



HAL
open science

Essays on the Transmission Channel of Monetary Policy into the Banking System

Juan Daniel Hernández Colmenares

► **To cite this version:**

Juan Daniel Hernández Colmenares. Essays on the Transmission Channel of Monetary Policy into the Banking System. Economics and Finance. Université Paris-Saclay, 2023. English. NNT : 2023UP-ASI018 . tel-04406262

HAL Id: tel-04406262

<https://theses.hal.science/tel-04406262>

Submitted on 19 Jan 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Essays on the Transmission Channel of
Monetary Policy into the Banking
System
*Essais sur le Canal de Transmission de La Politique
Monétaire dans le Secteur Bancaire*

Thèse de doctorat de l'université Paris-Saclay

École doctorale n° 630: Droit, Économie, Management (DEM)
Spécialité de doctorat: Sciences économiques
Graduate School : Économie - Management
Référent : ENS Paris-Saclay

Thèse préparée dans l'unité de recherche **CEPS (Université Paris-Saclay, ENS Paris-Saclay, Centre d'Économie de l'ENS Paris-Saclay)**, sous la direction de **Hubert KEMPF**, professeur émérite

Thèse soutenue à Gif-sur-Yvette, le 5 Décembre 2023, par

Juan Daniel HERNÁNDEZ COLMENARES

Composition du jury

Membres du jury avec voix délibérative

Eleni ILIOPULOS Professeure, Université d'Évry Paris-Saclay	Présidente
Antonia LÓPEZ-VILLAVICENCIO Professeure, Université Paris-Nanterre	Rapportrice & Examinatrice
Vincent BOUVATIER Professeur, Université Paris-Est Créteil Val de Marne	Rapporteur & Examineur
Michel GUILLARD Professeur, Université d'Évry Paris-Saclay	Examineur
Guillaume PLANTIN Professeur, Sciences Po Paris	Examineur
Jean-Guillaume SAHUC Professeur associé, Université Paris-Nanterre Conseiller recherche sénior, Banque de France	Examineur

Titre: Essais sur le Canal de Transmission de La Politique Monétaire dans le Secteur Bancaire

Mots clés: Politique monétaire, Transmission hétérogène, Actifs liquides de haute et de basse qualité, Secteur bancaire, Méthodes de Projection Locale, Fourniture optimale de liquidités

Résumé: Cette thèse aborde deux questions fondamentales. Premièrement, elle examine si la politique monétaire se transmet de manière hétérogène entre les différentes banques. Pour ce faire, cette étude met en lumière l'hétérogénéité de la composition des actifs liquides de haute et de basse qualité au sein du secteur bancaire aux États-Unis, puis elle estime de manière empirique comment cette hétérogénéité influence la transmission de la politique monétaire.

Deuxièmement, elle explore les éventuels effets secondaires des politiques visant à améliorer les services de liquidité offerts par les institutions financières. Cette recherche s'articule autour du développement et de la résolution d'un modèle théorique spécialement conçu pour analyser la fourniture optimale de liquidités dans le contexte d'économies concurrentielles, où les contrats bancaires optimaux restreignent l'accès aux services financiers

Title: Essays on the Transmission Channel of Monetary Policy into the Banking System

Keywords: Monetary policy, Heterogeneous transmission, High- and low-quality liquid assets, Banking sector, Local Projection Methods, Optimal liquidity provision

Abstract: This thesis addresses two fundamental questions. First, it investigates whether monetary policy transmits heterogeneously across banks. To do so, this study highlights the heterogeneity in the composition of high- and low-quality liquid assets within the U.S. banking sector and empirically estimates how this heterogeneity influences monetary policy transmission.

Second, it explores the potential secondary effects of policies aimed at improving the liquidity services offered by financial institutions. This inquiry is approached by developing and solving a theoretical model designed to analyze optimal liquidity provision in competitive economies where optimal banking contracts limit access to financial services.

Summary

This thesis is centered around two inquiries:

1. Does the effect of monetary policy on the banking sector is shaped by the composition of liquid assets? The research investigates how changes in monetary policy impact various aspects of banks' operations, including deposit flows, loan growth, liquidity creation, and profitability. Specifically, an empirical exercise is implemented to estimate the differences in how banks respond to high-frequency identified monetary policy shocks conditional on high- and low-quality liquid assets. To estimate the dynamic and heterogeneous responses, the thesis utilizes local projection methods on a sample of commercial U.S. banks. Additionally, the research addresses methodological challenges related to endogeneity and other potential sources of bias and explores alternative strategies to enhance the accuracy of the estimated dynamics.

Overall, the research provides new insights into how the composition of liquid assets shapes the effects of monetary policy on banks. In response to contractionary monetary shocks, the findings indicate that high-quality liquidity helps stabilize deposit flows in the short term but negatively impacts profit margins. Furthermore, it does not significantly affect loan growth or liquidity creation. In contrast, low-quality liquidity has more persistent effects, leading to increased deposit outflows, reduced loan growth, and lower profitability.

2. Do policies aimed at enhancing the liquidity provision of financial institutions unintentionally affect access to financial services? The main objective is to build a theoretical model apt for investigating the optimal provision of liquidity in competitive economies, where optimal banking contracts may not necessarily align with access to financial services. This thesis devises a theoretical model featuring a canonical banking problem as in Diamond and Dybvig (1983) in a framework with entry barriers to financial services. The research provides a characterization of the competitive equilibrium, revealing two sources of inefficiencies. In competitive markets with financial frictions, banks tend to offer ex-ante inefficient deposit contracts and, furthermore, restrict households' access to their services. This constrained access compels households to rely on assets that provide inefficient liquidity insurance. The model lays the groundwork for further exploration into identifying liquidity-related policies aimed at improving not only the liquidity insurance of deposit contracts but also increasing access to financial services.

In summary, this research provides valuable insights into the relationship between monetary policy, liquidity, and the banking sector. It offers a nuanced understanding of how different types of liquid assets influence the responses of banks to changes in monetary policy. These findings have practical implications for policymakers and regulators in their efforts to manage the stability and efficiency of the financial system.

Résumé

Cette thèse se concentre sur deux questions principales :

1. La composition des actifs liquides influence-t-elle l'effet de la politique monétaire sur le secteur bancaire ? Cette recherche examine comment les variations de la politique monétaire impactent divers aspects des opérations bancaires, notamment les flux de dépôts, la croissance des prêts, la création de liquidités et la rentabilité. Plus précisément, un exercice empirique est réalisé pour estimer les différences dans la façon dont les banques réagissent aux chocs de politique monétaire identifiés à haute fréquence, en fonction des actifs liquides de haute et de basse qualité. Pour estimer les réponses dynamiques et hétérogènes, cette thèse utilise des méthodes de projection locale sur un échantillon de banques commerciales aux États-Unis. De plus, cette recherche aborde les défis méthodologiques liés à l'endogénéité et à d'autres sources potentielles de biais, et explore des stratégies alternatives pour améliorer la précision des dynamiques estimées.

De manière générale, ce travail de recherche apporte de nouvelles perspectives sur la manière dont la composition des actifs liquides façonne les effets de la politique monétaire sur les banques. En réponse aux chocs monétaires restrictifs, les résultats indiquent que la liquidité de haute qualité contribue à stabiliser les flux de dépôts à court terme mais a un impact négatif sur les marges bénéficiaires. Elle n'a de plus pas d'effet significatif sur la croissance des prêts ou la création de liquidités. En revanche, la liquidité de basse qualité a des effets plus persistants, entraînant des sorties de dépôts accrues, une croissance des prêts réduite et une moindre rentabilité.

2. Les politiques visant à améliorer la fourniture de liquidités par les institutions financières affectent-elles involontairement l'accès aux services financiers ? L'objectif principal est de construire un modèle théorique adapté à l'étude de la fourniture optimale de liquidités dans les économies compétitives, où les contrats bancaires optimaux ne s'alignent pas nécessairement avec l'accès aux services financiers. Cette thèse élabore un modèle théorique présentant un problème bancaire canonique tel que décrit dans Diamond and Dybvig (1983), dans un cadre avec des barrières à l'entrée dans les services financiers. Cette recherche propose une caractérisation de l'équilibre concurrentiel, révélant deux sources d'inefficacités. Dans les marchés concurrentiels avec des frictions financières, les banques ont tendance à proposer des contrats de dépôt ex ante inefficaces et, en outre, à restreindre l'accès des ménages à leurs services. Cet accès limité contraint les ménages à compter sur des actifs qui fournissent une assurance de liquidité inefficace. Le modèle établit des bases pour une étude future visant à identifier des politiques liées à la liquidité qui amélioreraient non seulement l'assurance de liquidité des contrats de dépôt, mais qui contribueraient également à accroître l'accès aux services financiers.

En résumé, cette recherche apporte des perspectives précieuses sur la relation entre la

politique monétaire, la liquidité et le secteur bancaire. Elle offre une compréhension nuancée de la manière dont différents types d'actifs liquides influencent les réactions des banques aux changements de politique monétaire. Les conclusions ont des implications pratiques pour les décideurs et les régulateurs dans leurs efforts pour gérer la stabilité et l'efficacité du système financier.

Acknowledgements

I extend my profound gratitude to the Center for Economics at Paris-Saclay at the École normale supérieure Paris-Saclay for furnishing me with invaluable resources and creating an environment crucial for the completion of this research. My sincere appreciation goes to my thesis advisor, Professor Hubert Kempf, for his unwavering guidance and mentorship throughout this academic journey. His expertise, patience, and commitment have played a pivotal role in shaping my research and fostering my academic growth. Additionally, I express my heartfelt gratitude to all members of the jury for dedicating their time to reading and providing insightful comments on my thesis, as well as engaging in valuable discussions.

I would like to extend my gratitude to the members of all the institutions that welcomed me during my studies. This includes the esteemed faculty members of the CEPS (ENS Paris-Saclay), the EPEE (Université d'Évry), and the CREST (Institut Polytechnique de Paris), whose camaraderie and intellectual exchange enriched my doctoral experience. I am also grateful to the members of the European University Institute and the Universidad del Rosario, excellent academic institutions where I had the privilege of being a visiting Ph.D. student, for their warm welcome and collaborative spirit. Special thanks go to Professors Russell Cooper and Fernando Jaramillo for their precious mentoring, lessons, and engaging discussions during my visits. I am also grateful for the opportunity to have served as a teaching assistant at the Université d'Évry, where I actively engaged with students and colleagues. This experience has proven to be both fulfilling and personally rewarding.

I would like to extend my gratitude to my colleagues at the CEPS—Alix, Cyril, Guillaume, Jawad, Julien, Ninon, Sébastien, Thibault, Aymeric, Benjamin, Imen, Ibrahima, Juho, Malak, and Mathilde. Additionally, my appreciation goes out to the professors and all members of the research center, Thomas Vendryes, Morgan Patty, Michael Greinecker, Olivier Bos, François Pannequin, Akiko Azzopardi, and Oscar Peña.

I wish to express my profound appreciation to my friends and family. Dear Alicia, Ana Rita, Angelo, Céline, Elmar, Gerson, Iván, Jardany, Johanna, Juan Camilo, Katherine, Marcia, Mario, Natalia, Radia, and Sory, your presence and support have left an indelible mark on my heart, and I am deeply grateful for the significant contributions you have made to my well-being. To my family members Paulina, Magola, Guillermo, Astrid, Luis Guillermo, Rocio, Luis Gui, Memo, Laura, Jaquito, Mati, and Tobi, your unwavering kindness has been a constant source of warmth and encouragement, guiding me through the challenging phases of this journey. I am immensely thankful for your understanding and wholehearted endorsement.

Finally, I dedicate this thesis to my beloved parents, Ligia and William. Your dedication and love have been a guiding light throughout my life. I am profoundly grateful for the values, support, and encouragement you have provided me. Your unwavering belief in my abilities has fueled my determination and resilience. As I journey through life, I carry the lessons you have taught me and the love you have given me. Thank you for being my pillars of strength and shaping me into who I am today.

With all my love,

Daniel.

Contents

Summary	i
Résumé	iii
Acknowledgements	vi
1 Global Introduction	1
1.1 Liquid Assets and the Banking Business Model	2
1.1.1 Definition	2
1.1.2 Role within Banks	3
1.1.3 Relevance in the U.S. Banking System	5
1.2 Banking Channels of Monetary Policy	6
1.2.1 Bank Lending Channel	6
1.2.2 Bank Capital Channel	7
1.2.3 Balance Sheet Channel	8
1.2.4 Deposits Channel	8
1.2.5 Risk-Taking Channel	11
1.2.6 Interest rate risks, profitability, and bank net worth	12
1.2.7 Interest Rates Pass-Throughs	13
1.3 Institutional Background	15
1.3.1 Monetary Policy Frameworks	16
1.3.2 Banking Regulatory Framework	20
Appendices	27
2 Monetary Policy Transmission and the Role of Liquid Assets	33
2.1 Introduction	33
2.2 Monetary Policy Channels and the Role(s) of Liquidity	39
2.3 Data	43
2.3.1 Variables	43
2.3.2 Sample Selection	45
2.3.3 Descriptive Statistics	46
2.4 Empirical Specification	53
2.4.1 Benchmark Specification	53
2.4.2 Exploring Non-Linearities	56
2.4.3 Alternative Specifications	56
2.5 Effect on Deposit Flows	57
2.5.1 Results on Bank-Level Estimation	57
2.5.2 Robustness and Extensions	60
2.6 Effect on Loans Growth	62

2.6.1	Results on Bank-Level Estimation	63
2.6.2	Robustness and Extensions	64
2.7	Effects on Banks Liquidity Creation	66
2.7.1	Results on Bank-Level Estimation	66
2.7.2	Robustness and Extensions	67
2.8	Effect on Banks' Profits and Income	69
2.8.1	Results on Bank-level Estimations using the Cash Flow Approach	70
2.9	Unconventional Monetary Policies	74
2.9.1	Results on Bank-level Estimations	75
2.10	Conclusion	82
Appendices		83
3	Robustness Assessments: Investigating Permanent Heterogeneity in Monetary Policy Transmission and Addressing Endogeneity Concerns	133
3.1	Introduction	133
3.2	Consequences of Permanent Heterogeneity in the Transmission Channel .	134
3.2.1	Controlling for Within Bank Liquidity Variation	134
3.2.2	Controlling for Permanent Adjustments in Liquidity Ratios	140
3.3	Consequences of Endogeneity - Reverse Causality	145
3.3.1	Bartik's Instruments	145
3.3.2	Empirical Specification: IV Approach	146
3.3.3	Results	146
3.4	Conclusion	150
Appendices		152
4	Liquidity Provision in a Simple Banking Model with Entry Barriers	161
4.1	Introduction	161
4.2	Model	163
4.2.1	Households	164
4.2.2	Depository Institutions	165
4.2.3	Entrepreneur	168
4.2.4	Government	168
4.2.5	Market Clearing Conditions	169
4.2.6	Equilibrium with Passive Governement	169
4.3	Conclusion	172
Appendices		175

List of Figures

Figure 1.1	Evolution of Asset-Side Balance Sheet Composition in the U.S. Banking System	6
Figure 1.2	Canonical Bank Lending Channel	7
Figure 1.3	Canonical Bank Capital Channel	8
Figure 1.4	Deposits Channel	10
Figure 1.A.1	Policy Rates and Interest Rates	27
Figure 2.1.1	Evolution of Liquid Assets by Quality in the U.S. Banking System	34
Figure 2.3.1	High-Frequency Interest Rate Surprises Decomposition: Monetary vs. Non-monetary Surprises	45
Figure 2.3.2	Cross-Sectional Heterogeneity in Liquidity Ratios	48
Figure 2.3.3	Liquidity Ratios and Banks' Characteristics: Correlation Analysis Excluding Business Cycle Fluctuations and Bank-Specific Business Models	52
Figure 2.5.1	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Baseline)	59
Figure 2.5.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Non-linearities)	60
Figure 2.6.1	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Baseline)	64
Figure 2.6.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Non-linearities)	65
Figure 2.7.1	Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Baseline)	67
Figure 2.7.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Non-linearities)	68
Figure 2.8.1	Monetary Tightening Shock Conditional on HQ-Liquidity: Effect on Profit Margins - Part I (Baseline)	71
Figure 2.8.2	Monetary Tightening Shock Conditional on HQ-Liquidity: Effect on Profit Margins - Part II (Baseline)	71
Figure 2.8.3	Monetary Tightening Shock Conditional on Liquidity: Effect on Profit Margins (Non-linearities)	72
Figure 2.8.4	Monetary Tightening Shock Conditional on LQ-Liquidity: Effect on Profit Margins - Part I (Baseline)	73
Figure 2.8.5	Monetary Tightening Shock Conditional on LQ-Liquidity: Effect on Profit Margins - Part II (Baseline)	73
Figure 2.8.6	Monetary Tightening Shock Conditional on LQ-Liquidity: Effect on Profit Margins (Non-linearities)	74
Figure 2.9.1	Conventional and Unconventional Monetary Policy Shocks	76

Figure 2.9.2	Monetary Tightening Conditional on HQ-Liquidity: Effect on Total Deposit Growth (Baseline using Unconventional Shocks) . . .	78
Figure 2.9.3	Monetary Tightening Conditional on Liquidity: Effect on Total Loan Growth (Baseline using Unconventional Shocks)	79
Figure 2.9.4	Monetary Tightening Conditional on Liquidity: Effect on Liquidity Creation (Baseline using Unconventional Shocks)	80
Figure 2.9.5	Monetary Tightening Conditional on Liquidity: Effect on Interest Rate Margins (Baseline using Unconventional Shocks)	81
Figure 2.A.1	Testing Estimates of Betas: Replication Drechsler, Savov, and Schnabl (2021)	90
Figure 2.A.2	Testing Estimates of Bank HHI: Replication Drechsler, Savov, and Schnabl (2021) Drechsler, Savov, and Schnabl (2021)	92
Figure 2.B.1	Heterogeneity on High Quality Liquid Assets	94
Figure 2.B.2	Heterogeneity on Low-Quality Liquid Assets	95
Figure 2.B.3	Heterogeneity on Residualized Liquidity Ratios	95
Figure 2.B.4	Cross-sectional Heterogeneity on Liquidity Creation	97
Figure 2.B.5	Cross-sectional Heterogeneity on Profitability	97
Figure 2.B.6	Cross-sectional Heterogeneity on Other Banks' Characteristics .	98
Figure 2.B.7	Correlations with respect to Other Banks' Characteristics (Controlling for bank and time fixed effects)	101
Figure 2.B.8	Correlations Controlling for Other Variables	103
Figure 2.D.1	Monetary Tightening Shock Conditional on Liquidity: Effect on Different Deposit Accounts (Baseline)	107
Figure 2.D.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Core Deposit Flows (Baseline)	109
Figure 2.D.3	Monetary Tightening Shock Conditional on Liquidity: Effects on Total Deposit Flows (Baseline)	110
Figure 2.D.4	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Accounting for Hedging)	112
Figure 2.D.5	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Accounting for Supply-Demand Effects)	112
Figure 2.E.1	Monetary Tightening Shock Conditional on Liquidity:	113
Figure 2.E.2	Monetary Tightening Shock Conditional on Liquidity: Effects on Total Loans Growth (Baseline)	114
Figure 2.E.3	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Accounting for Hedging)	116
Figure 2.E.4	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Accounting for Supply-Demand Effects) . .	116
Figure 2.F.1	(Δ Fed Funds Rate)	117
Figure 2.F.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Baseline)	118
Figure 2.F.3	Removing Liquid Assets	121
Figure 2.G.1	Monetary Tightening Shock Conditional on Total Liquidity: Effect on Profit Margins (Baseline)	122
Figure 2.G.2	Monetary Tightening Shock Conditional on HQ-Liquidity: Effects on Profit Margins (Baseline)	123

Figure 2.G.3	Monetary Tightening Shock Conditional on LQ-Liquidity: Effects on Profit Margins (Baseline)	125
Figure 2.H.1	Monetary Tightening Conditional on Liquidity: Effect on Total Equity Ratio (Baseline using Unconventional Shocks)	127
Figure 3.2.1	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Within Variation)	136
Figure 3.2.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Within Variation)	137
Figure 3.2.3	Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Within Variation)	138
Figure 3.2.4	Monetary Tightening Conditional on Liquidity: Effect on Profit Margins (Within Variation)	139
Figure 3.2.5	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (State-dependent LP)	142
Figure 3.2.6	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (State-dependent LP)	142
Figure 3.2.7	Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (State-dependent LP)	143
Figure 3.2.8	Monetary Tightening Shock Conditional on Liquidity: (State-dependent LP)	144
Figure 3.3.1	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Bartik-IV)	147
Figure 3.3.2	Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Bartik-IV)	148
Figure 3.3.3	Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Bartik-IV)	148
Figure 3.3.4	Monetary Tightening Shock Conditional on Liquidity: Effect on Net Interes Margins (Bartik-IV)	149
Figure 3.3.5	Monetary Tightening Shock Conditional on Liquidity: Effect on Equity Value (Bartik-IV)	149
Figure 3.A.1	Heterogeneity in the Response of Liquidity Ratios to Monetary Shocks	152
Figure 3.A.2	Unconditional Effect of Monetary Tightening Shocks into Liquidity Ratios	153
Figure 3.B.1	Heterogeneity in Treatment, Instrument and Instrumented Treatment	154
Figure 3.B.2	Cross Sectional Heterogeneity in Predetermined Shares of Assets in 2013q2	155
Figure 3.B.4	Cross-sectional Heterogeneity in Relative Growth Rates	156
Figure 3.B.3	Time Series of the Liquidity Portfolio Shares by Bank Size	157
Figure 4.2.1	Time of Events	168
Figure 4.2.2	Incentive Compatible Deposit Contracts	171

List of Tables

Table 1.A.1	Regulatory Categories and Capital Requirements (2019)	28
Table 1.A.2	Regulatory Categories and Liquidity Requirements (2019)	29
Table 2.3.1	Normalization Parameters	46
Table 2.3.2	Statistics on Liquidity Ratios	47
Table 2.3.3	Banks' Characteristics Grouping by Quintiles	50
Table 2.A.1	Classification of Balance Sheet Items	84
Table 2.A.2	Descriptive Statistics on Int. Rates and Monetary Policy Shocks	89
Table 2.B.1	Liquidity Portfolio Grouping by Quintiles	96
Table 2.B.2	Characteristics Affecting Monetary Policy Transmission Grouping by Quintiles	98
Table 2.B.3	Transition Matrices for Quarterly Liquidity Ratios	99
Table 2.B.4	Summary Statistics: Correlation Structure	100

Chapter 1

Global Introduction

Monetary policy is pivotal in shaping the macroeconomic environment and influencing economic outcomes. One crucial aspect of monetary policy is the transmission channel through which changes in policy instruments impact the broader economy. Among these channels, the transmission of monetary policies into the banking system stands out as a crucial mechanism that deserves comprehensive analysis.

This doctoral thesis delves into the intricacies of the transmission channels of monetary policy into the banking system. These channels involve a complex interplay of economic, financial, regulatory, and behavioral factors. Typically, changes in monetary policy stances are expected to ripple through the economy, impacting the demand for loans, the creditworthiness of borrowers and lenders, and the overall health of financial markets, among other variables. However, banks, each with diverse portfolios of assets and liabilities, employing different business models, and operating in various market conditions, may experience varying influences of monetary policy.

Given that the impact of policies may not be uniform across all financial institutions, the primary aim of this research is to identify potential characteristics that could either mitigate or amplify the intended effects of monetary policies. Specifically, this work concentrates on examining how the composition of liquid assets influences the transmission of monetary policies. This is not a new research topic; however, this thesis explores new empirical strategies that contribute to a better understanding of the importance of liquid assets in financial systems. For this purpose, this manuscript is divided as follows:

This chapter, **Chapter 1**, presents a global introduction. What follows begins by defining liquid assets and outlining the reasons for banks to invest in them. Next, it delves into the theoretical links between monetary policy and banking outcomes. Lastly, it offers insights into the institutional framework defining the U.S. banking system. This chapter introduces key institutional and theoretical concepts that will support the empirical exercise in the following chapter.

Chapter 2 investigates the role of heterogeneity in monetary policy transmission in the banking system, explicitly examining the role played by liquid assets in the transmission mechanisms. The chapter presents the various mechanisms through which changes in monetary policy affect banks' outcomes, such as their lending behavior, funding sources, and cash flows. Empirical evidence draws on different econometric exercises applied to a dataset encompassing banking institutions in the U.S.

Chapter 3 extends the empirical evidence of Chapter 2 by conducting robustness exercises. The chapter discusses methodological challenges and applies alternative strategies to improve the identification of the effect of liquid assets in monetary policy transmission.

Finally, **Chapter 4** studies the liquidity efficiency of deposit contracts offered in the banking industry with entry barriers. In a simple framework, banks collect deposits in competitive markets and offer welfare-improving deposit contracts to households. In competitive markets, the benefits of banking services are exclusively offered to specific households, so the excluded fraction of the population uses less efficient liquidity services.

1.1 Liquid Assets and the Banking Business Model

1.1.1 Definition

Traditionally, an asset is deemed liquid if its holder can readily and cost-effectively convert it into cash to meet immediate liquidity requirements (Berger and Bouwman, 2009). Nevertheless, since certain assets that are not inherently liquid may exhibit this trait during certain periods, it becomes necessary to consider additional characteristics in refining the definitions of liquidity. The Basel Committee on Banking Supervision¹ has recently put forth a more extensive set of criteria for evaluating whether an asset qualifies as a liquid asset. This definition emphasizes three primary aspects: fundamental characteristics, market-related characteristics, and operational requirements.

Fundamental characteristics relate to attributes that indicate an asset's vulnerability to different risk factors², the way the asset is structured³, its association with other risky assets, and its level of acceptance within trading markets. In that order, an asset is deemed fundamentally liquid if it has minimal exposure to diverse risk sources, if its structure permits transparent valuation with a high level of certainty about its true worth, and if it exhibits a low correlation with other high-risk assets.

Market-related characteristics refer to aspects that reflect the operability of the markets in which assets are traded, price volatility, and the demand's behaviors during periods of stress. Specifically, assets are liquid if traded in markets with a large and diverse number of market participants. Usually, high trading volumes and low market concentration narrow low bid-ask spreads and increases the reliability of the liquidity in the market. Furthermore, liquid assets are associated with the flight-to-safe property, indicating that investors recognized the asset as a haven during periods of market stress.

Operational requirements refer to constraints that might impede timely monetization during a stressful period. Usually, those factors that deter the effectiveness of processes for monetization are related to the acceptance of assets as collateral through outright sale

¹See BIS (2019).

²The risk exposure criteria are broad and encompass, for instance, credit/default risks associated with the creditworthiness of the issuer and the degree of subordination of the asset; interest rate risk, which pertains to the asset's sensitivity to changes in interest rates; legal risk, relating to property rights; inflation risk, involving the asset's sensitivity to changes in aggregate prices; and foreign exchange risk, considering the asset's sensitivity to changes in exchange rates and its ease of convertibility into other currencies.

³This refers to the how the return of the asset (cash-flows) is linked to an underlying asset, the pre-defined features like maturity date, coupon date, capital protection level etc.

or repo transactions.

In summary, this more thorough definition of liquid assets aligns with key characteristics, emphasizing not only the swift convertibility into cash but also aspects like the relatively low-risk exposure, the ability to command high fire sale prices, and the widespread acceptance as collateral. However, is it possible for assets to perfectly exhibit these properties at all times? Assets may not always perfectly exhibit these properties in practice. Nonetheless, certain assets are inherently more likely to be liquid than others. This observation has led to the categorization of liquid assets based on quality criteria. High-quality liquid assets encompass those assets that are more likely to consistently exhibit these characteristics regardless of the state of the economy. In contrast, low-quality liquid assets, even if they meet risk-weighting and credit-rating criteria, tend to lose these properties during certain economic episodes.

This categorization is now reflected in the adoption of new liquidity requirements (See section 1.3.2.2), underscoring the importance of a comprehensive definition of liquid assets.

1.1.2 Role within Banks

Besides these definitions, another fundamental question arises: why do banks choose to hold liquid assets? The core functions of the banking business include accepting deposits from individuals, businesses, and institutions and utilizing those funds to provide loans and credit to borrowers⁴.

From a general perspective, three main functions define the banking model: liquidity transformation, risk transformation, and maturity transformation. Maturity transformation consists of issuing short-term liabilities to finance long-term assets, risk transformation of issuing riskless liabilities to finance risky assets, and liquidity transformation of issuing liquid liabilities to fund illiquid assets. The alignment or divergence of these functions depends on the specific assets and liabilities involved. For example, risk and liquidity transformation coincide when banks issue riskless liquid liabilities (e.g., insured deposits) to finance risky illiquid assets (e.g., loans) but diverge when financing risky liquid assets (e.g., equity). Similarly, liquidity and maturity transformation align when banks issue short-term deposits to fund long-term illiquid assets (e.g., C&I loans), while it diverges when financing long-term liquid assets (e.g., mortgage securities). Altogether, these functions are vital because they provide long-term credit, liquidity, and saving services to businesses and individuals.

Banks mainly generate profits from these functions by earning deposit spreads, i.e., lending at rates higher than the funding rates. For instance, through maturity transformation, banks can profit from term premiums (Paul, 2023), through risk transformation, they can benefit from risk premiums (Bernanke, Gertler, and Gilchrist, 1999), and through liquidity transformation, they can benefit from liquidity premiums (Bianchi and Bigio, 2022)⁵.

⁴In addition, banks offer a wide range of financial products and services like checking and savings accounts, credit cards, mortgages, personal loans, business loans, wealth management services, investment products, and more.

⁵Term premiums refer to the difference between long-term and short-term interest rates. Risk premiums signify the differential between the interest rates on risky and safe assets. Liquidity premiums represent the distinction in interest rates between illiquid and liquid assets.

However, by maximizing these sources of profits, banks became exposed to interest rates, defaults, and liquidity risks.

Consider a scenario where a bank invests in long-term assets using short-term liabilities (maturity transformation). If short-term interest rates increase, the bank's funding costs also increase. However, their profit margins decrease since the bank's assets have fixed interest rates (assuming no hedging or insurance measures). This can lead to a drop in the bank's stock prices and potentially insolvency⁶. Imagine another bank investing in illiquid assets using liquid deposits (liquidity transformation). If depositors unexpectedly decide to withdraw their deposits, the bank may face liquidity shortages, and they might become insolvent⁷.

Due to these particularities, banks are forced to implement risk management strategies that involve structuring their balance sheets to limit (or not) their risk exposure. Liquid assets are helpful tools to balance out different sources of risk; subsequently, they become fundamental to banking operations and risk management. In particular, the reasons prompting banks to maintain substantial holdings of liquid assets are multifaceted⁸. A summarized list of the main determinants is as follows:

1. Risk Management Perspective

Liquid assets play a twofold role in banks' risk management. Banks use them as instruments for hedging liquidity risk and interest rate risks.

- (a) **Liquidity Risk Management:** The primary purpose of holding liquid assets is to ensure the ability to accommodate both expected and unexpected cash withdrawals from customers (Poole, 1968)⁹. Closely related, liquid assets play a crucial role in reducing the likelihood of bank runs (Diamond and Dybvig, 1983) and might act as a buffer, protecting depositors from potential loan losses.

Other strands of the literature indicate that liquid assets, as a liquidity risk management tool, might play a role in the information-revealing process between banks and clients. Evidence is ambiguous in this regard. For some cases, liquid assets might substitute other liquidity risk instruments (e.g., public disclosure), hence reducing banks' transparency (Raz, McGowan, and Zhao, 2022), while in other cases, it can signal a solid and well-diversified portfolio (Stulz, Taboada, and Dijk, 2022).

- (b) **Interest Rate Risk Management:**

The main attraction of a liquid asset for risk management considerations is its

⁶This is related to the interest rate risk exposure literature revised in the following section.

⁷This is related to the bank-run literature revised in Chapter 4.

⁸Compared to non-financial firms, the reasons are also different from those governing non-financial firms (See Stulz, Taboada, and Dijk, 2022)

⁹Liquidity management entails optimizing the allocation of resources between high-yield illiquid loans and low-yield liquid assets. This fundamental trade-off has been founded on the seminal work of Poole (1968), where liquidity management is embedded in a banking portfolio choice problem in which banks choose the optimal amount of liquid assets based on their exposure to liquidity shortfalls and the easiness of getting funds from interbank markets. Banks exploit intermediation margins to maximize profits by investing in high-yield investment opportunities (e.g., loans). Nevertheless, banks' exposure to liquidity risks creates incentives for banks to hold low-yield liquid assets.

capacity to be readily converted into cash. However, recent evidence suggests that banks also benefit from the duration of liquid assets to hedge interest rate risks (Drechsler, Savov, and Schnabl, 2021)¹⁰.

2. Portfolio Investment Perspective

- (a) Banks might have investment motives to hold liquid assets. Liquid assets might offer attractive risk returns when considering diversification benefits and low monitoring costs, among other factors (Stulz, Taboada, and Dijk, 2022). Hence, banks might choose them to improve the risk-adjusted expected performance of banks' portfolios

For instance, MBS are held since a) they are profitable and almost credit-free. b) good alternative when loan demand is relatively low or during housing booms (usually when households take out new mortgages or refinance old ones) (See Drechsler, Savov, and Schnabl, 2023).

- (b) Provides flexibility in reallocating resources: Since liquid assets are easily convertible, banks can use them to reallocate their portfolio in response to more profitable opportunities. (See Stulz, Taboada, and Dijk, 2022).
- (c) Self-insurance: The gains from acquiring assets at fire-sale prices make it attractive for banks to hold liquid assets. (See Acharya, Shin, and Yorulmazer, 2011)
- (d) Balance sheet synergies: The banking business is characterized by lending via commitments, which, like deposits, clients can unexpectedly takedown. This adds an extra motive to hold a provision of liquid assets to satisfy their potential needs. For instance, Kashyap, Rajan, and Stein (2002) highlights that when deposit withdrawals and commitment takedowns are imperfectly correlated, the two activities can share the costs of the liquid-asset stockpile.

3. Regulatory Requirements

Liquid assets are used to comply with regulatory mandates. Traditionally, cash is used to comply with reserve requirements, and more recently, other types of securities are used to fulfill newly implemented requirements¹¹. Recent evidence suggests that liquidity-requirement policies encourage banks to increase their holdings of liquid assets (See Sundaresan and Xiao, 2023, for the case of high-quality liquidity).

1.1.3 Relevance in the U.S. Banking System

These various uses, coupled with the evolving landscape of market events, have translated into an increased willingness among banks to hold liquid assets.

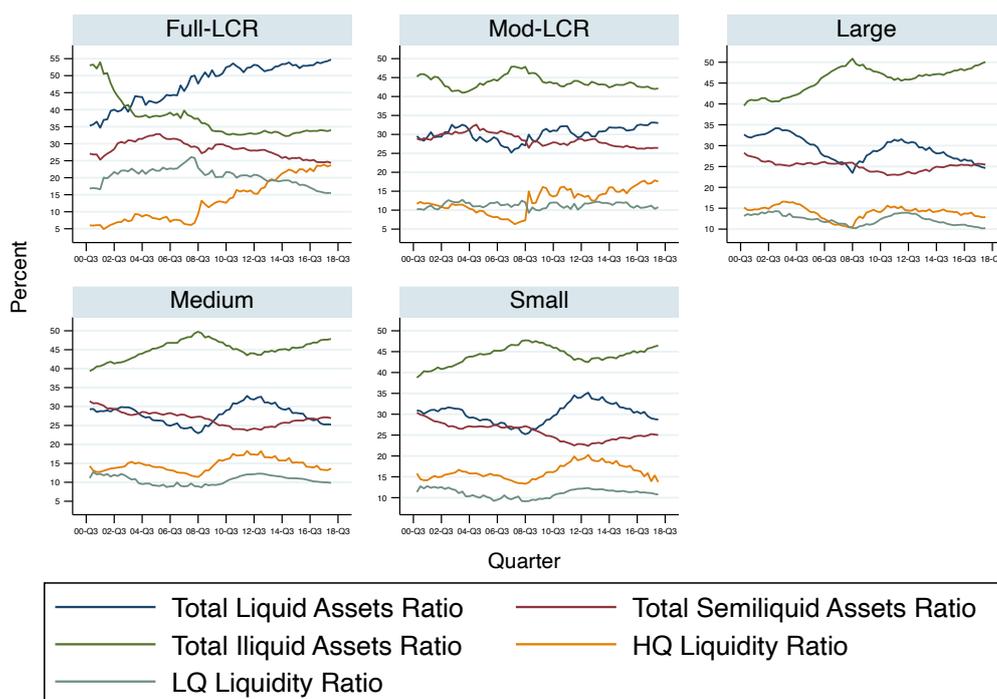
In the context of the U.S. banking system, Figure 1.1 illustrates how the participation of different asset types has evolved since the beginning of the 20th century. Notably, for the largest banks (LCR banks), liquid assets have consistently grown as a portion of their

¹⁰The value of long-term liquid assets falls in response to increases in short-term rates while the value of deposit franchise increases. This is explained in detail in Section 1.2.6.

¹¹This regulatory requirements are revised in Section 1.3.2.2.

asset portfolio, increasing from 35% in 2001 to 55% in 2018. Interestingly, investments in illiquid assets, such as loans, have decreased from 55% to a stable 30% during this period. Conversely, smaller banks typically maintain balance sheets consisting of 25% to 30% liquid assets, with the presence of liquid assets in their portfolios exhibiting a strong countercyclical pattern.

Figure 1.1: Evolution of Asset-Side Balance Sheet Composition in the U.S. Banking System



The figure illustrates the evolution of different asset categories based on the criteria of Berger and Bouwman (2009). The left axis reflects the ratios as a proportion of total assets. Full-LCR banks hold assets over \$250 billion, while Mod-LCR banks have assets between \$50 billion and \$250 billion. These banks are subject to liquidity coverage ratios. Banks with assets ranging from \$300 million to \$3 billion are small-sized, those with \$3 billion to \$10 billion are medium-sized, and those with assets between \$10 billion and \$50 billion are considered large banks. These graphs are based on data from the Call Reports for all U.S. commercial banks. The data sample covers the period from 2001q4 until 2018q1.

1.2 Banking Channels of Monetary Policy

To set the foundational knowledge necessary to delve into the empirical analysis of how monetary policy actions and the management of liquid assets influence the performance and stability of the banking sector, in this section, I introduce and discuss the different predictions proposed by the literature regarding the transmission of monetary policy into banks' outcomes.

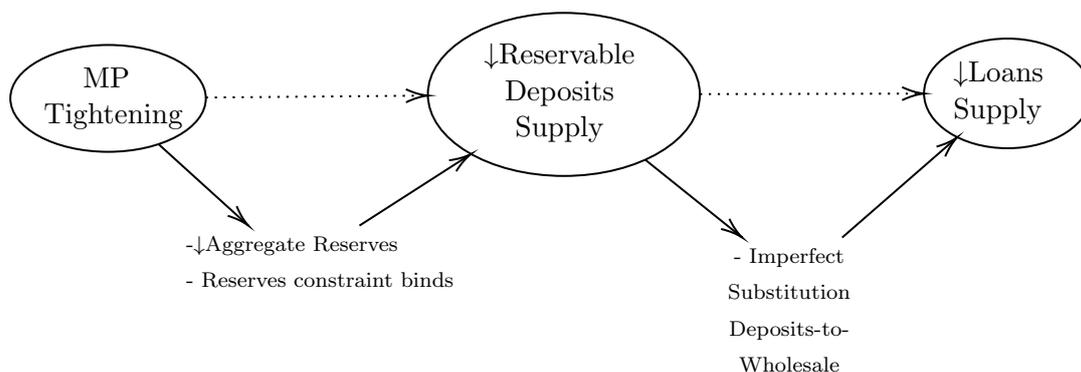
1.2.1 Bank Lending Channel

The bank lending channel (BLC) argues a causal relationship between monetary policy and banks' loan supply. In a nutshell, in response to monetary tightening, banks are forced

to contract the supply of (reservable) deposits. Due to the failure of the Modigliani-Miller theorem, banks are forced to contract lending supply since raising alternative funding is costly.

In the canonical version of the BLC Bernanke and Gertler (1995), this relationship is explained by the effect of monetary policy on systemwide reserves and how the contraction in aggregate reserves ultimately conditions the capacity of banks to raise reservable deposits. Specifically, a contractionary monetary shock via an open market operation reduces the aggregate level of reserves in the economy. Costly reserves limit banks' access to liquidity, so banks' reserve constraints start tightening. Banks must lower reservable deposits once they start experiencing a scarcity of reserves ($\frac{\partial \Delta_h RDep_{i,t}}{\partial mp_t} < 0$). The reduction of reservable deposits can be compensated by increased non-reservable liabilities (e.g., CDs, FED funds, equity, wholesale deposits, etc.). However, these alternative sources of funds are expensive, so the substitution is less than one-to-one. Ultimately, banks are forced to contract their loan supply if they operate with lower deposits due to costly alternative funding.

Figure 1.2: Canonical Bank Lending Channel



The main takeaway is that the transmission of monetary policy on lending is predicted to be negative ($\frac{\partial \Delta_h L_{i,t}}{\partial mp_t} < 0$). To be operational, banks must be liquidity-constrained in response to tightening monetary policy and have limited access to alternative funding sources.

1.2.2 Bank Capital Channel

The bank capital channel (BCC), pioneered by Van den Heuvel (2002), formalizes how changes in *capital adequacy* due to monetary policy affect banks' lending behavior.

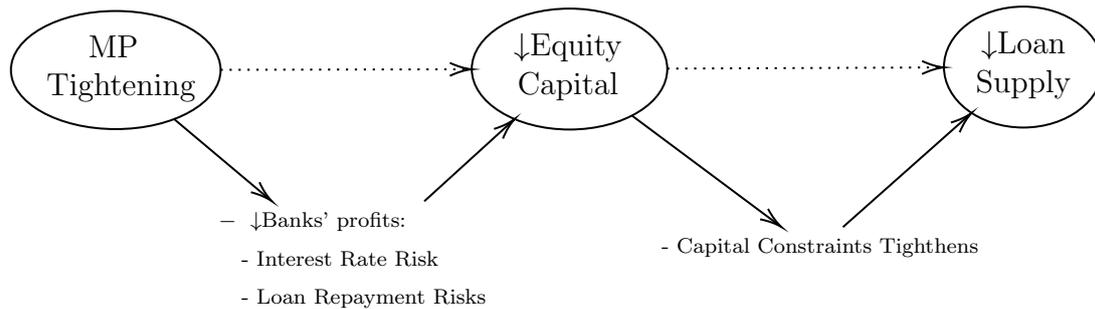
The channel involves two main stages. Initially, a contractionary monetary policy that increases loan default rates (due to slower economic activity) induces banks to experience reduced profitability. Consequently, banks' capitalization starts decreasing, and capital requirements start tightening. Like the BLC, since rising new equity is costly, capital requirements¹² compel banks to forgo profitable lending opportunities and allocate funds

¹²For a comprehensive review of risk-based capital requirements and leverage ratios, refer to Section 1.3.2

to assets not subject to regulations¹³. In the BCC, monetary policy leads weaker banks to cut back on new lending to maintain regulatory capital requirements¹⁴.

Notably, the BCC is operational if banks' capital responds endogenously to monetary policy. In the canonical BCC framework, a contractionary monetary policy shock negatively impacts profitability, directly translating into a weak capital position. However, the signs of these relationships are being debated in the existing literature. Due to the importance of these considerations, a discussion is left in section 1.2.6.

Figure 1.3: Canonical Bank Capital Channel



1.2.3 Balance Sheet Channel

The balance sheet channel (BSC), pioneered by Bernanke and Gertler (1989), primarily centers on the sensitivity of *the valuation* of banks' assets and liabilities to changes in interest rates. Its functioning relies on the differential effect of monetary policy on the *valuation* of assets relative to liabilities. Specifically, in response to a monetary tightening policy, the *book value* of assets is expected to decline by more than *the book value* of liabilities, thereby depressing net worth and forcing banks to shrink their balance sheets.

