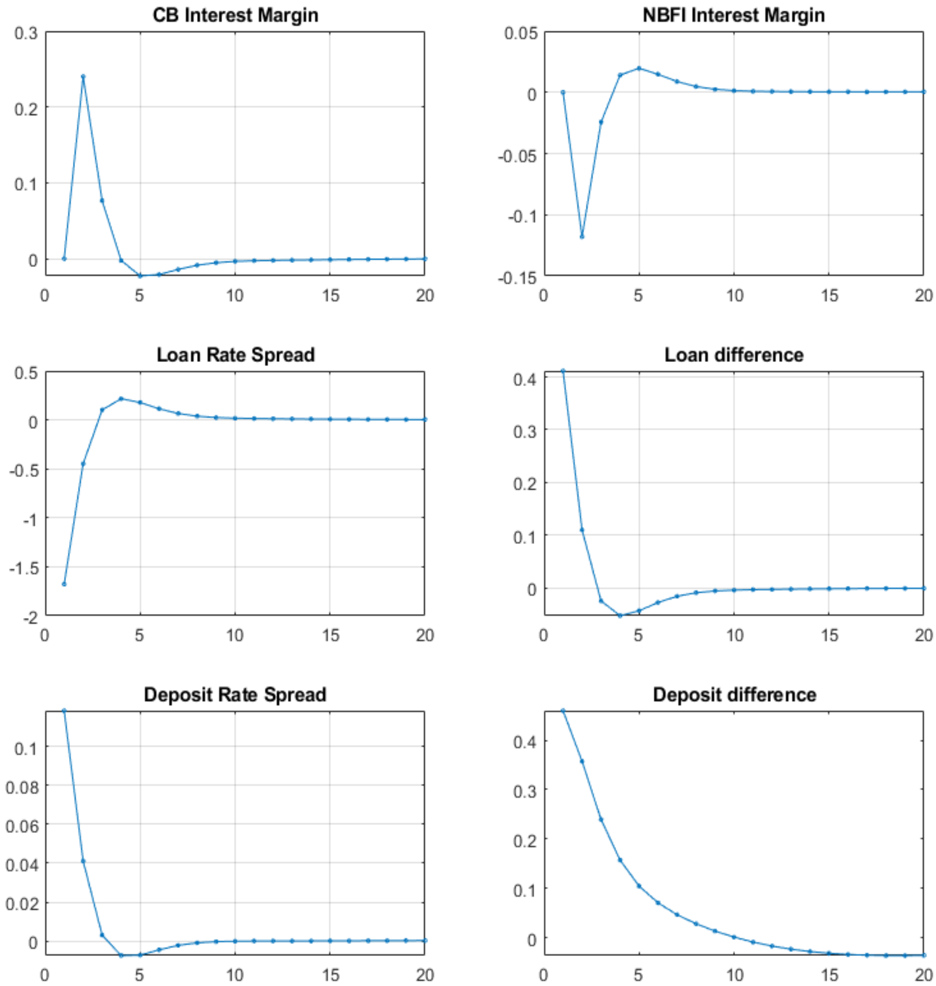

Figure 2.13: Changes after a contractionary MP shock. Interest margins are the differences between loan and deposit rates. The loan (deposit) rate spread is the gap between NBFI and CB borrowing (deposit) rates. The loan (deposit) difference equals the NBFI growth rate minus the CB loan (deposit) growth rate.

2.7.6 Changes to the number of commercial banks

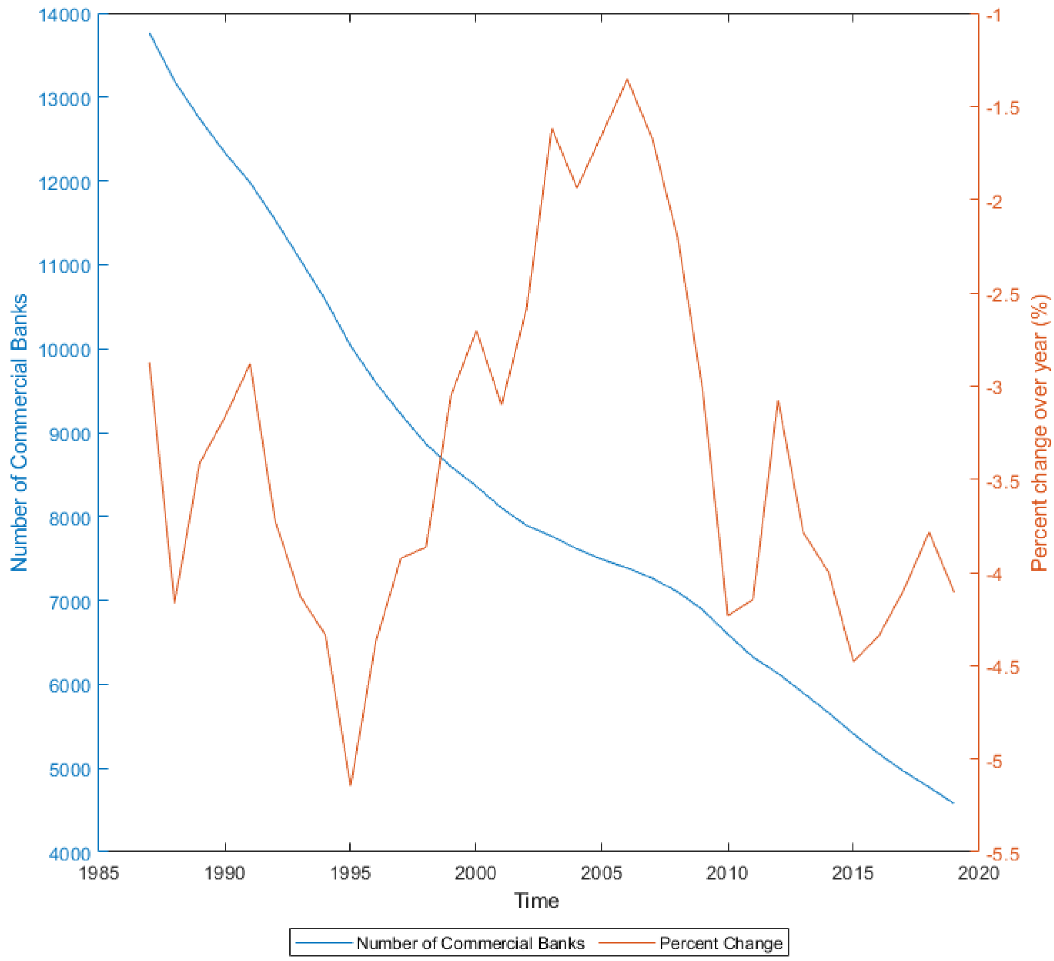

Figure 2.14: The decline in the number of commercial banks.