Contrary to the capital channel, whereby profits shocks are at the center of the mechanics, the balance sheet channel operates through equity-value shocks generated by monetary policy, which can tighten even more banks' constraints.

1.2.4 Deposits Channel

Recent versions of the BLC aim to identify different driving forces that explain the relationship between monetary policy and deposit supply. One alternative that has gained significant attention is the deposits channel (DC), named after Drechsler, Savov, and Schnabl (2017). What sets the DC apart is that it establishes a direct causal relationship between monetary policy and the supply of different deposit accounts, encompassing not only those subject to liquidity requirements, as seen in the BLC.

¹³Notice that banks' precautionary motives might be a source of amplification effects. While capital constraints may not always be binding, banks may limit lending to mitigate the risk of future capital inadequacy. With precautionary motives, banks become more sensitive to their capital constraints when monetary policy is tightened (making them care about hitting it).

¹⁴Note that there is an interaction between the BLC and the BCC. This occurs in two ways. Firstly, when risk-based capital requirements are binding, banks cannot expand lending without additional capital, which limits the effectiveness of liquid assets as a source of last-resort funding. Secondly, the amount of equity in banks can help mitigate adverse selection or moral hazard issues in the market for non-reservable bank liabilities. This, in turn, enables banks to respond more effectively to monetary tightening, as the cost of other sources of liabilities is expected to be lower.

The functionality of the DC is grounded in banks' incentives to increase their intermediation margins within a monopolistic competition framework. Specifically, banks, leveraging their power in local deposit markets¹⁵, can secure a deposit spread – the differential between risk-free illiquid bonds and deposit rates. Consequently, banks do not correspondingly elevate deposit rates one-to-one when faced with a rise in short-term policy rates. Instead, like any monopolist, they optimize intermediation margins by offering fewer deposit contracts.

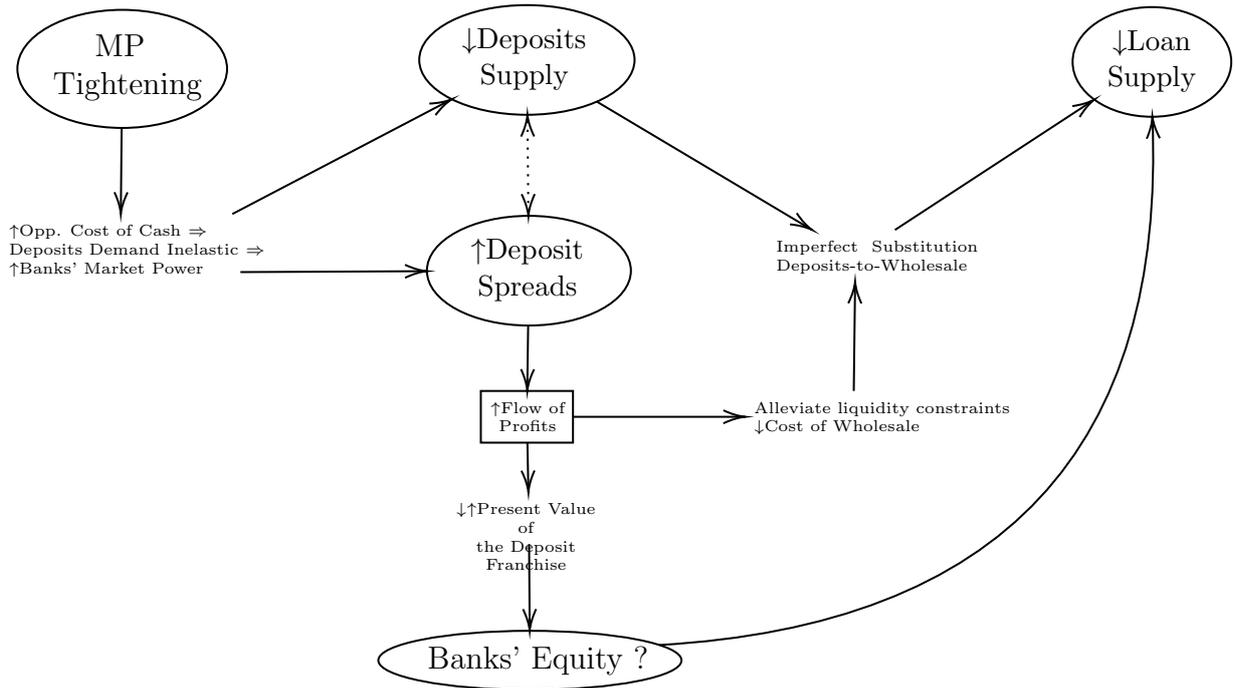
In Drechsler, Savov, and Schnabl (2017), banks provide differentiated liquidity services through deposit accounts in an imperfect competition environment¹⁶. This source of market power allows banks to offer deposit rates below the prevailing market rates (i.e., charge a deposit spread on clients). Households are willing to pay the deposit spread because they have preferences over liquidity services (cash and deposits), and physical currency and deposits are substitutes.

Monetary policy influences deposit market equilibrium in two ways. First, it shapes the elasticity of (aggregate) deposit demand since short-term policy rates impact the opportunity cost of holding cash. When policy rates are high, demand becomes inelastic as cash becomes a comparatively expensive source of liquidity. Ideally, households would prefer to hold bonds; however, since bonds do not provide liquidity, households will rely heavily on deposits to cover their liquidity needs. Conversely, when policy rates are low, cash becomes a less expensive source of liquidity, and households rely less on deposits to cover their liquidity needs. Second, monetary policy activates a market power channel. In response to a tightening shock, banks contract deposit supply to maximize deposit spreads. As deposit spreads widen, depositors respond by reallocating their portfolios towards alternative sources of liquidity that provide higher profitability, such as money market funds.

¹⁵Choi and Rocheteau (2023) argue that market power is insufficient for the deposit channel to operate.

¹⁶Differentiation in liquidity services is initially primitive in the model. In Drechsler, Savov, and Schnabl (2021), differentiability is a product of an investment in a deposit franchise. The deposit franchise gives banks market power over retail deposits, which allows them to borrow at rates that are both low and insensitive to market interest rates. Running a deposit franchise incurs operating costs (branches, salaries, marketing, technology), which tend to be relatively constant over time and are insensitive to interest rates.

Figure 1.4: Deposits Channel



The DC and the BLC share similar predictions about the effect on lending; however, there is a difference concerning the expected magnitudes. For a lower level of (retail) deposits, lending supply is expected to decrease as banks partially offset deposit outflows with costly wholesale funding (i.e., the Modigliani-Miller theorem fails). However, a distinctive aspect of the DC is that the overall impact on lending is anticipated to be mitigated owing to the interplay between the profitability generated by broader deposit spreads and the presence of liquidity (or leverage) constraints.

In Drechsler, Savov, and Schnabl (2017), the increase in profit flows due to higher deposit spreads can help alleviate banks' liquidity constraints. This reduces the cost of funds in the wholesale market, partially offsetting the negative effect of the policy rate increase on lending. This latter characteristic of the DC is an additional interaction with the BSC. If a monetary tightening shock enables banks to increase intermediation margins, does this flow of profits increase banks' net worth?

In the model proposed by Drechsler, Savov, and Schnabl (2017), which does not account for bank runs, it is not guaranteed that increasing profits translate into higher banks' equity. Higher profits are subject to a higher discount rate, potentially resulting in an unchanged or even decreased present value of the deposit franchise. Empirical evidence from Drechsler, Savov, and Schnabl (2021) supports this notion.

However, considering the influence of bank runs can alter the conclusion. As discussed by Drechsler, Savov, Schnabl, and Wang (2023), bank runs could constrain banks' ability to profit from deposit franchises, disrupting their interest rate hedging strategy and reducing banks' capital. When monetary policy tightens, the likelihood of a run increases because the deposit franchise's value rises with interest rates. It implies that banks' reliance on the deposit franchise is more significant in a tightening cycle, making runs even more costly ("deposit franchise is only valuable if depositors remain in the bank"). This

exacerbates banks' vulnerability and introduces uncertainty that can amplify the negative consequences of monetary policy on capital and lending. To take-away, the effect on lending might be state-dependent, and banks' interest rate hedging strategies based on deposit franchises can magnify the adverse impact of monetary policy on lending.

Cash Flow Channel

In a study by Gomez et al. (2021), income gaps are central to the monetary policy transmission. The fundamental concept resembles the Deposit Channel, highlighting the significance of income shocks resulting from monetary policy actions. These income shocks can boost bank profits, and by easing liquidity or leverage constraints, they support lending activities. However, a crucial distinction exists: income shocks generated by monetary policy tightening primarily stem from repricing floating-rate and matured positions, whereas in the DC channel, wider deposit spreads play a pivotal role in enhancing bank profitability.

1.2.5 Risk-Taking Channel

Previous channels emphasize the significance of the endogenous reactions of banks' capital (BCC) and deposits (BLC) to monetary shocks. Another perspective proposes that a pivotal factor in the transmission of monetary policies is how these policies influence agents' risk perceptions and willingness to bear risks. The risk-taking channel (RTC) formalizes the endogenous changes in banks' risk perception. In the literature, this channel operates through three main mechanisms (See Delis, Hasan, and Mylonidis (2017)): the search-for-yield mechanism, the valuation-default mechanism, and the moral hazard/adverse selection mechanism.

Increased Appetite for Riskier Assets In times of significantly low-interest rates, bankers tend to become more willing to take on riskier assets in search of higher yields. This behavior is driven by the challenge of achieving nominal target returns in prolonged periods of expansionary monetary policy (Rajan, 2005).

Mispricing of Risks When interest rates are low and monetary policy contributes to high asset valuations with reduced price volatility, bankers may misprice risks. This mispricing occurs because low rates boost the values of assets and collateral while reducing perceived price volatility. As a result, bankers underestimate default probabilities and become more inclined to take on higher-risk positions, often leading to an increase in loan supply with lowered credit standards (Borio and Zhu 2008).

Greater Risk-Taking with Policy Commitments In situations where monetary policy is fully committed to avoiding large downside risk scenarios, bankers may opt to take on greater risks. When monetary policy commits to lowering future interest rates in response to threatening shocks, it reduces the probability of significant downturns. This commitment and moral hazard encourage banks to assume more risks. This phenomenon is sometimes referred to as the Greenspan or Bernanke put, and it operates based on the expectation of lower interest rates in the future rather than the current low rates.

1.2.6 Interest rate risks, profitability, and bank net worth

The literature has been extensively focused on understanding the sources of interest rate risk and the hedging strategies employed by banks. This is a pivotal area of study because the impact of monetary policies on banks' profitability, and consequently their overall financial health, is intricately tied to this interaction. To ascertain whether a bank is shielded, either partially or completely, from the effect of monetary via profits and capital, one must consider various factors.

Firstly, banks inherently face interest rate risk due to the nature of their business model, distinct from other financial and non-financial firms¹⁷. In essence, when monetary policy tightens, banks might witness a decrease in earnings coupled with rising expenses, potentially leading to reduced profits or even insolvency. Banks optimize their profits by engaging in maturity transformation, borrowing short-term while lending long-term. This is predominantly achieved through the issuance of fixed-rate loans instead of floating-rate loans, while a substantial portion of interest-bearing liabilities is susceptible to short-term repricing.

However, the extent of a bank's exposure to interest rate risk is influenced by other factors. Firstly, market imperfections, such as monopolistic competition, can result in imperfect rate pass-throughs. Secondly, banks employ various hedging strategies to partially or fully mitigate their exposure to interest rate risks. The ultimate impact on profits hinges on two critical elements: a) the responsiveness of rates to changes in policy rates and b) the effectiveness of the employed hedging strategies. In the subsequent discussion, I delve into these factors separately.

1.2.6.1 How changes in policy rates might reflect in banks' profits (or not)?

The degree to which banks' profits respond to changes in policy rates depends on the interest rate sensitivity of their asset's cash flows relative to their liabilities' cash flows (net cash flows). When the sensitivities are impaired, monetary policy might put under pressure banks' profitability.

In essence, maturity transformation leads to a situation where the sensitivity of a bank's liabilities to changes in interest rates is higher than that of its assets. When policy rates increase, it triggers a repricing effect in liabilities. However, long-term assets typically generate fixed nominal cash flows unaffected by short-term interest rate movements. This discrepancy between the repricing of liabilities and the unchanging nature of cash flows from long-term assets results in a scenario where tightening monetary policy causes net cash outflows for the bank. However, the literature has found contradictory evidence regarding this mechanism.

First, Drechsler, Savov, and Schnabl (2021) find that banks perfectly match the sensitivity of their assets and their liabilities in response to changes in the level of the Fed funds rate¹⁸. They suggest that this is a consequence of the deposit channel, in which monopolistic competition induces imperfect pass-through toward deposit rates¹⁹. Second, beyond

¹⁷Microfoundations of why banks unlike other financial and non-financial firms, are exposed to this source of risk is discussed in Di Tella and Kurlat (2021)

¹⁸This result is replicated in Figure 2.A.1

¹⁹Recent evidence supports why adjustments in deposit rates are subject to upward rigidities. Some argue that this is due to monopolistic competition (Bellifemine, Jamilov, and Monacelli, 2022; Drechsler,

imperfect pass-throughs, other components of banks' balance sheets might explain why banks' profits do not necessarily drop in response to monetary tightening cycles. For instance, floating-rate positions and maturing assets can generate enough cash flows to increase profits. Gomez et al. (2021) and Haddad and Sraer (2020) document cash-flow shocks generated by repricing and maturity of assets and liabilities are significant to the point that in response to Fed Funds rate increases, larger income gap banks generate more earnings.

1.2.6.2 How changes in policy rates might reflect in banks' equity (or not)?

Recent evidence suggests that banks engage in significant maturity transformation, with an average duration mismatch of about 3.4 years (Drechsler, Savov, and Schnabl, 2021). This metric implies that a 100 bp level shock to interest rates would cause an immediate drop in banks' net worth of 34 percent. However, contrary to what this back-to-the-envelope calculation suggests, alternative evidence suggests that a 100 bp shock to interest rates induces only a 4.2% drop in banks' net worth (Drechsler, Savov, and Schnabl, 2021). Why the effect on banks' net worth is smaller than that implied by their duration mismatch?

There are at least two reasons why policy-induced changes in profits are not necessarily translated into one-to-one changes in bank equity. First, the present value of profits does not rise because the higher profits are discounted at a higher rate. Second, banks are fully insured against these risks due to their hedging strategies.

The hedging strategy hypothesis has been pioneered by Drechsler, Savov, and Schnabl (2021). They suggest that banks that operate under deposit franchise business models are effectively shielded against interest rate risk inherent to maturity transformation. This is because even though long-term fixed-rate assets expose banks to lower profits, the deposit franchise model allows banks to command higher deposit spreads (extract larger rents from depositors). Consequently, when banks' managers proficiently counterbalance both, the interest rate sensitivity of banks' cash flows approaches zero. Consequently, banks should not incur capital losses in response to monetary shocks.

The perfect hedging hypothesis posits that monetary policy exerts no impact on banks' capital. Nonetheless, alternative explanations have been proposed by other scholars. English, Van Den Heuvel, and Zakrajšek (2018) point out that an unexpected increase in either the level or the slope of the yield curve around the time of monetary policy announcements results in a substantial and statistically significant decline in bank equity values. Similarly, Paul (2023) aligns with this perspective, suggesting that monetary policy influences profits by inducing alterations in term premiums. Specifically, changes in anticipated short-term future interest rates could potentially have adverse effects on term premiums.

1.2.7 Interest Rates Pass-Throughs

Two arguments have challenged the mechanics of the canonical BLC. First, the effect of monetary policy on liquidity constraints seems to be limited (or non-existent) since

Savov, and Schnabl, 2017), information asymmetries Choi and Rocheteau (2023) or smoothing motives (Polo, 2021). Other complementary evidence suggests that adjustments in loan rates are also subject to downward rigidities Bellifemine, Jamilov, and Monacelli (2022) and Gödl-Hanisch (2022)

the aggregate level of reserves in the U.S. banking system is significantly high, so at the individual level, banks operate with excess reserves. Second, banks do not necessarily experience difficulties having full access to market-based funding in modern financial systems (See Disyata (2011)).

In response to this, alternative mechanisms propose that monetary policy is transmitted through adjustments in *required rates of return* (rather than changes in quantities levels induced by constraints) and, more specifically, on changes through interest rate premiums.

External Finance Premiums Disyata (2011) argues that monetary policy affects lending through the effect(s) on banks' funding costs. It highlights that funding costs might be influenced by policy in two ways.

On the one hand, deposit rates must reflect the compensation for depositors' alternative sources of liquidity, like risk-free bonds. Since monetary policy sets the opportunity cost of deposits, banks are forced to raise deposit rates to retain funds in response to increased policy rates (arbitrage channel).

On the other hand, monetary policy might influence banks' external finance premiums, that is, the premiums banks pay to uninsured depositors. In Disyata (2011), these premiums arise from the inherent riskiness of banks, which may not always be able to repay deposits fully. Banks' capital directly influences the likelihood of repayment, as it serves as a buffer against potential loan losses. Lower capital levels imply reduced depositor protection for a given loan amount. Consequently, when policy tightens and net worth declines, the conditional probability of banks defaulting increases. This leads to higher deposit rates and, thus, elevated rates on bank loans.

Following Bernanke, Gertler, and Gilchrist (1999), this same logic applies between lenders (banks) and borrowers (firms). That is, banks can simultaneously ask for compensation for taking on credit risk; hence, monetary policy might increase lending rates via external finance premiums.

Liquidity Premiums Another way monetary policy might induce changes in lending and deposits is via the direct effect on liquidity premiums. In the banking context, liquidity premiums are the component of the interest rate spread of an asset (loans, government bonds, and deposits) relative to a liquid asset (reserves) directly attributable to the risk of facing a need for liquid funds. Due to liquidity risk exposure, market interest rates must encompass compensation for scenarios where banks may face elevated expenses to acquire liquid funds – costs incurred through fire sales or borrowing in imperfect liquidity markets. By influencing the cost of liquidity, monetary policy changes banks' exposure to liquidity risk, ultimately influencing banks' portfolio choices.

Bianchi and Bigio (2022) put forth a framework where monetary policy has real effects via liquidity premiums. Monetary tightening increases liquidity scarcity, so the cost of accessing liquidity is high. In the form of compensation for the high costs of experiencing a liquidity shortage, banks pass through this cost into market interest rates (liquidity premiums). For instance, lending rates must compensate a bank for the risk-adjusted interbank market return, considering whether the bank has a liquidity surplus or a liquidity deficit.

Term Premiums In banking, the term premium compensates banks for engaging in arbitrage by investing long-term while financing it with short-term borrowing. Recent evidence from Paul (2023) suggests that changes in term premia have historically been reflected in banks' net interest margins. Consequently, if monetary policy influences term premiums, it indirectly affects banks' profits.

How might monetary affect the term premium? Bernanke (2020) points out the importance of the portfolio balance effect of monetary policies. In simple terms, when central banks buy a particular type of security (like government bonds, mortgage-backed securities, and corporate bonds), investors shift their investments toward other securities, influencing their prices.

For instance, in the context of large-asset purchases (QE), monetary policy might induce changes in the net supplies of long-term securities, which removes interest rate risk from the Treasury market, pushing investors to bid up the values of both remaining longer-term Treasuries.

1.3 Institutional Background

In order to examine the intricate relationship between monetary policy, the management of liquid assets, and their impact on banking outcomes, it is imperative to set the stage by first understanding the institutional landscape within the U.S. banking system.

The U.S. financial system operates within a multifaceted framework influenced by monetary and regulatory directives, rendering it one of the most heavily regulated industries in the United States (Lessambo, 2020). Banks operating within this system are subject to continuous regulatory oversight, supervision, and examination by a primary federal banking supervisor (either federal- or state-chartered banks) and, in some cases, by a state regulatory authority (only state-chartered banks).

In the United States, eight major federal financial regulatory bodies exist. Among them, four entities primarily focus on overseeing prudential banking practices and ensuring the safety and soundness of banking institutions. Three primary federal banking supervisors, the Federal Reserve (Fed), the Federal Deposit Insurance Corporation (FDIC), the Office of the Comptroller of the Currency (OCC), and one credit union regulator, the National Credit Union Administration (NCUA)²⁰. Concerning the federal banking supervisors, the OCC oversees national and federal savings banks. The Federal Reserve supervises state banks that opt to become members of the Federal Reserve System (state member banks). And finally, state state non-member banks fall under the regulatory purview of the FDIC.

This section examines historical changes in both the monetary policy and banking regulatory frameworks implemented by the primary banking supervisors. The aim is to highlight innovations in the post-global financial crisis era. The subsequent sections are organized as follows. Section 1.3.1 delves into the evolution of the monetary policy framework, offering insights into the pre and post-global financial crisis regimes and discussing

²⁰The remaining institutions consist of non-bank regulators with distinct focus areas. Financial Markets Regulation: The Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC). For Housing Finance Regulation, the Federal Housing Finance Agency (FHFA). And for Consumer Financial Protection, the Consumer Financial Protection Bureau (CFPB) (See Lessambo, 2020, for a description of their functions)

their operational features and key challenges. Subsequently, Section 1.3.2 provides an overview of the primary components of the U.S. banking regulatory framework.

1.3.1 Monetary Policy Frameworks

1.3.1.1 Conventional Framework

The conventional framework represents the approach to monetary policy traditionally employed before the global financial crisis. The central feature of this approach is that central banks convey their policy stance via short-term interest rates, such as overnight interbank rates or a minimum rate at which they engage in transactions with financial institutions. In theory, by determining the marginal cost banks incur for immediate liquidity support, monetary policy is expected to have a cascading effect on interest rates of various lending markets (e.g., money markets and deposit markets, among others). This framework generally comprises three key elements: a policy signal, an operational target, and an operational scheme (Disyatat, 2008).

Single-rate target. Prior to the financial crisis of 2008, the Federal Reserve operated within a single-rate operational framework. In this system, the Fed would establish a single-rate target, signaling either a contractionary or expansionary monetary policy stance. To implement this policy, the Fed targeted the fed funds rate by adjusting the supply of reserves using open market operations (OMOs) as its primary policy. The primary objective was to transmit its policy stance to the broader financial markets by ensuring that the effective federal funds rate (EFFR) closely mirrored the specified policy rate target.

Fed funds market. The Fed funds market holds a pivotal role within the financial system, involving critical players like commercial banks, savings banks, credit unions, and government-sponsored enterprises²¹. This market is purpose-built for overnight interbank lending, with its central feature being the access it provides to central bank balances. Participants in this market enter into unsecured lending contracts, typically denominated in U.S. dollars, to meet short-term liquidity requirements and support overall banking operations (Afonso, Kim, et al., 2020; Martin et al., 2013).

In practice, daily fluctuations in the supply of reserves within the Fed funds market are determined by exogenous changes in market participants' needs²². However, by design, the Fed can control the aggregate supply level in the market, especially at larger frequencies. Conversely, market participants, driven by their short-term liquidity needs and policy requirements, influence the aggregate demand for these reserves. The interplay between these factors determines the effective fed funds rate, which serves as a reference for interest rates in other short-term liquidity markets²³.

²¹Market participants, also known as 'primary dealers,' are listed in <https://www.newyorkfed.org/markets/primarydealers.html>.

²²In the absence of open market operations by the Federal Reserve, daily fluctuations in the supply of reserves within the Fed funds market result from transactions involving physical currency exchanges between banks and non-bank entities. These non-bank entities include the Treasury General Account (TGA), accounts held by government-sponsored enterprises, and various other financial market participants (See Afonso, Kim, et al., 2020).

²³e.g., Eurocurrency Market, Repo Market (Repurchase Agreement), Commercial Paper Market, Treasury Bills Market, Central Bank Discount Window, Money Market

Operating scheme. The Fed’s operational scheme encompasses an array of instruments and operations designed to foster the stability of the EFFR around the policy target. Before 2008, the Fed operated using instruments like open market operations (OMOs), discount window lending, and reserve requirements as major tools of monetary policy²⁴.

The differential aspect of the conventional operating scheme was the Feds’ reliance on supply-side interventions. For instance, OMOs consist of buying (or selling) U.S. government securities with primary dealer counterparties either temporarily (using repurchase agreements) or permanently (using outright transactions)²⁵. In most monetary theories²⁶, these operations are perceived as actions intended to provide the appropriate amount of reserves such that the supply of reserves intersects the demand curve at the desired policy target²⁷.

Challenges. After outlining the key features of the conventional framework, one crucial aspect to consider is the potential effectiveness of the framework as a whole. The literature has highlighted two significant challenges that could hinder its efficiency. Firstly, there are transmission-channel challenges related to how policy changes are reflected in market interest rates and agents’ behaviors²⁸. Secondly, operability challenges are associated with the central bank’s ability to control the Fed funds market effectively.

The Federal Reserve’s ability to consistently achieve its target rate may face limitations for several reasons. Firstly, maintaining the target rate requires accurate estimates of the demand for reserve balances and complete control over the aggregate supply, which can be challenging to achieve (Ennis and Keister, 2008). Nevertheless, historical evidence suggests that the Fed has successfully managed both challenges (Disyata, 2011).

Secondly, conventional supply-side interventions might show minimal or no impact on the effective Federal Funds Rate (Afonso, Giannone, et al., 2022; Afonso, Kim, et al., 2020). The efficacy of the conventional framework is highly dependent on the scarcity of reserves. In situations where markets operate with abundant reserves, the demand for reserves becomes elastic, meaning that changes in supply do not significantly impact interest rates²⁹.

²⁴Other tools in the traditional framework, mainly used in different countries, are standing facilities and interest rates on reserves.

²⁵Official information about policy implementation can be found here <https://www.newyorkfed.org/markets/domestic-market-operations/monetary-policy-implementation> and <https://www.federalreserve.gov/monetarypolicy/openmarket.htm>.

²⁶I refer to theoretical frameworks related to monetary policy implementation under different regimes. For instance, the canonical Poole (1968)’s model for regimes with a scarce supply of reserves, or Afonso, Kim, et al. (2020) for an ample supply regime.

²⁷An alternative interpretation argues that policy targets can be reached without actual changes in aggregate reserves. As long as the central bank commits credibly to using available instruments to achieve the target, the tools do not need to be used for this purpose (Disyatat, 2008).

²⁸This relates to the banking channels presented in Section 1.2.

²⁹Estimates by Afonso, Giannone, et al. (2022) reveal trends in the Fed funds reserve demand curve: a) Before the Global Financial Crisis (GFC), the Fed funds market operated in a scarce reserves environment with a steep downward-sloping demand curve, allowing the Federal Reserve to adjust rates through small daily open market operations. b) From 2009 to 2014, abundant reserves rendered minor reserve supply adjustments ineffective in influencing rates, as the demand curve became flat beyond required levels. c) Between 2015 and 2019, market frictions led to a smooth transition to an intermediate regime of ample reserves, characterized by a gently downward-sloping demand curve.

As discussed below, addressing this challenge has become a focal point in recent changes to the monetary policy regime.

1.3.1.2 Unconventional Framework

Post the Global Financial Crisis, the emergence of the unconventional monetary policy framework directly responded to the limitations of conventional policies caused by the effective lower bound on short-term interest rates and the above-mentioned challenges. This led to the development and implementation of a new framework encompassing two interconnected dimensions. Firstly, the adoption of a new operating scheme for short-term rates, which relies more heavily on demand-side interventions in the Fed funds market. Secondly, the incorporation of longer-term interest rates and asset prices in the set of policy targets.

1.3.1.2.1 New Operating Scheme on Short-rates

The distinctive aspect of the unconventional operating scheme is the Fed’s use of demand-side interventions in the Fed funds market.

To address the challenge posed by abundant reserves in the system³⁰, the Federal Reserve adopted the “floor operational system” in October 2008. This system involved abandoning the single-rate operational system and incorporating the interest rate on excess reserves (IOER) into its toolkit. The Fed’s objective was to establish a lower bound on the Fed funds rate, ensuring that participants in the Fed funds market had no incentive to lend at a rate lower than the IOER. Unlike the conventional framework, this approach fixes the opportunity cost of lending in the Fed funds market, representing a policy innovation that can be viewed as a demand-driven intervention aimed at influencing short-term rates (Afonso, Giannone, et al., 2022; Afonso, Kim, et al., 2020).

However, IOER did not effectively serve as a lower bound, primarily due to market segmentation and arbitrage opportunities (Afonso, Giannone, et al., 2022; Hogan, 2021). Consequently, as illustrated in Figure (1.A.1), the effective FFR consistently fell below the targeted IOER rate. In response, in 2013, the Fed introduced the interest rate on overnight reverse repurchase agreements (ON-RRP) into the toolkit, a system now known as the “sub-floor operational system”. The purpose was to establish a solid floor for the Fed funds rate by addressing market segmentation issues. This was achieved by permitting various money market participants, including Federal Home Loan Banks (FHLB) and money market funds (MMFs), to engage in overnight repos with the Federal Reserve at a fixed rate below the IOER.

In summary, both operational systems aimed to address the highly elastic demand for reserves by directly affecting the opportunity cost for market participants. The newer scheme placed more emphasis on demand-driven interventions; nevertheless, it is important to note that conventional supply-side interventions were not entirely discarded.

³⁰As pointed out before, the conventional framework primarily relied on adjusting the scarcity value of a limited supply of central bank reserves. However, the significant increase in liquidity during the abundant reserves regime reduced the effectiveness of controlling the Fed funds rate, because demand operated in a perfectly elastic region.

1.3.1.2.2 New Monetary Tools and Targets

In addition to implementing the new operating scheme for short-term rates, the unconventional framework encompassed operating not only short-term rates but also longer-term interest rates and other asset prices and yields. The most relevant instruments used by the Fed for this purpose were Large Scale Asset Purchase Programs (LSAP) and Forward Guidance (FG).

Quantitative easing (QE). Broadly speaking, QE involves the central bank purchasing long-term financial assets from the open market with the main objective of easing financial conditions. The underlying intuition is that by increasing the demand for long-term assets, their prices are expected to rise, causing their yields (interest rates) to fall inversely. Eventually, by lowering long-term interest rates, borrowing becomes cheaper, which in turn encourages businesses and consumers to react and stimulate economic activity.

In the U.S., the first program of large-scale asset purchases started in November 2008, when the Fed initially announced its plans to buy \$100 billion in agency debt securities and \$500 billion of agency MBS. In March 2009, the Fed expanded its asset purchase program by extending the purchase of agency MBS (an additional \$750 billion) and agency debt (an additional \$100 billion); and by including \$300 billion of longer-term Treasury securities over the next six months. QE1 concluded in the second quarter of 2010, with a final balance of approximately \$1.725 trillion³¹.

Following these unprecedented interventions, the Federal Reserve advanced its goal of exerting downward pressure on longer-term interest rates by issuing two subsequent announcements. From November 2010 to June 2011, the Fed committed to buying \$600 billion in additional Treasuries, a program known as QE2. From September 2011 through 2012, the Fed announced the Maturity Extension Program (aka Operation Twist), which consisted of lengthening the average maturity of its portfolio by a) selling off \$634 billion in Treasury securities with remaining maturities of 3 years or less and \$33 billion of Treasury security redemptions, and b) buying \$667 billion in Treasury securities with remaining maturities of 6 years to 30 years³²

The third and final round of LSAP started in September 2012 and ended in 2013. The QE3 outlook-contingent³³ program involved the acquisition of \$790 billion in Treasury securities and \$823 billion in agency MBS. The program was characterized by decreasing monthly acquisitions starting with \$40 (\$45) billion, later reduced to \$35 (\$40) billion in January 2014, and gradually decreasing by \$5 billion after each FOMC meeting until October 2014. Finally, balance sheet normalization started in October 2017 when the FOMC began to reduce its securities holdings.

Forward Guidance (FG). Forward guidance refers to the communication strategy central banks employ to guide the public and financial markets about the future path of the monetary policy stance. The underlying intuition is that by signaling the future

³¹Timelines and additional information can be found here: <https://www.newyorkfed.org/markets/programs-archive/large-scale-asset-purchases>

³²<https://www.federalreserve.gov/monetarypolicy/maturityextensionprogram.htm>

³³As defined by Bernanke (2020), to highlight

conduct of policy rates and announcing economic and policy projections, market participants will be more confident about the future. Hence, this provides a stimulus to economic activity.

In practice, FG takes many forms. Following Campbell, Evans, et al. (2012), Odyssean guidance includes explicit promises or commitments to follow a specified path for policy. In contrast, Delphic guidance is about providing information regarding the economic outlook and policy intentions. In the U.S., these forms of Forward guidance have not been exclusive to the post-crisis era. For instance, the 2003 Greenspan’s “considerable period” language³⁴ and other pre-crisis communications³⁴ by the FOMC have been largely discussed in the literature.

The evolution of forward guidance after the financial crisis is notable. Initially, it resembled qualitative guidance, similar to Greenspan’s “considerable period” language, which falls under the Delphic category. In contrast, Campbell, Fisher, et al. (2017) argued that effective forward guidance only became Odyssean (involving commitments like “lower for longer”) in 2011. In August 2011, the Federal Reserve provided increasingly precise and aggressive forward guidance, including explicit date-based commitments (“keep the fed funds rate near zero at least through mid-2013”). In December 2012, the FOMC transitioned from providing guidance that specified a particular date for policy action (calendar guidance), to guidance that involved describing the specific economic conditions or criteria that would need to be met for the central bank to consider raising interest rates (State-contingent-guidance).

1.3.2 Banking Regulatory Framework

In this section, I focus on two primary banking regulatory instruments: capital and liquidity requirements³⁵. As described in the following, since the aftermath of the GFC, banks have operated in an environment that implements more stringent capital requirements, enhanced liquidity and credit risk management practices, and increased transparency and reporting obligations for banks.

1.3.2.1 Capital Regulations

Capital is a pivotal component of the banking industry. It serves as a foundation for a bank’s operations, acts as a buffer against unforeseen losses and declines in asset values that might otherwise result in insolvency, and provides a safety net for uninsured depositors and debt holders during liquidation (Lessambo, 2020). Capital requirements are key tools to bolster banks’ resilience to unexpected losses and prevent them from assuming excessive leverage positions that could precipitate a bank’s collapse.

To evaluate the adequacy of banks’ capital, U.S. authorities use Capital-to-Risk-weighted

³⁴It refers to the promises of the FOMC in 2003–2004 to keep rates low “for a considerable period” or to remove accommodation “at a pace that is likely to be measured.”

³⁵The regulatory framework for banking comprises three fundamental pillars: regulations, supervision, and enforcement. Within this framework, the supervisory process involves on-site examinations, which can lead to enforcement actions when instances of unsafe, unsound, or illegal practices that violate laws are uncovered. A more detailed analysis of this aspect is a topic for future research. The reader can also refer to Ngambou and Melchisedek (2021) for a recent survey of prudential tools. They present a theoretical discussion about the transmission channel of prudential tools to the economy through the lenses of the risk-taking channel.

Assets Ratios (CRAR) as the main instruments. Generally, these ratios adopt the following formulation:

$$CRAR^{x,y} \equiv \frac{Capital^x}{RWExposures^y} \geq \kappa^{x,y}$$

First, $Capital^x$ denotes a specific form of capital- x , where the differences in types are associated with their varying abilities to absorb losses. The most prevalent measurements, ranked from the highest loss-absorbing capacity to the lowest, include Common Equity Tier 1 Capital, Tier 1 Capital, and total capital.

Secondly, $RWExposures^y$ represents a metric- y quantifying the risk exposure associated with banks' assets. This metric aims to comprehensively capture the credit risk inherent in a bank's assets. Typically, it is calculated as the weighted sum of the bank's assets on and off the balance sheet. The weighting is determined based on the Basel Committee's guidelines, considering the credit rating assigned to each asset.

Lessambo (2020) and Walter (2019) provide a detailed historical review of the overall changes in capital regulations. In what follows, I summarize the main changes, focusing on three aspects: a) the adoption of new capital requirements, b) changes in the minimum levels of capital, and c) changes in the methodology to measure the proper capital ratio.

Pre-GFC: The Basel I-based Rules. The framework for defining capital adequacy in the United States before the Global Financial Crisis (GFC) was established based on the principles of Basel I. This regulatory regime was introduced in January 1989, with the publication of the final rules, and was scheduled to become effective in December 1992. The main innovations that characterize this framework are as follows:

1. New risk-sensitive measures of capital (denominator): The risk-weighted standards categorized assets into five groups: 0% for cash and specific government-issued or government-guaranteed debt instruments; 20% for exposures to U.S. depository institutions; 50% for specific residential mortgage debt securities; and 100% for corporate debt and loans. Furthermore, it introduced off-balance-sheet (OBS) activities, such as lines of credit and commitments, in calculating risk exposure.
2. Narrower Capital Definition (numerator): It adopted Tier 1 capital instead of total capital to calculate CRARs.

Since the implementation date, all U.S. banks and bank holding companies (BHCs) were required to adhere to the following requirements:

- Minimum ratio of Tier 1 capital-to-RWA of 4 percent. Risk calculations must include OBS.
- Total capital-to-RWA of 8 percent.
- Tier 1 Leverage ratios (non-RWA ratios) of 3 or 4 percent.

Post-GFC Part I: New methodology for calculating risk-weighted assets. The first change occurred between December 7, 2007, with the publication of the final Basel II, and April 1, 2008, with the actual implementation of new capital rules. The new rules maintained the previous minimum capital ratios, and its main innovation was the introduction of a revised methodology for calculating risk-weighted assets (change in

the denominator). This considers heterogeneity in risk among financial institutions by defining two different calculation approaches based on banks' size:

1. Standardized approach: Banks with assets lower than \$250 billion kept the Basel I Tier 1 capital-to-RWA. Under this approach, small organizations did not gather information from internal risk models.
2. New Advanced approach:
 - It applied to large U.S. organizations named *covered institutions*. Specifically, banks with assets over \$250 billion, or at least \$10 billion in foreign exposures.
 - Changes in the denominator of capital ratios: It demanded the inclusion of comprehensive data related to expected asset losses. Moreover, it placed a heightened emphasis on accounting for variations in the risk profiles of banking organizations. This was achieved by incorporating more detailed risk metrics of assets and off-balance-sheet exposures.
 - Increase public disclosure requirements: Banks must disclose information about their risk-estimating models (describing the characteristics of individual assets, hedging, derivatives exposures, trading activities, etc.).

In summary, Basel II primarily addressed the calculation method for risk-weighted assets without changing minimum capital ratios from Basel I. These RWA adjustments mainly applied to the largest banks. Walter (2019) suggest that this results in limited changes to capital requirements for most organizations. As described below, it was only after the subsequent introduction of Basel III that significant alterations were made to requirements affecting all organizations compared to Basel I.

Post-GFC Part II: A new macroprudential perspective. The second post-GFC change in capital regulations came in 2010 when the U.S. government enacted a comprehensive financial reform known as the Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA). Furthermore, in 2013, the Basel III standards were adopted to complement the DFA's rules—this new framework, perceived as a more structural change, aimed at improving overall financial stability.

Major capital requirements (known as Basel III/DFA Capital Requirements) were in place. Overall, those changes are characterized by the following innovations:

1. Redefinitions in the CRAR:
 - Numerator: Added a new measure of capital, the CET1 capital. CET1 comprises common stock, retained earnings, as well as certain minority interests, and accumulated other comprehensive income (AOCI)³⁶.

Previously, the narrowest definition of capital was Tier 1 Capital (Basel II), followed by Total Capital and Leverage Ratios (Basel I). Tier 1 capital is akin to CET1 but includes certain types of preferred stock that CET1 excludes. These definitions of capital continue to be implemented. For standardized

³⁶Minority interests refer to external investments in the stock of the bank's subsidiaries, while AOCI represents unrealized gains and losses on specific assets and liabilities that haven't been included in net income, e.g., gains and losses on available-for-sale assets

banks, the CET1 capital requirement is set to 4.5%. The T1-capital requirement is 6%, and the Total capital requirement is 8%. Besides, Leverage Ratios remained unchanged at 4%.

Finally, the Supplementary Leverage Ratio (SLR) applies to advanced approaches banks and came into effect on January 1, 2018. Compared with the Leverage Ratio, both ratios use Tier 1 capital as the numerator; the SLR's denominator is more extensive, encompassing off-balance-sheet exposures like derivatives and credit commitments.

- Denominator:
 - The advanced approaches method is consistent with Basel II. However, institutions can use either standardized or advanced approaches. The lower ratio of these two is used to assess compliance with capital requirements.

$$CRAR^{x,y} \equiv \min\{\text{Risk-based Ratio under Standardized}, \\ \text{Risk-based Ratio under Advanced}\}$$

- The standardized approach aligns with the approach taken in response to Basel I, adding more risk weight categories than the four categories found earlier in Basel I.
2. New Capital Buffers: Besides the minimum capital requirements, supervisors have introduced two buffers as preventive measures. These buffers serve as early warning mechanisms for banking organizations experiencing rapid declines in capital. If an institution's capital falls below the required minimums, it must restrict distributions to shareholders and bonus payments to senior managers in response to the declining capital position. The buffers added are:

- (a) Capital conservation buffer (CCB): All institutions are subject to this buffer except those BHCs with assets less than \$1 billion. Initially, banks should add a capital amount of 2.5 percent. The new formula follows:

$$CRAR^{x,y} \geq \kappa^{x,y} + CCB$$

- (b) Countercyclical capital buffer (CCyB): Only advanced approach organizations are subject to this buffer. The CCyB is different from other capital requirements because it can change based on the state of the economy. When systemic risk increases, it goes up, and when the financial system becomes less vulnerable, it decreases.

Initially, for organizations with assets exceeding \$250 billion, the CCB requirement was 2.5%, and the CCyB requirement was 0%, with an extra 1.5% for GSIBs. The new formula is as follows:

$$CRAR^{x,y} \geq \kappa^{x,y} + CCB + CCyB$$

3. New requirements for U.S. Global Systemically Important Bank Holding Companies (GSIBs): In alignment with the principles of the Basel-II rules, the new framework retained a central focus on risk heterogeneity based on bank size and introduced new requirements to acknowledge the most complex institutions.

- (a) **GSIB surcharge:** This surcharge is designed to offset the additional risk GSIBs pose compared to non-GSIBs. It lowers the probability of GSIB failure, reducing their expected harm to a level similar to smaller, less interconnected organizations. The surcharge was phased between January 2016 and December 2018, ranging from 1.5% to 3.5% of common equity Tier 1 capital as a percent of RWA for U.S. GSIBs. It's enforced by limiting payouts to shareholders and senior managers.
- (b) **Total Loss-Absorbing Capacity (TLAC):** Consists in adding to the numerator of the Tier 1 capital ratio loss-absorbing (long-term) debt. Under U.S. rules, TLAC should be at least 18 percent of RWA plus the abovementioned buffers. Additionally, it must account for 9.5 percent of total leverage exposure, encompassing both on-balance-sheet assets and off-balance-sheet vulnerabilities.

Furthermore, the rule mandates GSIBs to maintain long-term debt equivalent to at least 6 percent of RWA, plus the GSIB surcharge and 4.5 percent of total leverage exposure.

GSIBs must comply with the TLAC rule by January 1, 2019.

- (c) **Stress Test:** Consists of tests where covered BHCs must demonstrate their ability to withstand adverse economic shocks of varying severity under different scenarios while still meeting their required capital ratios.

The Federal Reserve and other regulators perform annual stress tests for banks over \$250 billion in assets and periodic tests for those with assets between \$100 billion and \$250 billion.

Recent Modifications. On November 1, 2019, the U.S. regulatory authority released a set of amendments concerning the applicability thresholds for regulatory capital³⁷. These modifications were slated to come into effect on December 31, 2019. They are designed to reduce compliance burdens on financial institutions with lower risk profiles while maintaining stringent requirements for the largest and most intricate banks. Table 1.A.1 provides a concise summary of the current regulatory framework, emphasizing the risk-based thresholds and capital requirements that are currently in effect.

1.3.2.2 Liquidity Regulations

Liquidity requirements serve as tools to strengthen banks' ability to address disruptions in money markets, reducing their reliance solely on lender-of-last-resort interventions provided by central banks.

$$LR \equiv \frac{Liquidity}{ExpectedCashFlows} \geq \tau$$

Monnet and Vari (2023) provide a detailed historical review of the overall changes in liquidity regulations. In what follows, I summarize the main changes, focusing on two primary liquidity instruments: cash-reserve requirements and securities-reserve (or hybrid-reserve) requirements.