Chapter 3

Basel III Implementation in the US Context

3.1 Introduction

The traditional microprudential policies require universal standard capital adequacy for all commercial banks. To prevent financial crises, regulators lower the requirement during the buildup phase and increase capital buffers during a credit bust. After the Great Financial Crisis, Basel III changed the capital requirements for commercial banks in two ways by focusing on the benefits of macroprudential policies.[1] It first requires global systematically important banks (GSIBs) to hold more capital as they pose a systematic threat to financial stability. GSIB capital surcharge lowers the systemic risk these large financial institutions pose by increasing their resiliency.[2] The second, more controversial suggestion is to

[1](FSB, 2022) covers the Basel III progress of other pillars, such as net stable funding and liquidity coverage ratios.

[2]Koch et al. (2020) shows that a too-big-to-fail policy leads to large banks holding lower capital requirements than smaller banks.

conduct a counter-cyclical capital buffer (CCyB) to dampen the cyclical financial cycles. The US differs from most advanced and emerging economies because it has large and complicated non-bank financial sectors operating like commercial banks. Therefore, the international Basel III regulatory framework is too generalized to all countries. Given the framework in Yang (2022), the first question of this paper is how will the presence of non-bank financial intermediaries affect the implementation of the GSIB surcharge. The second question is how will counter-cyclical capital buffer be implemented when the GSIB surcharge is in place?

To answer these two questions, I first quantitatively examine the impact of GSIB capital surcharge with and without the non-bank sector. I use a highly persistent and smoothed AR(1) process capital requirement shock to simulate capital surcharge. I calculate the weighted-adjusted surcharge to the banking sector to simulate the empirical impact. Then, I observe how the buffer will be implemented when a sizable non-bank sector exists in the US. Next, I comment on the essential features of the loan rate stickiness and the growth of NBIFs. Then, I utilize the credit-to-GDP gap between its steady-state values and the capital buffer in a counter-cyclical rule. Finally, I consider two possible measures for the credit, bank credit only and aggregate credit, and the magnitude of the coefficient for CCyB to quantitatively evaluate its performance.

I first find out that the capital surcharge on large and important banks will lead to a 1.14% increase in capital requirement. The simulated results suggest that the capital surcharge will have a smaller impact on the real economy when only both types of intermediaries are present in the economy. The presence of non-bank financial intermediaries (NBFIs) amplifies the credit cycle as surcharges are implemented. The economic cycle of output and consumption is smooth due to the presence of NBFIs. A flexible rate is essential to generate opposite balance sheet responses to monetary policy and is also necessary quantitatively for this analysis. When both types of loans have flexible rates, the impact is underestimated by 10%. Since 2008, especially during the COVID period, non-banks have become more dominant: A more significant non-bank sector leads to dampened financial cycles by 20%

When CCyB is implemented, investment volatility increases while output is smoother. The results suggest the potential improvement in using total credit is moderate: bank credit only measure will only overestimate the results by 4% when the coefficient is one in the capital buffer rule. The responsiveness of CCyB creates a tradeoff between credit cyclicality and loan leakage. The larger the coefficient, the more dampened the credit cycle is at the cost of greater leakage. When the coefficient for the credit gap increases from one to five, the price of the physical good will decrease less in the future. As a result, the credit decrease is also smaller in both banks and non-banks. This result suggests that the potential downside of more aggressive CCyB will increase the relative credit leakage towards NBFIs.

There has been extensive empirical and structural research on the impact of capital requirements on lending volumes and spreads. MAG (2010) shows that credit volume is affected more than loan spreads due to the GSIB surcharge. As Bichsel et al. (2022) and others argue, an increase in capital requirements leads to an increase in lending rate. Slovik and Cournède (2011) shows that a 1% increase in capital requirement leads to 18 bps in the loan rate. MAG (2010) has similar quantitative effects. (Cosimano and Hakura, 2011) also reports similar estimates at 16 bps. (MAG, 2010) employs dozens of models and finds the median impact is ten basis points, closer to my estimation. Alessandri et al. (2015) argues the importance of the structural model in the decision-making of Basel III, and I contribute to this literature by further considering two financial sectors.

Several papers also stress that the regulatory design needs to be holistic to consider all intermediaries. In the original Basel III report, non-banks are always a concern for Basel III when designing policy. Rajan (2005) also stresses the importance of considering other financial intermediaries when designing regulatory oversight. A capital requirement must be better designed to leave many institutions outside with unintended consequences. Credit leakage could happen among banks: Aiyar et al. (2014) shows the empirical evidence of credit leakage when the UK tightens capital controls on UK-based banks. The foreign bank branches in the UK are unregulated yet perform similar functions. As a result, one-third of the credit tighten leaked through foreign-based banks. The credit leakage could also shift bank operation: Favara et al. (2021) shows the credit shift within the banking sector: when large banks are required to hold more capital, more corporate loans are migrated to smaller banks without the surcharge. Moreover, these large banks are more likely to terminate existing loans and lend less to small, risky firms. Relevant to my focus, Irani et al. (2020) shows the unintended consequences of tightening bank capital, which lead to syndicated corporate loans reallocating to non-banks by observing banks offloading loans from their balance sheets and selling them to non-banks in the secondary trading market. This shift leads to greater concern as non-banks are more prone to liquidity sudden stop in the financial market. Moreover, they lack deposit insurance to prevent them from running and do not have access to central bank liquidity, which makes them riskier and more likely to jeopardize financial stability, the objective of the Basel III accord. This paper focuses on the assets sides of intermediaries' balance sheets. However, on the liabilities side, Begenau and Landvoigt (2021) shows higher capital requirements lead to larger non-banks due to the competition effect. They suggest the optimal capital requirement is 16% when considering non-banks, as the moral hazard from deposit insurance gave banks an advantage over non-banks. The higher capital requirement helps address this moral hazard and financial fragility. Angelini et al. (2014) employs Gerali et al. (2010) framework with only commercial banks, which turns out to be quantitatively different for Basel III. Auer et al. (2022) finds NBFIs increase the growth of credit to smaller and riskier firms, which will be central for the tradeoff between financial volatility and stability, is that out of the scope of this paper.

The other strand of literature focuses exclusively on CCyB. First, the credit to GDP gap is a good measure when considering a rule because, As argued by MAG (2010) and Schularick and Taylor (2012), excessive credit growth is a good indicator of a financial crisis. Schularick and Taylor (2012) stresses the importance of credit channels in monetary policy analysis. Secondly, CCyB needs to take NBFIs into account for several reasons. Edge and Liang (2020) shows that governance structures affect the implementation of CCyB. The more financial stability committee member, the less likely CCyB will be implemented. More agencies on financial stability committees reflect a country having more complex financial systems, so capital reforms on banks might lead to more credit leakage to non-banks. Gebauer and Mazelis (2019) considers the implementation of CCyB, whereas I focus on the added impact of capital surcharge. Faria-e Castro (2021) offers a New Keynesian model to mortgage borrowers facing endogenous default risk and finds that CCyB helps significantly lower default rates to improve aggregate consumption. I am focusing on corporate loans from both banks and non-banks.