³⁷As detailed in their publication <https://www.occ.gov/news-issuances/federal-register/2019/84fr59230.pdf>

Pre Basel-III: Cash-reserve Requirements. Cash-reserve requirements in the U.S. have been the most used (and, for most of history, the unique) liquidity ratio in the past decades. Nowadays, The Federal Reserve Board’s Regulation D sets the guidelines for the mandatory requirements³⁸. First, the ratio is defined as cash balances at the Fed divided by reservable deposits. In the U.S. banking system, reservable deposits are net transaction deposits (NTD), non-personal time deposits, and euro-currency liabilities³⁹. Historically, this characteristic has remained unchanged. Second, the minimum requirements have traditionally been 0%, 3%, and 10% depending on two policy-determined cutoffs: the low reserve tranche thresholds and the reserve requirement exemption threshold. Specifically, cash-reserve requirements range from 0% for NTD below the “exemption amount”, %3 for NTD between the exemption amount and the “low reserve tranche”, and %10 for NTD above the low reserve tranche level. Since March 2020, reserve requirements have been set to 0% for any tranche. Finally, the computation periods for the liquidity ratios are either weekly or quarterly, underscoring their focus on addressing short-term liquidity risks⁴⁰.

Post Basel-III. The 2013 Basel III rules expanded the liquidity regulation framework, specifically emphasizing hybrid reserve requirements.

These regulations encompassed two essential liquidity ratios: the Liquidity Coverage Ratio (LCR), designed to address short-term liquidity risk, and the net stable funding ratio (NSFR), aimed at mitigating medium-term liquidity risks. Unlike traditional reserve requirements, the range of required liquid assets was extended beyond cash, and it also forces banks to include longer-time perspectives when defining their liquidity risk management strategies.

In September 2014, the federal bank regulatory agencies released the final version of the Liquidity Coverage Ratio⁴¹. The LCR necessitates that banks maintain enough high-quality liquid assets (HQLA) to cover total net cash outflows over 30 days. Specifically, this rule applies to banks categorized under the Advanced Approach (Basel III). However, Banking Holding Companies or Savings and Loan Holding Companies (SLHCs) with assets exceeding \$50 billion must adhere to a modified LCR with a 21-day horizon. Banks not meeting these criteria do not face quantitative liquidity ratio requirements but must meet qualitative liquidity management criteria.

Unlike the LCR, the Net Stable Funding Ratio (NSFR) operates over one year, focusing on stabilizing funding sources relative to assets. Implementing the NSFR in the United States has not yet occurred. However, a significant development occurred with the release of the final rule for the NSFR in February 2021⁴². This highlights the recent progress made in incorporating the NSFR into the regulatory framework of the banking industry.

Table 1.A.2 provides a concise summary of the current regulatory framework, emphasizing the risk-based thresholds and liquidity requirements currently in effect.

³⁸<https://www.federalreserve.gov/monetarypolicy/reservereq.htm>

³⁹Nevertheless, the last two are non-relevant, as the official reserve requirement ratios have been equal to zero since December 1990.

⁴⁰Details are found here: <https://www.federalreserve.gov/monetarypolicy/reserve-maintenance-manual-calculation-of-reserve-balance-requirements.htm>

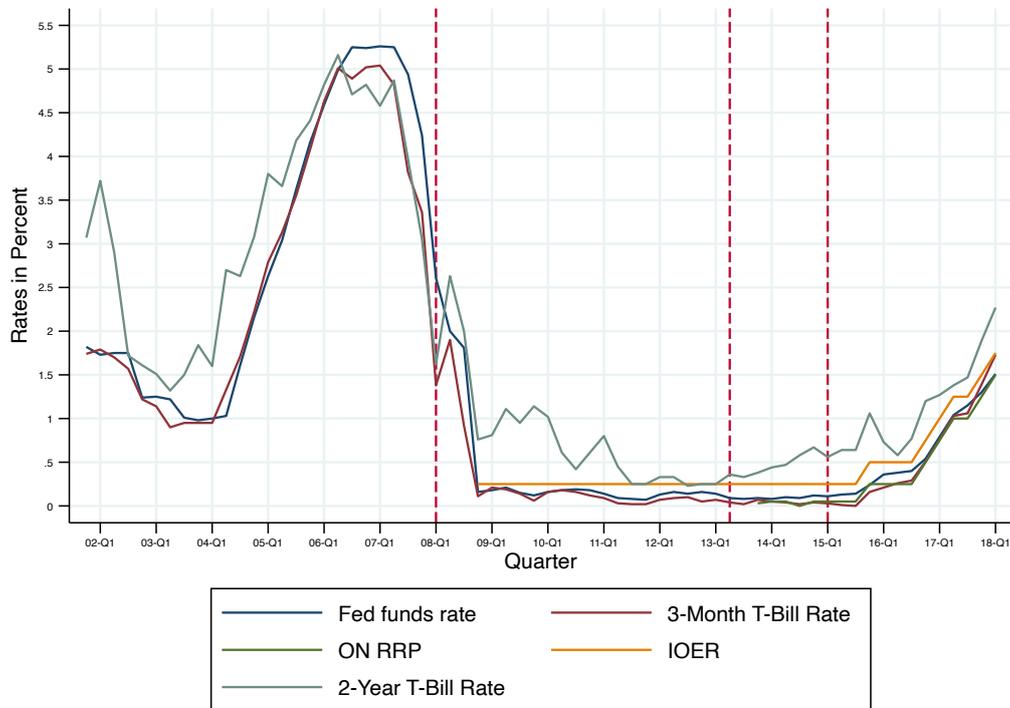
⁴¹See <https://www.occ.gov/news-issuances/federal-register/2014/79fr61440.pdf>

⁴²<https://www.occ.gov/news-issuances/bulletins/2019/bulletin-2019-52.html>

Appendix

Appendix 1.A Graphs and Tables

Figure 1.A.1: Policy Rates and Interest Rates



Notes: Dashed vertical lines correspond to the dates of the introduction of new liquidity regulations (2013q2-2015q1) and the beginning of the GFC (2007q4). Data retrieved from FRED, Federal Reserve Bank of St. Louis.

Table 1.A.1: Regulatory Categories and Capital Requirements (2019)

Categories	Category I	Category II	Category III	Category IV	Other Firms
TLAC/Long-term debt	YES	NO	NO	NO	NO
Stress Testing	Annual company-run stress testing. Annual supervisory stress testing. Annual capital plan submission.	Annual company-run stress testing. Annual supervisory stress testing. Annual capital plan submission.	Company-run stress testing every other year. Annual supervisory stress testing. Annual capital plan submission.	Supervisory stress testing (two-year cycle). Annual capital plan submission.	NO
Risk-Based Capital	GSIB surcharge. Advanced approaches. Countercyclical Buffer. No opt-out of AOCI capital impact.	Advanced approaches. Countercyclical Buffer. No opt-out of AOCI capital impact.	Countercyclical Buffer. Allow opt-out of AOCI capital impact.	Allow opt-out of AOCI capital impact.	Allow opt-out of AOCI capital impact.
Leverage Capital	Enhanced supplementary leverage ratio.	Supplementary Leverage Ratio.	Supplementary Leverage ratio.	Leverage Capital.	Leverage Capital.

Note: **Category I:** U.S. GSIBs. **Category II:** \geq \$700b Total Assets or \geq \$75b in Cross-Jurisdictional Activity. **Category III:** \geq \$250b Total Assets or \geq \$75b in nonbank assets, weighted short-term wholesale funding (wSTWF), or off-balance sheet exposure. **Category IV:** Other firms with \$100b to \$250b Total Assets. **Other Firms:** \$50b to \$100b Total Assets. Data Source: <https://www.federalreserve.gov/newsevents/pressreleases/bcreg20191010a.htm>.

Table 1.A.2: Regulatory Categories and Liquidity Requirements (2019)

Categories	Category I	Category II	Category III	Category IV	Other Firms
Liquidity (Holding Company)	Standardized: Full daily LCR (100%). Proposed full daily NSFR [†] (100%)	Standardized: Full daily LCR (100%). Proposed full daily NSFR [†] (100%).	Standardized: If wSTWF < \$75b: Reduced daily LCR and NSFR [†] (85%). If wSTWF ≥ \$75b: Full daily LCR and proposed NSFR [†] (100%)	Standardized: If wSTWF < \$50b: No LCR, If wSTWF ≥ \$50b: Reduced monthly LCR and proposed NSFR [†] (70%)	NO
Liquidity (Combined U.S. Operation)	Reporting: Report FR 2052a daily. Internal: Liquidity stress tests (monthly). Liquidity risk management	Reporting: Report FR 2052a daily. Internal: Liquidity stress tests (monthly). Liquidity risk management.	Reporting: Report FR 2052a. If wSTWF < 75b: monthly, if wSTWF ≥ 75b daily. Internal: Liquidity stress tests (monthly). Liquidity risk management	Reporting: Report FR 2052a monthly Internal: Liquidity stress tests (quarterly). Tailored liquidity risk management	NO

Note: **Category I:** U.S. GSIBs. **Category II:** ≥ \$700b Total Assets or ≥ \$75b in Cross-Jurisdictional Activity. **Category III:** ≥ \$250b Total Assets or ≥ \$75b in nonbank assets, weighted short-term wholesale funding (wSTWF), or off-balance sheet exposure. **Category IV:** Other firms with \$100b to \$250b Total Assets. **Other Firms:** \$50b to \$100b Total Assets. [†] The proposed net stable funding ratio (NSFR) rule finalized in February 2021. Data Source: <https://www.federalreserve.gov/newsevents/pressreleases/bcreg20191010a.htm>.

References

- [1] Viral V. Acharya, Hyun Song Shin, and Tanju Yorulmazer. “Crisis Resolution and Bank Liquidity”. In: *Review of Financial Studies*, 24.6 (2011), pp. 2166–2205. DOI: [10.1093/rfs/hhq073](https://doi.org/10.1093/rfs/hhq073).
- [2] Gara Afonso, Domenico Giannone, Gabriele La Spada, and John C. Williams. “Scarce, Abundant, or Ample? A Time-Varying Model of the Reserve Demand Curve”. In: *FRB of New York Staff Report*, No. 1019, 2022.Rev. June 2023 (2022), pp. 1–54. DOI: [10.2139/ssrn.4121823](https://doi.org/10.2139/ssrn.4121823).
- [3] Gara Afonso, Kyungmin Kim, Antoine Martin, Ed Nosal, Simon Potter, and Sam Schulhofer-Wohl. “Monetary Policy Implementation with an Ample Supply of Reserves”. In: *FRB of New York Staff Report*, No. 910.Rev. July 2023 (2020), pp. 1–47. DOI: [10.2139/ssrn.3524621](https://doi.org/10.2139/ssrn.3524621).
- [4] Marco Bellifemine, Rustam Jamilov, and Tommaso Monacelli. “Monetary Policy with Heterogeneous Banks”. In: *CEPR Discussion Paper*, DP17129 (2022), pp. 1–68.
- [5] Allen Berger and Christa Bouwman. “Bank Liquidity Creation”. In: *Review of Financial Studies*, 22.9 (2009), pp. 3779–3837. DOI: [10.1093/rfs/hhn104](https://doi.org/10.1093/rfs/hhn104).
- [6] Ben Bernanke. “The New Tools of Monetary Policy”. In: *American Economic Review*, 110.4 (2020), pp. 943–983. DOI: [10.1257/aer.110.4.943](https://doi.org/10.1257/aer.110.4.943).
- [7] Ben Bernanke and Mark Gertler. “Agency Costs, Net Worth, and Business Fluctuations”. In: *The American Economic Review*, 79.1 (1989), pp. 14–31.
- [8] Ben Bernanke and Mark Gertler. “Inside the Black Box: The Credit Channel of Monetary Policy Transmission”. In: *Journal of Economic Perspectives*, 9.4 (1995), pp. 27–48.
- [9] Ben Bernanke, Mark Gertler, and Simon Gilchrist. “The Financial Accelerator in a Quantitative Business Cycle Framework”. In: *Handbook of Macroeconomics in: J. B. Taylor & M. Woodford (ed.)* 1st ed. Vol. 1. 1999, pp. 1341–1393.
- [10] Javier Bianchi and Saki Bigio. “Banks, Liquidity Management, and Monetary Policy”. In: *Econometrica*, 90.1 (2022), pp. 391–454. DOI: [10.3982/ECTA16599](https://doi.org/10.3982/ECTA16599).
- [11] BIS. *Liquidity Coverage Ratio: High-quality liquid assets (LCR30)*. Tech. rep. Basel Committee on Banking Supervision, 2019, pp. 1–26.
- [12] Jeffrey R. Campbell, Charles L. Evans, Jonas D. M. Fisher, and Alejandro Justiniano. “Macroeconomic effects of Federal Reserve forward guidance”. In: *Brookings Papers on Economic Activity*. Federal Reserve Bank of Chicago. (2012), pp. 1–80.
- [13] Jeffrey R. Campbell, Jonas D. M. Fisher, Alejandro Justiniano, and Leonardo Melosi. “Forward Guidance and Macroeconomic Outcomes since the Financial Crisis”. In: *NBER Macroeconomics Annual*, 31.1 (2017), pp. 283–357. DOI: [10.1086/690242](https://doi.org/10.1086/690242).
- [14] Michael Choi and Guillaume Rocheteau. “A Model of Retail Banking and the Deposits Channel of Monetary Policy”. In: *Journal of Monetary Economics*, 139 (2023), pp. 127–147. DOI: [10.1016/j.jmoneco.2023.06.010](https://doi.org/10.1016/j.jmoneco.2023.06.010).
- [15] Manthos D. Delis, Iftekhar Hasan, and Nikolaos Mylonidis. “The Risk-Taking Channel of Monetary Policy in the U.S.: Evidence from Corporate Loan Data”. In: *Journal of Money, Credit and Banking*, 49.1 (2017), pp. 187–213. DOI: [10.1111/jmcb.12372](https://doi.org/10.1111/jmcb.12372).

- [16] Sebastian Di Tella and Pablo Kurlat. “Why Are Banks Exposed to Monetary Policy?” In: *American Economic Journal: Macroeconomics*, 13.4 (2021), pp. 295–340. DOI: [10.1257/mac.20180379](https://doi.org/10.1257/mac.20180379).
- [17] Douglas W. Diamond and Philip H. Dybvig. “Bank Runs, Deposit Insurance, and Liquidity”. In: *Journal of Political Economy*, 91.3 (1983), pp. 401–419.
- [18] Piti Disyata. “The Bank Lending Channel Revisited”. In: *Journal of money, Credit and Banking*, 43.4 (2011), pp. 711–734. DOI: [10.1111/j.1538-4616.2011.00394.x](https://doi.org/10.1111/j.1538-4616.2011.00394.x).
- [19] Piti Disyatat. “Monetary Policy Implementation: Misconceptions and Their Consequences”. In: *BIS Working Paper*, No. 269 (2008), pp. 1–28. DOI: [10.2139/ssrn.1334134](https://doi.org/10.2139/ssrn.1334134).
- [20] Itamar Drechsler, Alexi Savov, and Philipp Schnabl. “Banking on Deposits: Maturity Transformation without Interest Rate Risk”. In: *The Journal of Finance*, 76.3 (2021), pp. 1091–1143. DOI: [10.1111/jofi.13013](https://doi.org/10.1111/jofi.13013).
- [21] Itamar Drechsler, Alexi Savov, and Philipp Schnabl. “The Deposits Channel of Monetary Policy”. In: *The Quarterly Journal of Economics*, 132.4 (2017), pp. 1819–1876. DOI: [10.1093/qje/qjx019](https://doi.org/10.1093/qje/qjx019).
- [22] Itamar Drechsler, Alexi Savov, and Philipp Schnabl. “Why do banks invest in MBS?” In: *Working Paper* (2023), pp. 1–12.
- [23] Itamar Drechsler, Alexi Savov, Philipp Schnabl, and Olivier Wang. “Banking on Uninsured Deposits”. In: *NBER Working Paper Series*, WP 31138 (2023), pp. 1–36. DOI: [10.3386/w31138](https://doi.org/10.3386/w31138).
- [24] William B. English, Skander J. Van Den Heuvel, and Egon Zakrajšek. “Interest rate risk and bank equity valuations”. In: *Journal of Monetary Economics*, 98 (2018), pp. 80–97. DOI: [10.1016/j.jmoneco.2018.04.010](https://doi.org/10.1016/j.jmoneco.2018.04.010).
- [25] Huberto M. Ennis and Todd Keister. “Understanding Monetary Policy Implementation”. In: *Economic Quarterly*, 94.3 (2008), pp. 235–263.
- [26] Isabel Gödl-Hanisich. “Bank Concentration and Monetary Policy Pass-Through”. In: *FDIC Center for Financial Research Paper*, No. 2022-06 (2022), pp. 1–76. DOI: [10.2139/ssrn.4149637](https://doi.org/10.2139/ssrn.4149637).
- [27] Matthieu Gomez, Augustin Landier, David Sraer, and David Thesmar. “Banks’ exposure to interest rate risk and the transmission of monetary policy”. In: *Journal of Monetary Economics*, 117 (2021), pp. 543–570. DOI: [10.1016/j.jmoneco.2020.03.011](https://doi.org/10.1016/j.jmoneco.2020.03.011).
- [28] Valentin Haddad and David Sraer. “The Banking View of Bond Risk Premia”. In: *The Journal of Finance*, 75.5 (2020), pp. 2465–2502. DOI: [10.1111/jofi.12949](https://doi.org/10.1111/jofi.12949).
- [29] Thomas L. Hogan. “Bank lending and interest on excess reserves: An empirical investigation”. In: *Journal of Macroeconomics*, 69 (2021), pp. 1–20. DOI: [10.1016/j.jmacro.2021.103333](https://doi.org/10.1016/j.jmacro.2021.103333).
- [30] Anil K. Kashyap, Raghuram Rajan, and Jeremy C. Stein. “Banks as Liquidity Providers: An Explanation for the Coexistence of Lending and Deposit-taking”. In: *The Journal of Finance*, 57.1 (2002), pp. 33–73. DOI: [10.1111/1540-6261.00415](https://doi.org/10.1111/1540-6261.00415).
- [31] Felix I. Lessambo. *The U.S. Banking System: Laws, Regulations, and Risk Management*. 1st ed. Palgrave Macmillan Cham, 2020. DOI: [10.1007/978-3-030-34792-5](https://doi.org/10.1007/978-3-030-34792-5).
- [32] Antoine Martin, James McAndrews, Ali Palida, and David R. Skeie. “Federal Reserve Tools for Managing Rates and Reserves”. In: *SSRN Electronic Journal* (2013), pp. 1–52. DOI: [10.2139/ssrn.2335506](https://doi.org/10.2139/ssrn.2335506).

- [33] Eric Monnet and Miklos Vari. “A Dilemma between Liquidity Regulation and Monetary Policy: Some History and Theory”. In: *Journal of Money, Credit and Banking*, 55.4 (2023), pp. 915–944. DOI: [10.1111/jmcb.12930](https://doi.org/10.1111/jmcb.12930).
- [34] Djatche Ngambou and Joslem Melchisedek. “Monetary policy, prudential policy and bank’s risk-taking: A literature review”. In: *Journal of Economic Surveys*, 36.5 (2021), pp. 1559–1590. DOI: [10.1111/joes.12485](https://doi.org/10.1111/joes.12485).
- [35] Pascal Paul. “Banks, maturity transformation, and monetary policy”. In: *Journal of Financial Intermediation*, 53 (2023), pp. 1–14. DOI: [10.1016/j.jfi.2022.101011](https://doi.org/10.1016/j.jfi.2022.101011).
- [36] Alberto Polo. “Imperfect pass-through to deposit rates and monetary policy transmission”. In: *Bank of England Working Paper*, No. 933 (2021), pp. 1–69. DOI: [10.2139/ssrn.3900542](https://doi.org/10.2139/ssrn.3900542).
- [37] William Poole. “Commercial Bank Reserve Management in a Stochastic Model: Implications for Monetary Policy”. In: *The Journal of Finance*, 23.5 (1968), pp. 769–791.
- [38] Arisyi F. Raz, Danny McGowan, and Tianshu Zhao. “The dark side of liquidity regulation: Bank opacity and funding liquidity risk”. In: *Journal of Financial Intermediation*, 52 (2022), pp. 1–13. DOI: [10.1016/j.jfi.2022.100990](https://doi.org/10.1016/j.jfi.2022.100990).
- [39] René Stulz, Alvaro Taboada, and Mathijs van Dijk. “The determinants of liquid asset holdings”. In: *NBER Working Paper Series*, WP 30340 (2022), pp. 1–73.
- [40] Suresh M. Sundaresan and Kairong Xiao. “Liquidity Regulation and Banks: Theory and Evidence”. In: *Columbia Business School Research Paper Forthcoming* (2023), pp. 1–57. DOI: [10.2139/ssrn.4020511](https://doi.org/10.2139/ssrn.4020511).
- [41] Skander Van den Heuvel. “Does Bank Capital Matter for Monetary Transmission?” In: *FRRBNY Economic Policy Review* (2002), pp. 1–7.
- [42] John Walter. “US Bank Capital Regulation: History and Changes Since the Financial Crisis”. In: *Economic Quarterly*, 105.1 (2019), pp. 1–40. DOI: [10.21144/eq1050101](https://doi.org/10.21144/eq1050101).

Chapter 2

Monetary Policy Transmission and the Role of Liquid Assets

2.1 Introduction

Numerous empirical studies have investigated whether the ability of banks to respond effectively to various monetary policy measures is associated with specific attributes. Among these attributes, the composition of liquid assets on banks' balance sheets has garnered particular attention. For instance, previous research has shown that liquid assets can serve to stabilize lending supply when banks are confronted with changes in monetary policy (e.g., Kashyap and Stein, 2000). This chapter undertakes an empirical analysis of the role of liquid assets in the transmission of monetary policy, offering new insights into how the qualities of liquid assets affect the performance of banks throughout monetary policy cycles.

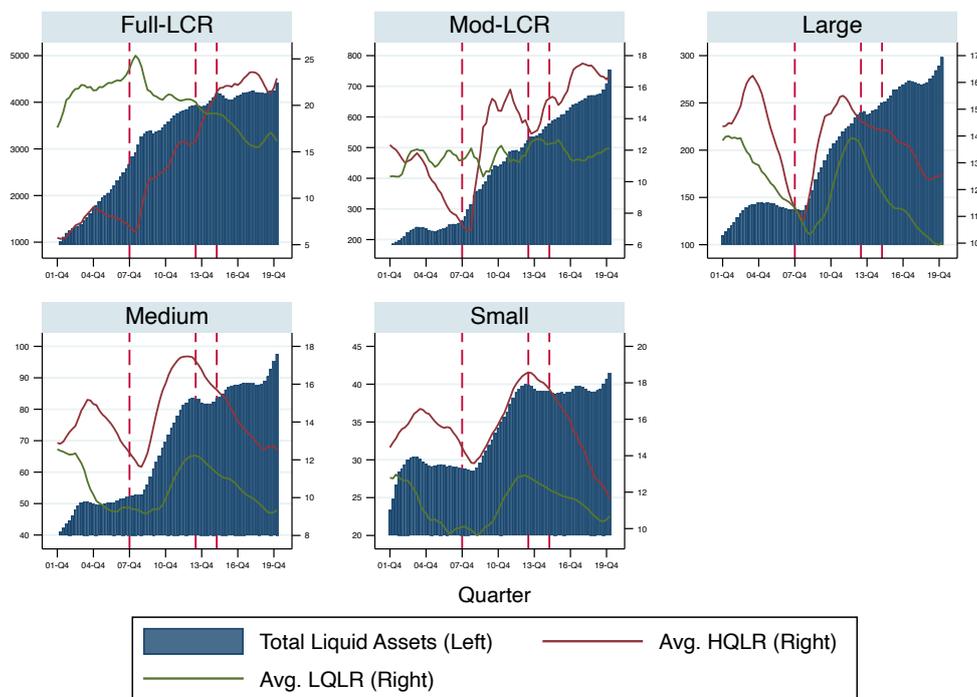
The continuous evolution of the banking industry, coupled with other factors, highlights the need to reexamine the role of liquid assets in the transmission of monetary policy. Specifically, there has been a change in how banks manage their liquid portfolios and the legal framework that regulates financial institutions. Recent banking events have also highlighted that the role of liquid assets during monetary cycles might destabilize the performance of banking institutions. The following paragraphs describe this new landscape in detail.

First, as depicted in Figure 2.1.1, U.S. banking institutions significantly increased their liquid asset holdings and transformed their liquid asset portfolios following the global financial crisis. Between 2001 and 2013, banks of all sizes boosted their liquid assets, ranging in factors between 2 and 4. Moreover, banks with total assets exceeding \$50 billion (LCR banks) expanded their allocation of high-quality liquid assets from 5% to nearly 20% of their balance sheets, concurrently reducing their holdings of low-quality liquid assets. Conversely, banks with total assets below the \$50 billion threshold (non-LCR banks) witnessed a rise in both low and high-quality liquid assets, with the latter gaining prominence on their balance sheets.

Note also that Figure 2.1.1 depicts a dynamic change in the composition of liquid asset portfolios. In particular, the implementation of new macroprudential regulations marked a divergence in the management practices of LCR banks and non-LCR banks. While LCR

banks continued to augment the presence of high-quality liquid assets in their balance sheets, non-LCR banks reduced the ratios of high-quality and low-quality assets¹. The interplay between the new macroprudential liquidity regulations and various other factors has continued to influence how banks manage their portfolios of liquid assets.

Figure 2.1.1: Evolution of Liquid Assets by Quality in the U.S. Banking System



Notes: The left-axis is measured in billions (2015 constant prices). The right-axis represents unweighted averages and is a percentage of gross total assets. Dashed vertical lines correspond to the dates of the introduction of new liquidity regulations (2013q2-2015q1) and the beginning of the GFC (2007q4). Series have been smoothed using a four-lag backward-looking moving average. Full-LCR banks hold assets over \$250 billion, while Mod-LCR banks have assets between \$50 billion and \$250 billion. These banks are subject to liquidity coverage ratios. Banks with assets ranging from \$300 million to \$3 billion are small-sized, those with \$3 billion to \$10 billion are medium-sized, and those with assets between \$10 billion and \$50 billion are considered large banks. These graphs are based on data from the Call Reports for all U.S. commercial banks. The data sample covers the period from 2001q4 until 2018q1.

Second, the banking failures of March 2023 suggest that, under specific scenarios, an excessive accumulation of liquid assets might signify inefficient banking management, potentially increasing a bank’s vulnerability to monetary tightening shocks. A review of this most recent banking crisis has revealed a significant influx of deposits, which were promptly invested in long-term securities. The rapid interest rate increase by the Federal Reserve, resulting in substantial price declines in long-term securities, incentivized uninsured depositors to withdraw their funds, ultimately leading to the collapse of regional banks (e.g., Drechsler, Savov, Schnabl, and Wang, 2023; Krainer and Paul, 2023). This chain of events thus underscores certain limitations in the new macroprudential regulation. Indeed, such a regulation endorses using high-quality liquid assets to enhance

¹For evidence on the management of the composition of high-quality liquid assets by LCR banks, see Ihrig et al. (2017). They highlight differences in the management practices of high-quality liquid assets among these banks.

financial system stability by mitigating risks linked to maturity mismatches and potential disruptions in short-term liquidity markets (BIS, 2019). Nevertheless, relying on long-term, high-quality liquid assets could expose banks to similar risks, suggesting that relying on such assets during monetary cycles may not always ensure banking stability.

Traditionally, researchers have mainly examined the role of liquid assets across monetary policy cycles by attempting to identify the specific attributes of these assets that can impact the effectiveness of transmission channels². For instance, the classic view is that liquid assets, unlike loans or other illiquid assets, can be quickly drawn down, monetized, or used as collateral in Repo transactions. These attributes enable banks to access additional funds when alternative funding sources like deposits become more costly, a situation often instigated by monetary policy tightenings. Under this perspective, the literature on the bank lending channel for monetary policy suggests that liquid assets shield lending growth during periods of tight monetary policy (e.g., Kashyap and Stein, 2000). Nevertheless, alternative mechanisms suggest that liquid assets are not perfect stabilizers, and under some circumstances, they can weaken the resilience of banks during monetary policy cycles.

The first alternative mechanism is related to the direct influence of monetary policies on the pricing of liquid assets. Since long-term liquid securities are exposed to interest rates, banks can be highly exposed to profit losses on securities when their prices decline. If these losses are unhedged, lower profits expose banks to capital losses and, consequently, to lower performance. In the context of the bank lending channel, the evidence suggests that capital losses resulting from the decline in security prices lead to a stronger contraction in lending supply for banks with higher security ratios (see Bluedorn, Bowdler, and Koch, 2017; Krainer and Paul, 2023).

A second alternative is associated with the impact of monetary policies on the characteristics of liquid assets, mainly focusing on their ease of convertibility. This perspective argues that the easy convertibility of liquid assets into available funds is limited due to operational constraints associated with handling large asset volumes. For example, Afonso et al. (2020) highlights that when dealing with exceptionally large quantities of assets sold in a single day, finding willing counterparties for purchases or Repo transactions can be challenging. This situation can lead to tough negotiations if counterparties perceive that the bank is under pressure to sell, which may result in banks accepting lower asset prices. Similar to the valuation effect mechanism, this can constrain the ability of liquid assets to generate funds during monetary cycles, thereby restricting a bank's capacity to respond effectively to monetary shocks.

A third alternative underscores the potentially destabilizing impact of monetary policies on banks' hedging strategies. For instance, Drechsler, Savov, Schnabl, and Wang (2023) shows that using the deposit franchise value to hedge against interest rate risk is an intrinsically unstable strategy, introducing the risk of a bank-run equilibrium triggered by monetary policy. According to this view, the pricing effect on securities induced by policy changes could impact banks, even if they are initially hedged.

These perspectives suggest no straightforward relationship regarding the stabilizing or destabilizing effects liquid assets might play through monetary cycles. To shed light on this, the chapter contributes new evidence of this interaction through a series of empirical

²For a review of the banking channel of monetary policies see Section 1.2.

estimations using panel data covering U.S. depository institutions from 2001 to 2018. The findings are derived from a sample of banks not subject to the latest macro-prudential liquidity regulations, hence representing the left tail of the bank size distribution. From a methodological perspective, the analysis is characterized by the following aspects.

First, I emphasize the classification of liquid assets, distinguishing them based on quality criteria. The key liquidity measurements I focus on are based on the criteria outlined by the Basel Committee on Banking Supervision (BIS, 2019), encompassing High-quality (HQ), Low-quality (LQ), total liquidity, and liquidity coverage ratios (LCR)³. Second, I study the interaction from a dynamic perspective. For this purpose, I undertake a series of empirical analyses using the local projection methodology established by Jordà (2005). In particular, I project growth rates and ratios of banks' performance metrics, such as liquidity creation, profitability, loan growth, and deposit flows, at various time horizons onto monetary policy shocks that interact with liquidity ratios at the moment of the shock. Finally, I focus on monetary shocks obtained from Jarociński and Karadi (2020) to consider possible biases emerging from endogenous monetary policy.

The empirical analysis conveys the following results.

First, a set of equilibrium conditions regarding banks' deposit flows is revealed. In response to monetary tightening shocks, banks with larger HQ liquidity ratios (and LCRs) experienced higher deposit growth rates in the short term. In contrast, those with larger LQ liquidity led banks to lower deposit growth rates permanently. A monetary shock inducing a 25bp increase in the federal funds rate leads banks with higher HQ liquidity ratios to expand their total deposits by 0.35% more relative to banks with less HQ-liquid asset holdings during the first eight quarters after the shock. The same shock leads banks with higher LQ liquidity ratios to contract their total deposits by 1.43% more relative to banks with less LQ-liquid assets four years after the shock. This evidence suggests that HQ liquidity stabilizes banks' funding in the short term after monetary shocks, while LQ liquidity destabilizes banks' funding permanently.

The second set of results reveals equilibrium conditions related to banks' lending behavior during tightening cycles. Initially, banks with higher HQ liquidity ratios (as well as LCRs) tend to experience reduced loan growth, according to the baseline findings. Nevertheless, after controlling for relevant confounding factors such as income and duration gaps, the influence of HQ liquidity on loan growth becomes positive but statistically insignificant. Meanwhile, the effect of LCR turns positive and significant. On the other hand, when exploring LQ liquidity-related heterogeneity, the evidence suggests that banks with larger LQ liquidity ratios experience lower growth rates in response to monetary shocks. This pattern persists even after controlling for income and valuation shocks induced by monetary policy. Regarding the quantitative effect, a monetary shock inducing a 25bp increase in the federal funds rate leads banks with higher liquidity coverage ratios to expand permanently their total loans by 0.35% more relative to banks with lower LCRs four years after the shock. The same shock leads banks with higher LQ liquidity ratios to contract

³As presented in Section 1.1, this categorization represents a departure from the conventional definition of liquidity, which primarily emphasizes the swift convertibility of assets into cash. The new definition includes additional aspects such as low-risk exposure, the ability to command high fire sale prices, and widespread acceptance as collateral. Under the new Basel definition, high-quality liquid assets are generally expected to maintain their liquidity attributes more reliably than low-quality liquid assets, which, in contrast, are more susceptible to changes in particular economic conditions.

their total loans by 0.89% more relative to banks with less LQ-liquid assets four years after the shock.

The third set of results reveals the effect related to banks' liquidity transformation activities during tightening cycles. Initially, according to the baseline findings, after a 25bp increase in the Fed's funds rate, banks with higher HQ liquidity ratios (as well as LCRs) tend to reduce liquidity creation by 0.14pp (and 0.18pp) relative to the total size of their balance sheet. This effect is statistically significant between quarters 4 and 13 after the shock. Nevertheless, after controlling for relevant confounding factors, the influence of both liquidity ratios on liquidity transformation becomes statistically insignificant. Furthermore, no heterogeneous effect is implied by LQ liquidity ratios on the transmission of monetary shocks toward banks' liquidity transformation activities.

Fourth, when examining profit dynamics. In response to a monetary tightening shock, banks with higher HQ liquidity ratios are associated with lower net interest margins. In response to a 25bp surprise increase in the Fed's fund rate, the net interest margins of banks standing 1sd above the HQ liquidity distribution are about 0.014pp lower at their peak, occurring in quarter ten. These patterns remain consistent after including controls, albeit with slightly smaller response differences. In response to the same shock, the net interest margins of banks standing 1sd above the LQ liquidity distribution are about 0.007pp lower at their peak, occurring in quarter six. These patterns persist even after controlling for other factors, although the differences in responses become slightly smaller once controls are incorporated.

Related Literature

This research builds on different strands of the literature estimating the heterogeneous effects of monetary policy on the U.S. banking system.

First, it closely relates to the empirical literature on the role of liquid assets⁴. The seminal work of Kashyap and Stein (2000) provides a first empirical attempt to quantify whether the effect of monetary policy on lending supply is amplified (or diminished) due to securities holdings. Bluedorn, Bowdler, and Koch (2017) present renewed evidence on this subject by highlighting the sensitivity of estimations to the nature of the monetary policy shock. Like Kashyap and Stein (2000), when monetary policy is measured as the change in the effective federal funds rate, securities mitigate lending contractions. On the contrary, when monetary policy is measured as surprise shocks, securities amplify the lending contraction⁵. I build on these papers and differentiate from them in the following ways: First, I focus on the cross-sectional heterogeneity in high and low-quality liquidity and definitions of liquidity that align with the regulation-based categories of the newly implemented liquidity coverage ratio. Second, there is a difference in the methodology used. While I applied a dynamic framework using local projections, they used a static

⁴Other studies focus on different banks' characteristics that shape the effect of monetary policies on credit supply. For instance, recent attention has been given to the role of competition and market power in the banking industry (e.g., Drechsler, Savov, and Schnabl, 2017; Gödl-Hanisch, 2022), banks' capital and leverage (e.g., Kishan and Opiela, 2000; Paz, 2022; Van den Heuvel, 2002), income shocks and maturity gaps (e.g., English, Van Den Heuvel, and Zakrajšek, 2018; Gomez et al., 2021), securitization (e.g., Di Maggio et al., 2017).

⁵An evolving literature is emerging trying to estimate the effects of monetary policy-driven changes in market value on securities on lending (e.g., Krainer and Paul, 2023, for the 2023 tightening monetary cycle)

two-step regression approach. Finally, the set of monetary policy shocks is obtained with more recent high-frequency identification strategies, cleaning out the new effect of monetary policy announcements.

Second, it closely relates to the empirical literature on the factors (de)stabilizing banks' funding, profits, and equity during monetary cycles. Recent studies highlight the importance of the role of banks' market power on the stabilization of funding sources (e.g., Drechsler, Savov, and Schnabl, 2017, for monetary cycles) while (Li, Loutskina, and Strahan, 2023, for business cycles). Other studies study directly⁶ the interest rate risk exposure of banks to monetary cycles (Begenau, Piazzesi, and Schneider, 2015; Di Tella and Kurlat, 2021; Drechsler, Savov, and Schnabl, 2021; English, Van Den Heuvel, and Zakrajšek, 2018; Paul, 2023). To my knowledge, in this regard, no other research has studied the role of liquidity in stabilizing banks' funding and profits during monetary cycles.

Third, it is connected to the literature on banks' liquidity creation. Since the seminal work of Berger and Bouwman (2009), the literature has explored the relationship between banks' capacity and willingness to create liquidity and other balance sheet characteristics like equity Berger and Bouwman (2009) and Evans and Haq (2021). Since I focus on the interaction between liquidity and monetary policies, the closest paper is Berger and Bouwman (2017), which estimates the impact of conventional monetary policy on U.S. banks' liquidity creation from 1984q1 until 2008q4. They find that the impact of monetary policy mainly occurs for small banks during non-crisis times, while the effects are weak and mixed for medium and large-sized banks. On the other hand, Kapoor and Peia (2021) estimate the effects of the large-scale asset purchase programs on bank liquidity creation and find that banks with a higher share of assets in mortgage-backed securities before the start of the third round of the QE program have increased liquidity creation more.⁷ My research indicates that high-quality and low-quality liquidity do not have varying effects in the transmission of either conventional or unconventional monetary shocks toward liquidity creation activities.

Finally, this paper contributes to the literature that analyses the consequences of newly implemented liquidity regulations. Banerjee and Mio (2018) find that UK banks adjusted the composition of assets and liabilities after introducing liquidity regulations. Specifically, banks increased the share of high-quality liquid assets and non-financial deposits while decreasing intra-financial loans and short-term wholesale funding. Gete and Reher (2021) studies the unintended consequences of LCR regulation. They observe that LCR regulation has led to an increase in the market share of lenders operating with a precarious funding model. Furthermore, it has amplified the credit risk shouldered by U.S. taxpayers who provide insurance for Federal Housing Administration loans. Roberts, Sarkar, and Shachar (2023) study the changes in U.S. banks' balance sheets after in-

⁶In a more indirect way, other studies explore banks' characteristics that explain imperfect pass-through (e.g., Bellifemine, Jamilov, and Monacelli, 2022; Gödl-Hanisch, 2022; Polo, 2021)

⁷Another strand of the literature on bank liquidity creation focuses on the effects of macro and micro-prudential policies. For instance, Roberts, Sarkar, and Shachar (2023) estimate the effects of the liquidity coverage ratios, Berger, Bouwman, et al. (2016) study the effects of regulatory interventions and bailouts, Danisewicz et al. (2018) focus on the effects of bank supervisors' enforcement actions, and Nguyen et al. (2020) study the effect of stress tests. Finally, regarding other types of shocks, Berger, Guedhami, et al. (2022) study the effect of economic policy uncertainty on banks' liquidity hoarding. Beladi et al. (2020) examine the impact of the disruption of the interbank market on banks' liquidity creation and funding ability.

roducing liquidity coverage ratios. They find that since the announcement of the LCR policy, banks subject to this constraint have created less on-balance-sheet liquidity than unconstrained banks. They highlight that the primary adjustment in liquidity creation happens on the assets side as LCR banks significantly increase their shares of liquid assets (including HQ-liquid assets) while reducing illiquid and semi-liquid assets. In contrast, the policy does not seem to induce differences in liabilities significantly. My research indicates that larger high-quality and low-quality liquidity ratios do not shield banks' profits after contractionary monetary shocks. This documented evidence captures the secondary effects of liquidity regulations on the transmission of monetary policies for the sample of unregulated banks.

Overview. The rest of the chapter is organized as follows. Section 2.2 introduces some theoretical underpinnings related to banks' uses of liquid assets and their role in the transmission channels of monetary policy. Section 2.3 presents the data used, discusses the construction of the variables of interest, and highlights some stylized facts regarding the heterogeneity in the U.S. banking system. Section 2.4 presents the benchmark empirical specification employed and discusses some challenges in the estimations. Sections 2.5 to 2.8 presents the estimation results based on the benchmark specification. Section 2.9 presents results based on the benchmark specifications for monetary shocks of an unconventional nature. Finally, Section 2.10 concludes.

2.2 Monetary Policy Channels and the Role(s) of Liquidity

One compelling argument underscores the significance of the interplay between monetary policies and liquidity. While monetary policies can potentially disrupt the performance of banks, liquid assets can serve as stabilizing agents, bolstering their resilience in the face of monetary policy fluctuations. Furthermore, the beneficial property of liquid assets can either be amplified or hindered by monetary policy measures. In this section, I discuss whether, through the lenses of the banking channels (discussed in Chapter 1 Section 1.2), monetary policies might have a differential impact on characteristic- $Y_{i,t}$ due to holdings of liquid assets (and their types) and what would be the sign of this relationship.

Fund of Last Resort

The classic interpretation of the role of liquidity in the bank lending channel suggests that liquid assets act as a last resort fund when external financing for banks becomes costly. With their capacity to generate immediate cash flows, banks can draw down liquid assets to protect their loan portfolios in response to a tightening monetary policy that reduces retail deposits. This interpretation has been tested empirically by Kashyap and Stein (2000), who found that banks with higher ratios of securities to assets can internally refinance in response to monetary shocks, reducing the contraction in lending supply.

However, recent evidence, such as the study by Bluedorn, Bowdler, and Koch (2017), suggests that this classic view might not always hold true. Various factors can influence this interaction. One significant factor to consider is the potential impact of policy-induced pricing effects, which will be discussed further in the following sections. Another crucial factor is the size of funding withdrawals; banks may discover that their liquid

assets are inadequate to cover all deposit withdrawals, especially when facing substantial shocks. The dynamic estimation approach using local projections aims to delve into these complexities comprehensively. Furthermore, examining liquidity coverage ratios to measure actual bank liquidity might provide deeper insights into these dynamics.

Unhedged Interest Rate Risk

As mentioned before, a mechanism through which monetary policy and liquid assets interact is through the valuation effect of monetary policy on securities prices. Specifically, since long-term liquid securities are exposed to interest rates, banks can be highly exposed to capital losses on securities. In line with the prediction in the balance sheet channel, banks are expected to contract lending more aggressively in response to monetary tightening shocks. Motivated by the banking events of March 2023, recent evidence in Krainer and Paul (2023) suggests that fluctuations in asset valuations of bank security holdings induced by the strong monetary tightening cycle of 2022 have a negative spillover effect on credit supply.

Risk Management Dilemma

In contrast to the previous point, when banks are fully hedged against policy-driven fluctuations in securities' prices, changes in policy rates should not impact their net worth. Recent empirical studies support this notion, indicating that banks employ their deposit franchise as a hedge against interest rate risk associated with their assets (Drechsler, Savov, and Schnabl, 2021). Nevertheless, recent occurrences suggest that tightening monetary cycles can still disrupt banks even with full mitigation against asset valuation fluctuations.

Drechsler, Savov, Schnabl, and Wang (2023) propose a model that reconciles these contrasting ideas. Since securities might play a dual role in risk management, there are situations in which they can serve banks to either hedge themselves to interest rates or liquidity risk but not both. In particular, when banks choose securities with long-term duration to hedge interest rate risk, banks become exposed to a run if interest rates rise. On the contrary, when securities with shorter duration are used to hedge liquidity risks, banks become exposed to insolvency if the rate falls.

The dilemma occurs because the deposit franchise hedging strategy is inherently unstable. As presented above, banks earn a deposit spread because they invest in fixed operating costs that entitle them to monopoly power in deposit markets. The deposit franchise has a negative duration, meaning its value positively correlates with interest rates. To hedge fluctuations in the deposit franchise, banks invest in assets with positive duration, that is, assets such that their value is negatively correlated with policy rates, e.g., long-term loans and securities. Nevertheless, this hedging strategy can break down when deposits that highly contribute to the value of the deposit franchise (i.e., with low deposit-spread-betas) are withdrawn from the banking system⁸.

⁸Drechsler, Savov, Schnabl, and Wang (2023) present this as a multiple equilibria result: “When interest rates are low, the value of the deposit franchise is small, and the valuation of assets is high. A run does not occur because the value of the bank would be unaffected if it did occur. But when interest rates rise, and the deposit franchise comes to dominate the value of the bank, a run equilibrium arises. This is true even if the bank is fully hedged to interest rates in the sense that its value is insensitive to interest rate shocks outside the run equilibrium.”

Finally, Drechsler, Savov, Schnabl, and Wang (2023) suggest that the dilemma is resolved when uninsured deposits have high-deposit spread-betas because banks find it optimal to allocate these types of deposits into short-term assets⁹. Under these conditions, the bank's goals for managing interest rates and liquidity are in harmony.

Cash-flow Effects

Liquid assets are also subject to repricing and maturity, hence changes in policy rates generate income flows due to the repricing or maturity of securities. Therefore, they play a role in the lines of the cash-flow channel (Gomez et al., 2021), in the sense that income shocks can help to alleviate constraints on lending.

Demand-side Roles

Banks usually are in the obligation to refinance a fraction of their liabilities. Through this process, banks' creditors make a choice based on banks' solvency and market interest rates. However, under information asymmetries, creditors cannot correctly observe banks' solvency status. Liquidity assets might influence the despositors' choice, to shift their deposits from one bank to another or to change the deposit product used.

Analogous to Disyata (2011) interpretation on capital, banks with higher liquidity ratios should face lower external finance premiums because the cash-generating capacity of liquid assets can insure depositors. This might transfer confidence to depositors, increasing deposit flow stability.

Nevertheless, liquidity is not necessarily a clean signal of a safe balance sheet structure or the bank's capacity to respond against shocks. In contrast to the idea that liquid assets unconditionally reduce banks' liquidity risks, a strand of the literature considers that accumulating liquidity buffers increases funding liquidity risk. This is due to the complementarities with other liquidity management instruments, specifically, banks' public communication. Raz, McGowan, and Zhao (2022) provides evidence supporting that the accumulation of liquid assets triggers an increase in liabilities' liquidity risks.

High-quality and low-quality liquidity can serve as important indicators in the capital channel, signaling to the public whether a bank is facing a dearth of lending opportunities. These signals are observed by investors who use them to anticipate a bank's ability to generate profits in the future. If these signals suggest that a bank is likely to struggle in terms of profitability, it can have several implications. One significant outcome is a reduction in the bank's equity. Investors may become less attracted to the bank's profile, which, in turn, impacts the bank's equity levels.

Asymmetric Pricing Behavior

Excess Liquidity may play a role in determining lending and deposit rates. For instance, Agénor and Aynaoui (2010) show that excess reserves create asymmetries in the pass-through of policy rates towards deposits and lending rates. Specifically, deposit rates are less responsive to increases in the refinance rate (or to reductions in the required reserve ratio) because banks internalize the fact that raising the deposit rate will induce

⁹Allocating uninsured deposits with low-deposit spread-betas into short-term assets increases exposure to interest rate risk since the deposit franchise and short-term assets have negative duration.

households to shift more of their assets into bank deposits – thereby increasing eventually the actual stock of reserves and compounding (all else equal) the initial problem of excess liquidity. If true, liquidity may play a role in determining deposit spreads.

Similarly, the greater the degree of excess reserves, the more banks may be willing to weaken the procedures they normally use to check the creditworthiness of potential borrowers, credit exposure limits, and other standard contract terms or loan covenants. This might suggest that banks with higher levels of liquidity become more risk-averse following an expansionary monetary shock.

Possible differentiated roles of liquidity categories

Why differentiation in liquidity qualities might be relevant for the transmission channel? Differences in the response to the interaction between monetary policy shocks and liquidity ratios are expected because of inherent differences in fundamental characteristics like (a) low risk, (b) ease and certainty of valuation, (c) low correlation with risky assets, (d) listed on a recognized exchange, (e) active and sizable market, (f) low volatility, (g) flight to quality or h) limited cash convertibility.

First, consider differentiation in collateral function. Boissay and Cooper (2020) distinguishes collateral types according to the private information available about the value of the pledgeable portion of the asset. Certain assets can serve as outside collateral because their *market value* can be pledged, such as using treasuries in a repo arrangement. In contrast, other assets can function as inside collateral, with only their *cash flows* available for pledging, like cash flows in the asset-backed commercial paper market. Since the cash flow generated by the assets supporting inside collateral is considered private information, the pledgeability of these assets is endogenous and hinges on the degree of informational asymmetry and the quality of banks' assets.

Therefore, banks whose balance sheets consist more of inside collateral than outside collateral are at a higher risk of facing self-fulfilling liquidity dry-ups, a phenomenon often referred to as the “collateral trap”. This distinction becomes particularly relevant when comparing LQ-liquid assets (such as asset-backed securities) to HQ-liquid assets (like treasuries). It also ties into the concept that banks' lenders might hold pessimistic views about a bank's quality based on its liquid asset portfolio composition.

Secondly, consider the potential limitations on the convertibility or monetization capacity of assets. Operational constraints can come into play here, potentially restricting the ease with which securities can be converted into cash. For instance, Afonso et al. (2020) highlights that when dealing with unusually large quantities of assets being sold on the same day, finding willing counterparties to purchase or engage in repo transactions for these assets can be challenging. This could be due to a perception that such a large-scale attempt to convert assets into cash might signal financial stress. Consequently, counterparties might opt to hold onto their cash reserves, anticipating potential future needs. This aspect is particularly significant when it is assumed that securities classified as HQ liquid assets can be readily and swiftly converted into cash. However, the operational constraints associated with handling very large quantities of assets, even those as seemingly liquid as HQ securities, are often overlooked.

Alternatively, the same operability constraint might translate into differentiability in fire sale prices. Afonso et al. (2020) highlights that unusually large sales might drive a hard

bargain if counterparties believe that the bank is under pressure to sell, resulting in the bank accepting significantly lower prices for its assets.

Finally, consider differences in signaling. Differences between HQ and LQ liquidity might arise from the signal liquidity sent to clients. For instance, clients can perceive that HQ liquidity is less opaque than complexly structured LQ assets like (CMOs). From the depositors' perspective, less opaque assets have lower exposure to asymmetric information problems concerning the value of the bank's assets.

2.3 Data

I gather quarterly data on banks' balance sheets at the bank and bank-holding levels and structural monetary policy shocks from the following sources. Quarterly balance sheet items at the bank level are from the quarterly Call Reports reported by the FDIC¹⁰. Quarterly balance sheets items at the bank-holding level are obtained from the FR Y-9C reports¹¹. High-frequency structural monetary policy shocks are from the publicly available time series constructed by Jarociński and Karadi (2020)¹².

Call reports contain statistics on all depository institutions in the U.S. which are FDIC-insured (insured subsidiaries). This universe of institutions comprises commercial, credit card, and saving banks, and the information reported is related to the main categories of banks' balance sheets. I deflate all balance sheet items using the seasonally adjusted GDP Implicit Price deflator in the U.S. (base 2015=100).

2.3.1 Variables

2.3.1.1 Categories of Liquidity

I employ the methodologies proposed by Ihrig et al. (2017) and Roberts, Sarkar, and Shachar (2023) to calculate the stock of high-quality assets. These approaches align with the 2013 final rule, which implements a quantitative liquidity requirement in accordance with the Liquidity Coverage Ratio (LCR) standard established by Basel III. In the U.S., the eligible assets falling under the high-quality category include excess reserves, treasury securities, debt or mortgage-backed securities issued by government agencies and enterprises, and privately issued securities. The high-quality assets are further divided into three subcategories: Level-1, Level-2A, and Level-2B. Table 2.A.1 summarizes the specific assets deemed eligible, with further details provided in Appendix 2.A.1.

The total stock of HQLA is simply the weighted sum of all eligible liquid assets ($HQ = Reserves, Treasuries, \dots$), where the weights (w_a) are haircuts defined by the LCR requirement¹³:

$$HQLA_{i,t} = \sum_{a \in HQ} w_a * A_{i,t} = \sum_{a \in L1} A_{i,t}^{L1} + \sum_{a \in L2a} 0.85 \cdot A_{i,t}^{L2a}$$

¹⁰Available at https://www7.fdic.gov/sdi/download_large_list_outside.asp

¹¹Available at <https://www.ffiec.gov/npw/> and <https://www.chicagofed.org/banking/financial-institution-reports/bhc-data>.

¹²Available at <https://marekjarocinski.github.io>

¹³Unlike the references, the measurements are done at the bank-level i and not at the bank-holding level.

For the baseline estimations, I do not consider regulatory haircuts and caps; instead, I assume that $w_a = 1 \forall a$. I use these haircuts in robustness exercises. Furthermore, baseline estimations are based on the total level of HQLA. For robustness, I also use Level-1 HQLA (the most liquid category)¹⁴. Finally, I normalize liquidity creation by GTA to make these variables relative to the size of each bank. To alleviate possible concerns on endogeneity due to the determination of banks' decisions, the measure of HQ-liquid assets used in the regressions is the four-quarter rolling average $HQLA_{i,t} = \sum_{j=0}^3 HQLA_{i,t-j}$.

The low-quality liquid category is the sum of all the remaining securities and debt assets issued by the U.S. government or private agents, assets held in trading accounts, and federal funds sold and reverse repurchased. It is important to note that I do not include other types of cash (e.g., *chcic*, *chus*, *chnus*). These assets are summarized in Table 2.A.1.

The total holdings of liquid assets are measured consistently with the methodology outlined in Berger and Bouwman (2009), and are thus defined as:

$$LA = HQ-Liquidity + LQ-Liquidity + Other\ Cash \quad (2.1)$$

Finally, the liquidity coverage ratio (LCR) is defined as:

$$LCR = \frac{HQLA}{ENCO30} \quad (2.2)$$

The denominator *ENCO30* is the total expected net cash outflows over a prospective 30-day calendar period. I construct this variable using the methodology outlined in Sundaresan and Xiao (2023) and Hong, Huang, and D. Wu (2014).

2.3.1.2 Structural Monetary Shocks

A common source of biases in the estimated effect of monetary policy on multiple banking variables is the co-determination of the Federal Reserve policies and aggregate economic conditions. Following the literature (e.g., Gareth and Ambrogio, 2020; Jeenas, 2018), I address this concern using the high-frequency identified (HFI) quarterly measurement of structural monetary shocks constructed by Jarociński and Karadi (2020).

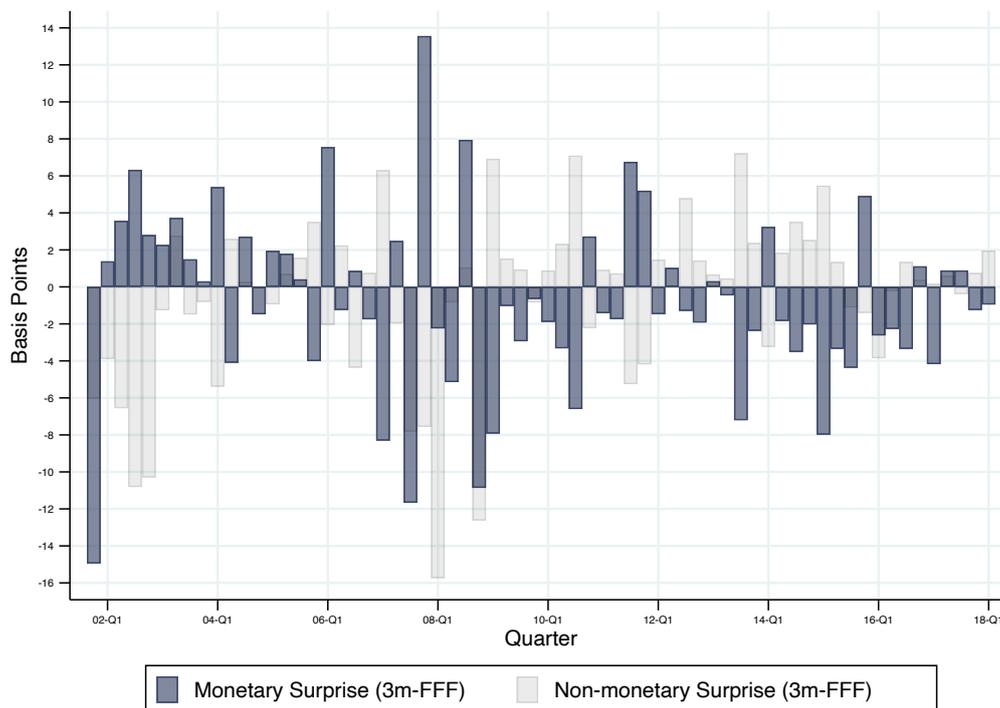
Figure 2.3.1 presents the quarterly measure of the structural monetary shocks (dark blue) together with the FED-information shocks (light gray). I use the sum of the daily structural monetary shocks within a quarter to obtain a quarterly measurement of the shocks. The structural monetary shocks are interpreted as policy-driven changes in the 3-month Fed funds futures rates¹⁵ that is consistent with a decrease in equity prices. Moreover, these monetary shocks should capture the overall monetary policy stance, which is unexpected changes in expectations about short-term interest rates induced by either actual rate setting or near-term forward guidance.

For comparison and future interpretability of the results, Table 2.3.1 shows the implied change of different market yields due to monetary shocks. A 25 basis points (1bp) increase in the monetary policy shock- ΔMS implies a 52.72 basis points (2.10bp) increase in the 1-year treasury yield or an 87.33 basis points (3.49bp) increase in the Fed Funds Rate. A 7.16bp increase in ΔMS equivalently implies a 25bp increase in the Fed fund rate.

¹⁴Notice that due to the lack of disaggregated data, I cannot estimate the Level-2B of HQLA.

¹⁵For robustness, I also use Jarociński and Karadi (2020) shocks estimated using the change in the first principal component of the surprises in fed funds futures and euro-dollar futures with one year or less to expiration. A proxy for changes in short-term rates suggested by Nakamura and Steinsson (2018).

Figure 2.3.1: High-Frequency Interest Rate Surprises Decomposition: Monetary vs. Non-monetary Surprises



Notes: Quarterly FED shocks using data from Jarociński and Karadi (2020). The underlying interest rate is the 3-month Fed funds future rate (FFF). By construction, $\Delta FFF_t = \Delta MS_t + \Delta NMS_t$

2.3.1.3 Other Bank-Level Variables

Throughout the research, other bank-level variables, characterizing different dimensions of the banking system, are estimated using methodologies suggested by the literature. On-balance sheet liquidity creation is estimated following Berger and Bouwman (2009). The bank-level income gap is measured following Gomez et al. (2021). Estimates of bank-level ‘betas’, duration mismatch, and local deposit market power are obtained following the methodologies implemented by Drechsler, Savov, and Schnabl (2021, 2017) and English, Van Den Heuvel, and Zakrajšek (2018). Credit and deposit markups are calculated based on the methodology proposed by Belligemine, Jamilov, and Monacelli (2022). Lending opportunities and deposits volatility following Stulz, Taboada, and Dijk (2022). For ease of exposition, details about methodologies, replication results, and potential differences in the estimations are left in Appendix 2.A.3.

2.3.2 Sample Selection

First, I exclude all savings/thrift banks as identified in the dataset. Additionally, I remove all remaining commercial banks that meet the following criteria: 1) do not have outstanding commercial real estate or commercial and industrial loans; 2) have zero deposits; and 3) possess an equity capital to total assets (GTA) ratio lower than 1% (following Berger and Bouwman, 2017).

Second, to have a more consistent computation of the level of high-quality liquid assets

Table 2.3.1: Normalization Parameters

	(1)	(2)	(3)	(4)
	ΔFFR	$\Delta 1yTB$	$\Delta 5yTB$	$\Delta 10yTB$
ΔMS_t	87.33*** (7.43)	52.72*** (3.41)	9.141 (0.51)	1.259 (0.08)
Constant	1.484 (0.43)	-0.948 (-0.21)	-4.500 (-0.86)	-4.958 (-1.04)
Observations	118	118	118	118

Notes: a) This table presents OLS estimates obtained from regressing changes in interest rates on the monetary shocks estimated by Jarociński and Karadi (2020). Monetary shocks are rescaled such that one unit change equals a 25bp increase. The sample goes from 1990q1 until 2019q2. b) Data on Treasury yields comes from <https://www.macrotrends.net>.

at the bank-quarter level, I remove commercial banks with total assets lower than \$300 million since this set of banks do not have to report their holdings of reserve balances due from Federal Reserve Banks. Reporting requirements and limitations are detailed in Appendix 2.A.1.

Third, banks included are all depository institutions that do not face post-crisis liquidity requirements beyond standard reserve requirements¹⁶. This sub-sample is hereafter named the Non-LCR sample since it follows the criteria established in the liquidity coverage ratio. The description of the categorization is presented in Appendix 2.B.

Finally, to alleviate issues in the estimations, I winsorize bank-quarter observations below the 1st and above the 99th percentile of the main dependent variable to control for outliers (see Jeenas, 2018). I balance the sample by excluding any bank entering or exiting during the sample period.

2.3.3 Descriptive Statistics

In this section, I provide descriptive statistics for the sub-sample of non-LCR depository institutions. After excluding LCR banks, the fully balanced sample consists of 29,106 bank-quarter observations and includes 441 unique banks over 66 quarters. Based on size, there are 180 small banks, 171 medium banks, and 93 large banks.

2.3.3.1 Banks' Portfolio of Liquid Assets

First, the holdings of liquid assets (cash + securities portfolio) are extensive, accounting for around 29 percent of gross total assets on average. Table 2.3.2 column 1 summarizes the composition of banks' liquidity by asset class. The average bank allocates around 15% in HQ liquidity and around 11% in LQ liquidity. Most banks' HQ-liquid assets are mainly comprised of Level 2a assets, which account for about 10.4 percent of the total

¹⁶The estimations are performed on this sub-sample to prevent the results from being influenced by the interaction between monetary policies and new liquidity constraints. To some extent, this allows one to focus on the characteristics of a liquid asset in transmitting the shock without being concerned about whether the bank is facing a binding constraint.

balance sheet. From this category, GSEs debt and GSEs residential-MBS are the most significant asset classes, accounting for around 4.1 and 5.8 percent, respectively. The remaining component of HQ assets, Level 1 assets, account for only 3.1 percent, and it is mainly composed of reserves (2.2%) and some GNMA residential-MBS (1.0%). Regarding LQ-liquid assets, the most significant asset classes are debt issued by states and political subdivisions (5.0%), collateralized mortgage obligations (3.3%), and Fed funds and reverse repos (1.1%). Relative to expected cash flows, the average bank operates with a liquidity coverage ratio of 0.58, indicating that its HQ liquidity does not fully cover the expected deposit outflows within a quarter. Second, banks exhibit considerable

Table 2.3.2: Statistics on Liquidity Ratios

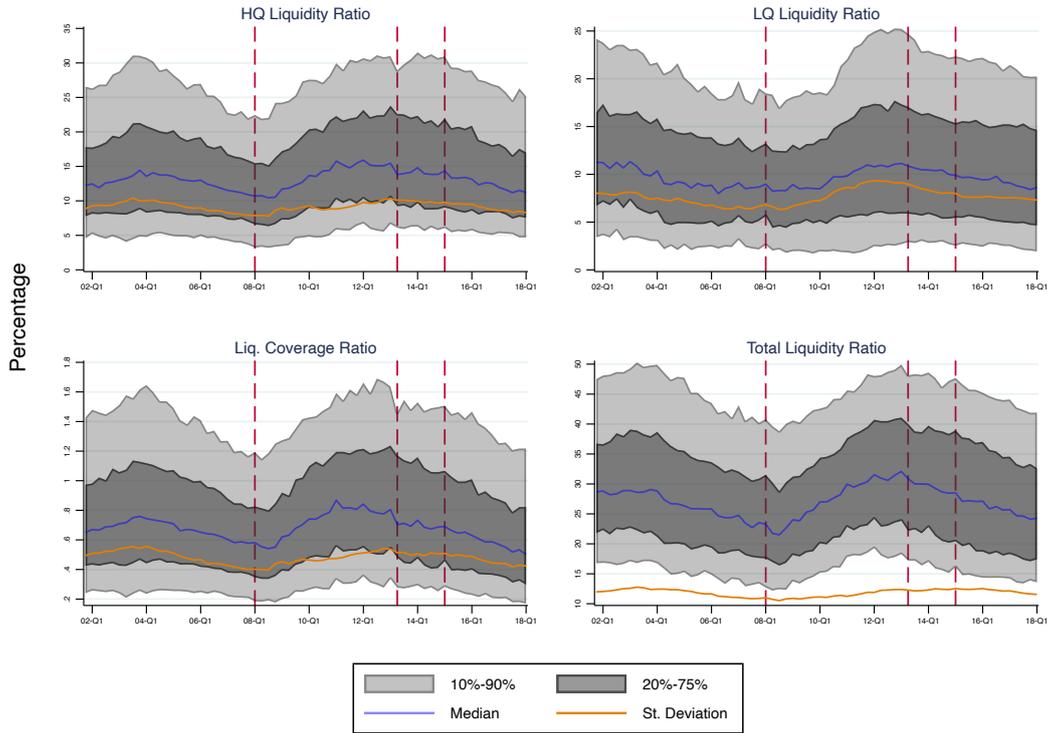
	Mean	SD	Min	Max	10th percentile	25th percentile	50th percentile	75th percentile	90th percentile
Total Liquid Assets Ratio	28.99	12.23	5.18	72.14	15.02	19.89	27.02	36.12	46.16
HQ Liquidity Ratio	14.94	9.31	0.28	52.56	4.90	8.24	13.00	19.56	28.10
HQ-L1 Liquidity Ratio	3.11	5.04	0.00	38.12	0.03	0.20	1.06	3.72	8.93
Reserves	2.17	3.71	0.00	29.01	0.01	0.10	0.60	2.53	6.40
Treasury Securities	0.77	2.43	0.00	20.43	0.00	0.00	0.00	0.26	1.77
RMBS by GAs	0.01	0.19	0.00	5.58	0.00	0.00	0.00	0.00	0.00
Other Debt by GAs	0.05	0.36	0.00	5.41	0.00	0.00	0.00	0.00	0.00
HQ-L2a Liquidity Ratio	10.38	8.25	0.00	49.93	1.79	4.35	8.56	14.20	21.26
Other Debt by GSEs	4.18	5.97	0.00	34.08	0.00	0.00	1.53	6.37	12.23
RMBS by GSEs	5.81	6.45	0.00	40.80	0.05	1.01	3.85	8.34	13.82
CMBS by US Gov. (Pass-Throughs)	0.24	0.73	0.00	7.16	0.00	0.00	0.00	0.04	0.75
CMBS by US Gov. (Other)	0.37	1.11	0.00	9.04	0.00	0.00	0.00	0.00	1.09
LQ Liquidity Ratio	11.12	7.89	0.00	45.44	2.43	5.39	9.61	15.05	21.57
Fed Funds Sold & Reverse Repo	1.13	2.27	0.00	20.66	0.00	0.00	0.02	1.26	3.71
CMOs and REMICs by US Gov.	3.25	4.58	0.00	32.88	0.00	0.00	1.40	4.77	9.14
Securities by Political Subdiv.	5.00	4.88	0.00	28.98	0.13	1.15	3.61	7.53	11.83
Other Debt Securities	0.70	1.53	0.00	11.69	0.00	0.00	0.01	0.65	2.24
RMBS by Privates	0.30	0.95	0.00	9.20	0.00	0.00	0.00	0.02	0.79
Other CMBS	0.01	0.10	0.00	1.73	0.00	0.00	0.00	0.00	0.00
ABS	0.09	0.45	0.00	6.54	0.00	0.00	0.00	0.00	0.02
Structured Financial Products	0.07	0.31	0.00	3.48	0.00	0.00	0.00	0.00	0.07
Foreign Debt Securities	0.03	0.18	0.00	2.37	0.00	0.00	0.00	0.00	0.01
Trading Account Assets	0.06	0.33	0.00	6.43	0.00	0.00	0.00	0.00	0.01
Liq. Coverage Ratio	0.58	0.41	-0.01	2.49	0.15	0.28	0.50	0.78	1.15

Notes: This table shows bank-level in-sample averages of the main liquidity ratios. Variables are all scaled by gross total assets, except the Liquidity Coverage Ratio. For a dynamic representation of the data, see Figure 2.3.2.

heterogeneity in their investments in liquid assets from the different categories. Table 2.3.2 column 2 highlights significant variation in liquidity ratios. The in-sample standard deviations reveal a dispersion of 12.2pp concerning total liquidity, 9.3pp for HQ liquidity, and 7.9pp for LQ liquidity. Beyond the average estimates, Figure 2.3.2 illustrates the evolution of heterogeneity across banks over time concerning the biggest liquidity categories. Notably, the degree of heterogeneity across the different types of liquidity has remained relatively stable over time, with a slight and temporary increase in dispersion of LQ liquidity observed after the Global Financial Crisis. Banks' HQ liquidity ratios move uniformly across the percentiles, while changes in LQ liquidity ratios in the bottom 20 percentile exhibit different patterns relative to the remaining sample. Figure 2.3.2, beyond showing how banks differ concerning their liquidity holdings, highlights that liquidity presents a significant cyclical component. To understand if economic cycles and banks' invariant characteristics fully explain the degree of heterogeneity observed, evidence on the evolution of residualized-liquidity after controlling for banks and quarter-fixed effects is presented in Appendix Figure 2.B.3. The differences in liquidity ratios across banks are lower; however, around 6 percent of the heterogeneity remains unexplained.

Additional descriptive statistics characterizing the heterogeneity for narrower asset categories and the portfolio of liquid assets by quintile groups are presented in Appendix

Figure 2.3.2: Cross-Sectional Heterogeneity in Liquidity Ratios



Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

2.B.2.1. Furthermore, Table 2.B.3 presents the transition matrices for liquidity ratios.

2.3.3.2 Balance Sheet Characteristics

What are the distinctive attributes that differentiate banks according to their varying levels of liquidity? Table 2.3.3a presents detailed bank-level data, providing insights into the average balance sheet characteristics within each of the five liquidity quintiles.

Starting with banks' lending activities, as expected, banks at the top of the distribution of the different liquidity ratios tend to have lower shares of loans. Nonetheless, the composition of the loan portfolio adheres to a consistent pattern across the distributions. Banks tend to allocate more significant resources to commercial real estate loans, followed by residential real estate loans, with C&I loans representing the third category in this progression.

Regarding banks' funding composition, a consistent trend emerges across the spectrum of liquidity ratios, wherein total domestic deposits consistently represent approximately 78% to 80% of the total assets. In contrast, bank capital makes up approximately 10%. Delving into the breakdown of deposit funding on banks' balance sheets, a significant proportion of funds stem from non-transaction accounts, constituting an average of around 67%, with transaction accounts contributing around 12.5%. Although there are variations in the distribution of these shares across liquidity quintiles, the differences between quintiles are generally contained within a 2.0 percentage point range.

Among the different types of deposits, banks rely on sources that usually offer higher interest rates. That is the case for time deposits (e.g., CDs), which emerge as the primary source, accounting for 27.5%, followed by money market deposits at 23.4%, other savings deposits at 15.7%, and demand deposits at 8%. These patterns persist across the liquidity distributions, with slight variations in shares but not exceeding the 3.0 percentage point range between quintiles. Altogether, this composition implies that banks rely on high-rate funding sources that are more responsive to monetary policy¹⁷.

Regarding interest-rate hedging, the data reveals that banks generally use only a few derivatives to manage their exposure to interest-rate risks. Notably, banks with lower HQ liquidity tend to hold more interest rate contracts than those in higher liquidity quintiles. Swaps are the most common form of hedging employed by these banks. This aligns with findings from Gomez et al. (2021), which indicate that the median bank typically has no active interest-rate contracts.

Finally, Table 2.3.3b illustrates the variations in profitability among banks. Despite the association between larger holdings of liquid assets and lower profit margins, the differences in profitability among the different liquidity quintiles are relatively small. The average net interest margin in the sample stands at 3.8%, and notably, disparities in interest rate margins across the liquidity distribution do not exceed 0.48pp. Additionally, average interest rates earned and paid exhibit similarities across the quintiles. Further descriptive statistics detailing the evolution of cross-sectional heterogeneity in profit margins are available in Appendix 2.B.2.2.

¹⁷Recent evidence describing how rates on time deposits are typically higher but also rise more in response to a higher fed funds rate is available here <https://libertystreeteconomics.newyorkfed.org/2023/04/deposit-betas-up-up-and-away/>

Table 2.3.3: Banks' Characteristics Grouping by Quintiles

(a) Balance Sheet

	Quintiles of HQ Liquidity Ratios					Quintiles of LQ Liquidity Ratios					Quintiles of Liq. Coverage Ratios					
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Total
Gross Total Assets (Log)	13.59	13.76	13.59	13.47	13.43	13.58	13.64	13.56	13.45	13.61	13.60	13.76	13.52	13.53	13.43	13.57
Total Loans	71.72	69.05	65.54	61.78	52.15	71.38	67.89	63.54	62.76	53.92	70.62	68.88	65.40	61.73	53.38	63.98
Commercial Real Estate Loans	29.72	27.98	25.55	25.24	21.48	29.69	29.14	25.37	25.35	20.10	29.28	27.95	26.06	24.71	21.89	25.98
Residential Real Estate Loans	22.29	21.78	22.60	19.89	17.11	21.60	21.82	20.84	20.99	18.21	22.54	22.15	21.47	20.26	17.17	20.71
Commercial & Industrial Loans	11.93	12.58	10.32	9.92	7.93	12.55	10.24	9.78	10.35	9.56	10.91	12.15	10.86	9.92	8.76	10.51
Consumer Loans	3.90	3.79	4.74	4.19	3.30	4.07	3.48	4.71	3.87	3.79	4.43	3.76	3.98	4.68	3.05	3.98
Agricultural Loans	2.12	1.56	1.46	1.33	1.22	1.61	2.03	1.82	1.20	1.02	1.84	1.78	1.88	1.04	1.16	1.54
Total Domestic Deposits	79.33	78.80	80.04	79.75	79.75	80.13	79.77	79.48	79.94	78.35	80.21	79.65	79.48	79.22	79.14	79.54
Transaction Deposits	11.42	11.62	12.32	12.70	14.54	12.40	12.45	12.35	12.71	12.76	11.33	11.50	12.60	12.87	14.36	12.53
Demand Deposits	7.29	7.86	8.31	8.08	9.34	8.44	8.12	8.05	7.98	8.30	7.27	7.67	8.06	8.26	9.63	8.18
Non Transaction Deposits	67.86	67.18	67.59	67.02	65.00	67.69	67.29	67.06	67.22	65.30	68.83	68.17	66.84	66.24	64.54	66.92
Money Market Deposit	21.94	25.10	23.86	23.64	22.82	22.53	24.72	23.49	23.39	23.11	23.28	25.54	21.58	23.87	22.88	23.44
No Transaction Time Deposits	29.69	27.15	27.82	27.22	25.90	29.57	29.06	27.02	27.08	24.97	29.02	27.35	29.11	26.95	25.47	27.57
Other Savings Deposits	16.12	14.91	15.94	15.92	15.86	15.47	13.52	16.35	16.53	16.99	16.41	15.20	16.15	15.36	15.70	15.76
Fed Funds Purchased & Repos	2.88	2.82	2.96	3.12	4.13	2.67	3.12	3.18	3.13	3.85	2.88	2.84	2.71	3.64	3.83	3.19
Equity Capital	10.08	10.32	9.89	9.71	10.01	9.99	10.04	10.08	9.89	10.00	10.05	10.08	10.05	9.66	10.15	10.00
Core Deposits	67.99	68.73	70.62	69.99	70.34	68.59	69.47	69.78	70.14	69.72	69.58	69.59	69.09	69.80	69.59	69.53
bro_GTA	4.66	3.07	2.12	2.13	0.92	4.01	2.59	2.69	2.50	1.04	4.05	2.73	2.79	2.02	1.31	2.58
trnipcoc.GTA	9.76	9.84	10.45	10.52	11.81	10.82	10.44	10.28	10.14	10.71	9.68	9.57	10.55	10.69	11.91	10.48
ntripce.GTA	62.51	62.02	62.13	61.38	59.22	63.50	61.96	60.70	61.64	59.27	63.91	62.45	60.71	60.72	59.34	61.44
Total Time and Savings Deposits	72.02	70.90	71.63	71.64	70.25	71.68	71.61	71.41	71.96	69.76	72.90	71.97	71.40	70.85	69.33	71.29
Insured Deposits	59.27	56.27	59.79	58.63	57.80	59.15	59.37	58.59	58.33	56.36	59.97	57.19	59.42	58.81	56.50	58.37
Interest-bearing Deposits	65.54	64.87	65.74	64.62	63.52	65.63	65.14	64.78	64.88	63.77	66.20	65.36	65.86	64.40	62.49	64.85
Interest-bearing Deposits (Foreign)	1.02	2.52	31.19	5.60	6.70	2.85	2.60	2.45	0.06	24.18	0.53	1.94	0.90	27.82	8.02	9.30
Interest Rate Contracts	4.57	4.38	2.26	2.05	1.06	3.38	2.54	3.01	2.68	2.64	3.97	3.76	3.13	2.15	1.27	2.85
IR Swaps (NV)	1.85	2.20	1.44	1.01	0.60	1.17	1.49	1.56	1.49	1.36	1.73	1.79	1.59	1.23	0.72	1.41
IR Futures and Forward	1.26	0.87	0.48	0.48	0.22	1.07	0.47	0.48	0.58	0.70	1.05	0.87	0.63	0.53	0.23	0.66
IR Written Option Contracts	0.98	0.64	0.37	0.23	0.17	0.69	0.44	0.45	0.39	0.42	0.83	0.66	0.35	0.37	0.17	0.48
IR Purchased Option Contracts	0.31	0.26	0.19	0.19	0.08	0.14	0.09	0.34	0.25	0.21	0.29	0.24	0.15	0.20	0.14	0.21
Liquidity Creation (On BS)	36.21	34.80	30.90	28.70	21.58	36.56	33.77	29.84	29.26	22.14	35.38	34.95	30.52	28.50	22.60	30.38
Total Liquid Assets Ratio	20.83	23.41	27.42	31.29	41.63	21.17	24.68	29.22	30.42	39.89	22.07	23.64	27.43	31.42	40.29	28.99
Total Semiliquid Assets Ratio	27.19	26.65	28.17	25.30	21.31	26.68	26.08	26.51	25.94	23.20	28.00	26.90	26.33	26.00	21.27	25.69
Total Illiquid Assets Ratio	51.80	49.93	44.67	43.49	37.16	52.04	49.26	44.23	43.67	37.25	49.74	49.41	46.32	42.84	38.60	45.37
Total Liquid Liabilities Ratio	52.61	54.60	55.43	55.82	58.32	53.38	53.91	55.70	56.07	57.84	54.16	55.21	53.15	56.36	57.80	55.36
Total Semiliquid Liabilities Ratio	35.28	32.97	32.94	32.54	29.91	34.52	34.11	32.26	32.15	30.49	33.77	32.75	34.86	32.21	30.18	32.73
Total Illiquid Liabilities Ratio	11.05	11.39	10.72	10.65	10.91	11.00	10.92	10.99	10.80	10.98	11.01	11.01	10.99	10.58	11.09	10.94

(b) Profitability

	Quintiles of HQ Liquidity Ratios					Quintiles of LQ Liquidity Ratios					Quintiles of Liq. Coverage Ratios					
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Total
Net Int. Rate Margin	3.99	3.89	3.84	3.79	3.51	4.01	3.84	3.84	3.75	3.57	4.06	3.87	3.79	3.77	3.52	3.80
Int. Rate Income	5.48	5.33	5.24	5.16	4.78	5.46	5.25	5.23	5.13	4.90	5.50	5.29	5.25	5.16	4.79	5.20
Int. Rate Expenses	1.51	1.44	1.40	1.37	1.27	1.46	1.41	1.39	1.39	1.33	1.45	1.42	1.45	1.39	1.27	1.40
Non Int. Income	1.21	1.25	1.11	1.04	1.19	1.21	1.07	1.33	1.09	1.11	1.24	1.18	1.12	1.06	1.20	1.16
Non Int. Expenses	3.05	3.02	2.98	2.92	2.88	3.13	2.93	3.09	2.91	2.79	3.08	3.00	2.96	2.90	2.91	2.97
ROA	1.14	1.09	1.02	1.04	1.04	1.06	0.98	1.15	1.02	1.11	1.17	1.06	1.05	1.02	1.02	1.06
Provision For Credit Losses	0.34	0.35	0.32	0.26	0.22	0.36	0.31	0.29	0.30	0.21	0.34	0.33	0.30	0.29	0.22	0.30
Int. Rate on Loans and Leases	3.68	3.64	3.71	3.72	3.73	3.75	3.67	3.73	3.67	3.65	3.72	3.62	3.71	3.73	3.69	3.69
Int. Rate on Safety	2.10	2.10	2.04	2.05	2.00	1.99	1.99	2.06	2.10	2.15	2.09	2.08	2.07	2.04	2.00	2.06
Int. Rate on Securities	2.17	2.13	2.08	2.09	2.04	2.04	2.04	2.11	2.14	2.19	2.15	2.11	2.11	2.09	2.04	2.10
Int. Rate on Fed Funds	3.71	4.46	3.59	3.50	3.88	4.32	3.95	3.35	3.81	3.61	3.84	4.46	4.31	2.79	3.84	3.81
Int. Rate on Balances Due from DIs	0.16	0.16	0.19	0.18	0.19	0.21	0.14	0.20	0.16	0.17	0.16	0.15	0.17	0.19	0.20	0.17
Int. Rate on Deposits	0.87	0.82	0.81	0.78	0.73	0.85	0.82	0.80	0.80	0.75	0.85	0.82	0.84	0.79	0.73	0.80
Int. Rate on IB Deposits	1.03	0.97	0.95	0.94	0.89	1.01	0.97	0.95	0.95	0.90	1.00	0.97	0.98	0.95	0.89	0.96
Int. Rate on Deposits (Net)	0.62	0.56	0.53	0.50	0.44	0.59	0.55	0.50	0.53	0.48	0.57	0.57	0.56	0.50	0.45	0.53

Notes: This table shows bank-level in-sample averages of the main liquidity ratios by quintile groups based on liquidity ratios. The last column presents the in-sample average. Variables are all scaled by gross total assets.

2.3.3.3 Correlation Structure

What are the characteristics that exhibit strong correlations with liquidity ratios? Table 2.B.4 provides an overview of the linear correlation structure among banks' attributes in the sample. Examining columns 1 to 3, we observe that liquidity ratios exhibit strong negative correlations with profitability measures, which aligns with the expectation that higher levels of liquid assets generally lead to lower interest rate income. Furthermore, several variables stand out with notably high correlation coefficients: a) Positive linear

correlation with deposit-spread-betas with coefficients between 0.11 and 0.13. b) Positive and high linear correlation with risk-weighted capital-to-asset ratios with a coefficient of 0.47-0.45 for HQ liquidity and 0.24 for LQ liquidity¹⁸. c) Positive and high linear correlation with duration mismatch with coefficients between 0.15 and 0.22¹⁹. d) Negative and high linear correlation with income gaps with a coefficient between -0.17 and -0.23. Finally, there are some exclusive correlations: HQ liquidity negatively correlates with expected loan growth (-0.18 and -0.20), while LQ liquidity positively correlates with deposit markups (0.20).

Do common factors drive these correlation coefficients? I estimate correlation coefficients accounting for aggregate business cycle fluctuations and banks' specific business models to explore the importance of common factors in the correlation structure of Table 2.B.4. To do so, I present binned scatter plots illustrating the relationship between residualized liquidity ratios and residualized banks' characteristics, where the residuals are obtained after controlling for bank-fixed and time-fixed effects. Figure 2.3.3 displays the results for the variables strongly correlated with the liquidity ratios. The results of this exercise confirm the directional trends observed in Table 2.B.4, with a couple of noteworthy exceptions: HQ liquidity ratios exhibit a stronger correlation with deposit volatility than indicated by the previous correlation coefficients²⁰. Additionally, LQ liquidity is found to be uncorrelated with duration gaps. This evidence underscores the importance of considering potential sources of omitted variable biases in the analysis.

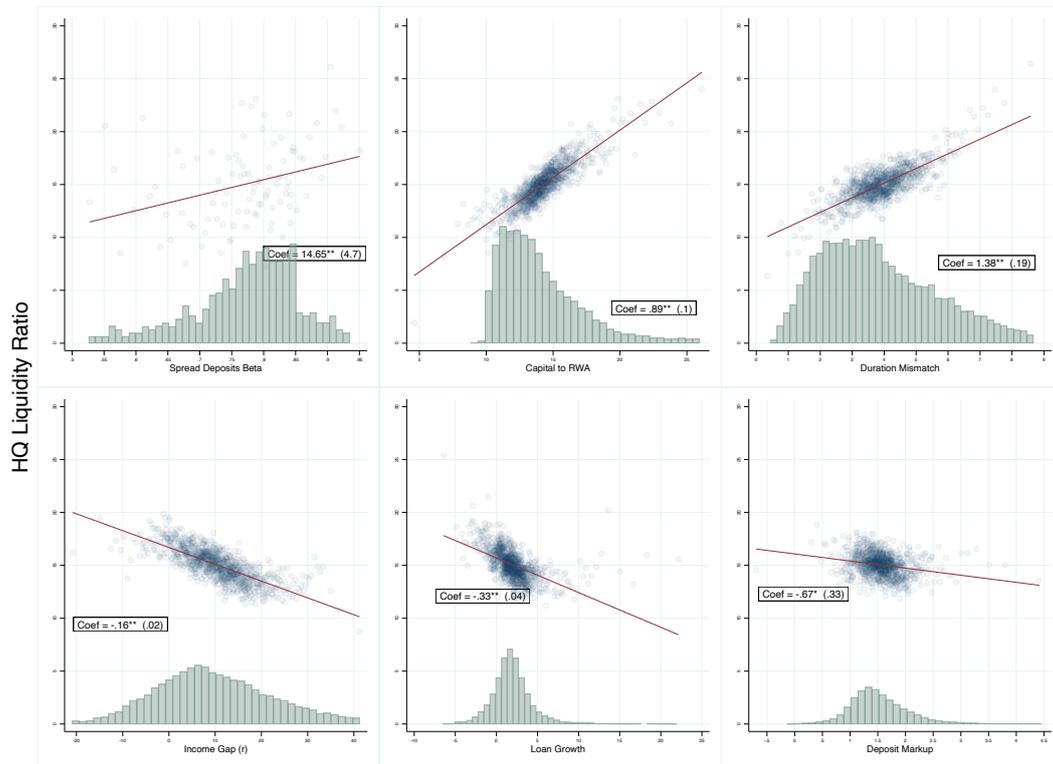
Descriptive statistics for other banks' characteristics and using extra bank-specific controls are left in Appendix 2.B.3.

¹⁸The high correlation can be mainly attributed to capital requirements. Since assets such as excess reserves or Treasury securities (HQLA-1) carry a zero risk weight, banks can comply with their capital requirements with additional HQ liquidity (See Ihrig et al., 2017).