The rest of the paper is organized as follows. Section 2 discusses the GSIB capital surcharge. Section 3 describes the counter-cyclical capital buffer. Section 4 concludes.

3.2 GSIB Capital Surcharge

This section first calculates weight-adjusted capital requirement from GSIB surcharge for the US banking sector. Then, I simulate the capital requirement shock given the structural framework from Yang (2022) with and without NBFIs. Lastly, I investigate the impact of loan rate stickiness and the growth of NBFIs on the main results.

3.2.1 Calculating Capital Surcharge

FSB (2022) shows that all countries reporting to the Financial Stability Board have adopted and implemented capital surcharges for GSIBs in their jurisdictions. The GSIBs are assigned into different brackets of capital surcharge requirement depending on their GSIB score. The score is calculated based on size, interconnectedness, infrastructure, complexity, and cross-country activity.[3] Figure (3.1) shows as of November 2022, 30 large financial institutions are on this list across advanced and emerging economies. The exact capital surcharges range from 1% to

[3] Passmore and von Hafften (2020) has a comprehensive review of GSIBs and the calculation of this score in detail.

2.5% among the eight US-based banks.[4] In the third quarter of 2022, commercial banks' total assets reach $22.85 trillion. These eight GSIBs combined have more than 60% of the total banks' assets. The banking sector is even more concentrated at the top: The big four banks make up 50% of the total assets.[5] Using their call reports in Q3 of 2022, I extract their total assets and calculate the asset-weighted contribution to the aggregate banking capital. After calculation, the aggregate banking capital sufficiency increased by 1.14% for the US banking sector.[6]

[4]JP Morgan Chase, Bank of America, Citigroup, Goldman Sachs, Morgan Stanley, Wells Fargo, State Street, and Bank of New York Mellon are classified as GSIBs in the US.

[5]The big four: JP Morgan Chase, Bank of America, Citigroup, and Wells Fargo.

[6]This calculation does not take risk-adjusted weight into account.

G-SIBs as of November 2022[11] allocated to buckets corresponding to required levels of additional capital buffers

Bucket[12]	G-SIBs in alphabetical order within each bucket
5 (3.5%)	(Empty)
4 (2.5%)	JP Morgan Chase
3 (2.0%)	Bank of America Citigroup HSBC
2 (1.5%)	Bank of China Barclays BNP Paribas Deutsche Bank Goldman Sachs Industrial and Commercial Bank of China Mitsubishi UFJ FG
1 (1.0%)	Agricultural Bank of China Bank of New York Mellon China Construction Bank Credit Suisse Groupe BPCE Groupe Crédit Agricole ING Mizuho FG Morgan Stanley Royal Bank of Canada Santander Société Générale Standard Chartered State Street Sumitomo Mitsui FG Toronto Dominion UBS UniCredit Wells Fargo

Figure 3.1: Different brackets of all GSIBs. This figure is taken from the FSB 2022 annual report on GSIBs.

3.2.2 Structural Framework

Having calibrated the size of the capital shock, I use the main framework from Yang (2022) to simulate, as it includes both banks and non-banks. I am using calibrated and estimated parameters from Yang (2022) because the sample period is 1987Q1 to 2007Q4, just before Basel III is consolidated across international regulatory bodies. In the US, the Basel III framework will take full effect at the beginning of 2023 and will phase over the next five years. This paper adds a persistent capital requirement shock using the following AR(1) process:

$$\nu_t^C = (1 - \rho_{\nu^C})\nu^C + \rho_{\nu^C}\nu_{t-1}^C + \epsilon_{\nu^C t} \tag{3.1}$$

ρ_{ν^C} is set at 0.9, indicating high persistence. Following the Yang (2022) framework, steady-state capital requirement ν^c is 8% according to Basel II. The error term $\epsilon_{\nu^C t}$ is the shock to the bank capital. Since NBFIs are not subject to capital regulations, this shock asymmetrically impacts both sectors.

3.2.3 Simulated Results

First, I simulate the model with a negative capital shock: the deviation is 1.14% from the target leverage ratio, equivalent to 14.25% from the steady-state ratio. The main exercise compares results with and without NBFIs. I then conduct comparative statics analysis focusing on loan product differentiation and non-bank growth.

Main Result Figure (3.2) shows the simulated results. Commercial banks and non-banks immediately extend fewer loans in response to a negative shock of capital requirements. Due to the fixed borrowing rate, non-bank loan contracts less. Deposit rates follow the policy rate, however, banks find it optimal to increase the lending rate by six basis points (bps). A 0.06% increase in the CB loan rate leads to a smaller than 0.06% decrease in bank loans, suggesting the loan demand elasticity is less than 1.[7] Deposits dynamics follow loan dynamics as the model

[7]The interest rate elasticity of loan demand has important implications. DeFusco and Paciorek (2017) shows that the elasticity of mortgage demand is well above one. This estimation implies homebuyers are contracting borrowing by more than one percent if the mortgage rate goes up by one percent.

does not fully incorporate household portfolio choice. Compared to the country-country and country-model results from MAG (2010), the results combine wider lending spreads and reduced lending volumes, but the estimated impacts are on the lower end. I estimate banks' loan spreads change by eight bps, whereas their median estimate is 16 bps.

Investment deviates from the equilibrium by 0.15% after five quarters. Consumption deviates by less amount as households, and entrepreneurs have habit persistence. In response to slower GDP growth and lower inflation, monetary policy cuts the interest rate by 0.015%. This easing suggests the capital surcharge shock will not lead to a significant decline in the real economy and subsequent policy rate cuts by the Fed. Notably, NBFIs dampen surcharge impact as they become the “bedrock” for tightening bank capital requirements.

Impulse responses from capital requirement shock

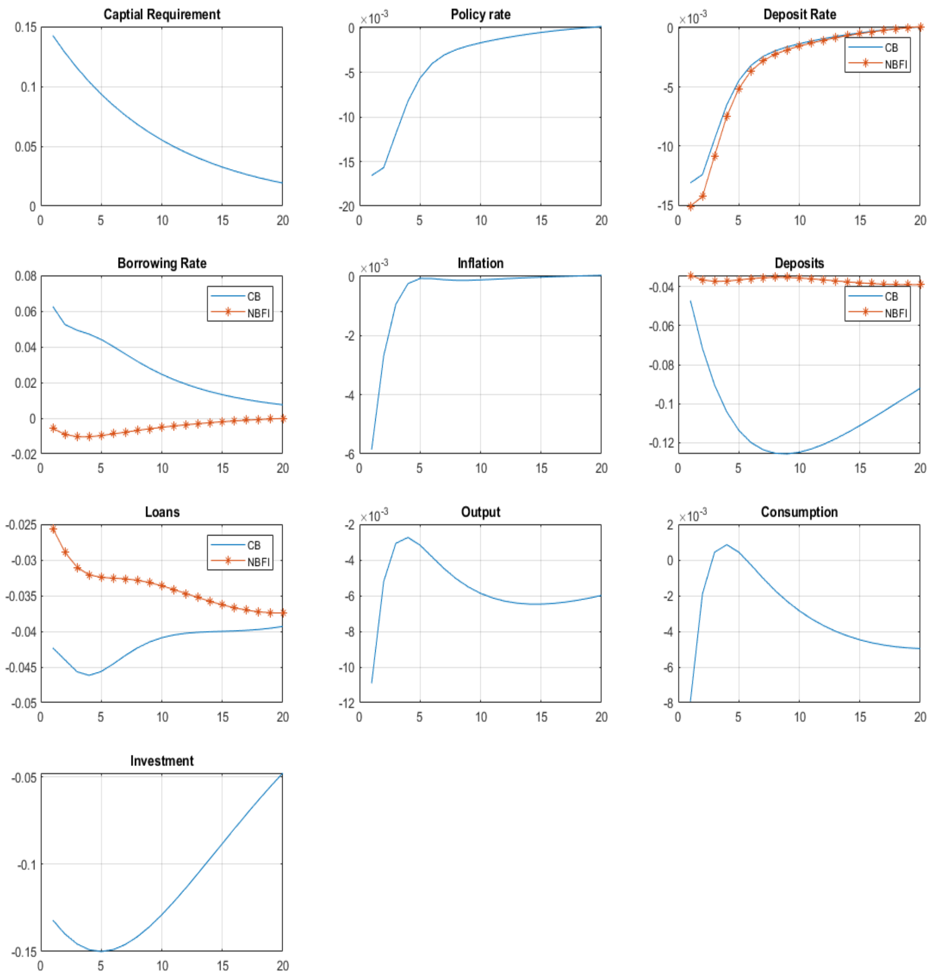

Figure 3.2: Impulse response functions to GSIB capital surcharge shock. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state.

Without NBFIs FSB (2020) shows banks remain the largest financial sector in most jurisdictions.[8] Among large economies, the US differs from most countries as its banks are not the predominant creditors. This section investigates the impact of the presence of NBFIs on capital surcharges. The commercial bank-only model is simplified from (Yang, 2022) without the other financial sector.

[8]Ireland, Cayman Islands, Netherlands, and Luxembourg have much larger NBFIs than banks.

Figure (3.3) reports the simulated output. Capital requirement slowly follows the AR(1) process to the steady state level. In response to tightening capital requirements and lower returns on equity, banks, in both cases, widen the lending spreads with respect to the deposit rate. However, when non-banks are absent, commercial banks will cut the deposit rate by almost 0.04% while the loan rate increases slightly. When non-banks are present, deposit rates will contract much less. When only considering commercial banks, the impact of this surcharge is mixed. Investment decreases much less by 0.06% while output decreases more by 0.023% from their respective steady state in the first quarter. Bank loans decrease less as the bank loan rate increases slightly in the first period. Investment decreases by less than half as bank loans have lower volatility. The output dynamics are driven by its largest component consumption. Without NBFIs, monetary policy cuts interest rate by 0.04 % compared to less than 0.02% in the first case as the output and inflation fall much more. Banks, in both cases, find it optimal to increase borrowing rates, consistent with the empirical literature studies from various countries at various periods. However, when non-banks are present, commercial banks will increase borrowing rates much more aggressively to have a greater lending spread. Monetary policy has to respond much more as output and inflation decrease significantly when only banks are present. Commercial bank deposits decrease less because the deposit rate decreases less. CB loans decrease even more because they increase loan rates more aggressively. On the other hand, commercial banks found it optimal to increase borrowing rates in response to the capital requirement.

Impulse responses from capital requirement shock

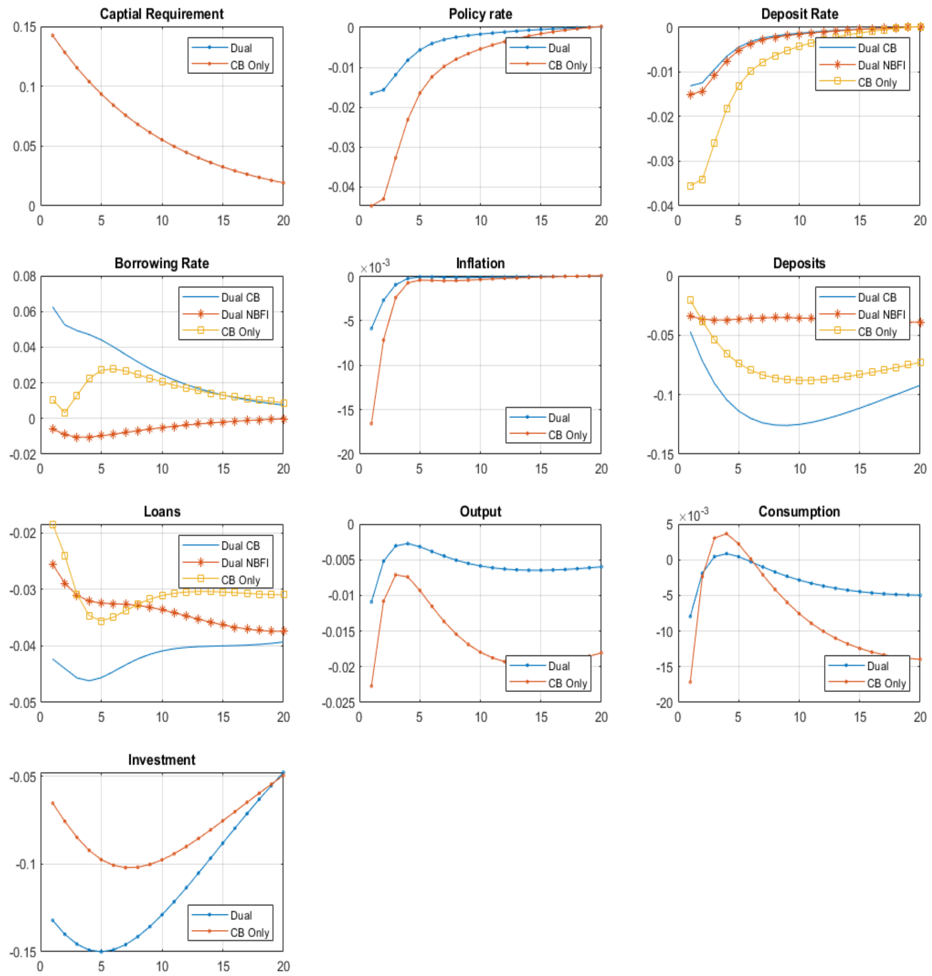

Figure 3.3: Impulse response functions to GSIB capital surcharge shock with and without NBFIs. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. "CB Only" refers to the model with only commercial banks. "Dual" refers to the framework consisting of two financial sectors.