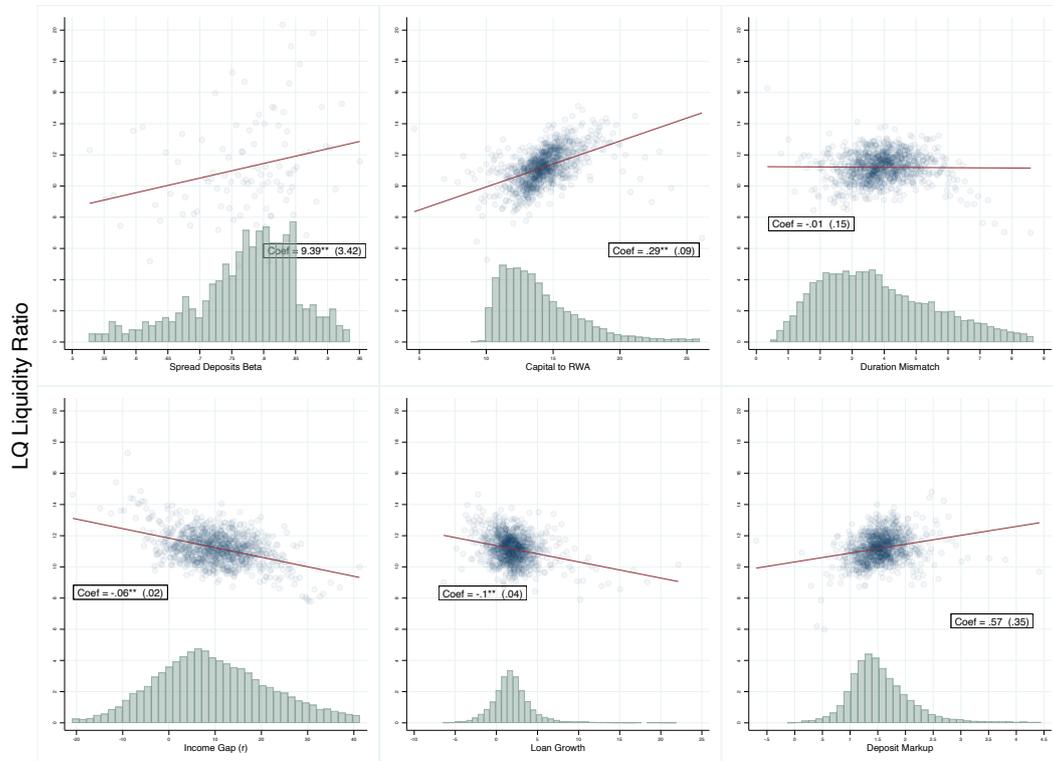
¹⁹This correlation might be explained because liquidity is composed of long-term assets, and banks hedged their deposit franchise by extending the maturity of their balance sheet (See Drechsler, Savov, and Schnabl (2021)).

²⁰This aligns with the evidence presented in Stulz, Taboada, and Dijk (2022), suggesting that banks' holdings of liquid assets are influenced more by their lending opportunities than by precautionary motives.

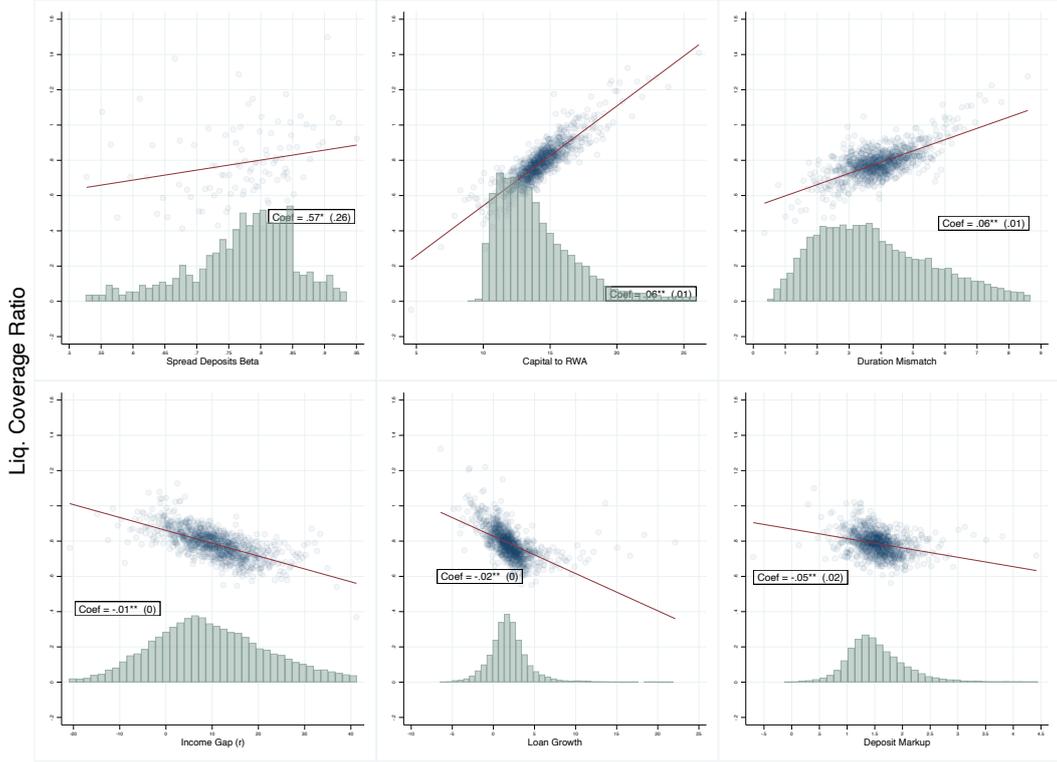
Figure 2.3.3: Liquidity Ratios and Banks' Characteristics: Correlation Analysis Excluding Business Cycle Fluctuations and Bank-Specific Business Models



(a) HQ liquidity and Banks' Characteristics



(b) LQ liquidity and Banks' Characteristics



(c) LCR and Banks' Characteristics

Notes: **a)** To prepare the data, the x-axis and y-axis variables were residualized using bank and quarter-fixed effects. Subsequently, the sample was divided into 1000 equally sized bins based on the residualized x-variable. The Spread Deposit Betas, however, were not residualized, and the data was divided into 100 bins. For each bin, the unweighted average of the x-axis and y-axis variables was calculated, and the mean of each variable was added back to the corresponding residual. Spread Deposit Betas are not residualized, and data was divided into 100 bins. **b)** The resulting graph provides a visual representation of the underlying distribution of the x-variable.

2.4 Empirical Specification

2.4.1 Benchmark Specification

Throughout the following sections, I employ local projection methods to study whether the documented evidence on the cross-sectional heterogeneity in liquidity ratio affects monetary policy transmission into the banking system. To this end, I estimate panel regressions projecting measures of bank-level characteristics on the interaction term of the banks' liquidity-to-GTA ratio and a structural monetary shock.

The baseline set of local projections follows:

$$\Delta_h Y_{i,t+h} = (\psi^h + \gamma^h mp_t) LR_{i,t-1} + \Gamma^h mp_t X_{i,t-1} + \Psi^h Z_{i,t-1} + f_i^h + f_{t+h}^h + u_{i,t+h}^h \quad (2.3)$$

where $h = 0, 1, \dots, H$ denotes the horizon at which the relative impact effect is estimated, with $H = 16$ ²¹.

$\Delta_h Y_{i,t+h} \equiv Y_{i,t+h} - Y_{i,t-1}$ denotes the cumulative difference h -quarters after the monetary

²¹The estimation for the horizon $h=0$ includes 65 quarters per bank and for the horizon $h=16$ includes 48 quarters per bank.

shock. The characteristics of the banks studied are the ratio of on-balance sheet liquidity creation to gross total assets, deposit flows, interest rate margins, and loan growth. The coefficients of interest in equation (2.3) are γ^h , which capture the average differential impact of a monetary tightening shock on characteristic- Y conditional on ex-ante liquidity ratio LR .

The different liquidity ratios $LR_{i,t-1} = \{HQLR, LQLR, LCR, TOTLR\}$ are measured as the four-quarter rolling average. This is to address the joint determination of liquidity and banks' future decisions²², and to reduce issues related to the seasonality in the reporting (See Jeenas (2018)). These variables are also included in lagged values to ensure a degree of exogeneity concerning the monetary shock.

The quarterly monetary structural shocks (mp_t) are measured as the sum of daily shocks from Jarociński and Karadi (2020). In robustness exercises, I present results using other identified monetary shocks.

f_i^h denotes bank-level fixed effects in banks' cumulative difference over horizon $h + 1$. Bank-level fixed effects are included to account for unobserved banks' characteristics that might be correlated with the interaction term and the characteristic- Y . For instance, specific business models can expose banks more to monetary shocks and simultaneously induce banks to hold higher holdings of liquidity²³. Moreover, it is argued in the literature that it helps to reduce serial correlation problems in local projection estimations.

f_{t+h}^h denotes quarter fixed effects for the $h + 1$ -quarter difference measured in period $t + h$. I include quarter fixed effects to control for aggregate shocks, which might induce correlation between depository institutions in the U.S. banking system across time²⁴.

Finally, $Z_{i,t-1}$ and $X_{i,t-1}$ are vectors of lagged bank-level and time-varying controls, with $X_{i,t-1} \subseteq Z_{i,t-1}$. Control variables are included as lagged values to reflect that banks' decisions are made before the monetary policy shocks.

Clustering Standard Errors

Ideally, to build the confidence intervals, the strategy is to obtain standard errors that allow for fully flexible dependence in the error term in two dimensions: a) Across time within each bank, which might be the case if some bank-level shocks have some degree of persistence. b) Across banks within each quarter, which might be the case if some bank-level shocks have contagion effects²⁵. For this purpose, I include confidence intervals robust to both arbitrary heteroskedasticity and arbitrary autocorrelation. The confidence intervals are obtained using heteroskedastic and autocorrelation-consistent

²²Consider, for instance, banks might potentially accumulate a significant amount of reserves or treasuries to expand future lending.

²³Regarding this last point, Ihrig et al. (2017) highlights the fact that internal liquidity risk management decisions reflect individualized liquidity needs. Hence, banks specializing in payment, settlement, or clearing activities might hold higher stocks of liquid assets.

²⁴To estimate the linear regression with multiple fixed-effects parameters, I use the Stata package *reghdfe* described in Correia (2017).

²⁵Since I control for quarter-fixed effects, this is only necessary if bank-level shocks are correlated within any given quarter because of other reasons besides system-wide shocks. For instance, we can think about the presence of local-contagion effects.

standard errors (Newey-West)²⁶.

Variables adjustments

For ease of interpretation, I adjust variables in three ways consistent with the literature. First, to control for outliers, estimations at each horizon- h exclude observations of the dependent variable $\Delta_h Y_{i,t+h}$ below the 1st and above the 99th percentile per quarter. Second, I standardize the liquidity ratios $LR_{i,t-1}$ by centering the variable around its sample mean and rescaling by its standard deviation. Finally, the series of monetary policy shocks is equivalent to a 1bp surprise increase in the three-month fed funds future rate. To understand the quantitative relevance of the monetary shocks, we can use the coefficients presented in table (2.3.1). For example, an 11.85 bp increase in the HFI-monetary shock is equivalent to a 25bp increase in the 1y treasury yield. Notice also that the standard deviation of the shock in the estimation sample is 4.80 basis points (See Table (2.A.2)).

Altogether, estimates of γ^h represent the average cumulative response of outcome- Y after a 1bp surprise increase in the three-month fed funds future rate (3m-FFF). This response occurs over h quarters and is specific to banks with a liquidity ratio of 1sd above the average ratio.

Identification and Endogeneity

The identification strategy involves exploiting the time and cross-sectional variation in liquidity ratios (LR). The baseline regression exploits this cross-sectional heterogeneity and consists of estimates γ^h in specification (2.3) where the vector on bank-specific characteristics $X_{i,t-1}$ is empty. Nevertheless, biases in the baseline estimates of γ^h might appear since the differential exposure in liquidity a) correlates with other banks' characteristics and b) might be itself a bank's endogenous choice.

First, I use the joint-regression approach to address omitted variable bias, which reduces the bias due to *observable* omitted characteristics. Specifically, the baseline regression is extended by including in specification (2.3) a non-empty vector on bank-specific characteristics $X_{i,t-1}$ that interacts simultaneously with monetary policy shocks. The selection criteria of the subset $X_{i,t-1}$ depends on the outcome of interest Y , and it is discussed separately in each of the following sections. However, the common conduct I follow is to choose variables that are coincident with the decisions about holdings of liquid assets and, at the same time, that might directly impact characteristic- Y via the transmission of monetary policies. I select a small set of variables to reduce biased estimators at longer horizons, as suggested in Herbst and Johannsen (2021).

Second, I follow the standard practice in the literature to address reverse causality. For baseline and joint specifications, I include one period lag of the 4-quarter rolling average of the HQ liquidity ratio. The underlying assumption is that banks' future Y -outcomes do not determine past liquidity choices. Other strategies to address other sources of endogeneity are discussed and implemented in Chapter 3.

²⁶Another alternative was to use robust standard errors clustered two ways at the bank and quarter levels. However, this clustering assumes that local-contagion effects are not relevant. To deal with this is to cluster at the quarter-county levels; however, data in Call Reports about geographical locations is about the main branch, so it is not representative of the presence of a bank in a specific county.

2.4.2 Exploring Non-Linearities

The heterogeneity in monetary policy transmission captured by the γ^h coefficients in (2.3) are obtained from examining the impact of marginal changes in liquidity ratios on the transmission of monetary shocks. To investigate the monotonicity of effect in the entire distribution, I group banks into bins based on liquidity ratios. This exercise allows for unearthing possible nonlinearities introduced by liquidity conditions and estimates group-specific impulse responses to shocks.

To explore potential non-linearities, the following specification is estimated.

$$\Delta_h Y_{i,t+h} = \sum_{g \in G} (\psi_{gr}^h + \gamma_{gr}^h mp_t) \mathbb{1}_{i,t-1}^g + \Gamma^h mp_t X_{i,t-1} + \Psi^h Z_{i,t-1} + f_i^h + f_{t+h}^h + u_{i,t+h}^h \quad (2.4)$$

Equation (2.4) introduces an interaction term with an indicator variable $\mathbb{1}_{i,t-1}^g$ that captures the membership of a bank in a specific region of the cross-sectional distribution of liquidity ratios one quarter before the monetary shock. The sample is divided into quintiles based on the distribution of liquidity ratios, with $\mathbb{1}_{i,t-1}^g$ taking a value of one if bank i falls into the g -th quantile at time $t - 1$. The quintiles considered are $G = 2nd, 3rd, 4th, 5th$. The parameter of interest, denoted as γ_{gr}^h , captures the differential effects of monetary policy shocks on the characteristic- Y of banks in the G groups compared to banks with liquidity ratios lower than the first quintile.

2.4.3 Alternative Specifications

Before proceeding with the presentation and discussion of results based on the benchmark and non-linear specification, it is pertinent to make some preliminary observations.

1. The potential repricing effects stemming from monetary policies on security prices have garnered increased attention in estimating interaction coefficients denoted as γ^h . However, it is noteworthy that the available dataset lacks the granularity necessary to incorporate bank-security-specific prices, which could enable direct control over such effects. In response to this limitation, an attempt is made to address these concerns by introducing control measures informed by the hedging strategy hypothesis, as outlined in the work of Drechsler, Savov, and Schnabl (2021).
2. It is imperative to acknowledge that the dataset at hand represents equilibrium realizations, and due to its inherent structure, the application of alternative fixed-effect identification strategies to disentangle demand- or supply-related effects is not feasible. In response to this limitation, an attempt is made to address these concerns by introducing measurements of bank-specific supply sensitivities in the spirit of the Deposit Channel (Drechsler, Savov, and Schnabl, 2017).

The detailed methodologies for these supplementary analyses are elaborated upon in Appendix 2.C. Given these inherent constraints and limitations, I hereby present preliminary results and advocate for exploring supplementary exercises in forthcoming research.

2.5 Effect on Deposit Flows

Liquid assets can play diverse roles in transmitting monetary policies to banks' deposit flows. On the one hand, the ability to generate instantaneous cash flows may be perceived by clients as a safeguard for their funds, thereby enhancing deposit stability. On the contrary, if liquid assets are substitutes for other liquidity management instruments, the potential rise in the banks' opacity induced by the complexity of measuring the value of liquid assets may diminish the stability of their deposits. This section presents the findings on the influence of different types of liquid assets in transmitting monetary policy shocks to deposit flows. Before delving into the results, a couple of clarifications are in place.

First, the dataset reflects equilibrium outcomes within the deposit markets. From a theoretical perspective, the effect of monetary policy can manifest through demand or supply effects. The deposit channel advocates for a transmission mechanism via deposit supply, while theories on self-fulfilling bank runs propose a transmission mechanism driven by depositors' demand²⁷. Consequently, I interpret the γ^h coefficients as indicative of the effect of monetary policy shocks conditional on ex-ante liquidity ratios on *equilibrium* deposit flows.

Second, this section's set of control variables, X_i , comprises bank size (measured as the logarithm of total assets) and capitalization (measured as the total capital ratio adjusted for risk). These variables capture various constraints that banks may encounter in deposit markets, typically related to their size or risk level. Although I tested the inclusion of other pertinent controls—such as variables measuring profitability (quantified as net interest rate margins or the return on total assets), insolvency risk (measured using the z-score and the ratio of non-performing loans), income shocks triggered by changes in monetary policy (quantified by the income gap), and interest rate risk exposure (quantified by the maturity gap)—their addition did not lead to significant changes in the joint-estimates coefficients.

2.5.1 Results on Bank-Level Estimation

Figure 2.5.1 presents estimates of γ^h in specification (2.3) when the dependent variable is the log change in total deposits. Each impulse response function depicts the differential impact of a 1bp monetary tightening shock on deposit growth rates for banks standing 1sd above the mean of the respective liquidity distribution. At any horizon h , positive coefficients mean that banks with larger liquidity ratios stabilize more the outflows of deposits induced by monetary policy shocks (less negative growth rate)²⁸

²⁷In the classic Diamond and Dybvig (1983) model, depositors withdraw deposits because monetary policy induces banks to sell their assets at distressed prices, leading depositors to run on their banks in anticipation of insolvency. An alternative is proposed by Drechsler, Savov, Schnabl, and Wang (2023) in which uninsured depositors withdraw their funds because tightening monetary policy disproportionately increases the value of the deposit franchise relative to the value of banks' assets. This heightened liquidity risk prompts the breakdown of banks' interest-rate hedging strategies, leading depositors to anticipate bank insolvency and initiate a run on their banks.

²⁸This is arguably the more appropriate interpretation because evidence suggests that aggregate deposits flow out when monetary policy tightens—alternatively, greater inflow of deposits (more positive growth rate). Including quarter-FE does not allow me to estimate the unconditional effect of monetary policy but favors the estimation of γ by controlling for other non-monetary aggregate shocks destabilizing

Starting with the impact of HQ-liquid assets, the dynamics based on the baseline point estimates are negative for banks with an HQ liquidity ratio standing 1sd above the mean of the distribution. However, once we account for variables that reflect banks' constraints in deposit markets, the dynamics change quantitatively and qualitatively. Focusing on the joint regression point estimates, banks with larger holdings of HQ liquidity experience lower outflows in total domestic deposits in the short term, specifically within 0 to 6 quarters after the shock. Only the differences manifesting over short horizons are statistically significant, suggesting that HQ liquidity does not exert prolonged effects.

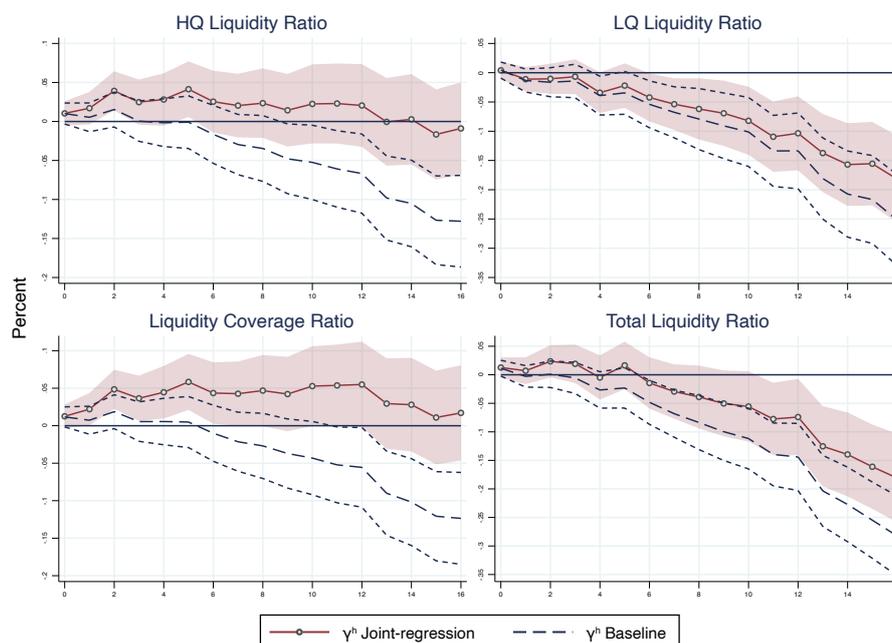
In terms of quantitative relevance, the estimates imply that in response to a monetary tightening shock causing a surprise 1bp increase in the fed funds futures rate, banks with higher HQ liquidity ratios witness deposit growth approximately 0.05% higher in the first two years after the shock²⁹. This evidence highlights that HQ liquidity stabilizes short-term deposit fluctuations triggered by monetary tightenings. This phenomenon may be attributed to the idea that liquid assets can alleviate banks' constraints, thereby reducing depositors' risks and funding costs.

When analyzing heterogeneity resulting from differences in liquidity coverage ratios, the dynamic response closely mirrors the impulse response function of the HQ liquidity ratio. This alignment is expected as the numerator of the liquidity coverage ratio comprises only HQ-liquid assets. However, it is worth noting that this ratio might more precisely capture the capacity of banks to cover unexpected deposit outflows and provide better insights into banks' abilities to handle short-term liquidity demands. With this in mind, heterogeneity in banks' capacity to address short-term liquidity needs translates into larger estimated coefficients relative to the coefficients from the HQ liquidity ratio.

deposits.

²⁹To rephrase it, a 25bp increase in the 3-month fed funds futures rate (3m-FFF) corresponds to a 1.25% higher growth rate. From Table 2.3.1, it is worth noting that a 25bp increase in the 3m-FFF results in an 87.33bp increase in the Fed funds rate (FFR). Therefore, in terms of the FFR, a monetary tightening shock, which causes a 25bp increase in the FFR, leads to approximately 0.35% higher deposit growth in banks with higher HQ liquidity ratios in the first two years after the shock.

Figure 2.5.1: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Baseline)



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Turning to the influence of LQ-liquid assets, both the baseline and joint-regression point estimates reveal similar dynamics. The point estimates are negative for banks with an LQ liquidity ratio that stands 1sd above the mean of the distribution. This suggests that banks with higher LQ liquidity ratios experience larger outflows in total domestic deposits when subjected to a monetary tightening shock. Importantly, this negative effect persists and remains statistically significant for up to six quarters after the shock. Regarding quantitative significance, the estimates imply that in response to a monetary tightening shock causing a surprise 1bp increase in the fed funds futures rate, banks with larger LQ liquidity ratios witness deposit growth approximately 0.2% lower over the four years following the shock³⁰.

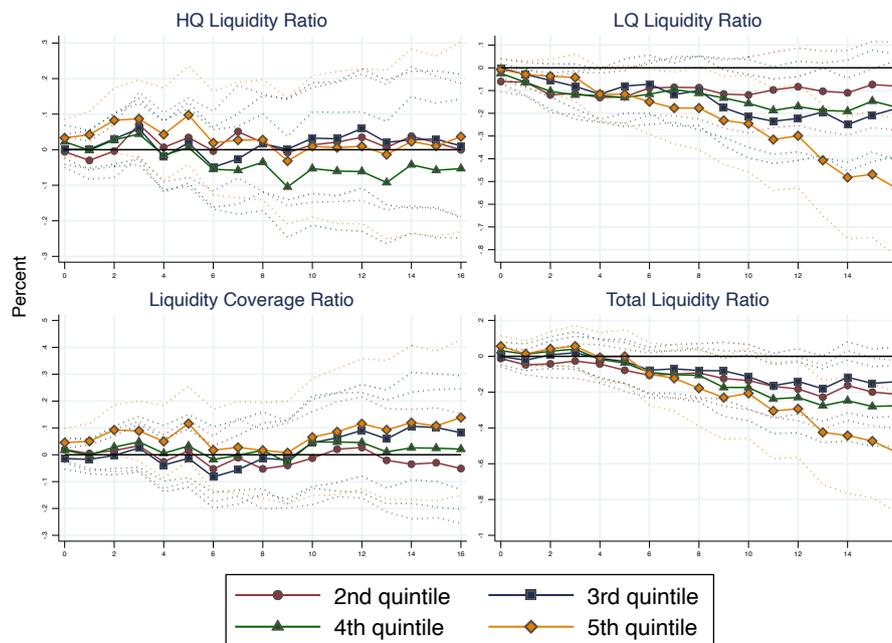
Combining both sets of results, the heterogeneity stemming from the total liquidity ratio encompasses the characteristics of both HQ and LQ liquidity. Specifically, total liquidity acts as a buffer for banks against more substantial deposit outflows during the first five quarters after the shock, akin to the effect of HQ liquidity. However, this stabilization effect of HQ liquidity appears to be short-lived, as evidenced by the subsequent weaker deposit growth attributed to LQ liquidity. These findings underscore the importance of distinguishing among various liquidity types, as their combined influence on banking outcomes can be quite nuanced and dynamic over time.

Finally, figure 2.5.2 displays the outcomes derived from the non-linear specification (2.4) when control variables are included. The results indicate that the impact of liquidity ratios on transmission is non-strictly monotonic. The magnitude of the coefficients in

³⁰Similar as in the footnote Page 58, a 25bp increase in the FFR is equivalent to a 1.43% growth rate.

absolute value does not consistently increase with higher quintile groups from the second until the fourth quintile. In contrast, banks positioned above the fifth quintile of the liquidity distribution have larger coefficients and closely mirror the dynamics in Figure 2.5.1 for each liquidity category.

Figure 2.5.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Non-linearities)



Notes: The graph displays the results for γ_{gr}^h obtained from specification (2.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.5.2 Robustness and Extensions

Alternative exercises have been conducted to gain a deeper understanding of the previously described results. The following points elucidate the nature of these extensions, and for the sake of clarity in the exposition, the results are presented in Appendix 2.D.

1. I investigate whether compositional effects can help explain the findings in Figure 2.5.1. Appendix 2.D.1 reports results based on the different types of deposit accounts: Money Market Accounts, Saving Accounts, Time Deposit Accounts, and Demand Deposits³¹. Figure 2.D.1 panel (a) shows that money market deposit accounts echo the conclusions drawn from the analysis of total deposits: a) High-quality liquidity has short-term stabilizing effects b) Low-quality liquidity, conversely, consistently reduces deposit growth in response to monetary shocks. Instead, other deposit accounts do not seem to follow the same dynamics, and most of the coefficients from baseline and joint regressions are non-significantly different from zero. This can be consistent with the idea that money market investors are more sensitive to banks' performance during monetary cycles.

³¹Usually, demandable deposits are highly liquid, while time deposits are locked in for a term and, hence, relatively illiquid.

I also examine the impact of the interaction on core deposits, given that this category of funds constitutes the primary source of deposits for banks in the sample³². The estimates presented in Figure 2.D.2 reveal that no differences are observed in the dynamic response when the dependent variable is the log change in core deposits instead of total deposits.

2. I investigate the relevance of the monetary shocks used in the baseline analysis. Appendix 2.D.2 reports the results obtained using alternative policy measures where the dependent variable is Total Deposits. Changes in the monetary shocks do not change the magnitudes and dynamics observed in Figure 2.5.1, whether the analysis centers on baseline estimates or examines LQ liquidity as the source of heterogeneity. However, the results differ when looking at joint-regression estimates influenced by heterogeneity in HQ liquidity.
3. Appendix 2.D.3 presents the results on alternative specifications.

- (a) In Figure 2.D.4, we observe coefficients that account for actual interest rate risk exposure following the specification outlined in (2.6). Specifically, in Panel A (Panel B), the η_2^h coefficients pertain to the influence of HQ liquidity (LQ liquidity) for banks with a NIMY-beta of zero. This signifies banks that are entirely hedged against fluctuations in interest rates. Conversely, the η_3^h coefficients reflect the impact experienced by banks with some exposure to interest rates.

Comparing these η_2^h coefficients of the HQ liquidity interaction to the earlier γ^h coefficients in Figure 2.5.1, we observe that they follow the same patterns but exhibit a more pronounced magnitude. In essence, when we control for the influence of banks' vulnerabilities to interest rate risks, the stabilizing effect of HQ liquidity becomes more prominent and remains statistically significant up to quarter seven. Regarding LQ liquidity, the destabilizing effect vanishes for banks with a NIMY-beta of zero. In fact, the point estimates are positive, although they do not reach statistical significance. The destabilization effects of HQ- and LQ liquidity are fully captured by η_3^h coefficients.

- (b) In Figure 2.D.5 we observe coefficients that account for supply sensitivity to monetary policy following specifications (2.7). Specifically, in Panel A (Panel B), the η_0^h coefficients pertain to the influence of HQ liquidity (LQ liquidity) for banks with a deposit-spread-beta of zero³³. This signifies banks exert monopoly power and hence shift more supply to increase profits. Conversely, the η_1^h coefficients reflect the impact experienced by banks with lower capacity to adjust deposits supply.

The results presented here are preliminary, and no definitive conclusions can be drawn at this stage. This is because the coefficients η_0^h and η_1^h exhibit perfect symmetry. I have conducted diagnostics to understand this phenomenon better, and one potential explanation is that the heterogeneity in deposit spread betas within quintile groups of the liquidity ratios' distribution is very low.

³²Total deposits are equivalent to core deposits plus wholesale deposits. Core deposits are equivalent to 70% of total assets on average (See Table 2.3.3a)

³³Or its minimum value .57

Further research and analysis are needed to explore this observation further and draw meaningful conclusions.

2.6 Effect on Loans Growth

The concept that liquidity acts as a buffer against contractions in banks' lending growth in response to tight monetary policy has been the subject of extensive research. The pioneering work of Kashyap and Stein (2000) proposes that when a bank experiences deposit outflows due to monetary policy, it can utilize its liquid assets to offset the reduction in lending supply. Subsequent studies have expanded upon these findings and investigated the suitability of various measures of monetary policy for assessing bank lending behavior (e.g., Bluedorn, Bowdler, and Koch, 2017).

This section builds upon this existing body of literature in three distinct ways: Firstly, I assess the heterogeneity in lending responses to monetary policy with a specific focus on different types of liquidity. Secondly, I employ various measures of monetary policy that are characterized by their ability to remove the influence of new shocks, a feature typically present in other studies³⁴. Finally, using local projections enables the identification of the conditional effect of monetary shocks on loan sensitivity in a more dynamic manner.

Like the previous section, the γ^h coefficients identify equilibrium conditions. This means that the results are understood as the heterogeneous effect of ex-ante liquidity ratios on policy-induced changes in the loan market equilibrium. Assuming that lending drops in response to a monetary tightening policy, the positive coefficient can be interpreted as liquidity stabilizing loan growth when monetary policy tightens.

The empirical strategy remains consistent, following the specification (2.3). The dependent variable is the log change in the book value of three types of loans: Total Loans, Commercial and Industrial Loans, and Real Estate Loans. The set of controls in the joint regressions includes the standard variables known to affect the transmission of monetary policy to bank lending: size and leverage (Kishan and Opiela, 2000; Paz, 2022), local deposit concentration (Drechsler, Savov, and Schnabl, 2017), the repricing/maturity gap (Drechsler, Savov, and Schnabl, 2021; English, Van Den Heuvel, and Zakrajšek, 2018), and the income gap (Gomez et al., 2021).

Crucially, including the maturity and income gap variables helps account for banking channels that have previously been overlooked in the analysis of liquidity-related heterogeneity. Liquid assets play a significant role in the cash flow and balance sheet channels. On the one hand, specific liquid securities adjust their value in the short term, influencing cash flow effects. On the other hand, some securities represent long-term debts, and their value declines in response to monetary tightening, impacting the balance sheet effect. Without controls, the monetary shock interacting with the liquidity ratio is more likely to encompass both effects. Therefore, incorporating income and maturity gaps provides the advantage of regulating both channels.

However, it is important to note that since other assets are also factored into the calcu-

³⁴For example, while Bluedorn, Bowdler, and Koch (2017) employs high-frequency identification techniques to derive monetary shocks, their measurements do not differentiate between purely monetary surprises and FED-news shocks. The type of shocks I utilize for the estimations offers a much clearer separation of these two effects (See Section 2.A.2 for the case of Jarociński and Karadi (2020) shocks)

lation of these variables, the policy-induced repricing of assets beyond securities is also being considered. An alternative approach, recently adopted in Krainer and Paul (2023), is directly controlling for market value losses on securities during specific monetary tightening cycles. This approach relies on utilizing security prices at the bank level from the FRY-14Q dataset. Unfortunately, this data is not publicly accessible.

2.6.1 Results on Bank-Level Estimation

Figure 2.6.1 presents estimates of γ^h in specification (2.3) when the dependent variable is log changes in total loans³⁵. Based on the baseline estimations, the loan growth of banks with HQ liquidity standing 1sd above the mean is about 0.1% permanently lower³⁶, meaning that HQ liquidity does not shield lending during tightening cycles. This evidence goes against the results in Kashyap and Stein (2000) but is consistent with empirical strategies using HFI-monetary shocks. In fact, Bluedorn, Bowdler, and Koch (2017) argues that the *fund of last resource effect* is only observed when using changes in the realized fed fund rate, suggesting that biases from confounding factors explain this result.

Nonetheless, the findings from the joint-regression analysis do not contradict the outcomes reported in Kashyap and Stein (2000) even when considering the policy measure as HFI-monetary shocks. Upon closer examination of the point estimates, banks with HQ liquidity positioned 1sd above the mean undergo more loan growth in response to the monetary shock (the average point estimate is between 0% and 0.025%). Note that these estimates do not reach statistical significance. In contrast, when looking at heterogeneity due to liquidity coverage ratios, the magnitudes of the effects are larger and significant. After a monetary tightening shock caused a surprise 1bp increase in the fed funds futures rate, banks with higher LCRs experienced loan growth approximately 0.05%³⁷ higher in the following four years after the shock.

What is particularly noteworthy is that these results emerge after accounting for income and duration gap variables. This suggests that when controlling for income and valuation shocks prompted by monetary policy, high-quality liquidity relative to total assets or expected deposit outflows does not appear to have a destabilizing effect on loan growth, as implied by Bluedorn, Bowdler, and Koch (2017).

The story is different when looking at low-quality liquidity-related heterogeneity. Evidence suggests that in response to monetary shocks, banks standing 1sd above the mean experience permanently lower growth rates (-.15%). This pattern persists even after accounting for income and valuation shocks induced by monetary policy. When analyzing total liquidity, the dynamics follow the pattern of LQ liquidity. This indicates that LQ liquidity's destabilization effect predominates over HQ liquidity's non-effect.

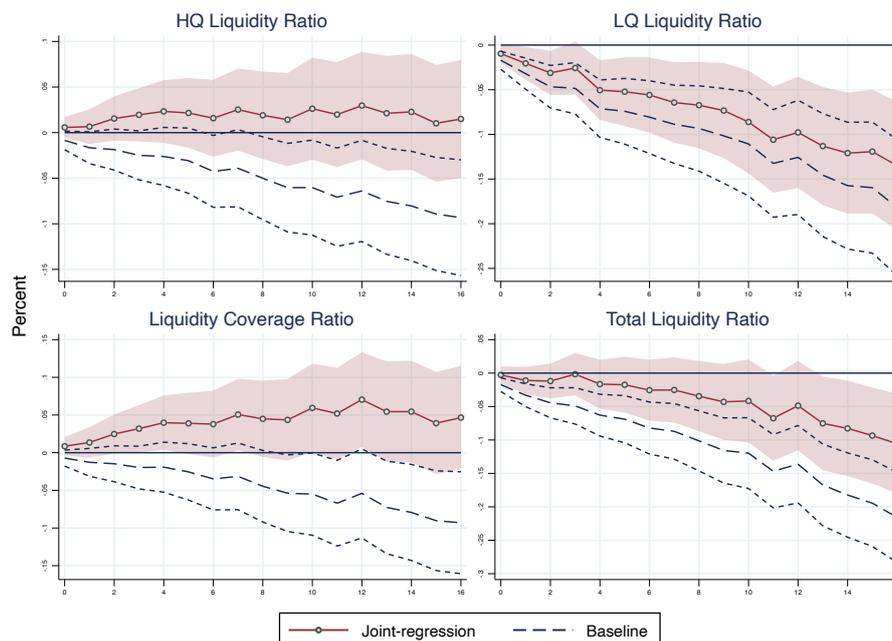
Figure 2.6.2 displays the outcomes derived from the non-linear specification (2.4) including control variables. The results indicate similar conclusions to the one derived when analyzing deposit flows. The impact of liquidity ratios on the transmission channel is not strictly monotonic. a) banks positioned above the fifth quintile of the liquidity distribution closely mirror the dynamics in Figure 2.6.1 in each liquidity category. b) The

³⁵I also try real rates of growth but results remain unchanged.

³⁶To express it in terms of a 25bp increase in the FFR, this corresponds to approximately a 0.72% change.

³⁷or 0.35% after a 25bp increase in the FFR.

Figure 2.6.1: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Baseline)



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

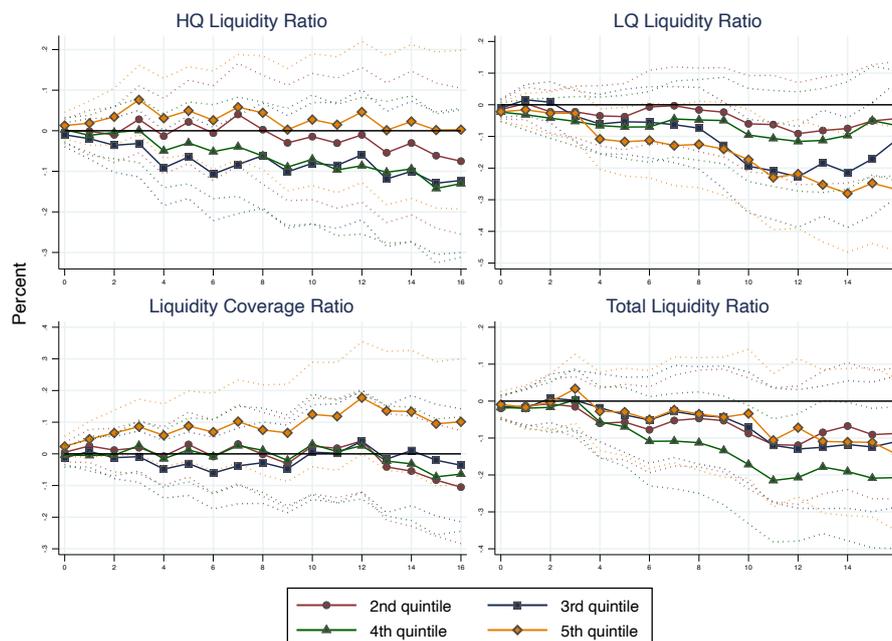
average impulse responses of banks falling between the second and fourth quintile exhibit similar patterns and magnitudes.

2.6.2 Robustness and Extensions

Alternative exercises have been conducted to understand the previously described results better. The impulse response functions of these exercises are reported in Appendix 2.E for brevity.

1. In line with prior research, I investigate whether compositional effects can help explain the earlier findings. Section 2.E.1 replicates the same analysis for two specific loan categories: Commercial and Industrial Loans and Real Estate Loans. The results, as illustrated in Figure 2.E.1, echo the conclusions drawn from the analysis of total loans: a) High-quality liquidity has, at best, neutral effects on transmitting monetary shocks to loan growth after accounting for income and duration gaps. b) Low-quality liquidity, conversely, consistently reduces loan growth in response to monetary shocks.
2. Results using alternative policy measures are reported in Appendix 2.E.2. Changes in the monetary shocks do not change the magnitudes and dynamics observed in Figure 2.5.1 if focusing on HQ liquidity. However, the results differ when looking at joint-regression estimates influenced by heterogeneity in LQ liquidity (the effect is non-negative).
3. Appendix 2.E.3 presents the results on alternative specifications.

Figure 2.6.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Non-linearities)



Notes: The graph displays the results for γ_{gr}^h obtained from specification (2.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

- (a) In Figure 2.E.3, we observe coefficients that account for actual interest rate risk exposure following the specification outlined in (2.6).

When we compare the η_2^h coefficients of the HQ liquidity interaction to the earlier γ^h coefficients in Figure 2.6.1, we notice that the η_2^h coefficients are positive and larger. This suggests that removing the influence of banks' vulnerabilities to interest rate risks reveals evidence consistent with the findings in Kashyap and Stein (2000) when considering HQ liquidity. However, the impact of LQ liquidity remains, at best, non-positive but non-significant. The η_3^h coefficients capture the destabilization price effects of both HQ and LQ liquidity.

- (b) In Figure 2.E.4 we observe coefficients that account for supply sensitivity to monetary policy following specifications (2.7). Same as the previous section, the results presented here are preliminary, and no definitive conclusions can be drawn at this stage because coefficients η_0^h and η_1^h exhibit perfect symmetry.

2.7 Effects on Banks Liquidity Creation

Within the financial system, banks undertake a multifaceted role where their functions of liquidity creation, risk transformation, and maturity transformation can intersect or diverge depending on the context. Given the intricate interplay between the core banking operations, this section concentrates on factors that enable banks to transform/create liquidity³⁸. Specifically, I examine directly the role of different types of liquid assets in transmitting monetary policy shocks toward on-balance sheet liquidity creation³⁹.

The empirical strategy remains consistent, following the specification (2.3). The dependent variable is the change in liquidity creation ratios⁴⁰ from quarter $t - 1$ to quarter $t + h$. The control variables used in the joint regressions include variables known to affect the transmission of monetary policy: size (e.g., Kashyap and Stein (2000)), local deposit concentration (e.g., Drechsler, Savov, and Schnabl (2017) and Li, Loutskina, and Strahan (2023)), the repricing/maturity gap of English, Van Den Heuvel, and Zakrajšek (2018).

2.7.1 Results on Bank-Level Estimation

Figure 2.7.1 presents estimates of γ^h in specification (2.3) when the dependent variable is the on-balance sheet liquidity creation to asset ratio. Each impulse response function depicts the conditional effect of monetary policy for banks standing 1sd above the mean of the respective liquidity distribution. At any horizon h , negative coefficients mean that banks with larger liquidity ratios at the time of a shock create less liquidity than banks with lower levels of liquidity.

Based on the baseline point estimates, banks with more HQ liquidity (and greater LCR) at the time of a monetary contraction incur less in liquidity transformation activities. Specifically, after a 1bp surprise increase in the 3-month fed funds future rate, banks with HQ liquidity ratios 1sd deviation above the distribution experience a reduction in liquidity creation activities equivalent to -0.02pp of total assets⁴¹. This effect is statistically significant 6 to 12 quarters after the shock⁴². Once controlling for other confounding factors, the effect is non-significant.

Analyzing heterogeneity in LQ liquidity, point estimates are consistently negative and similar between baseline and joint regression specifications. To provide specifics, following

³⁸Recent studies have shown that this measure of banks' activity has a substantial influence on various macroeconomic variables and is a superior measure of banks' output. For instance, Berger and Sedunov (2017) studies the relation between bank liquidity creation and economic output. Davydov, Vähämaa, and Yasar (2021) and Zhang et al. (2021) investigates whether liquidity creation affects systemic risk. Davydov, Fungáčová, and Weill (2018) investigates whether liquidity creation may amplify business cycle fluctuations. Fungacova, Turk, and Weill (2021) estimate that high liquidity creation is associated with a greater probability of bank failure using Russian banks.