Flexible Rate This section relaxes loan rate stickiness assumption by eliminating quadratic adjustment cost, and Figure (3.4) reports simulated results. For real aggregates, the impact of the surcharge is further weakened by 10%. Previously, non-bank loan rates were unresponsive to policy rate changes. NBFI loan rate is adjusting freely, allowing non-bank loans to expand more since it's more appealing to entrepreneurs. As argued in Yang (2022), the flexible rate is empirically evident and important to generate opposite responses to monetary policy. We will overestimate the dampening effect without considering this important feature because the non-bank loan rates and volumes will differ.

Impulse responses from capital requirement shock

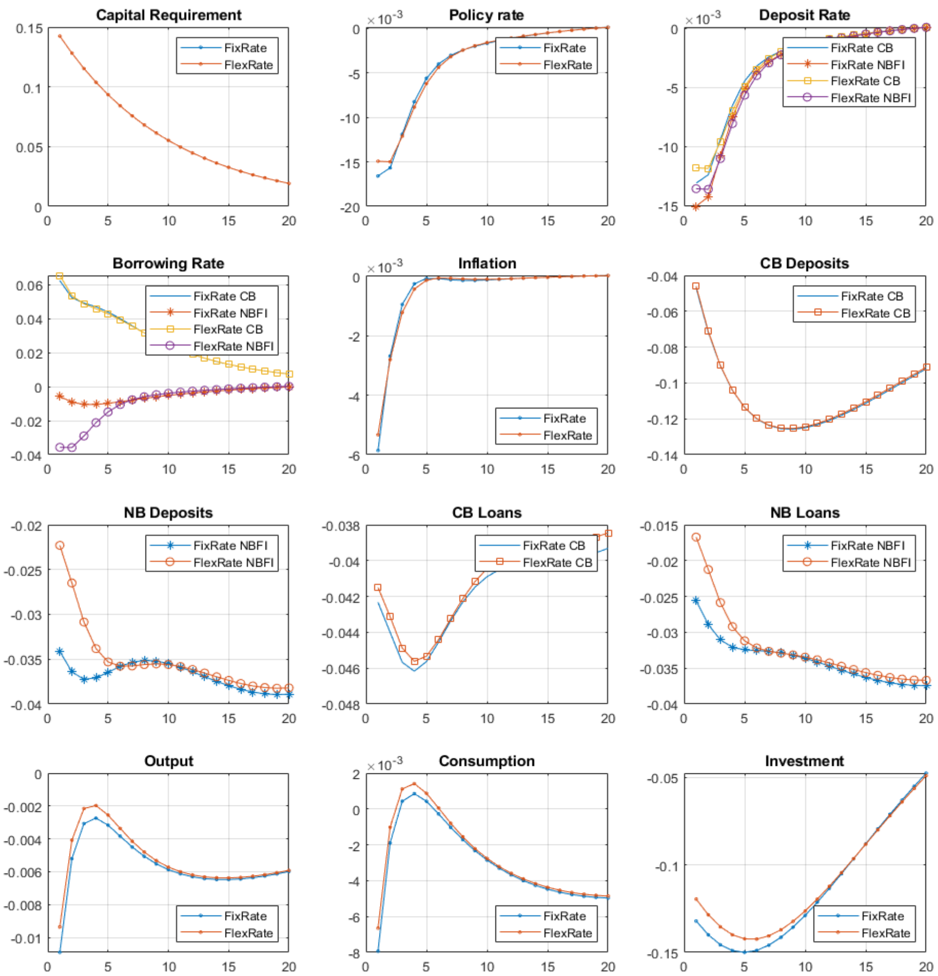

Figure 3.4: Impulse response functions to GSIB capital surcharge shock when loan rates are flexible. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. "FixRate" refers to the model with fixed non-bank loan rates. "FlexRate" refers to the model with floating loan rates.

Growth of Non-Banks As FSB (2022) shows, globally, non-bank activities have surpassed the 2008 levels. In 2008, other financial intermediaries consisted of 42% of total financial assets. In 2021, they have reached almost 50%. This section re-calibrates the loan-to-value ratio from 1/3 to 1/2 to reflect the development in the relative growth. As of 2019Q4, the sum of total NBFI assets is about the same as total CB assets for the US. Figure (3.5) demonstrates the difference. When non-banks intermediate half of the credit, the surcharge impact is further dampened by more than 20%. The results are quantitatively different, suggesting regulators must constantly monitor the size of two sectors when considering the overall impact. Further analysis needs a better framework to capture the tradeoff between dampening credit cycles and increased risk in the unregulated sector.