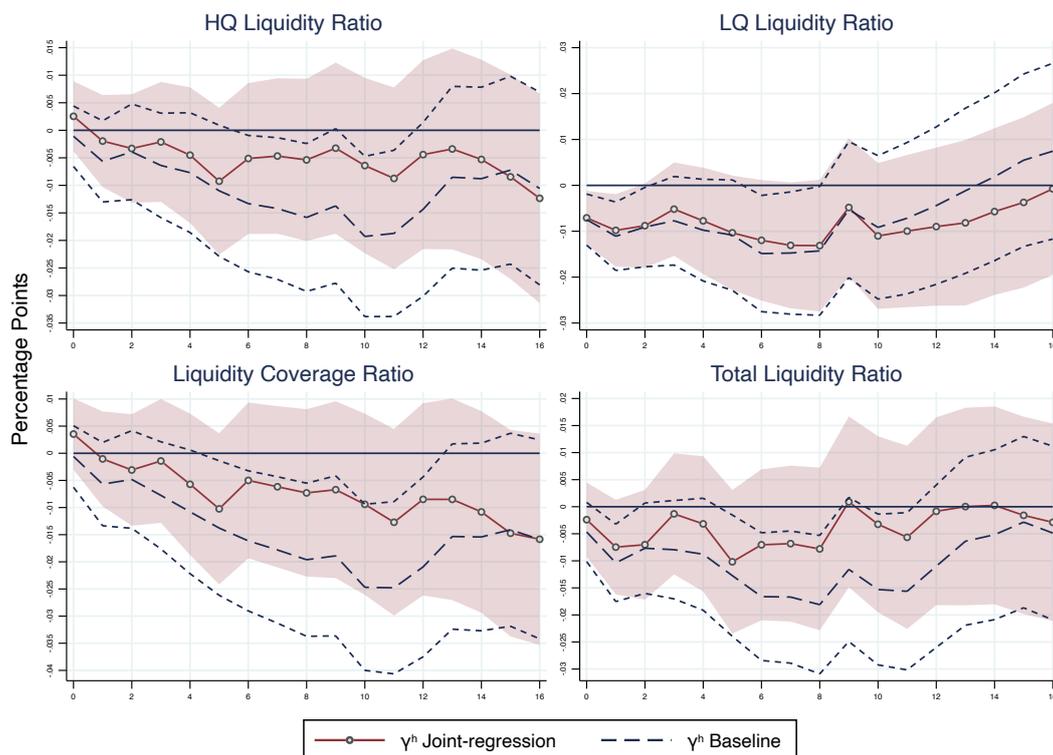
³⁹Other strands of the literature focus on maturity transformation, arguing that this role is central to business cycle dynamics. For instance, Li, Loutskina, and Strahan (2023) argues that deposit market power, by increasing long-term credit supply, helps alleviate credit cycles. higher risk borrowers choosing to borrow long term to alleviate refinancing risk

⁴⁰Liquidity Creation per billion dollars of assets.

⁴¹Equivalent to -0.14pp relative to a 25bp increase in the FFR.

⁴²Evaluated at the average liquidity creation ratio in the sample (30.3%), this translates into cumulative differences in liquidity creation of around \$2.5 million, equivalent to only about 0.2% of the banking industry liquidity creation.

Figure 2.7.1: Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Baseline)



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

a 1bp surprise increase in the 3-month fed funds future rate, banks with LQ liquidity ratios 1sd above the distribution witness a reduction in liquidity creation activities equivalent to -0.01pp of total assets. It is important to note that this effect is statistically significant, only up to 2 quarters. Similarly, the impact of total liquidity is minor and non-statistically significant, different from zero.

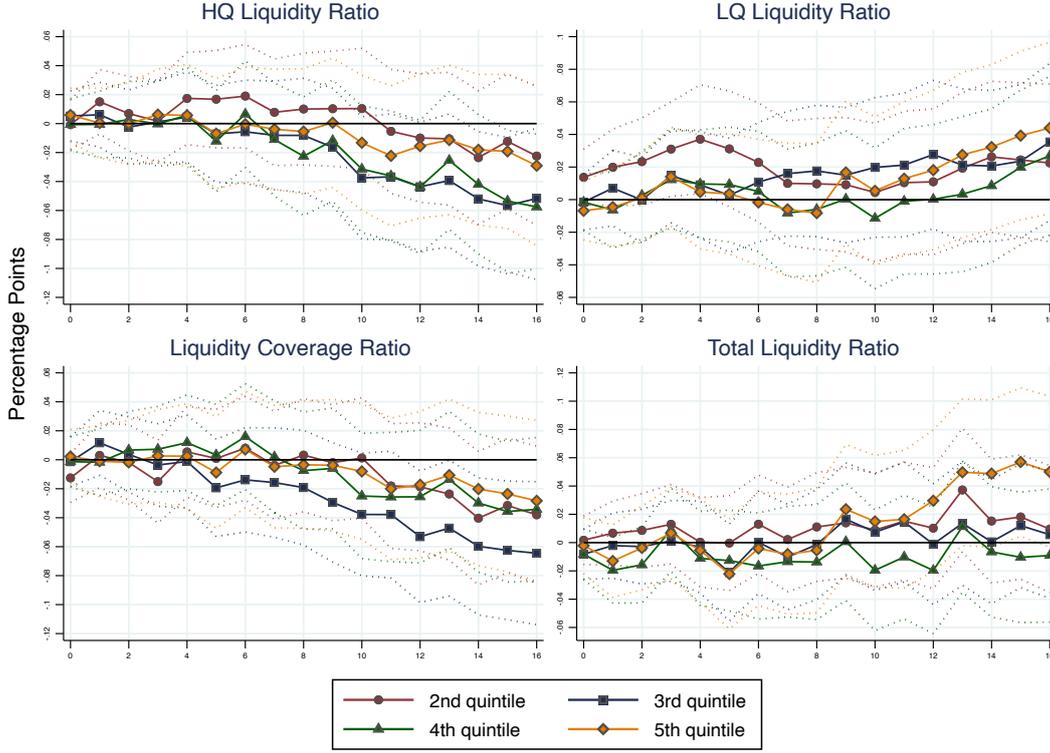
Figure 2.7.2 displays the outcomes derived from the non-linear specification (2.4) including control variables. The impulse response functions across the various quintile groups do not exhibit a monotonic pattern. In other words, the coefficient's magnitude (in absolute value) does not consistently increase with higher quintile groups. However, each group follows relatively similar dynamics. For example, when looking at HQ liquidity, the average impulse responses of banks in the third and fourth quintiles exhibit similar patterns and magnitudes over all horizons.

2.7.2 Robustness and Extensions

Alternative exercises have been conducted, and results are presented in Appendix 2.F.

1. To explore the previous results deeply, I reestimate equation (2.3) using the liquid, semi-liquid, and illiquid categories of the liquidity creation index as dependent variables. The RHS remains unchanged for both the baseline and joint regressions.

Figure 2.7.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Non-linearities)



Notes: The graph displays the results for γ_{gr}^h obtained from specification (2.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

The parameters of interest are named γ_h^{CAT} for $CAT = \{IA, SA, LA, IL, SL, LL\}$ ⁴³. Results are left in Appendix 2.F.2.

The absence of a heterogeneous effect observed in Figure 2.7.1 can mainly be attributed to banks encountering higher liquid liabilities ratios in response to the shock. However, they also experience a similar increase in liquid assets. Because these factors offset each other in the liquidity creation index, the total heterogeneous effect on liquidity creation is nearly zero. In other words, banks expand liquid liabilities without creating liquidity because they invest in liquid assets.

2. A concern about the baseline regression specification is that liquid assets are included (with a weight of $-1/2$) in the liquidity creation variable via the liquid-asset component. In contrast, the lagged liquid assets ratio is the variable interacting with the monetary policy shock. To explore the consequences of this, I reestimate equation (2.3) replacing the dependent variable by $\Delta_h \widehat{LIQR}_{i,t+h} = LIQR_{i,t+h} - \widehat{LIQR}_{i,t-1}$ where $\widehat{LIQR}_{i,t-1}$ excludes liquid assets to avoid potential direct mechanical relation. The findings from this exercise, as shown in fig. 2.F.3, are quantitatively and qualitatively similar to those presented in Figure 2.7.1.

⁴³As remarked by Berger and Bouwman (2009), the γ^h coefficients are expected to equal the weighted sum of the γ_h^{CAT} coefficients.

2.8 Effect on Banks' Profits and Income

Liquid assets might play different roles in transmitting monetary policies toward banks' profits. On the one hand, the capacity to generate instantaneous cash flows could be used to finance (or refinance) new high-interest-rate loans, hence profiting from better loan conditions. On the contrary, the interest rate risk inherent to long-term securities might expose banks to larger valuation losses, which can tighten constraints (or break hedges), preventing them from generating more profitable loans. This section presents results on how liquidity -and its different categories- increases or mitigates banks' net income exposure to monetary policy shocks.

This section contributes to the empirical literature on the effect of monetary policy on banks' profits and capital. Remarkably, evidence in this branch is diverse and sometimes does not convey the same results. Drechsler, Savov, and Schnabl (2021) present empirical evidence suggesting that even if banks engage in significant maturity transformation (maturity mismatch of 3.4 years), they actively match the interest sensitivities of their income and expenses so that banks do not experience large drops in their net worth in response to monetary tightening. In contrast, Paul (2023) suggest that banks are exposed to interest rate risk via the effect of monetary policies on future expected short-term rates and term premiums. Their evidence based on equity prices suggests that bank profit margins decline to an increase in future expected short-term rates but rise if term premia increases. My contribution to this literature centers on assessing how the initial holdings of liquid-to-asset ratios influence the sensitivity of banks' cash flows to monetary shocks. To conduct this analysis, I employ the cash flow approach, which differs from the Present-Value Approach, as it relies on book values rather than market equity values⁴⁴.

The strategy employed here follows the specifications outlined in equation (2.3). The dependent variable represents changes in profit margins from time $t - 1$ to time $t + h$. The examined profit margins include net interest margins and their constituent parts, encompassing interest rate income and expenses. Additionally, it considers total net income (quantified as the return on assets) and the remaining components, which comprise non-interest rate income and expenses⁴⁵.

For the joint regressions, the vector $X_{i,t-1}$ includes bank size (measured as log total assets), capitalization (measured as the total capital ratio adjusted for risk), balance sheet maturity mismatch, a proxy capturing expected income shocks generated by changes in policy rates (measured as income gap), and a proxy for local market power (measured as the HHI index in deposit markets as suggested by Drechsler, Savov, and Schnabl (2021)). Since banks' income gap controls for any positive (or negative) income shock induced by changes in policy rates, γ^h estimates from the joint regressions explain the effect of liquid assets beyond repricing effects. Furthermore, since liquid assets expose banks to interest rate risks (in the absence of hedges), the maturity gap variable helps control interest rate risk exposure.

⁴⁴See Drechsler, Savov, and Schnabl (2021) for the differences in the approaches.

⁴⁵All variables are expressed annually and as a ratio of the average earning assets, except for total net income, which is presented as net income after taxes (annualized) as a percentage of average total assets.

2.8.1 Results on Bank-level Estimations using the Cash Flow Approach

HQ-Liquidity: Figure 2.8.1 displays the results depicting the conditional effect of monetary policy on changes in all profit margins, specifically focusing on the influence of HQ liquidity. It highlights that higher HQ liquidity ratios are associated with lower net interest income in response to a monetary tightening shock. Remarkably, this result arises over a relatively long horizon and is statistically significantly different from zero.

Focusing on the point estimates from the joint regression, in response to a 1bp surprise increase in the 3m-FFR rate, the net interest margins of banks standing 1sd above the HQ liquidity distribution are about 0.002pp lower at its peak, which is quarter 10⁴⁶. These patterns remain consistent across both baseline and joint-regression estimates, albeit with slightly bigger differences in responses in the baseline-regression estimates.

Changes in interest-rate income and expenses drive the differences in net interest margin dynamics. Firstly, banks with higher HQ liquidity ratios tend to display greater sensitivity in interest rate income, leading to reduced interest rate income in response to monetary shocks. This discrepancy can be attributed to the joint regression's consideration of profit losses from long-term assets through the maturity gap, which is expected to be higher for banks with elevated liquidity ratios. Secondly, banks with higher HQ liquidity ratios tend to exhibit greater sensitivity in interest rate expenses, resulting in increased interest rate expenses in response to monetary shocks. In this instance, the dynamics between baseline and joint-regression estimates do not align. When accounting for exposure to income shocks via the income gap, the evidence suggests that banks with higher HQ liquidity ratios experience higher interest rate expenses. Finally, the net interest margin responses translate into similar equity ratio reactions. For higher HQ liquidity ratios, the book value of banks' capital as a percentage of total assets drops by about 0.006pp in response to the same monetary shock.

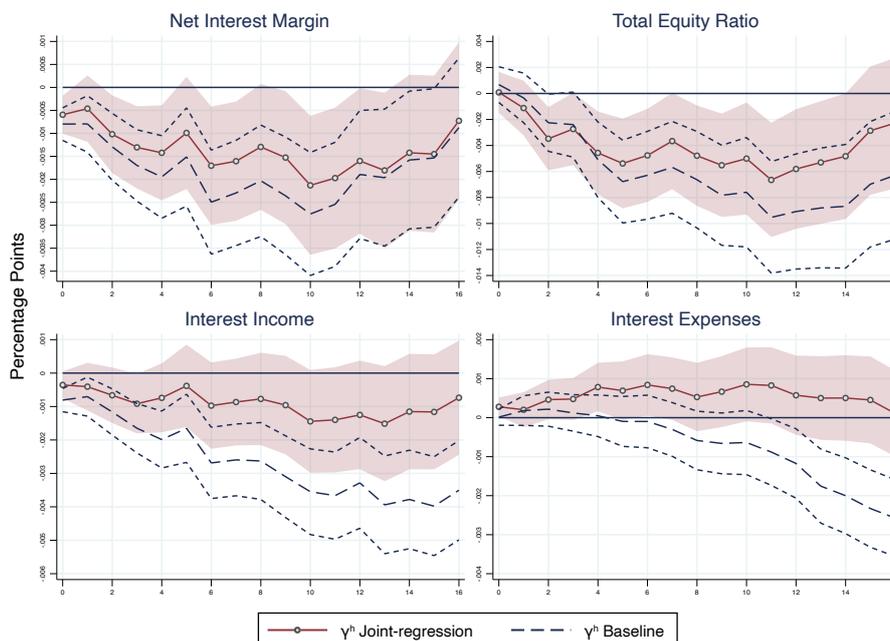
The net interest margin responses do not translate into similar net income reactions. Figure 2.8.2 highlights that the conditional effect becomes non-significant when taking into account differences in sources of income and expenses not related to interest-earning assets or liabilities⁴⁷.

Finally, the dynamics in Figure 2.8.1 are monotonically decreasing, as highlighted in Figure 2.8.3. The absolute value of the coefficients increases with quintile groups, such that the higher quintiles experience lower net interest margins.

⁴⁶Relative to a 25bp increase in the FFR, the coefficient is 0.014pp. Notice also that the in-sample average net interest rate margin is 3.81%, while the in-sample average change in net interest rate margins is -.008pp per quarter.

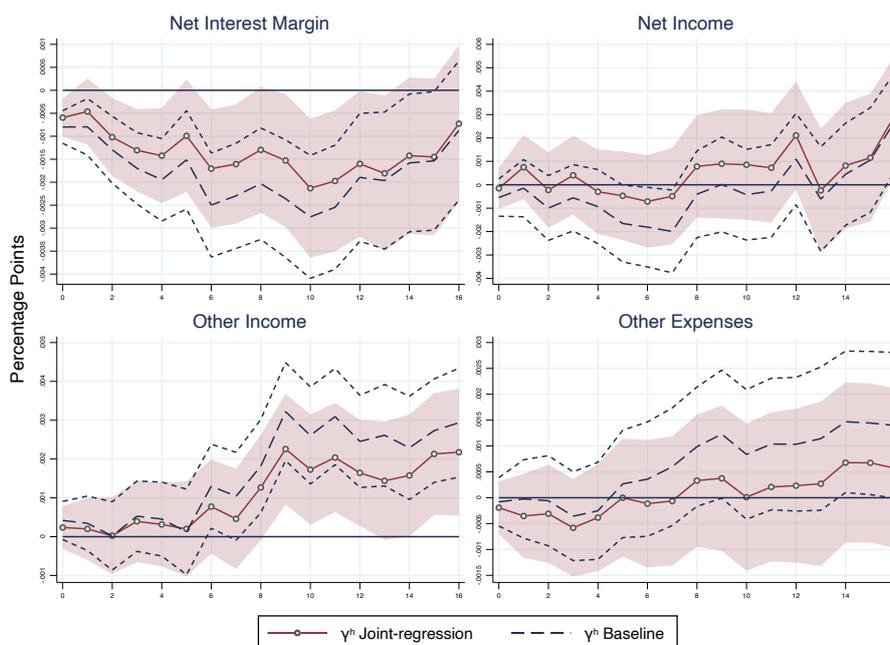
⁴⁷Paul (2023) argues that this differences might be explained by the alternative denominator (total assets vs. total interest-earning assets) and possibly due to offsetting responses of noninterest income. This remark is relevant because – as discussed in the theoretical section– deposit franchise cost is usually translated into operational cost that enters into the other expenses variable.

Figure 2.8.1: Monetary Tightening Shock Conditional on HQ-Liquidity: Effect on Profit Margins - Part I (Baseline)



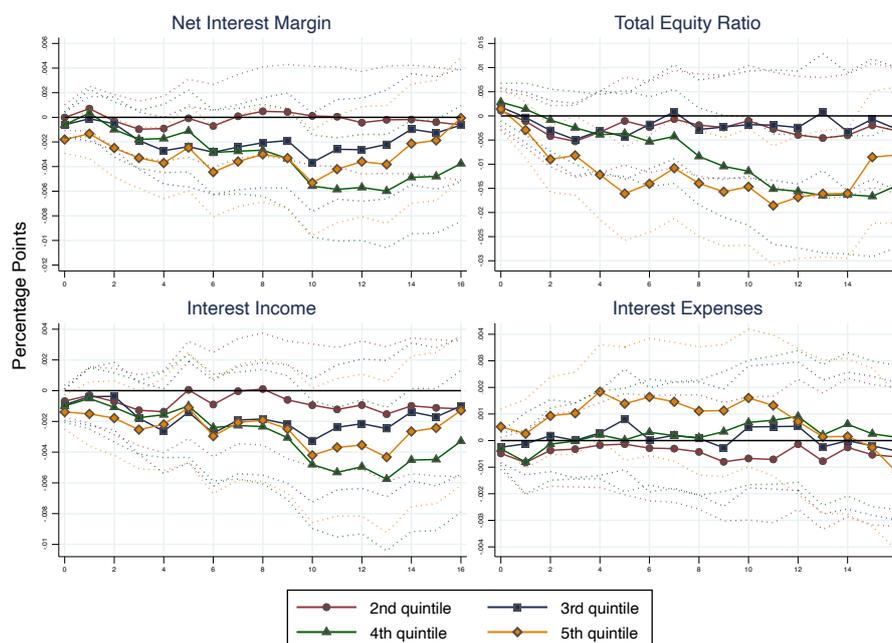
Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.8.2: Monetary Tightening Shock Conditional on HQ-Liquidity: Effect on Profit Margins - Part II (Baseline)



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.8.3: Monetary Tightening Shock Conditional on Liquidity: Effect on Profit Margins (Non-linearities)



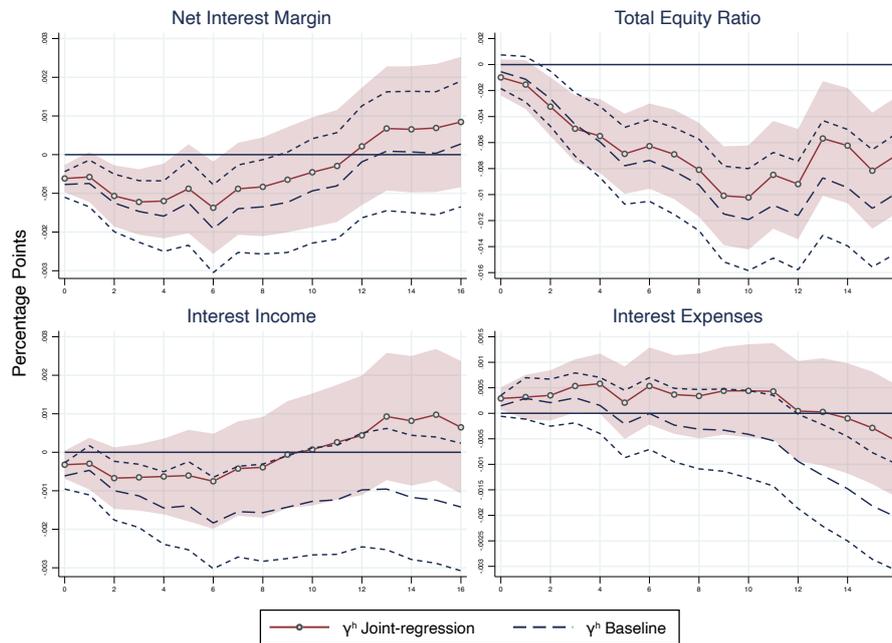
Notes: The graph displays the results for γ_{gr}^h obtained from specification (2.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

LQ-Liquidity: Figure 2.8.4 presents results on the impact of monetary policy on profit margins, focusing on LQ liquidity. Both baseline and joint regression estimates reveal that banks with higher LQ liquidity experience lower net interest income six quarters after a monetary tightening shock.

One notable distinction between the two liquidity types is that the impact on equity ratios seems to be more pronounced and longer-lasting when examining LQ liquidity. When confronted with a 1bp unexpected increase in the 3m-FFB rate, banks positioned 1sd above the LQ liquidity distribution experienced a reduction of approximately 0.01pp in their equity ratio at its peak in quarter ten. These trends persist across both baseline and joint-regression estimates, although the differences in responses are somewhat more pronounced in the baseline-regression estimates. The findings related to total liquidity ratios (See Figure 2.G.1) mirror the patterns observed in the analysis of LQ liquidity.

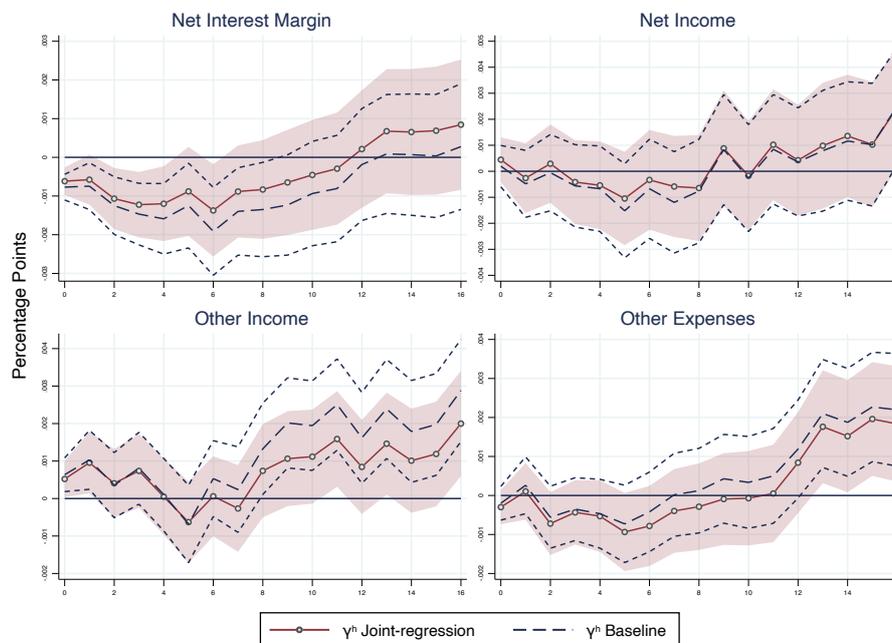
The dynamics in Figure 2.8.4 are non-strictly monotonic, as highlighted in Figure 2.8.6. Looking at net interest margins, while the value of the coefficients of banks in the second and fourth quartile is positive over the four-year horizon, the coefficients for banks in the third and fifth quintile are non-positive up to quarter ten and, after that, positive. Further, looking at equity ratios, banks in the fifth quintile group mainly explain the dynamics in Figure 2.8.4.

Figure 2.8.4: Monetary Tightening Shock Conditional on LQ-Liquidity: Effect on Profit Margins - Part I (Baseline)



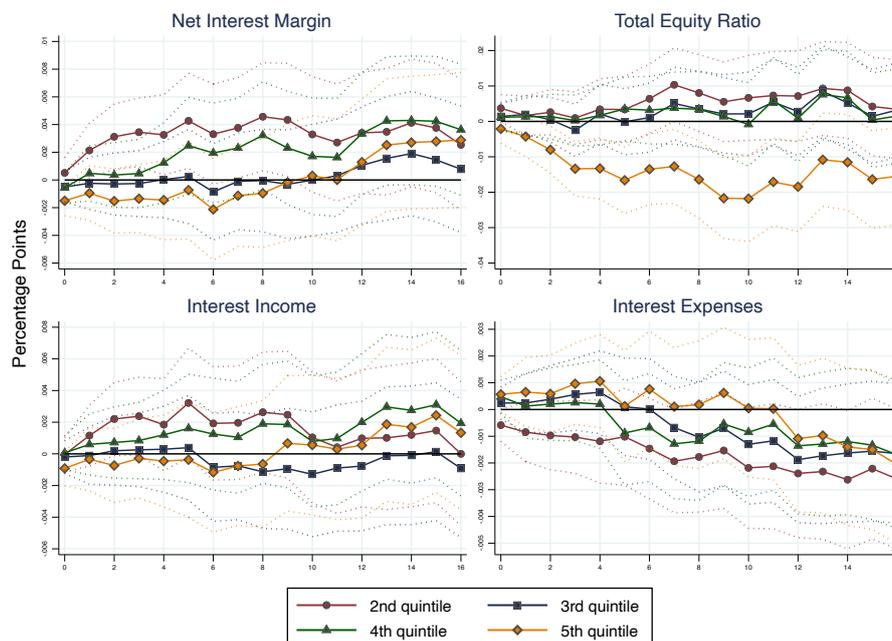
Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.8.5: Monetary Tightening Shock Conditional on LQ-Liquidity: Effect on Profit Margins - Part II (Baseline)



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.8.6: Monetary Tightening Shock Conditional on LQ-Liquidity: Effect on Profit Margins (Non-linearities)



Notes: The graph displays the results for γ_{gr}^h obtained from specification (2.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.9 Unconventional Monetary Policies

Is the role of liquidity distinct depending on the type of monetary policy? As presented in Chapter 1, the conduct of the monetary policy has evolved, and new policy instruments have been deployed. Each instrument might destabilize banks' outcomes in different ways and, more importantly, might deter or improve the capacity of liquidity to counteract these effects.

The distinction between various policy shocks has demonstrated its significance in the banking literature, particularly when examining banks' profitability and income responses to interest rate surprises. For instance, studies that concentrate on policy-induced changes in government bond yields with different maturities (e.g., English, Van Den Heuvel, and Zakrajšek, 2018; Paul, 2023), and shifts in term premiums (e.g., Paul, 2023) as indicators of monetary policy, reveal evidence indicating that banks exhibit a high degree of exposure to interest rate risks. In contrast, research by Drechsler, Savov, and Schnabl (2021), which centers on changes in the level of the federal funds rate, suggests that banks achieve nearly perfect interest rate hedging.

To better understand the consequences of the post-GFC monetary policy framework, I use Jarociński (2021) monetary shocks to test whether differences in the policy instruments have different consequences for the results observed previously. Figure 2.9.1 presents the time series of the structural monetary shocks used in this section. Each shock accounts for standard and non-standard monetary policy since each expresses unexpected changes in the near-term fed funds futures, 2- and 10-year Treasury yield, and the S&P500 stock index. The economic interpretation of each series goes as follows.

- The Standard monetary shock (u1) captures unexpected changes in the near-term fed funds futures that have a diminishing effect on longer maturities and depress stock prices. These characteristics align with conventional monetary policy actions.
- The Odyssean shock (u2) captures unexpected changes in the 2-year Treasury yield, no effects on longer or shorter maturities, and depress the stock prices. It replicates the intended effects of underlying commitments regarding the future course of short-term policy rates.
- The LASP shock (u3) captures unexpected changes in the 10-year yields, little effect on shorter maturities, and significantly negative changes in asset prices during some of the most important asset purchase announcements. It replicates long-term rate changes and is interpreted as a large-scale asset purchase policy.
- The Delphic shock (u4) captures Fed-news shocks. It captures the same changes in yields as the u2 shock, with the difference that it triggers an increase, rather than a decrease, in the stock prices.
- The measure of monetary shocks used in the previous sections (3m-FFF) is placed on the left top for comparison. This single catch-all monetary policy shock is highly correlated with both u1 and u2 (but does not capture asset purchases u3).

The strategy employed here follows the same specifications outlined in equation (2.3), and I keep the same set of controls used in the previous sections. Following the literature, for the ease of interpretability, each shock is rescaled so that a one unit u1 shock raises the expected fed funds rate after FOMC meetings (MP1) by 1bp, a one unit u2 and u4 raises the 2-year Treasury yields (ONRUN2) by 1bp, and a one unit u3 shock raises the and 10-year Treasury yields (ONRUN10) by 1bp.

2.9.1 Results on Bank-level Estimations

Figures 2.9.2 to 2.9.5 summarizes the role played by HQ liquidity (Panel a) and LQ liquidity (Panel b) in the transmission of multiple monetary shocks.

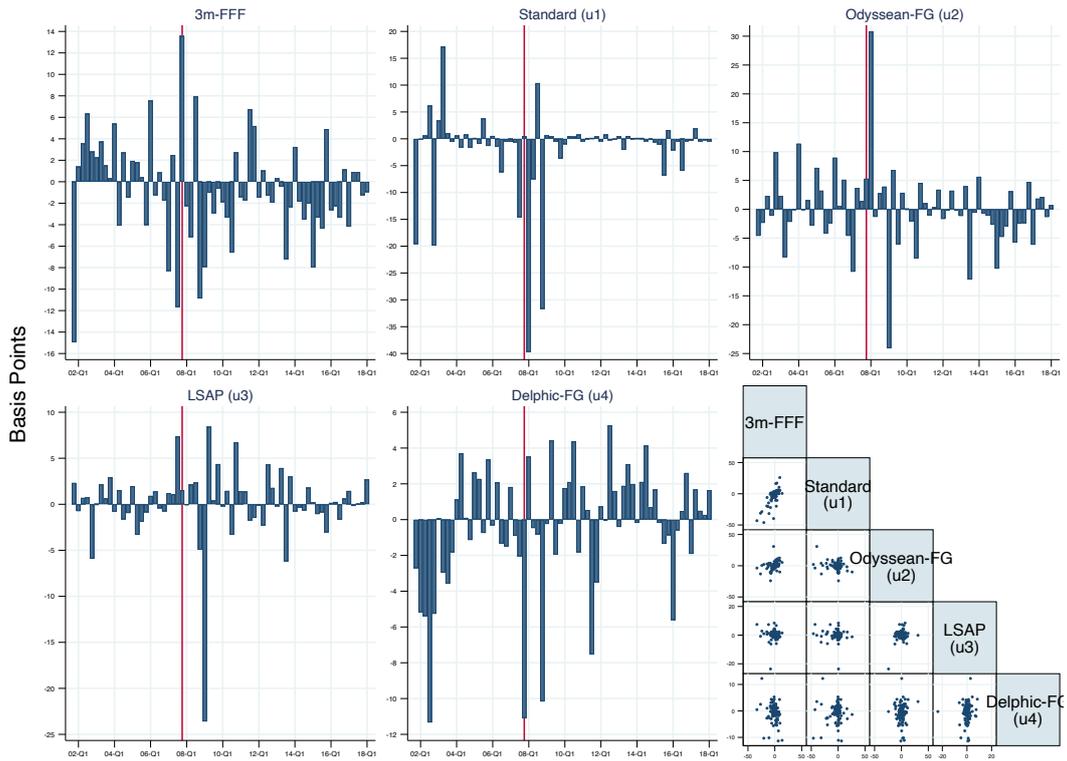
Deposit Flows: Figure Figure 2.9.2 provides the results concerning the role of HQ and LQ liquidity in transmitting various monetary policy shocks on the log change of total deposits.

In response to standard monetary shocks, the short-term stabilization effect of HQ liquidity disappears. However, this stabilization effect is relatively present in response to QE and Odyssean shocks. The destabilization effect of LQ liquidity observed in Figure 2.5.1 is captured by the interaction with standard monetary shocks. Odyssean shocks also show a negative effect on deposit growth. QE and Delphic shocks, on the other hand, have no interaction effect.

Loan Growth: Figure 2.9.3 provides the results concerning the role of HQ and LQ liquidity in transmitting various monetary policy shocks on the log change of total loans.

The interaction between HQ liquidity and standard or Odyssean monetary shocks resembles the dynamics observed in Figure 2.6.1. Notably, the interaction with QE shocks suggests that banks with larger HQ liquidity ratios experience greater loan growth up

Figure 2.9.1: Conventional and Unconventional Monetary Policy Shocks



Notes: This figure depicts the time series of conventional and unconventional monetary policy shocks and their correlation. Data on the baseline 3m-FFF shock comes from Jarociński and Karadi (2020), and the remaining series come from Jarociński (2021). Series corresponds to the unweighted sum of the high-frequency shocks within a quarter.

to one year after the shock, with the coefficients being significant. In the baseline estimates, banks with larger HQ liquidity ratios experience permanently greater loan growth in response to a Delphic shock. However, after including controls, this effect becomes zero.

In contrast, the interaction between LQ liquidity and standard shocks partially resembles the dynamics observed in Figure 2.6.1, with only the baseline coefficients reflecting similar trends. Notably, the interaction with QE and Delphic shocks suggests that banks with larger LQ liquidity ratios experience greater loan growth, with a particular emphasis on the coefficients being significant for the Delphic shock.

Liquidity Creation: Figure 2.9.4 provides the results concerning the role of HQ and LQ liquidity in transmitting various monetary policy shocks on liquidity creation.

The interaction between HQ liquidity and standard monetary shocks better captures the dynamics observed in Figure 2.7.1. Baseline estimates suggest negative and significant coefficients up to quarter ten, but once controls are included, the coefficients become non-significant. The interaction with the remaining shocks suggests that banks with larger HQ liquidity ratios transform more liquidity as a fraction of their total assets. However, these coefficients are mainly non-significant in both baseline and joint-regression estimates.

When examining LQ liquidity, the interaction with multiple shocks reveals various trends.

For up to 4 quarters after a Standard shock, liquidity creation is lower for banks with larger LQ liquidity, but then it becomes positive. In contrast, for up to 4 quarters after an Odyssean shock, liquidity creation is greater for banks with larger LQ liquidity, but then it turns negative. Finally, the interaction with QE and Delphic shocks suggests that banks with larger LQ liquidity ratios experience greater loan growth, with the coefficients being significant for the Delphic shock.

Net Interest Margins: Figure 2.9.5 provides the results concerning the role of HQ and LQ liquidity in transmitting various types of monetary policy shocks on interest rate margins⁴⁸.

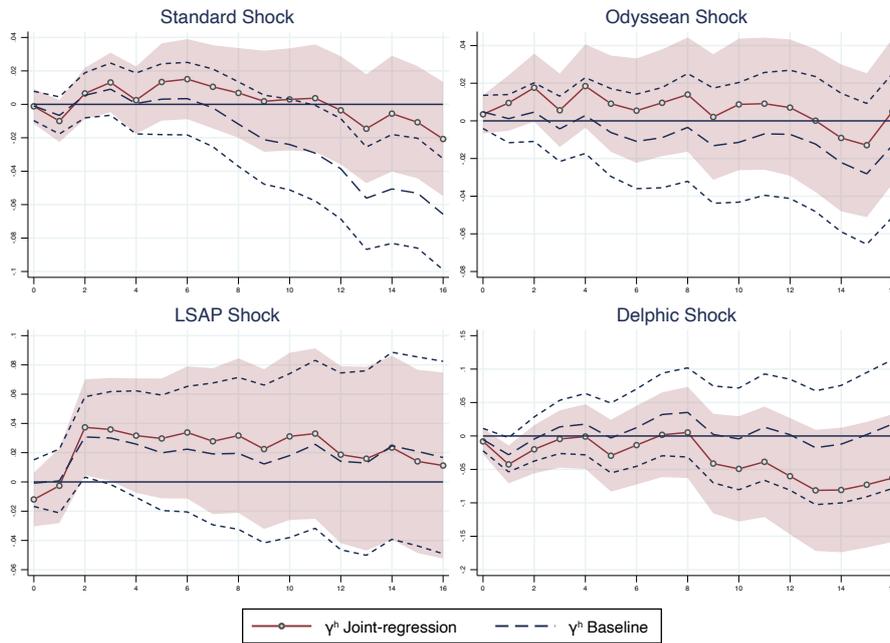
When examining the interaction between HQ liquidity and Standard shocks, the negative effect on net margins observed in Figure 2.8.1 is only replicated up to 8 quarters. In contrast, the interaction with Odyssean and LSAP shocks does not provide substantial evidence to support the idea that HQ liquidity plays a significantly different role in transmitting these shocks. However, a noteworthy trend emerges when considering the interaction with the Delphic shock: banks with higher HQ liquidity ratios tend to experience greater profit margins in the eight quarters following these shocks.

The interaction between LQ liquidity and standard monetary shocks better captures the dynamics observed in Figure 2.8.4. Notably, the interaction with Odyssean and QE shocks suggests that banks with larger LQ liquidity ratios experience greater net interest margins, particularly emphasizing the significant coefficients for the Odyssean shock. The interaction with Delphic shocks is zero and non-significant up to quarter ten and becomes positive and significant in quarter 12.

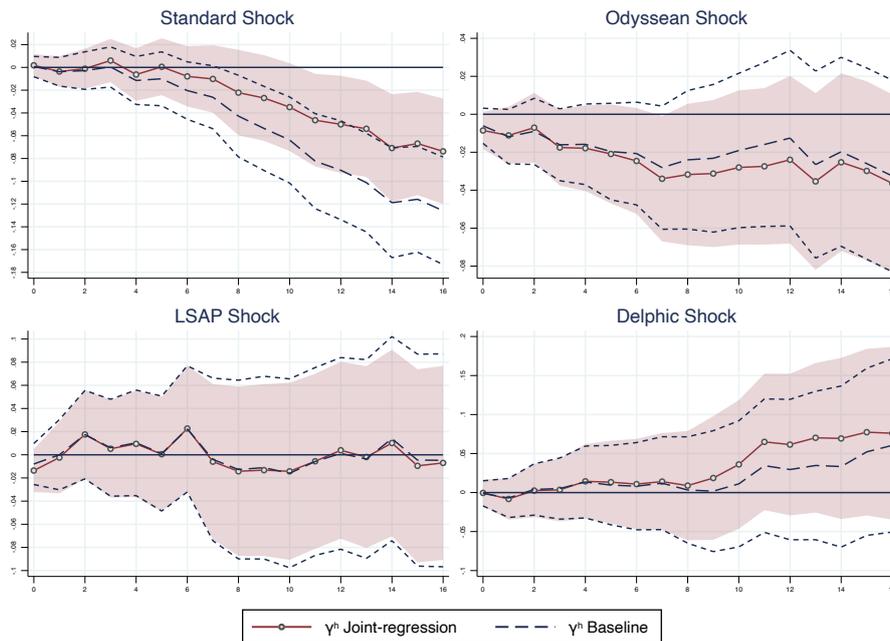
Baseline and joint-regression estimates yield nearly identical results.

⁴⁸Figure 2.H.1 depicts the changes in the total book value of banks' capital ratio.

Figure 2.9.2: Monetary Tightening Conditional on HQ-Liquidity: Effect on Total Deposit Growth (Baseline using Unconventional Shocks)



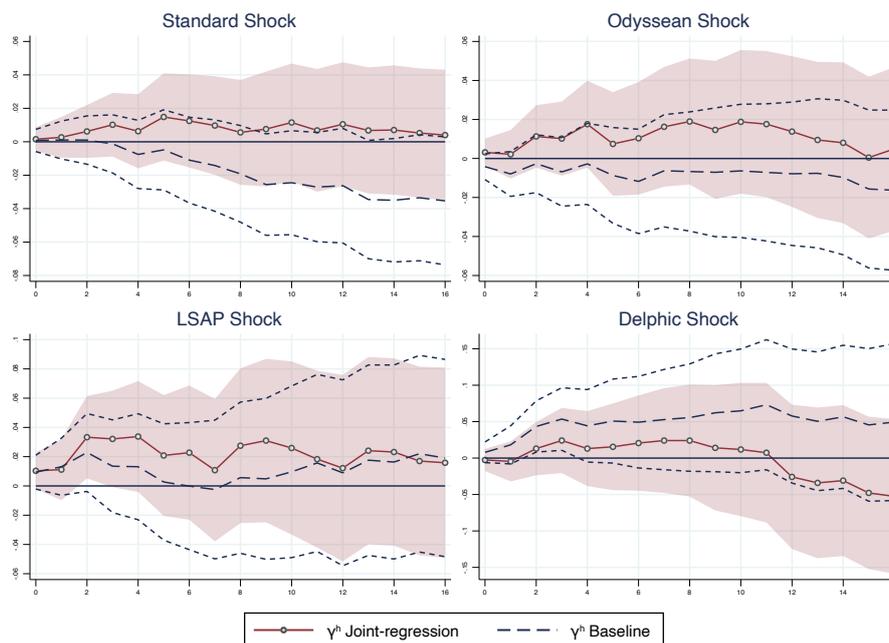
(a) Heterogeneity Induced by HQ liquidity



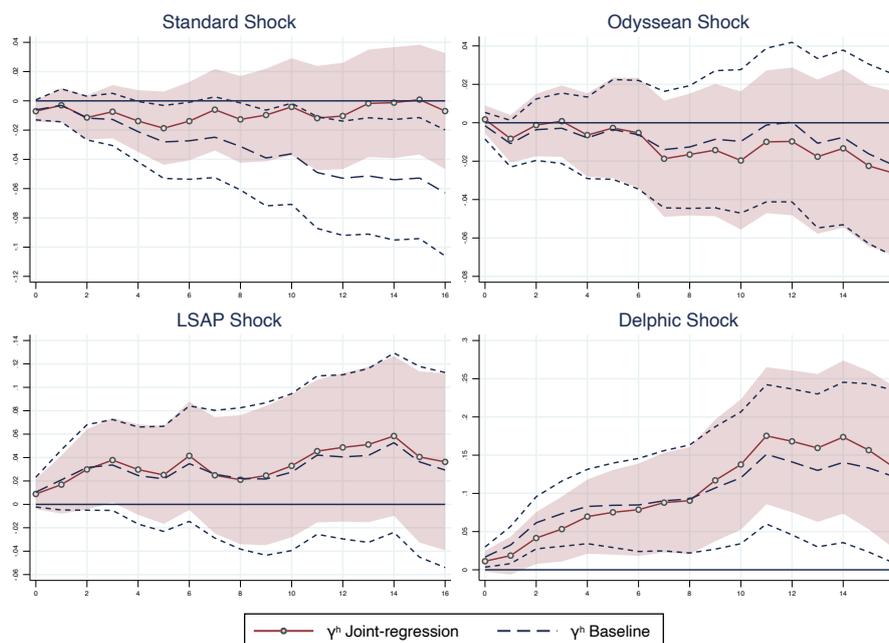
(b) Heterogeneity Induced by LQ liquidity

Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.9.3: Monetary Tightening Conditional on Liquidity: Effect on Total Loan Growth (Baseline using Unconventional Shocks)



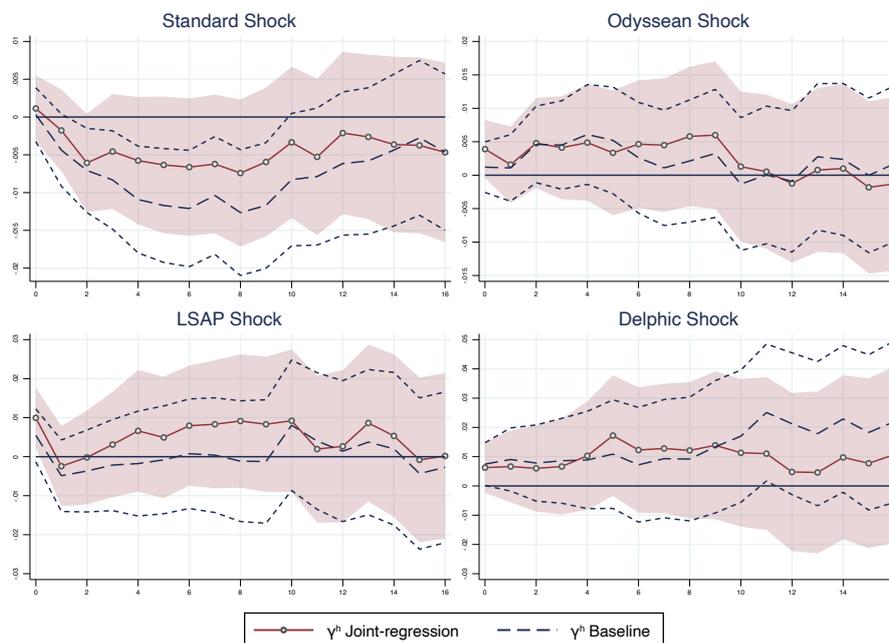
(a) Heterogeneity Induced by HQ liquidity



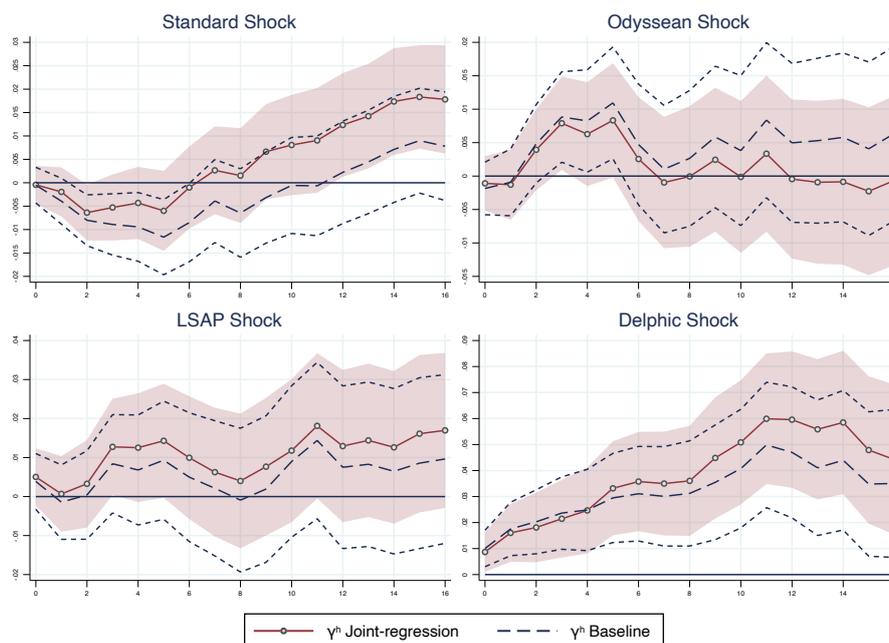
(b) Heterogeneity Induced by LQ liquidity

Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.9.4: Monetary Tightening Conditional on Liquidity: Effect on Liquidity Creation (Baseline using Unconventional Shocks)



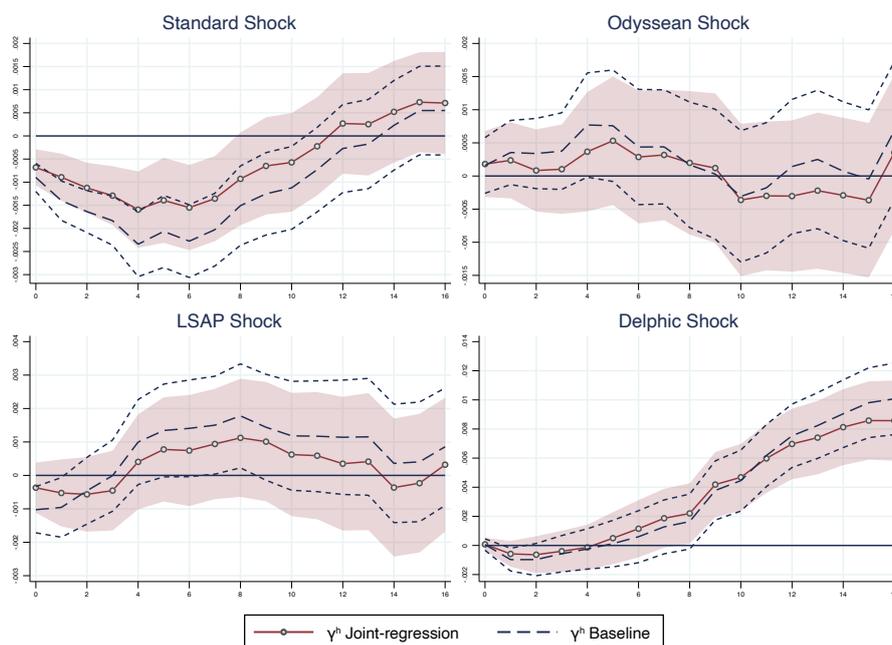
(a) Heterogeneity Induced by HQ liquidity



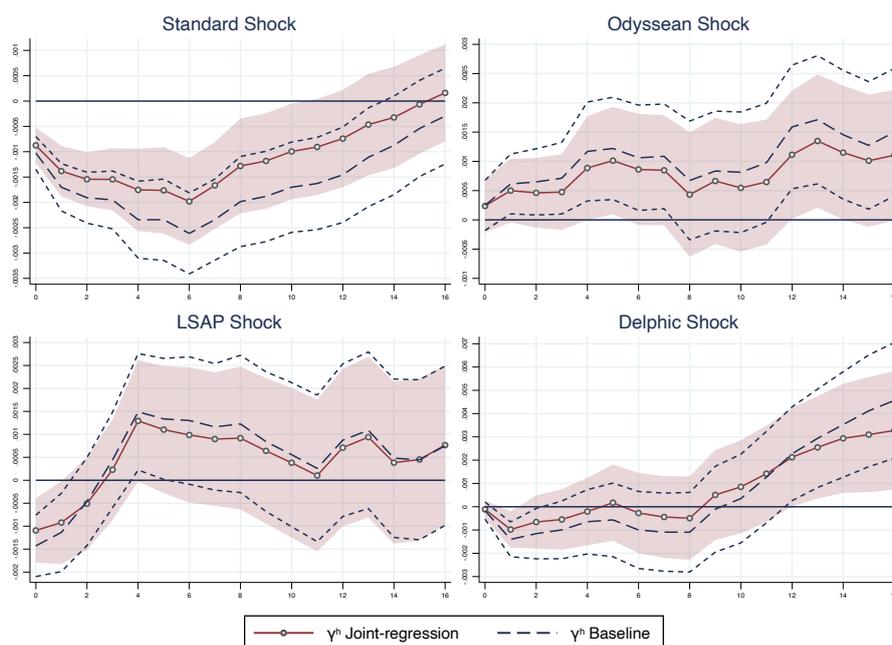
(b) Heterogeneity Induced by LQ liquidity

Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.9.5: Monetary Tightening Conditional on Liquidity: Effect on Interest Rate Margins (Baseline using Unconventional Shocks)



(a) Heterogeneity Induced by HQ liquidity



(b) Heterogeneity Induced by LQ liquidity

Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.10 Conclusion

This chapter traces the effects of monetary policy conditional on holdings of multiple types of liquidity into different banking industry outcomes. I use local projections to estimate the dynamic heterogeneity in deposit flows, lending, liquidity creation, and profit margins generated by the interaction between monetary shocks and ex-ante liquidity ratios. The main evidence is derived from a sample of U.S commercial banks with assets less than \$50 billion dollars. The analysis centers on the interaction between HFI-monetary shocks and four liquidity ratios: High-quality, Low-quality, total liquidity, and liquidity coverage ratios, producing the subsequent findings.

When analyzing conventional monetary policy shocks, High-quality liquidity stabilizes deposit outflows in response to monetary shocks in the short term. In comparison, low-quality liquidity does lead to a permanent decrease in deposit growth in response to monetary shocks (Section 2.5). After controlling for income and duration gaps, high-quality liquidity shows no statistically significant heterogeneous effects in transmitting monetary shocks on loan growth. In contrast, low-quality liquidity does lead to a decrease in loan growth in response to monetary shocks (Section 2.6). High- and Low-quality liquidity do not create heterogeneity in the transmission of monetary shocks to banks' liquidity creation (Section 2.7). High- and Low-quality liquidity expose banks to larger profit losses in response to tightening monetary shocks. The findings indicate that most banks experience lower net interest income flows when short-term interest rates rise, even when accounting for sources of interest rate risk exposure (2.8). Finally, the chapter concludes with an exercise exploring the role played by liquidity ratios in response to monetary shocks that reflect unconventional monetary policy instruments (Section 2.9).

In summary, this chapter improves our understanding of how monetary policy is transmitted within the banking sector. Altogether, the empirical contribution of this chapter complements and expands previous literature that has explored the role of liquidity in the transmission mechanism of monetary policy into the banking system. Since the literature has uniquely explored one dimension of liquidity, this research contributes to studying multiple types of liquidity and identifies that liquidity might play alternative roles in transmitting shocks outside the traditional fund-of-last-resort view.

Although this study does not explicitly explore the implications of macroprudential instruments, the findings indicate potential adverse effects of high-quality liquidity and liquidity coverage ratios, such as reduced profit margins. This suggests unintended destabilizing factors associated with recent trends in banks' accumulation of high-quality liquidity. This point raises questions for future research regarding the interaction between monetary policies and macroprudential instruments.

Appendix

Appendix 2.A Data

2.A.1 Liquidity Categories

Variables descriptions and limitations are sourced from the FDIC website⁴⁹. Balance-sheet items are summarized in Table 2.A.1.

2.A.1.1 Description and limitations of High-Quality Liquid Assets - Level 1

1. Balances Due from Federal Reserve Banks (chfrb)

The total cash balances due from Federal Reserve Banks as shown by the reporting bank's books. This amount includes Reserves and Other Balances.

- Beginning in 2001, FFIEC Call filers did not report this item with total assets < \$300 million. Before 2001, this item was reported in the "Cash and balances due" categories for FFIEC Call Report filers with total assets of < \$100 million.

2. U.S. Treasury Securities (scust*)

Total U.S. Treasury securities not held in trading accounts. It includes all bills, certificates of indebtedness, notes, and bonds, including T-Strips bonds and inflation-indexed bonds.

3. Mortgage-Backed Pass-Through Securities issued by GNMA (scgnm*)⁵⁰

MBSs structured as pass-throughs⁵¹. It only includes securities issued by the Government National Mortgage Association (GNMA). GNMA MBS benefits from an explicit government guarantee.

- As of June 2018, banks filing an FFIEC Call Report 51, or banks with domestic offices only and total assets < \$1 billion, report these together with FNMA and FHLMC securities (below in scfmn).

⁴⁹<https://banks.data.fdic.gov/bankfind-suite/help?helpTopic=glossary-and-variable-definitions> For Securities <https://www.fdic.gov/resources/bankers/call-reports/crinst-031-041/2017/2017-03-rc-b.pdf>

⁵⁰The mark * indicates that the item includes both held-to-maturity at amortized cost and available-for-sale at fair value on a consolidated basis.

⁵¹Structure such that mortgage payments are collected and passed through to investors, e.g., commercial banks holding the asset. Mortgage loans in an RMBS act as collateral in the event of default while principal and interest are passed on to investors otherwise.

Table 2.A.1: Classification of Balance Sheet Items

	Assets	Liabilities
Illiquid	Commercial Real Estate Loans (cre) Loans to finance agricultural production (lnag) Commercial and industrial institutions loans (lncl) Other real estate owned (ore) All other assets (idoa) Goodwill and other intangibles (intan) Bank premises and fixed assets (bkprem)	Subordinated debt - Debenture (subnd) All other liabilities (idoliab) Total equity capital (eqtot)
Semi-liquid	Residential Real Estate Loans (rre) Consumer loans (lncon) All other loans & leases (lnotci)	Total nontransaction time deposits - CDs (ntr-time) Other borrowed funds (idobrmgt)
Liquid	High Quality (Level 1)	Cash Balances Due from Federal Reserve Banks (chfrb) Treasury Securities (scust) RMBS Pass-Through by GNMA (scgmm) Other Obligations by GAs (scaot)
	High Quality (Level 2A)	RMBS Pass-Through by GSE (scfmn) CMBS Pass-Through by GAs (sceptg) CMBS Other by GAs (scemog) Other Obligations by GSEs (scspn)
	Low Quality	CMOs and REMICs by GAs and GSE (sccol) Securities by States & Political Subdivisions (scmuni) RMBS by Privates (scrmbpi) Other CMBS (scmos) ABS (scabs) Structured financial products (scsfp) Other Domestic Debt Securities (scodot) Foreign debt securities (scford) Equity securities not held for trading (sceqnt) Assets held in trading accounts (trade) Federal funds sold and reverse repurchase (frepo)
	Other	Cash and due from other institutions (chbal) + Cash items in process of collection (chcic) + Balances due from depository institutions in the U.S. (chus) + Balances due from foreign banks (chnus)

Classification is based on Berger and Bouwman (2009) and Ihrig et al. (2017).

4. U.S. Government Agencies⁵² Obligations (scaot*)

Other obligations (notes, bonds, and discount notes) that U.S. GAs issue. It excludes all MBSs.

- This detailed item ended in March 2018 (2018q2). To extend the data, I use the total amount of obligations excluding MBS (idscas) and extrapolate it using the share observed in 2018q2.

2.A.1.2 Description and Limitations of High-Quality Liquid Assets - Level 2A

1. Obligations Issued by U.S. Government Sponsored Enterprises⁵³ (scspn*)

⁵²U.S. GAs include but are not limited to agencies such as the Government National Mortgage Association (GNMA), the Federal Deposit Insurance Corporation (FDIC), and the National Credit Union Administration (NCUA).

⁵³U.S. GSEs include but are not limited to agencies such as the Federal Home Loan Mortgage Corporation (FHLMC) and the Federal National Mortgage Association (FNMA)

Other obligations issued by U.S. GSEs. It excludes all MBS.

- Same as scaot.

2. Mortgage-Backed Pass-Through Securities issued by FNMA and FHLMC (scfmn*)

MBSs, which are structured as pass-throughs. They are only issued by the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Fannie Mac). GSE debt carries the implicit backing of the U.S. government but is not a direct obligation of the U.S. government.

- As of June 2018, this item includes GNMA-MBS for banks filing the FFIEC Call Report 51 or banks with domestic offices only and total assets less than \$1 billion.

3. Commercial Mortgage-Backed Securities issued by U.S. Government (scptg + sccmog)

Unlike RMBS, CMBSs are secured by mortgages on commercial properties rather than residential real estate.

a. CMBSs structured as pass-through (scptg*).

b. CMBSs with other structures. Such as CMOs⁵⁴ (plus residuals), REMICs (plus residuals), stripped mortgage-backed securities, and commercial paper backed by loans secured by properties other than 1-4 family residential properties (sccmog*).

- Data began in March 2011 (2011q1).

2.A.1.3 Description and limitations of Low-Quality Liquid Assets

1. Securities Issued by States & Political Subdivisions (scmuni*)

All securities issued by states and political subdivisions in the U.S. not held for trading.

2. Collateralized Mortgage Obligations and REMICS Issued by U.S. Government Agencies or Sponsored Agencies (scol*)

All classes of CMOs (plus residuals), REMICs (plus residuals), and stripped mortgage-backed securities backed by loans secured by 1-4 family residential properties. It also includes REMICs issued by the U.S. Department of Veterans Affairs that are backed by 1-4 family residential mortgages.

3. Asset Backed Securities (scabs*)

All ABSs excluding mortgage-backed securities. It includes asset-backed commercial paper non-held for trading.

- Before March 2001, ABSs are included in SCODOT for those institutions that file a FFIEC Call Report.

⁵⁴Collateralized Mortgage Obligations are multiple pools of securities structured in slices or tranches. Each tranche is given a credit rating, determining the rates returned to investors.

4. Other Commercial Mortgage-Backed Securities (sccmos*)

CMBS structured as CMOs, REMICs, CMO and REMIC residuals, stripped mortgage-backed securities, and commercial paper backed by loans secured by properties other than 1-4 family residential properties that have been issued or guaranteed by non-U.S. Government issuers.

5. Other Domestic Debt Securities (scodot*)

It includes:

a) Bonds, notes, debentures, equipment trust certificates, and commercial paper (except asset-backed commercial paper) issued by U.S.-chartered corporations and other U.S. issuers.

b) Preferred stock of U.S.-chartered corporations and business trusts that, by its terms, either must be redeemed by the issuing corporation or trust or is redeemable at the option of the investor (i.e., redeemable or limited-life preferred stock), including trust preferred securities issued by a single U.S. business trust that is subject to mandatory redemption.

c) Detached U.S. Government security coupons and ex-coupon U.S. Government securities held as the result of either their purchase or the bank's stripping of such securities and Treasury receipts such as CATS, TIGRs, COUGARs, LIONs, and ETRs. Refer to the Glossary entry for "coupon stripping, Treasury receipts, and STRIPS" for additional information.

- Before March 2001, ABSs are included for FFIEC Call Reporters.

6. Privately Issued Residential Mortgage-Backed Securities (scrmbpi*)

Privately Issued Residential Mortgage-Backed Securities

7. Structured Financial Products (scsfp)

Total structured financial products (cash, synthetic and hybrid) on a consolidated basis. Data began in June 2009.

One of the more common structured financial products is collateralized debt obligations (CDOs). Other products include synthetic structured financial products (such as synthetic CDOs) that use credit derivatives and a reference pool of assets, hybrid structured products that mix cash and synthetic instruments, collateralized bond obligations (CBOs), re-securitizations such as CDOs squared or cubed (which are CDOs backed primarily by the tranches of other CDOs), and other similar structured financial products.

8. Federal Funds Sold & Reverse Repurchase Agreements (frepo)

Total federal funds sold and securities purchased under agreements to resell in domestic offices.

9. Equity Securities Not Held for Trading (sceqnft)

All other equity securities available-for-sale at fair value. This item includes equity securities without readily determinable fair values at historical cost.

10. Foreign Debt Securities (scford*)

All foreign debt securities includes:

- (1) Bonds, notes, debentures, equipment trust certificates, and commercial paper (except asset-backed commercial paper) issued by non-U.S.-chartered corporations.
- (2) Debt securities issued by foreign governmental units.
- (3) Debt securities are issued by international organizations such as the World Bank, the IDB, and other international institutions.
- (4) Preferred stock of non-U.S.-chartered corporations that, by its terms, either must be redeemed by the issuing enterprise or is redeemable at the option of the investor (i.e., redeemable or limited-life preferred stock).
 - Before 2001, institutions that filed an FFIEC Call Report and had less than \$100 million in total assets included ‘foreign debt securities’ in ‘other domestic debt securities.’

11. Assets Held in Trading Accounts (trade)

All securities and other assets acquired with the intent to resell to profit from short-term price movements.

- Effective January 1, 1994, this item includes revaluation gains.

2.A.1.4 Construction of Liquidity Creation Index

Berger and Bouwman (2009) offers a classification of assets and liabilities based on “the ease, cost, and time for customers to obtain liquid funds from the bank, and the ease, cost, and time for banks to dispose of their obligations to meet these liquidity demands” (Berger and Bouwman, 2009). Categories of assets are presented in Table 2.A.1.

Assets and liabilities are classified into three categories: liquid, illiquid, and semi-liquid. A general overview of the balance-sheet categories is as follows. Starting from the asset side of the balance sheet, illiquid assets (IA) are mainly commercial and agricultural loans and non-financial assets like fixed or intangible assets. Semi-liquid assets (SA) are all other loans that are more easily securitized, like residential real estate or consumer loans. Finally, liquid assets (LA) are cash holdings, securities (fixed or flexible rate), and reverse-REPOs. The composition of liabilities is the following. Liquid liabilities (LL) are mainly core deposits, money market deposits, and REPOs-lending. Semi-liquid liabilities (SL) are non-transaction deposits like certificates of deposit and other borrowed funds. Finally, illiquid liabilities (IL) are debts owed to unsecured creditors, liabilities on acceptances, and equity. Table 2.A.1 presents a detailed representation of this categorization.

Based on this categorization, the balance sheet liquidity creation of a depository institution i at quarter t is defined as:

$$LC_{i,t} = \frac{1}{2} \left(\sum_{a \in IA} \text{Iliq Asset}_{i,t}^a + \sum_{l \in LL} \text{Liq Liab}_{i,t}^l \right) - \frac{1}{2} \left(\sum_{a \in LA} \text{Liq Asset}_{i,t}^a + \sum_{l \in IL} \text{Iliq Liab}_{i,t}^l \right)$$

This index proxies the liquidity provision services offered by the banking sector, as it reflects how much illiquid assets are funded with liquid liabilities.

For the empirical analysis, I normalize liquidity creation by gross total assets (GTA⁵⁵) to make the dependent variables comparable across banks and to avoid the results being driven by the most prominent institutions. I call this variable liquidity creation ratio (LIQR). Finally, I limit the empirical analysis to understand the dynamics of on-balance liquidity creation. I do not estimate liquidity created off-balance (through derivatives, commitments, or letters of credit, among other instruments). The main reason is due to data limitations. The second one relates to the fact that even if a significant amount of liquidity is created off-balance sheet, the related empirical literature has failed to identify a connection between monetary policy on these items.

2.A.2 Monetary Shocks

2.A.2.1 Estimation of Baseline Monetary Shocks

Jarociński and Karadi (2020) methodology can be summarized in two stages, which combine high-frequency identification techniques and sign restrictions.

Stage 1 Similar to the literature, the objective is to identify contemporaneous shocks from changes in financial market variables within a 30-minute window around FOMC announcements. Like most event-study methodologies, the underlying assumption is that within narrow windows of time, no shocks besides monetary policy systematically influence changes in financial market yields.

Stage 2 Unlike the related literature, Jarociński and Karadi (2020) decomposes the raw-interest rate surprises obtained in the event-study application between purely structural monetary shocks and non-monetary or FED-news shocks. This strategy applies sign restrictions on two high-frequency surprise variables: a) one capturing expected short-term interest rates (measured as the change in the three months fed funds futures rate) and b) the other capturing stock price surprises (measured as changes in the S&P index). The underlying assumption is that shocks that lead to a positive co-movement of interest rates and equity prices reflect an accompanying information shock. If, instead, shocks that lead to a negative co-movement of interest rates and equity prices are interpreted as driven by structural monetary surprises. The key is that equity market prices help learn the content of the signal inherent in central bank announcements.

A few results from Jarociński and Karadi (2020) are worth mentioning regarding the macroeconomic relevance of these shocks in the U.S. economy. In response to the monetary shocks, stock prices drop by about 1 percent while the excess bond premium increases by about five bps (financial conditions tighten). Concerning real activity, real GDP and the price level decline persistently by about 10 and 5 basis points, respectively.

2.A.2.2 Alternative Monetary Shocks

In the robustness exercises, I use other identified monetary shocks proposed by Acosta (2022) and Bu, Rogers, and W. Wu (2021).

⁵⁵Total assets plus the allowance for loan and lease losses.

Table 2.A.2: Descriptive Statistics on Int. Rates and Monetary Policy Shocks

	2001-2018				1990-2019			
	mean	sd	min	max	mean	sd	min	max
Δ Fed Funds Rate	-2.36	40.30	-165.00	58.00	-5.14	43.80	-165.00	91.00
Δ 1y T-bond	-0.61	42.43	-179.00	89.00	-4.95	49.73	-179.00	124.00
Δ 5y T-bond	-2.12	51.58	-146.00	101.00	-5.19	54.77	-146.00	102.00
Δ 10y T-bond	-2.87	49.28	-160.00	84.99	-5.05	49.92	-160.00	94.00
Δ S&P Index (around FOMC)	1.53	70.72	-203.88	143.37	5.30	74.02	-203.88	277.25
Δ Synthetic Rate (around FOMC)	-2.46	8.30	-36.12	9.99	-3.63	10.53	-46.99	17.97
Δ 3m-FFF (around FOMC)	-1.42	5.66	-23.50	9.00	-3.25	9.36	-43.50	17.00
Monetary Surprise (3m-FFF)	-0.79	4.80	-14.96	13.57	-1.90	7.12	-33.33	13.57
Monetary Surprise (Synthetic)	-1.32	6.47	-21.13	17.38	-2.14	8.38	-37.07	17.38
Monetary Surprise (BRW)	-0.93	7.12	-23.70	14.63	-0.70	6.13	-23.70	14.63
Monetary Surprise (Acosta)	-0.27	1.50	-3.83	5.18	-0.14	1.43	-3.83	5.18
Monetary Surprise (J2021)	-2.22	11.07	-47.28	20.14	-2.93	12.19	-53.22	23.00
Standard (u1)	-1.88	7.88	-39.70	17.11	-2.80	10.30	-46.03	26.01
Odyssean-FG (u2)	0.02	6.76	-24.08	30.82	0.14	6.02	-24.08	30.82
LSAP (u3)	0.08	3.95	-23.61	8.44	0.09	3.18	-23.61	8.44
Delphic-FG (u4)	-0.44	3.46	-11.34	5.27	-0.36	3.30	-11.34	12.26
Non-monetary Surprise (3m-FFF)	-0.63	4.46	-15.75	7.22	-1.35	4.75	-20.51	7.79
Observations	66				118			

Notes: a) Data in basis points b) ‘Synthetic’ refers to the synthetic interest rate. Implying that the underlying interest rate surprise indicator was computed by extracting a principal component from multiple markets’ interest rates on future contracts.

2.A.3 Estimated Variables

2.A.3.1 Income gap

Gomez et al. (2021) computes income gaps at the bank holding level. They argue that this measure proxies the sensitivity of a bank’s net interest income to changes in policy rates, also known as a bank’s cash-flow exposure. Under some assumptions, it measures income shocks driven by policy interest rate changes.

$$IG_{i,t} = RSA_{i,t} - RSL_{i,t} \quad (2.5)$$

where RSA is the dollar amount of assets that either reprice or mature within a year and RSL is the dollar amount of liabilities that mature or reprice within a year. This measure is then normalized by the total assets.

Regarding repricing or maturity of assets, Call Reports provide detailed information about mortgage pass-through backed by closed-end first lien 1-4 residential mortgages, other debt securities, closed-end loans, and all other loans secured by first liens on 1-4 residential loans, and outstanding balance under the PPPLF. Regarding repricing or maturity of liabilities, Call Reports provide detailed information about time deposits, FHLB advances, and other borrowings.

In Tables 2.B.2, it is important to highlight that the in-sample average income gap at the bank level is 9.82% of gross total assets. This figure is somewhat lower than the average income gap of 12.2% reported by Gomez et al. (2021). One potential explanation for this difference is that their measure is based on BHC-level averages, and their sample period spans from 1986 to 2013.

2.A.3.2 Duration Mismatch

Banks' duration mismatch is approximated using the repricing maturity method employed by Drechsler, Savov, and Schnabl (2021) and English, Van Den Heuvel, and Zakrajšek (2018). Duration mismatch, measured in years, is the difference between the assets' repricing maturity and liabilities' repricing maturity.

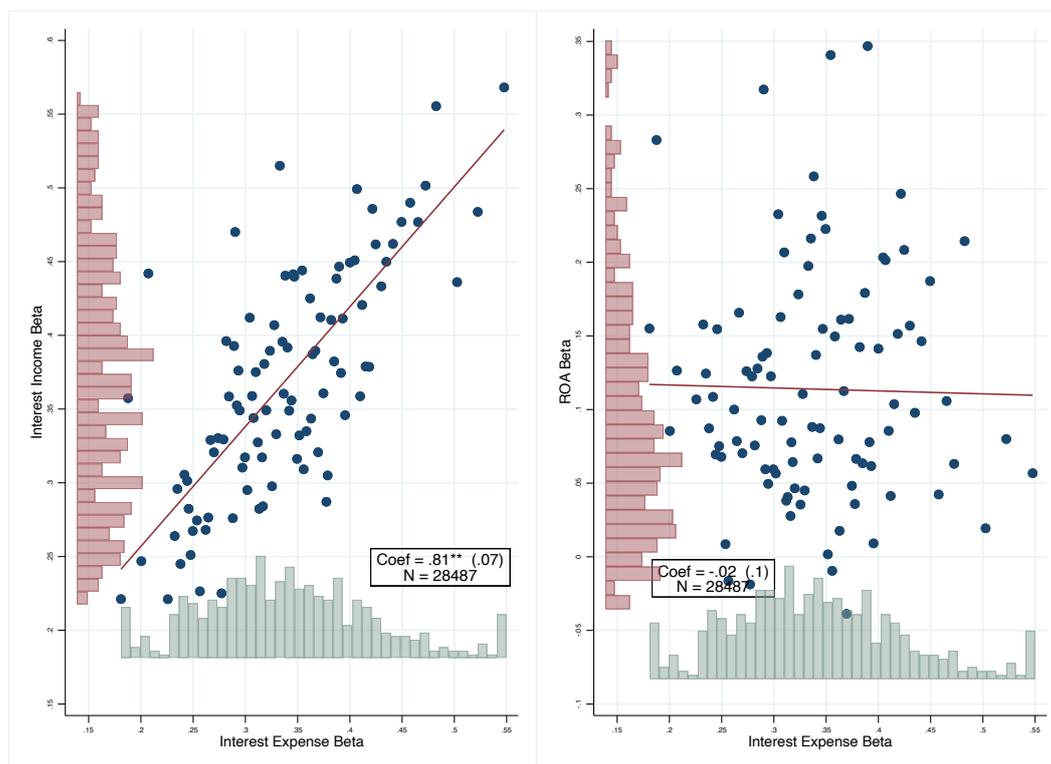
The in-sample average duration, at the bank level, is 3.76 years, similar to Drechsler, Savov, and Schnabl (2021) where the estimated mismatch is at 3.9 years for the period 1997 to 2017.

2.A.3.3 Betas

Estimates of bank-level deposit spread betas and local deposit market power are obtained following the methodology implemented by Drechsler, Savov, and Schnabl (2017). The average spread beta is 0.77 and the average local deposit concentration is 0.10.

Deposit Spread beta reflects how an increase of 1% in the Fed funds rate is transmitted towards the bank's deposit cost.

Figure 2.A.1: Testing Estimates of Betas: Replication Drechsler, Savov, and Schnabl (2021)



This figure shows binned scatter plots of interest expense, interest income, and ROA betas. This figure replicates Figure 6 in Drechsler, Savov, and Schnabl (2021) for the sample period 2000 to 2018.

2.A.3.4 Local Market Competition

To measure market power at the individual bank level, I calculate two concentration indices using branch-level data from the Summary of Deposits (SOD).

2.A.3.4.1 Based on Level of Deposit

I follow Drechsler, Savov, and Schnabl (2017):

Step 1: Estimate Branch-HHI as the sum of the square of each bank's deposit share in a given county, year (c,t):

$$Branch - HHI_{c,t} = \sum_i (Deposit\ Market\ Share_{i,c,t})^2$$

This variable captures the competitive conditions in the county

Step 2: Estimate Bank-HHI (i,t) as follows:

$$Bank - HHI_{i,t} = \sum_c (Bank\ Deposit\ Share_{i,c,t}) \times Branch - HHI_{c,t}$$

This variable captures a bank's average market power across all markets in which it has branches, weighted by the share the bank raises in each market.

2.A.3.4.2 Based on Presence in Local Markets

Following Drechsler, Savov, and Schnabl (2021), I calculate a Herfindahl-Hirschman index (HHI) for each U.S. county by computing each bank's share of the total branches in the county and summing the squared shares. Then, create a bank-level HHI by averaging the county HHIs of each bank's branches, using the bank's branches' presence in each county as weights.

Step 1: Estimate Branch-HHI as the sum of the square of each bank's share of branches in a given county, year (c,t):

$$Branch - HHI_{c,t} = \sum_i \left(\frac{Nbr.Branches_{i,c,t}}{Nbr.Branches_{c,t}} \right)^2$$

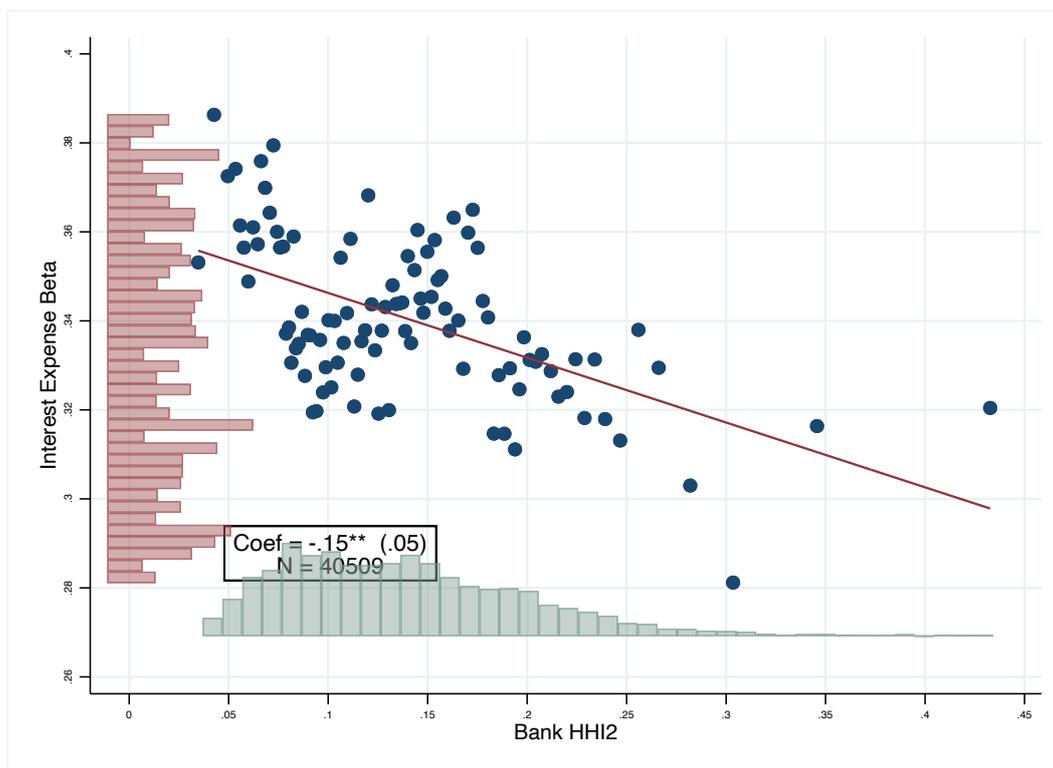
Step 2: Estimate Bank-HHI (i,t) as follows:

$$Bank - HHI_{i,t} = \sum_c 1_{i \in c} \times Branch - HHI_{c,t}$$

2.A.3.5 Markups

Credit and deposit markups are calculated based on the methodology proposed by Belifemine, Jamilov, and Monacelli (2022). Credit markup is the ratio between the price banks charge on loans over the marginal cost of producing an extra unit of credit. The average credit markup is 1.94. Deposit markup is the ratio of a proxy for the safe rate of return that banks can obtain out of their funds over the marginal cost of raising one additional unit of deposits. The average deposit markup is 1.58.

Figure 2.A.2: Testing Estimates of Bank HHI: Replication Drechsler, Savov, and Schnabl (2021) Drechsler, Savov, and Schnabl (2021)



Interest expense betas and market concentration based on Bank’s presence in Local Markets. This figure replicates Figure 10 in Drechsler, Savov, and Schnabl (2021) for the sample period 2000 to 2018.

2.A.3.6 Lending opportunities, deposits volatility, bank size

Following Stulz, Taboada, and Dijk (2022), lending opportunities are proxied as the lagged eight-quarter average loan growth, and deposit volatility is proxied as the four-quarter standard deviation of the deposits to total assets ratio.

Following Berger and Bouwman (2009), bank size is proxied as the natural log of banks’ total assets. The natural log is used to avoid potential specification distortions, coming from the fact that the dependent variable is generally in the [0,1] interval.

2.A.4 Other Call Report Variables

- Leverage ratio is the ratio of Tier-1 capital⁵⁶ over average total assets⁵⁷ minus ineligible intangibles⁵⁸.
- Non-current loans to gross total loans ratio to account for banks’ risk⁵⁹.

⁵⁶Tier 1 capital includes common equity plus noncumulative perpetual preferred stock plus minority interests in consolidated subsidiaries less goodwill and other ineligible intangible assets.

⁵⁷Total assets for the leverage ratio is average total consolidated assets, less deductions from common equity tier 1 capital and additional tier 1 capital, less other deductions defined by regulatory capital rules of the bank’s primary federal supervisor.

⁵⁸The amount of eligible intangibles (including mortgage servicing rights) included in core capital is limited by supervisory capital regulations.

⁵⁹Total non-current loans and leases, Loans and leases 90 days or more past due plus loans in non-

- Earning Assets are all loans and other investments that earn interest or dividends

Appendix 2.B Additional Descriptive Statistics

2.B.1 Banks' Size Categories

Following the related literature, banks are split by size and regulatory obligations.

For the categorization based on regulatory obligations, I use total consolidated assets obtained using the bank-holding level data set and map each depository institution with the bank-holding company (BHC) to which it belongs. Depository institutions that report to be stand-alone banks are also included.

Categories based on regulatory obligations, and more specifically liquidity requirements, are formed as follows:

LCR-banks: Banks subject to the liquidity coverage ratio are BHCs with an excess of \$50 billion in total consolidated assets.

Within the LCR category, BHCs with assets between \$50 and \$250 billion are considered modified-LCR banks, while those with assets larger than \$250 belong to Standard-LCR. From the regulatory perspective, Standard-LCR BHCs have more stringent liquidity requirements than modified-LCR BHCs.

Non-LCR banks: Banks not constrained by LCR regulation are BHCs with less than \$50 billion in total consolidated assets.

Within this group of banks, BHCs with assets between \$3 and \$50 billion are considered medium-size banks, while those with assets below \$3 billion are considered small-sized banks. I define 2013q2 as the period of reference to create the categories⁶⁰.

2.B.2 Additional Cross-sectional Dynamics

2.B.2.1 Liquid Assets

Regarding the overall dynamics of HQ liquidity ratios, four trends are observed. Before 2004, the HQ liquidity ratio dynamics were mainly driven by debt securities holdings issued by government-sponsored enterprises. In specific, residential MBS and other debt, both belonging to the L2A category). During 2004-2008, the ratios decreased as banks started to reduce their ratios of level 1 and level 2a liquid assets. After the GFC, L1-liquid assets started to gain participation, driving the positive trend of HQLA – consistent with the aggregate trend in the banking sector –.

The post-crisis trend has reverted since introducing new liquidity regulations (2013), decreasing until the end of the sample. In particular, the ratio decrease was driven by a rapid decrease in L1 assets and a softer decrease in L2a assets.

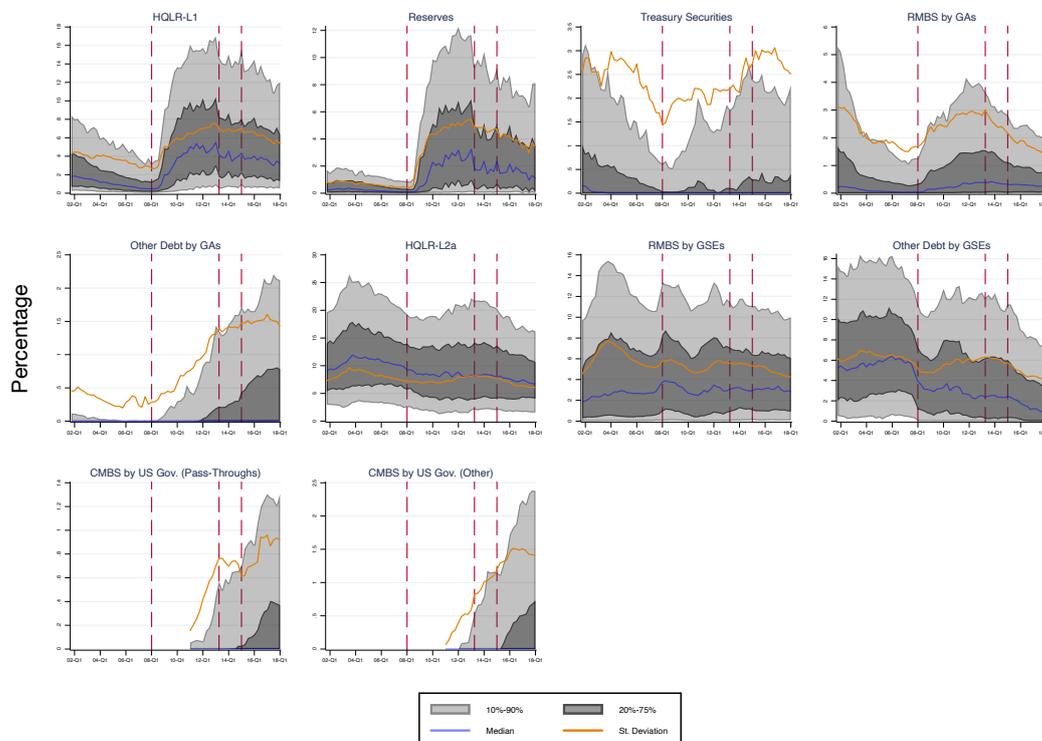
Figure 2.B.1 presents separately cross-sectional heterogeneity in the holdings of each asset belonging to the HQ categories. The degree of cross-sectional heterogeneity changes with

accrual status, as a percent of gross loans and leases

⁶⁰Following Roberts, Sarkar, and Shachar (2023), this date marks the quarter after the Basel liquidity coverage ratio rule was finalized.

the type of HQ asset. For instance, banks tend to differ more relative to the holdings of GSE securities than those of Treasuries or GNMA-MBS. In particular, it highlights the sudden increase in dispersion of L1-assets since the aftermath of the GFC relative to the pre-crisis period. Beginning with L1-assets, Reserves and MBS issued by GAs are the

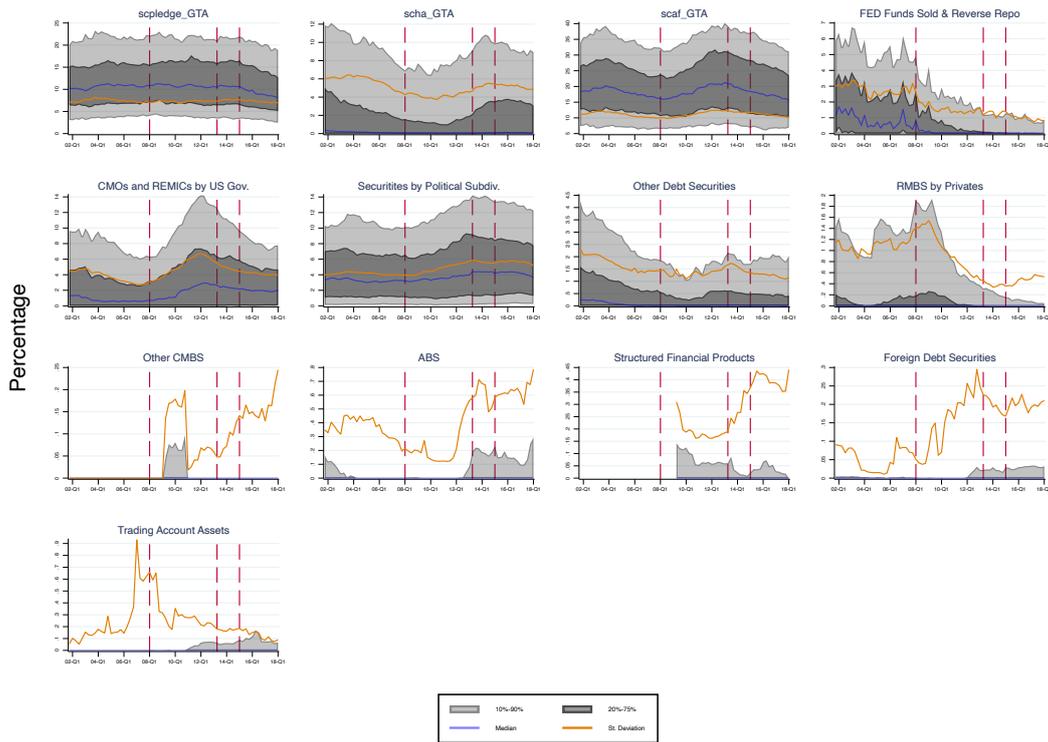
Figure 2.B.1: Heterogeneity on High Quality Liquid Assets



Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

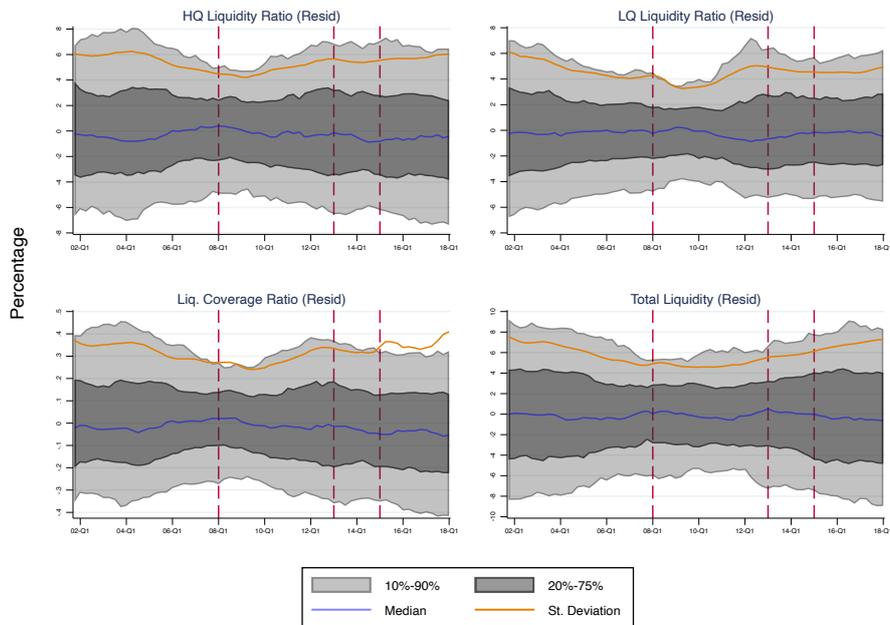
main drivers of the dynamics of L1-assets. In particular, GNMA-MBS better explains the pre-crisis trends, while reserves match the post-crisis dynamics. Furthermore, the degree of heterogeneity in reserves explains the degree of heterogeneity in L1-assets (especially since the aftermath of the GFC). In contrast, banks are more homogeneous concerning Treasuries and non-GSE debt (at least among 75% of banks). Regarding L2a assets, GSE Debt and GSE-MBS play the leading role in the dynamics of this category. Since 2008, there has been a significant decrease in dispersion regarding GSE-Debt (at least among 50% of banks), while dispersion in GSE-MBS has been constant. Looking at reserves, it is remarkable that there was almost no heterogeneity in the reserves-to-assets ratio before the GFC. In contrast, after the GFC dispersion, it increased significantly until the introduction of liquidity coverage ratios. Finally, notice that banks kept differences in the holdings of reserves even after the beginning of the full implementation of liquidity regulations.