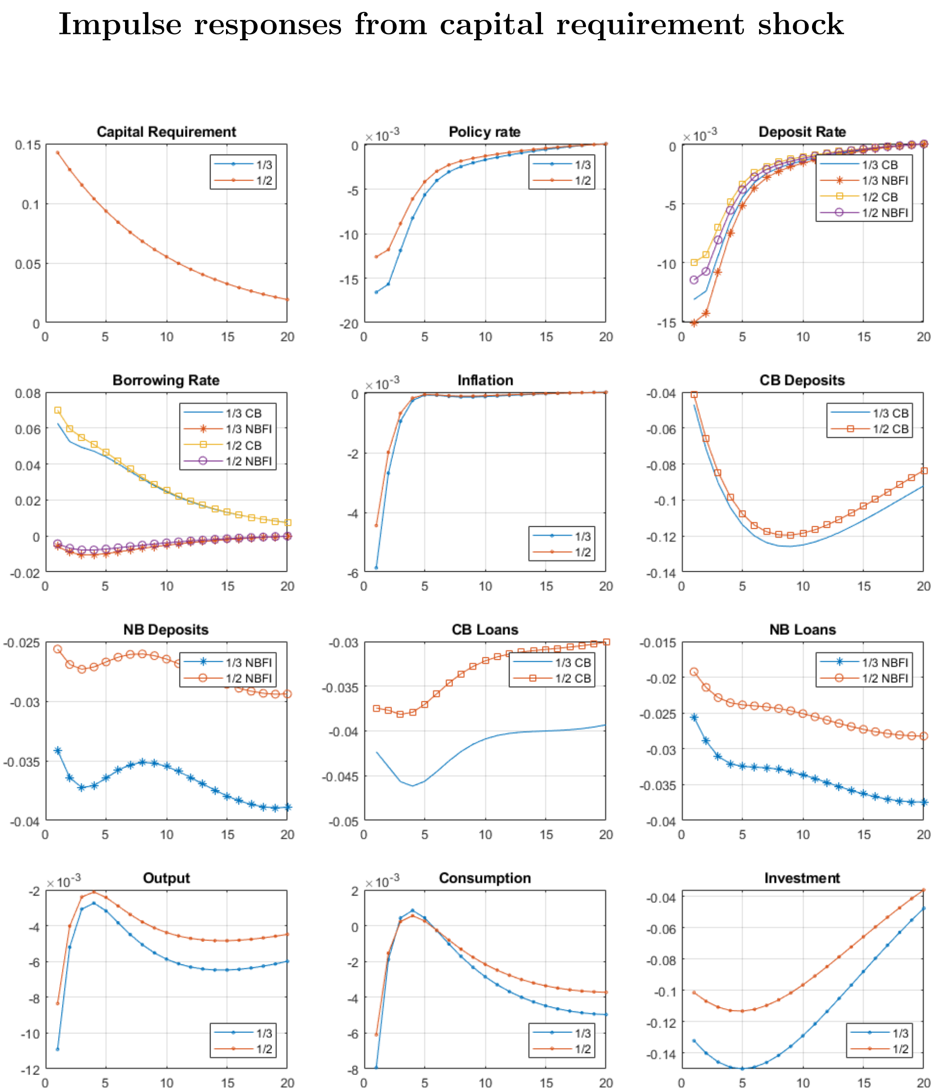

Figure 3.5: Impulse response functions to GSIB capital surcharge shock when NBFIs intermediate 1/2 of total credit. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. "1/3" refers to the calibration using data from 1987-2008. "1/2" reflects the updated size of non-banks.

3.3 Counter-cyclical Capital Buffer

This section first discusses the CCyB implementation. Then, I compare simulated results from two different credit measures. Lastly, I comment on the responsiveness of CCyB to credit.

3.3.1 Overview

Shim (2013) shows that the Basel II framework on risk-weighted assets made the credit cycles more procyclical as banks build up more buffers during the downturn. In response to the weakness in Basel II, Basel III recommends implementing a counter-cyclical capital buffer to dampen the procyclicality in credit cycles. When regulators activate the buffer, GSIBs are subject to a maximum of 13% capital requirement, a much higher capital requirement than the Basel II framework before 2008, when credit growth was fast.[9]

Edge and Liang (2020) summarizes that 14 jurisdictions have implemented CCyB. Although the upper bound is 2.5%, most countries have implemented moderately at 1%. Faria-e Castro (2021) provides a recent review of the CCyB literature. The 2022 FSB (2022) annual report acknowledges that most countries and economies adopted the counter-cyclical framework. However, implementing this framework requires more attention, as many have yet to include it in their regulatory agenda. The Federal Reserve publicly announced it has yet to have an agenda for implementing CCyB soon. The procyclicality dampening is facing significant delays in most jurisdictions partly due to the lack of structural research, so this paper contributes to the policy debate in the US by considering the interaction between the capital surcharge and CCyB. There have been several studies from other countries conducted on CCyB. Hájek et al. (2017) studies Czech Republic implementation while Alessandri et al. (2015) studies Italy. Alessandri et al. (2015) argue that Italy does not have to worry about NBFIs as Italian banks are the main creditors. Auer et al. (2022) shows Swiss has CCyB for residen-

[9] 8% (Basel II) + 2.5% (Capital Surcharge) + 2.5% (Buffer) = 13%

tial mortgages since 2013 to prevent excessive growth in housing prices. Douglas J. Elliott and Lehnert (2013) gave an overview of various macroprudential policies in the US and shows that the real estate sector has always implemented various macroprudential policies such as underwriting standards and loan-to-value ratios. (Clancy and Merola, 2017) argues that macroprudential policy is even more critical in economies with no control over exchange and policy rates, so CCyB might also be in place to attenuate the business cycle.

The original BIS proposal recommends the credit-to-GDP gap as the single best leading indicator for credit cycles. This indicator is supported by other research such as Kalatie et al. (2015), Drehmann and Tsatsaronis (2014), and Schularick and Taylor (2012). However, Kalatie et al. (2015) argues there are more indicators to consider, such as property prices, private sector debt, and external imbalances. European Systemic Risk Board identifies six areas to monitor when implementing CCyB. Shin (2011) emphasize foreign currency-denominated borrowing in small open economies such as South Korea. Drehmann and Tsatsaronis (2014) concludes that combining credit gap with other warning indicators improves the performance of CCyB.

3.3.2 The CCyB Rule

Based on the credit-to-GDP gap, the buffer follows a smoothed AR(1) process

$$\nu_t^C = (1-\rho_{\nu^C})\nu^C + \rho_{\nu^C}\nu_{t-1}^C + \chi\Delta_{B^C} + \epsilon_{\nu^C t} \tag{3.2}$$

where

$$\Delta_{B^C} = \frac{B_t^C}{Y} - \frac{B^C}{Y} \tag{3.3}$$

is the bank credit gap relative to output between the actual and steady-state levels. B^C and Y are the steady-state levels of bank loans and output. If χ is positive, the rule is counter-cyclical: Regulators tighten bank capital requirements when credit growth is above the trend.[10] Regulators are microprudential here as they emphasize bank credit to increase bank regulation, ignoring other intermediaries.

3.3.3 Simulated Results

This section simulates the CCyB rule on when the capital surcharge shock hits the economy.

Without NBFIs Figure (3.6) displays the results excluding NBFIs. These results resemble those in figure (3.3). While the changes in output and consumption are less pronounced, and their dynamics remain consistent, there is a notable shift in investment dynamics. Initially, the investment drops steeply but rebounds faster than the outcomes with only commercial banks, recovering after six quarters. Bank loans recover much quicker than figure (3.3), which shows the benefit of this counter-cyclical rule. Whetherr NBFIs are present or not, the credit cycle is dampened by more than 10%.

[10]This trend is calculated using the HP filter from the methodology suggested by MAG (2010) and beyond the scope of this paper. Instead, I examine the performance of this rule in my framework.

Impulse responses from capital requirement shock

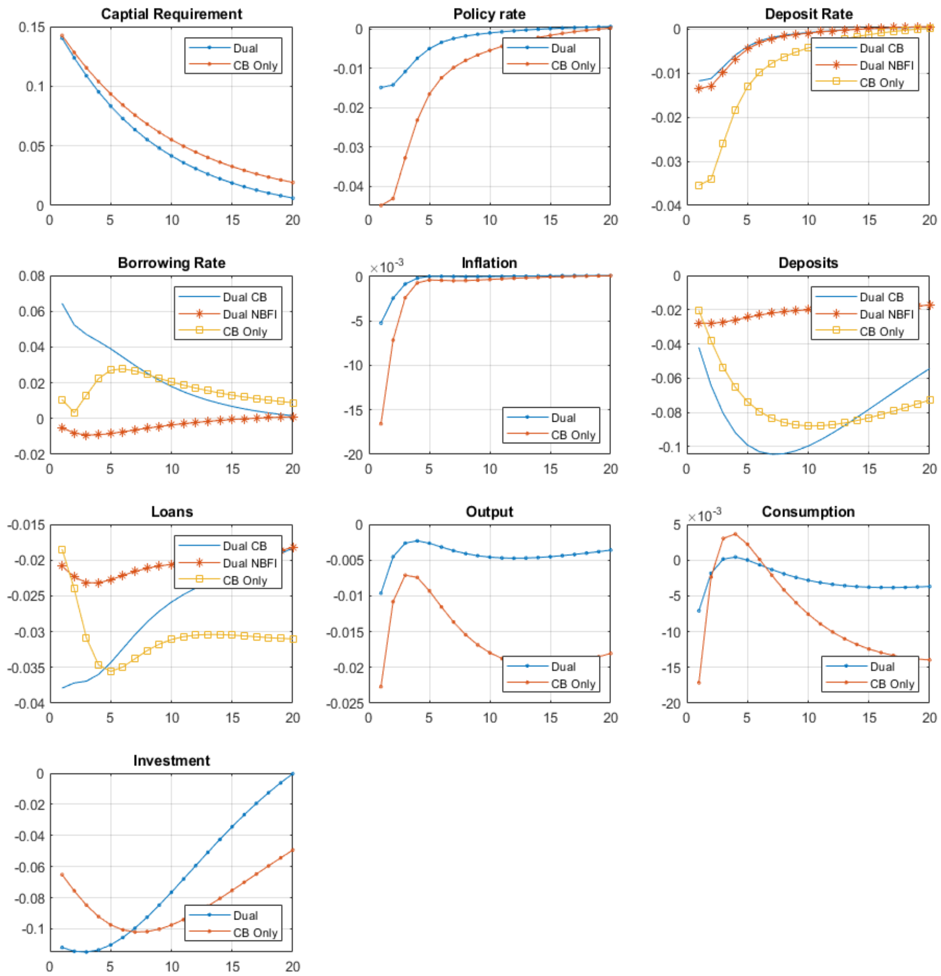

Figure 3.6: Impulse response functions to GSIB capital surcharge shock with and without NBFIs if CCyB is implemented. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. "Dual" refers to the main framework. "CB Only" refers to the bank-only framework.

Credit Measure Although regulators cannot regulate non-banks directly, more prudent regulators will consider non-bank credit when conducting counter-cyclical policy to dampen the aggregate credit cycles. The rule in this section is the same as before

$$\nu_t^C = (1 - \rho_{\nu^C})\nu^C + \rho_{\nu^C}\nu_{t-1}^C + \chi\Delta_B + \epsilon_{\nu^C t} \tag{3.4}$$

However, the credit measure is an aggregate measure instead of bank credit:

$$\Delta_B = \frac{B_t^C + B_t^N}{Y_t} - \frac{B^C + B^N}{Y} \tag{3.5}$$

. B^N is the steady state non-bank loan.

As figure (3.7) shows, CCyB will be implemented similarly on both credit measures when the surcharge is in place. Investment response is dampened by about 4%. Quantitative results show the benefit of a dampened credit cycle when considering both bank and non-bank credit. However, the improvement is small in response to the GSIB surcharge. If non-bank credit is harder to monitor and the non-bank sector mediates half of the bank credit, then less prudent regulators are moderately off from the better measure. Moreover, the decrease in credit cycles is asymmetric: bank loans reduce less by 2.37% whereas NB loans reduce by much more at 4.79%. Again, the prudent regulator achieves lower credit volatility, benefiting non-banks more.

Impulse responses from capital requirement shock

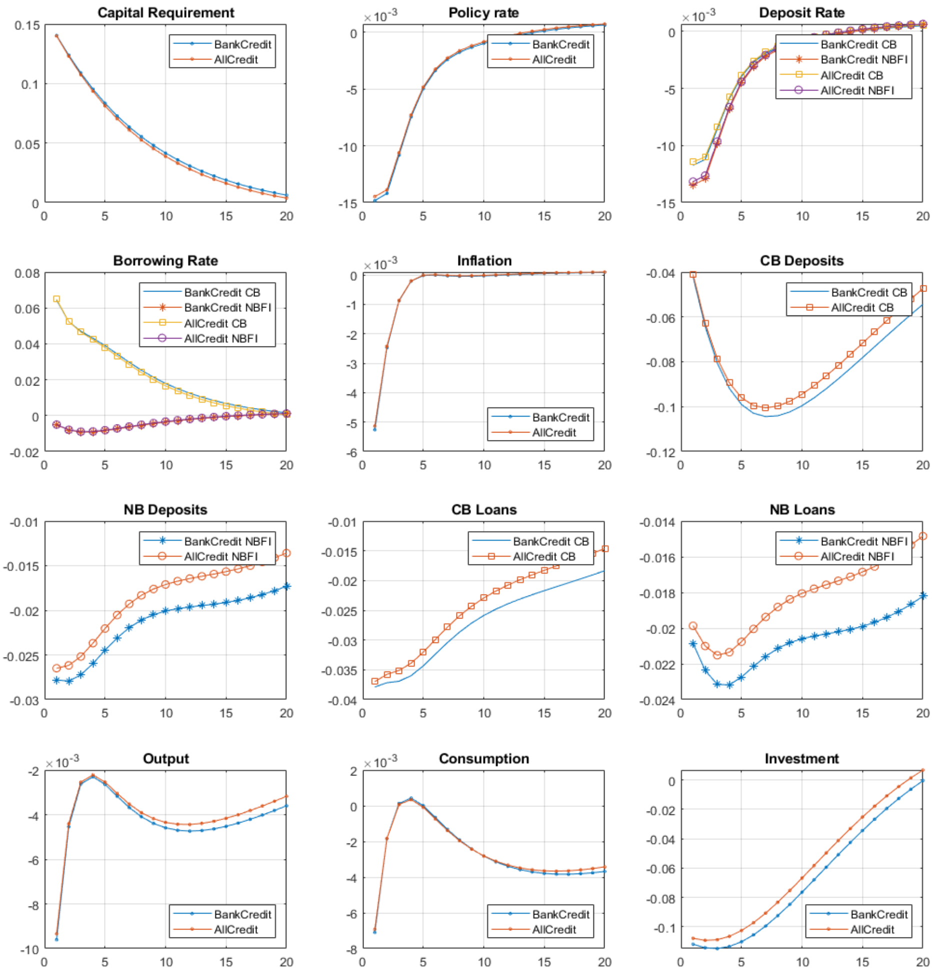

Figure 3.7: Impulse response functions to GSIB capital surcharge shock when CCyB responds to the bank or aggregate credit. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. "BankCredit" refers to CCyB with bank credit. "AllCredit" refers to CCyB with aggregate credit.

Rule Magnitude This section simulates different values for sensitivity analysis. As Figure (3.8) shows, when the degree of responsiveness χ increases from one to five, investment volatility is further dampened by almost 30%. This result is due to the smaller decrease in the future price of physical capital if CCyB is more counter-cyclical. A stricter rule will affect future asset prices and ultimately affect borrowing at time t as the collateral value is tied to the expected value. This linkage shows that regulators' stance will impact real borrowing through asset prices. The downside is that it disproportionately benefits non-bank more: bank loans shrink 20% less while non-bank loans shrink 40% less. In this comparative statics exercise, the larger the χ, the better to dampen the credit cycle and the greater the credit leakage to NBFIs.

Impulse responses from capital requirement shock

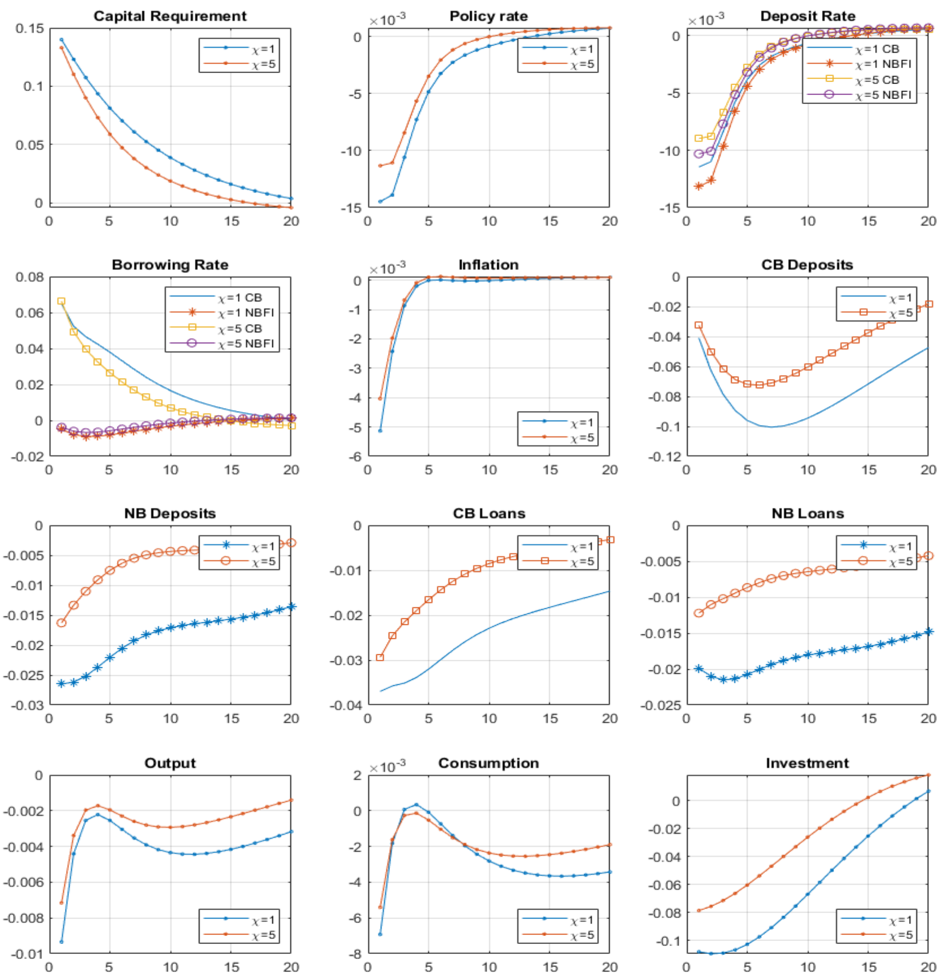

Figure 3.8: Impulse response functions to GSIB capital surcharge shock when CCyB is more responsive. Real variables are percentage deviations from the steady state. Interest rates and inflation are in absolute deviations from the steady state. "$\chi = 1$" is used before. "$\chi = 5$" means capital requirement increases more significantly in response to the same increase in credit gap growth.

3.4 Conclusion

Non-bank financial institutions help to dampen the impact of GSIB capital surcharge by creating credit leakage. The quantitative results suggest that NBFIs must be incorporated into the current framework to evaluate changes to bank regulations. If the capital surcharge is in place, a counter-cyclical buffer will further dampen credit cycles and more significant credit leakage towards NBFIs. Due to the collateral values tied to future asset prices, a more aggressive CCyB smooths financial cycles and creates even more considerable leakage.

Rule-based CCyB offers apparent benefits, but there are several caveats, and it has a long way to go. Empirically, the detrending credit-to-GDP gap is important to determine the optimal size of CCyB, as argued by Drehmann and Tsatsaronis (2014). Further empirical analysis is needed as the potential structural break in commercial bank operation will affect the trend due to interest on reserves, affecting the prescription shortly after the Great Financial Crisis. When implementing, there are two potential asymmetries to take into account. The first one is that the increasing capital buffers are more accessible and cost-effective in credit booms, as argued by Shim (2013). The other asymmetry is that Shim (2013) argues it is crucial to consider banks' operating strategy. For example, if banks have more non-interest incomes, such as asset management and investment banking, then these banks' capital buffers should be lower. Heterogeneity is an important thing to consider, even among banks. Clancy and Merola (2017) The third one is about another heterogeneity: the credit to GDP gap performs worse in the release phase of the credit cycle, so we need to take this into account as well. Similar findings in Repullo and Saurina (2011) on the release phase.

The structural framework needs to analyze the tradeoff between smoothing financial cycles and credit leakage, potentially enlarging the cycle. The counter-cyclicality needs to be evaluated against credit leakage. The possible direction could be reducing the leakage from NBFI reform. Future Basel framework needs to increase non-bank regulation to complement Basel III regulation on commercial banks as money market funds and repo markets are already subject to closer monitoring and tighter regulation to reduce run risk and liquidity squeeze. Lastly, this paper only studies the interaction between the capital surcharge and counter-cyclical buffer; the interaction between CCyB and other key Basel III pillars, such as net stable funding ratio and liquidity coverage ratio, needs further examination.

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