Figure 2.B.2: Heterogeneity on Low-Quality Liquid Assets



Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

Figure 2.B.3: Heterogeneity on Residualized Liquidity Ratios



Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1. Residuals are obtained from panel regressions of the following specification $LR_{i,t}^j = f_i + f_t + \epsilon_{i,t}$ for any liquidity ratio- j .

Table 2.B.1: Liquidity Portfolio Grouping by Quintiles

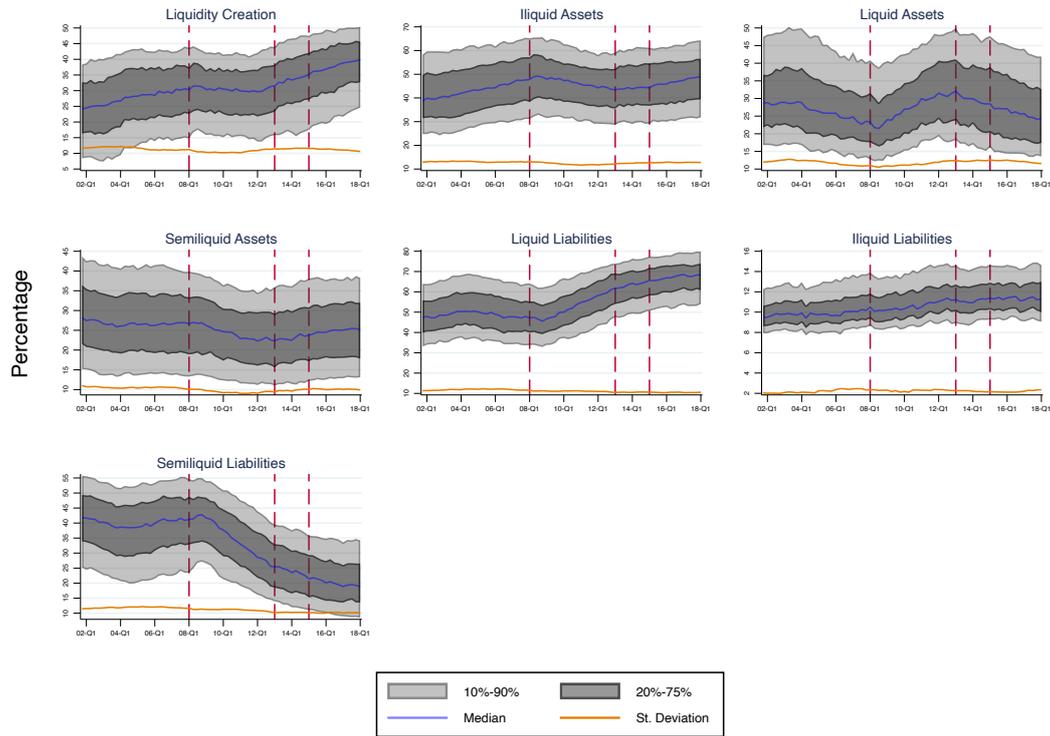
	Quintiles of HQ Liquidity Ratios					Quintiles of LQ Liquidity Ratios					Quintiles of Liq. Coverage Ratios					
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	Total
Total Liquid Assets Ratio	20.83	23.41	27.42	31.29	41.63	21.17	24.68	29.22	30.42	39.89	22.07	23.64	27.43	31.42	40.29	28.99
HQ Liquidity Ratio	6.92	10.29	13.31	17.21	26.65	13.99	14.64	15.92	14.37	15.86	7.66	10.66	13.41	17.06	25.82	14.94
HQ-L1 Liquidity Ratio	1.72	2.31	2.85	3.23	5.40	3.66	2.82	3.38	2.73	2.96	1.64	1.99	2.77	3.38	5.75	3.11
Reserves	1.52	1.76	2.20	2.34	3.02	2.86	1.95	2.16	1.94	1.93	1.43	1.58	2.07	2.55	3.22	2.17
Treasury Securities	0.16	0.41	0.58	0.80	1.88	0.72	0.73	0.84	0.66	0.91	0.18	0.34	0.56	0.74	2.01	0.77
RMBS by GAs	0.00	0.01	0.01	0.01	0.03	0.02	0.01	0.02	0.01	0.01	0.00	0.01	0.01	0.01	0.03	0.01
Other Debt by GAs	0.04	0.05	0.05	0.04	0.06	0.02	0.03	0.08	0.06	0.04	0.03	0.05	0.05	0.04	0.07	0.05
HQ-L2a Liquidity Ratio	4.57	6.95	9.05	12.26	18.82	9.33	10.46	10.64	10.26	11.26	4.25	7.31	9.29	12.41	18.59	10.38
Other Debt by GSEs	1.79	2.51	3.93	4.80	7.77	4.66	5.11	3.68	3.72	3.70	1.35	2.62	4.01	5.11	7.80	4.18
RMBS by GSEs	2.62	4.11	4.84	7.10	10.27	4.47	4.93	6.54	6.13	7.09	2.61	4.37	5.04	6.93	10.09	5.81
CMBS by US Gov. (Pass-Throughs)	0.19	0.23	0.21	0.30	0.29	0.12	0.25	0.20	0.33	0.33	0.28	0.26	0.16	0.28	0.24	0.24
CMBS by US Gov. (Other)	0.15	0.48	0.41	0.46	0.34	0.18	0.38	0.39	0.46	0.43	0.33	0.46	0.30	0.46	0.27	0.37
LQ Liquidity Ratio	11.12	10.20	11.20	11.38	11.65	3.94	7.50	10.28	13.33	20.92	11.55	10.52	11.00	11.40	11.11	11.12
Fed Funds Sold & Reverse Repo	1.04	0.75	1.13	1.08	1.60	0.87	1.07	1.30	1.17	1.22	1.06	0.76	0.87	1.27	1.65	1.13
CMOs and REMICs by US Gov.	3.64	3.25	3.04	3.37	2.96	0.93	1.77	3.23	3.71	6.77	3.91	3.18	3.14	3.21	2.81	3.25
Securitized by Political Subdiv.	4.67	4.72	5.26	5.08	5.27	1.47	3.43	4.58	6.52	9.17	4.92	4.82	5.72	4.88	4.72	5.00
Other Debt Securities	0.65	0.65	0.58	0.83	0.79	0.33	0.59	0.50	0.83	1.27	0.53	0.75	0.57	0.83	0.84	0.70
RMBS by Privates	0.44	0.34	0.32	0.27	0.12	0.10	0.17	0.26	0.32	0.65	0.50	0.37	0.22	0.25	0.14	0.30
Other CMBS	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.01	0.02	0.01	0.01	0.01	0.01
ABS	0.12	0.08	0.09	0.09	0.04	0.03	0.07	0.06	0.13	0.15	0.12	0.15	0.03	0.06	0.07	0.09
Structured Financial Products	0.05	0.08	0.09	0.04	0.09	0.02	0.03	0.07	0.09	0.14	0.05	0.07	0.10	0.05	0.08	0.07
Foreign Debt Securities	0.02	0.03	0.03	0.04	0.03	0.01	0.03	0.01	0.02	0.08	0.03	0.02	0.02	0.04	0.05	0.03
Trading Account Assets	0.06	0.05	0.07	0.05	0.05	0.02	0.05	0.04	0.05	0.12	0.07	0.03	0.06	0.06	0.06	0.06
Liq. Coverage Ratio	0.27	0.40	0.52	0.67	1.04	0.58	0.58	0.61	0.55	0.60	0.24	0.39	0.52	0.68	1.08	0.58

Notes: This table shows bank-level in-sample averages of the main liquidity ratios by quintiles. Variables are all scaled by gross total assets, except the Liquidity Coverage Ratio.

2.B.2.2 Other Banks' Characteristics

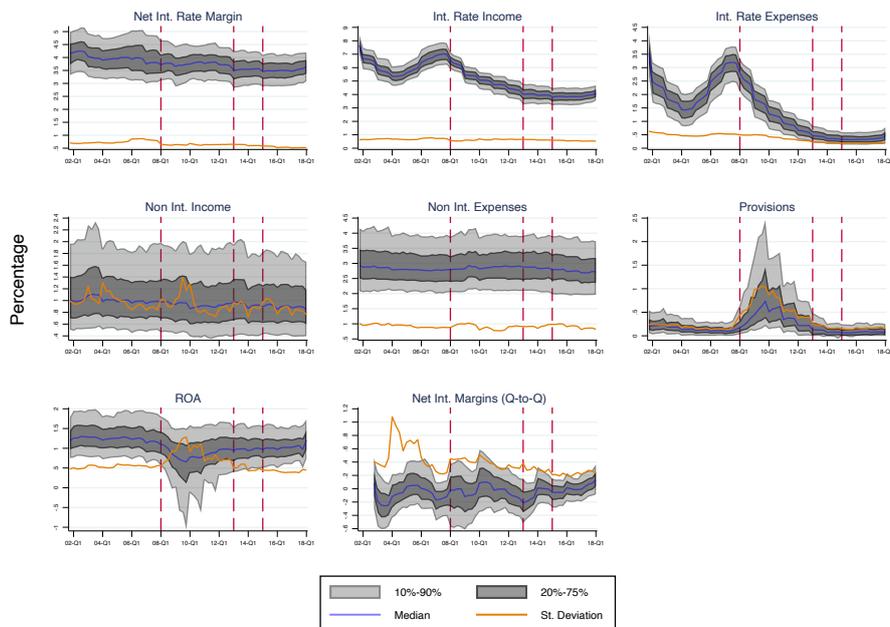
- Figure 2.B.4 depicts the evolution of liquidity creation across the cross-section of banks. In general, liquidity creation increased steadily over time. Regarding the degree of heterogeneity, significant cross-sectional differences exist in liquidity creation of at least 10pp, and this heterogeneity has been constant over time (from the cross-sectional standard deviation). Section 2.7 attempts to explain this heterogeneity.
- Figure 2.B.5 depicts the evolution of multiple profit margins in the cross-section of the sampled banks. Consistent with the literature, this picture shows that net interest margins have decreased steadily over time and across all the distribution of banks (e.g., Paul, 2023).
- Figure 2.B.6 displays the cross-sectional evolution of the main control variables used in the joint regressions. Table 2.B.2 complements this by presenting average based on quintile groups.

Figure 2.B.4: Cross-sectional Heterogeneity on Liquidity Creation



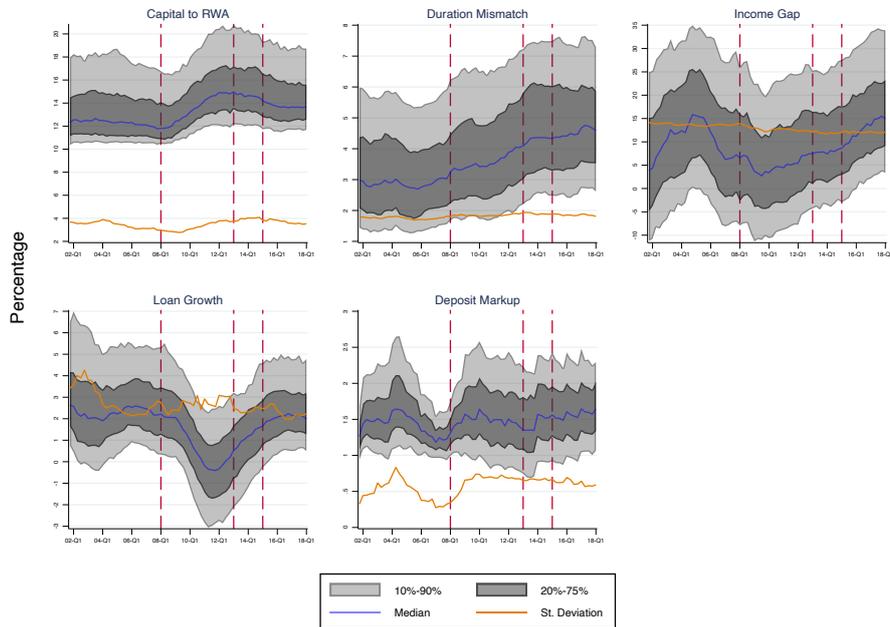
Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

Figure 2.B.5: Cross-sectional Heterogeneity on Profitability



Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

Figure 2.B.6: Cross-sectional Heterogeneity on Other Banks' Characteristics



Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

Table 2.B.2: Characteristics Affecting Monetary Policy Transmission Grouping by Quintiles

	Quintiles of HQ Liquidity Ratios					Quintiles of LQ Liquidity Ratios					Quintiles of Liq. Coverage Ratios					Total
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Leverage Ratio	9.32	9.35	9.19	9.07	9.55	9.44	9.17	9.33	9.20	9.34	9.34	9.05	9.41	9.02	9.65	9.29
Capital to RWA	13.05	13.44	13.72	14.26	16.86	13.42	13.57	14.55	14.21	15.71	13.27	13.05	14.14	14.11	16.81	14.28
T1 Capital to RWA	12.66	13.03	13.23	13.98	16.69	13.04	13.15	14.26	13.81	15.48	12.84	12.67	13.71	13.69	16.73	13.93
CET1 Capital to RWA	9.47	9.71	10.20	10.47	12.70	9.85	9.93	10.69	10.31	11.87	9.62	9.47	10.37	10.45	12.67	10.52
Noncurrent Loans	1.34	1.46	1.60	1.39	1.65	1.60	1.54	1.45	1.50	1.34	1.35	1.39	1.60	1.52	1.57	1.49
Z score	17.09	16.70	17.28	17.04	16.57	14.94	17.31	17.15	17.29	18.07	17.55	16.81	17.48	17.36	15.51	16.94
Duration Mismatch	3.42	3.34	3.69	4.10	4.22	3.28	3.59	3.78	3.90	4.27	3.42	3.51	3.85	3.94	4.09	3.76
Income Gap	11.54	13.54	10.90	7.37	6.06	13.53	9.19	10.53	9.56	6.18	10.92	12.83	9.35	8.30	7.72	9.82
Credit Markup	1.82	1.86	1.83	1.84	1.86	1.78	1.83	1.88	1.83	1.88	1.85	1.83	1.82	1.85	1.84	1.84
Deposit Markup	2.00	2.11	1.96	1.95	1.83	1.80	1.95	2.04	2.01	2.05	2.06	2.04	1.96	1.94	1.84	1.97
Deposit Market Power	0.10	0.09	0.10	0.10	0.11	0.10	0.09	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.11	0.10
Loan Growth	2.10	2.20	1.58	1.78	1.43	1.83	2.04	1.91	1.72	1.57	2.05	2.19	1.63	1.72	1.49	1.82
Dep. Volatility	1.34	1.35	1.13	1.17	1.18	1.26	1.22	1.24	1.22	1.22	1.22	1.30	1.21	1.20	1.23	1.23
Deposit Spread Beta	0.71	0.71	0.73	0.73	0.74	0.71	0.73	0.73	0.73	0.74	0.72	0.72	0.73	0.73	0.74	0.73
Int. Expenses Beta	0.36	0.34	0.32	0.33	0.32	0.34	0.33	0.34	0.33	0.32	0.35	0.34	0.32	0.33	0.33	0.33
Int. Income Beta	0.38	0.40	0.37	0.34	0.36	0.41	0.39	0.37	0.36	0.31	0.38	0.39	0.36	0.35	0.37	0.37
NIM Beta	0.02	0.05	0.04	0.01	0.03	0.06	0.05	0.03	0.02	-0.01	0.03	0.05	0.03	0.01	0.03	0.03
ROA Beta	0.12	0.13	0.15	0.08	0.08	0.14	0.12	0.11	0.12	0.06	0.12	0.12	0.13	0.10	0.08	0.11
Credit Markup Beta	-0.05	-0.05	-0.04	-0.05	-0.05	-0.04	-0.05	-0.05	-0.04	-0.06	-0.05	-0.04	-0.05	-0.05	-0.05	-0.05
Deposit Markup Beta	-0.17	-0.18	-0.16	-0.16	-0.13	-0.13	-0.15	-0.19	-0.16	-0.17	-0.18	-0.16	-0.18	-0.15	-0.14	-0.16

Notes: This table shows bank-level in-sample averages of the main liquidity ratios by quintiles. Variables are all scaled by gross total assets

2.B.3 Correlation Structure

This section includes data on the correlation structure of the liquidity ratios.

1. Table 2.B.4 contains in-sample means, standard deviation, and correlation coefficients of the main balance sheet variables. Columns 0 to 3 focus on the correlations between liquidity ratios and other banks' characteristics.
2. In the main text, Figure 2.3.2 shows that the percentiles of the liquidity ratios distribution vary considerably over time. Table 2.B.3 displays the Markov matrix for HQ- LQ liquidity ratios and the liquidity coverage ratio and highlights that the presence of a bank placed within a specific percentile group of the liquidity ratio distribution is persistent.
3. Figure 2.B.7 displays the correlation between liquidity ratios (y-axis) and other banks' characteristics (x-axis). This complements the correlation structure presented in the main text, specifically in Figure 2.3.3.
4. Figure 2.B.8 shows the correlations with the main variables (as in the main text) after controlling for other banks' characteristics. The objective is to remove the influence of other bank characteristics on the relationship between liquidity ratios and other bank-specific characteristics.

Table 2.B.3: Transition Matrices for Quarterly Liquidity Ratios

	1	2	3	4	5
1	0.85	0.13	0.01	0.00	0.00
2	0.14	0.68	0.16	0.02	0.00
3	0.01	0.17	0.66	0.15	0.01
4	0.00	0.01	0.16	0.73	0.10
5	0.00	0.00	0.01	0.10	0.89

(a) HQ liquidity

	1	2	3	4	5
1	0.87	0.12	0.01	0.00	0.00
2	0.12	0.72	0.14	0.01	0.00
3	0.01	0.14	0.71	0.13	0.01
4	0.00	0.01	0.13	0.75	0.10
5	0.00	0.00	0.01	0.10	0.89

(b) LQ liquidity

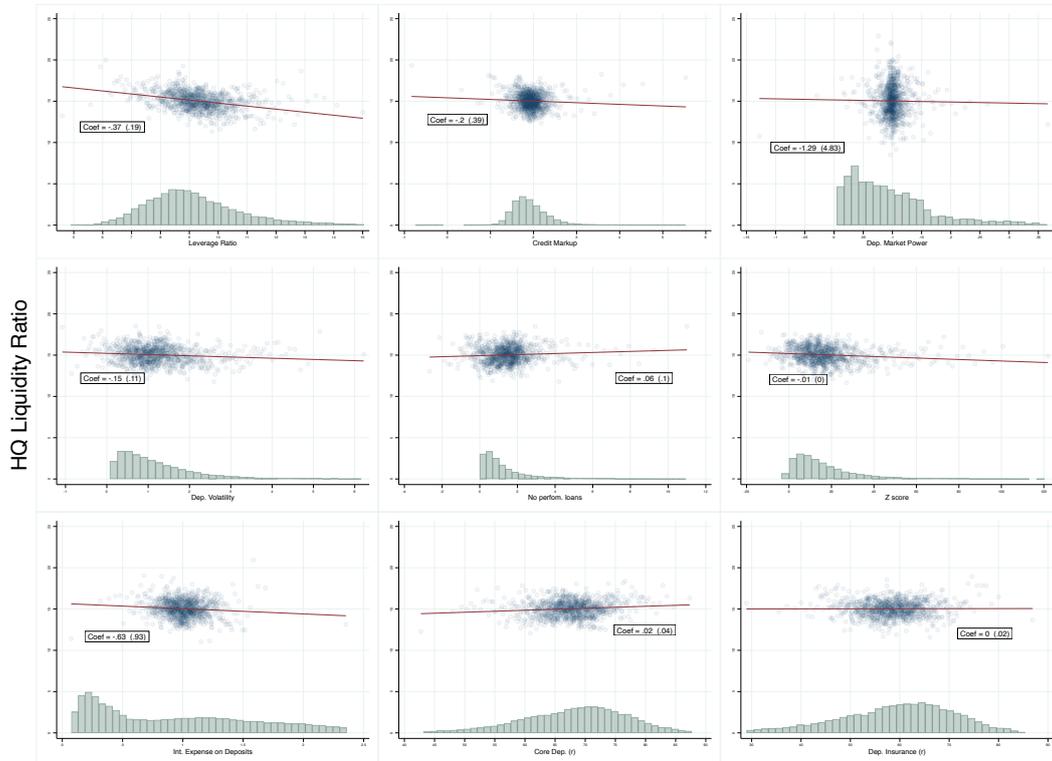
	1	2	3	4	5
1	0.85	0.14	0.01	0.00	0.00
2	0.14	0.67	0.17	0.02	0.00
3	0.01	0.17	0.66	0.15	0.01
4	0.00	0.01	0.16	0.72	0.10
5	0.00	0.00	0.01	0.11	0.88

(c) Liq. Coverage Ratio

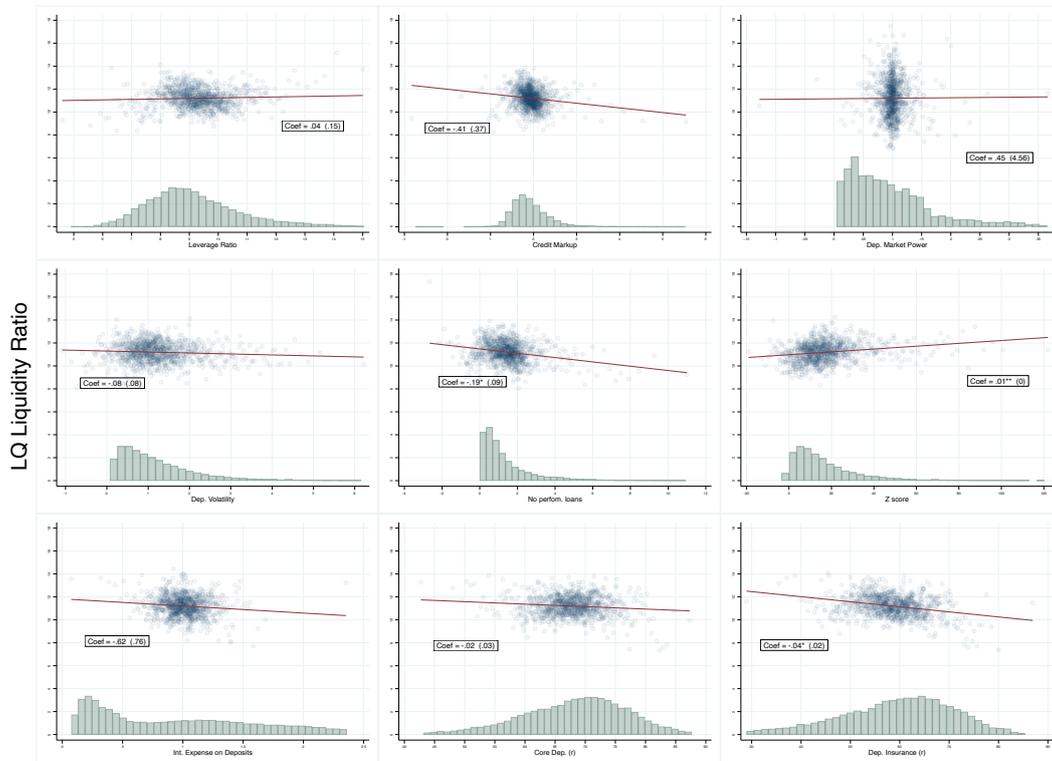
The table shows that the probability of a liquidity ratio staying in its quintile in the next quarter (diagonal entries) is much higher than transitioning to any other quintile, with this result being particularly strong in the lowest and highest quintiles of the distribution. This result is necessary, but not sufficient, for bank-level liquidity ratios to encode important information about the liquidity state of banks.

Figure 2.B.7: Correlations with respect to Other Banks' Characteristics (Controlling for bank and time fixed effects)

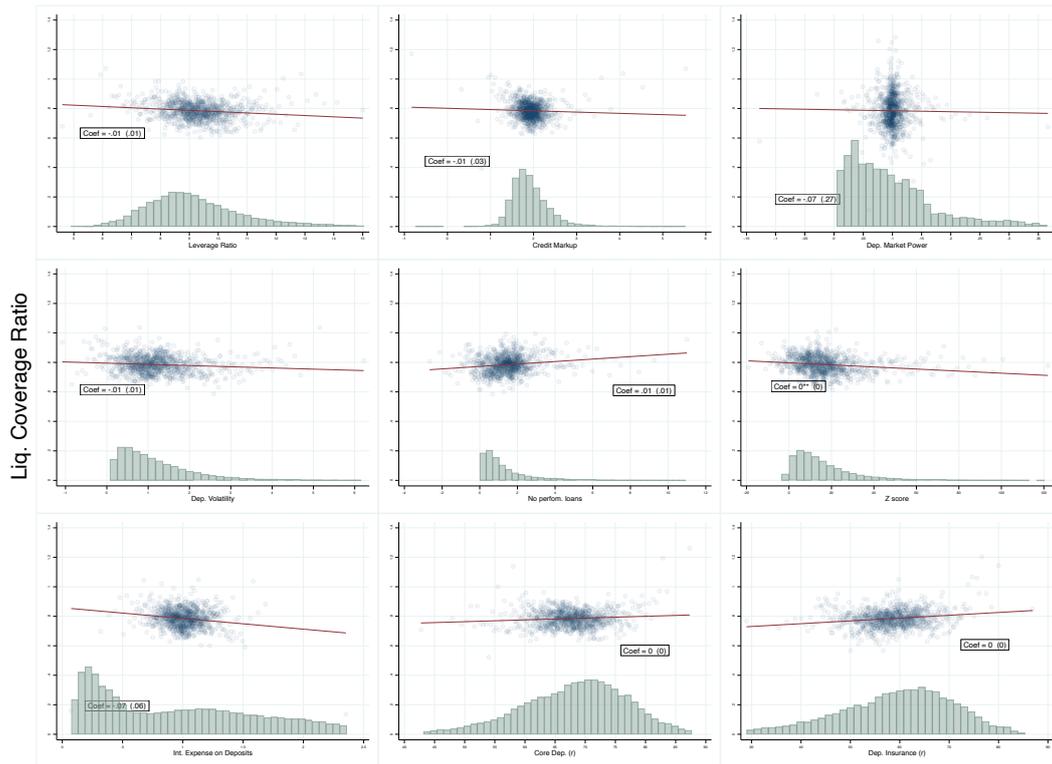
(a) HQ liquidity and Banks' Characteristics



(b) LQ liquidity and Banks' Characteristics



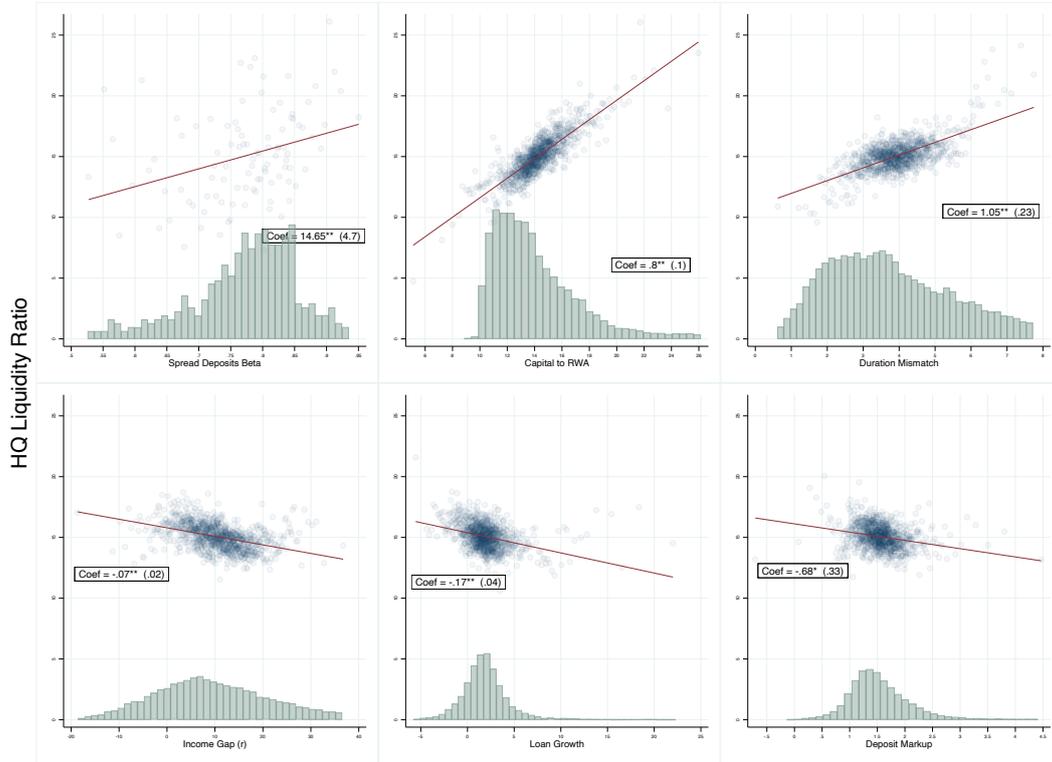
(c) LCR and Banks' Characteristics



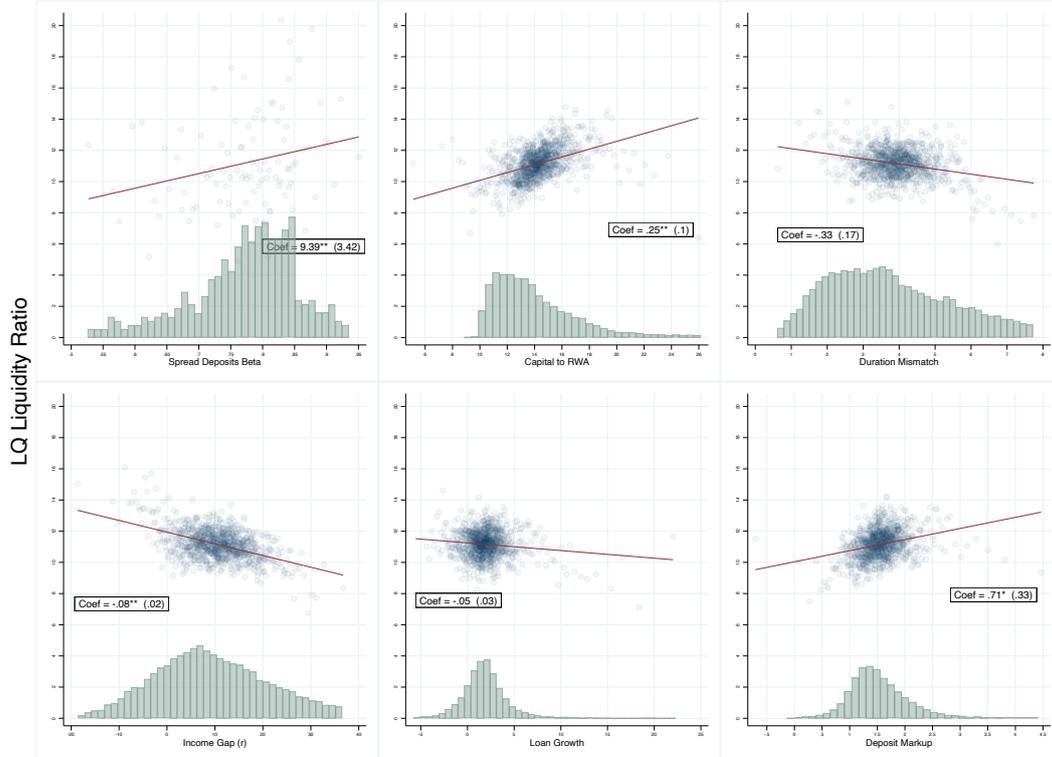
Notes: **a)** To prepare the data, the x-axis and y-axis variables were residualized using bank and quarter-fixed effects. Subsequently, the sample was divided into 1000 equally sized bins based on the residualized x-variable. The Spread Deposit Betas, however, were not residualized, and the data was divided into 100 bins. For each bin, the unweighted average of the x-axis and y-axis variables was calculated, and the mean of each variable was added back to the corresponding residual. Spread Deposit Betas are not residualized, and data was divided into 100 bins. **b)** The resulting graph provides a visual representation of the underlying distribution of the x-variable.

Figure 2.B.8: Correlations Controlling for Other Variables

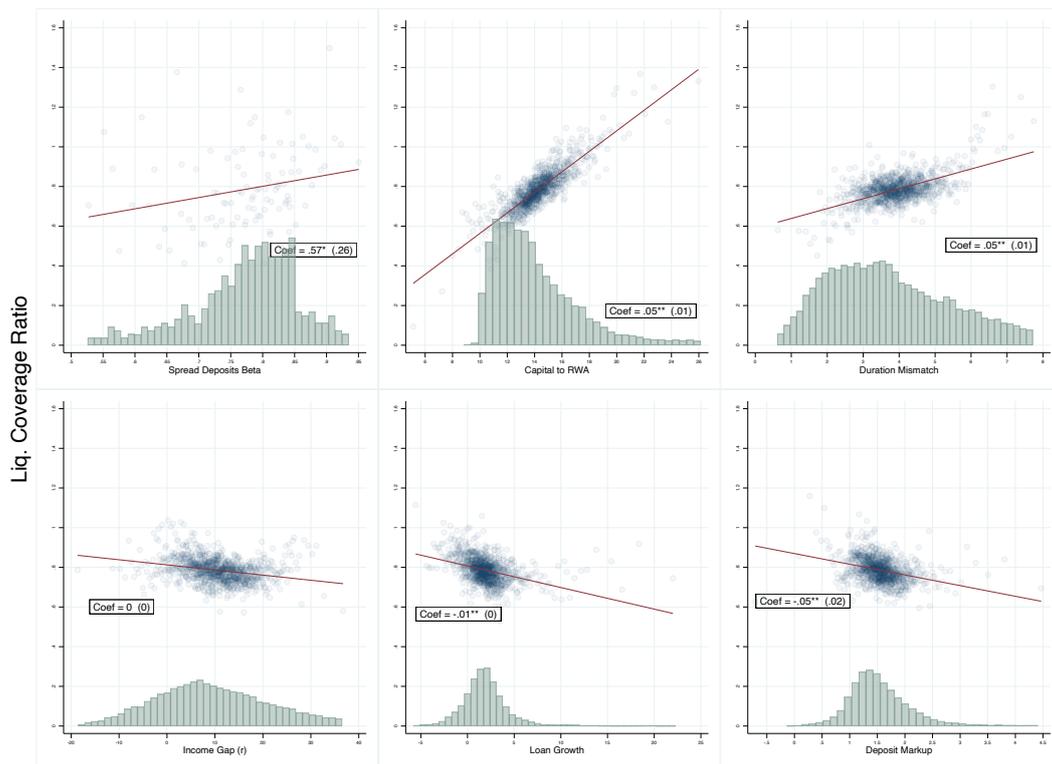
(a) HQ liquidity and Banks' Characteristics



(b) LQ liquidity and Banks' Characteristics



(c) LCR and Banks' Characteristics



Notes: **a)** To prepare the data, the x-axis and y-axis variables were residualized using bank-FE, quarter-FE, and the remaining variables in the graph. Subsequently, the sample was divided into 1000 equally sized bins based on the residualized x-variable. For each bin, the unweighted average of the x-axis and y-axis variables was calculated, and the mean of each variable was added back to the corresponding residual. **b)** The resulting graph provides a visual representation of the underlying distribution of the x-variable.

Appendix 2.C Alternative Empirical Specifications

2.C.1 Accounting for Hedging

In Section 2.2, I present different roles liquid assets play in transmitting monetary policies. To explore the difference between the source-of-last resort and the change in price effect, I propose an alternative exercise that consists of controlling directly for bank-specific interest rate exposure. The underlying intuition is that banks with higher exposure to interest rate fluctuations (measured by a higher net income beta) are more vulnerable to changes in security prices; therefore, banks with high exposure must experience larger deposit outflows.

The regression specification follows a triple interaction approach:

$$\Delta_h Y_{i,t+h} = (\eta_2^h + \eta_3^h |\beta_i^{nim}|) mp_t LR_{i,t-1} + \Gamma^h mp_t X_{i,t-1} + \Psi^h Z_{i,t-1} + f_i^h + f_{t+h}^h + u_{i,t+h}^h \quad (2.6)$$

To measure interest rate risk exposure, I use the absolute value of net interest rate beta (β_i^{NIM})⁶¹. β_i^{NIM} equal zero indicates that the bank perfectly matches its interest rate income and expense fluctuations, implying low exposure to interest rates. Positive or negative β_i^{NIM} indicate a degree of interest rate exposure, the reason why I include this as an absolute value.

The coefficient η_2^h captures part of the conditional effect of liquidity, which is not explained by the actual exposure to interest rate risks. Consider a bank- i such that $\beta_i^{nim} \neq 0$. The deposit growth of this bank might change because its interest risk exposure induces exposing depositors to changes in security prices. On the contrary, in a bank- i such that β_i^{nim} is close to zero, changes in security prices are not supposed to affect banks' profits. The coefficient η_3^h measures the conditional effect of monetary policy because banks cannot fully hedge interest rate risk and might be potentially more affected by securities price fluctuations.

2.C.2 Demand-Supply

Due to the nature of the data, the heterogeneity in monetary policy transmission captured by the γ^h coefficients in (2.3) are equilibrium realizations. In other words, the quantitative relevance of the coefficient can be attributed to the interaction term's role in influencing supply and demand factors.

In an attempt to quantify the magnitude of demand and supply responses, I propose an estimation exercise that consists of exploiting the predictions of the deposit channel by directly controlling for banks' market power in deposit markets. The underlying intuition is that supply effects are expected to be more relevant for banks with higher monopoly power.

To control for the effect of policy-driven changes in the supply of deposits, I extend specification (2.3) in a triple-interaction fashion as follows.

$$\Delta_h Y_{i,t+h} = (\eta_0^h + \eta_1^h \beta_i^{Spread}) mp_t LR_{i,t-1} + \Gamma^h mp_t X_{i,t-1} + \Psi^h Z_{i,t-1} + f_i^h + f_{t+h}^h + u_{i,t+h}^h \quad (2.7)$$

⁶¹Equivalent to the difference between the interest rate sensitivity of income and expenses ($\beta_i^{INC} - \beta_i^{EXP}$). These variables are estimated using Drechsler, Savov, and Schnabl (2021)'s methodology. Their results are replicated in Appendix 2.A.3.3

where the beta spreads β_i^{Spread} is a proxy of the bank-specific deposits' supply sensitivity to interest rate fluctuations⁶².

Intuitively, high-beta banks have low deposit supply sensitivity relative to low-beta banks. Therefore, η_1^h represents a triple interaction parameter that accounts for the sensitivity of deposit supply to interest rate fluctuations. It quantifies how much more or less responsive the supply of high-beta banks is to interest rate shocks compared to low-beta banks. η_0^h is expected to capture any changes in outcome- Y not explained by this sensitivity.⁶³

When η_1^h takes on positive values, it signifies that high-beta banks, positioned 1sd above the mean of the liquidity distribution, experience lower outcome- Y relative to low-beta banks, which are also positioned 1sd above the mean of the liquidity distribution. These differences are attributed to supply-driven factors affecting outcome- Y . In other terms, a non-zero η_1^h implies that high-beta banks, despite being in a similar liquidity position as low-beta banks, have less stable deposit flows in response to interest rate shocks, which can be attributed to factors combining their liquidity management strategies and their monopolistic power.

Other identification strategies were also considered. For instance, Drechsler, Savov, and Schnabl (2017) go around this issue by estimating the changes in deposit rates as dependent variables in a separate regression. They argue that the effect is supply-driven because, in response to changes in the level of the Fed funds rate, deposit spreads increase and quantities decrease. However, I lack access to the deposit rate database.

2.C.3 Comment on Lending Opportunities

The magnitude of the γ^h coefficients in (2.3) capture the total conditional effect of monetary policy on deposits (direct and indirect effects). Estimating the direct/causal effect of monetary policy on deposits faces a well-known identification challenge arising from the impact of monetary policy on banks' lending opportunities. The argument is that monetary policy indirectly influences deposit supply as banks adjust it based on their current lending opportunities, which, to some extent, are also determined by monetary policy.

To address this issue, the literature adopts two strategies: A) within-bank estimations, comparing branches of the same bank to control for lending opportunities. B) Within-county estimations, which include time-county fixed effects for better control over local market opportunities (See Drechsler, Savov, and Schnabl (2017)). However, it is worth noting that data from Call Reports about the geographical location may not fully represent a bank's presence across the entire U.S. territory, as it only includes the location of the main office. In contrast, banks may have multiple branches across the country.

⁶²This is obtained following Drechsler, Savov, and Schnabl (2017). The higher the beta, the less monopoly power a bank owns; therefore, lower supply-side shifts are expected. Their results are replicated in Appendix 2.A.3.3.

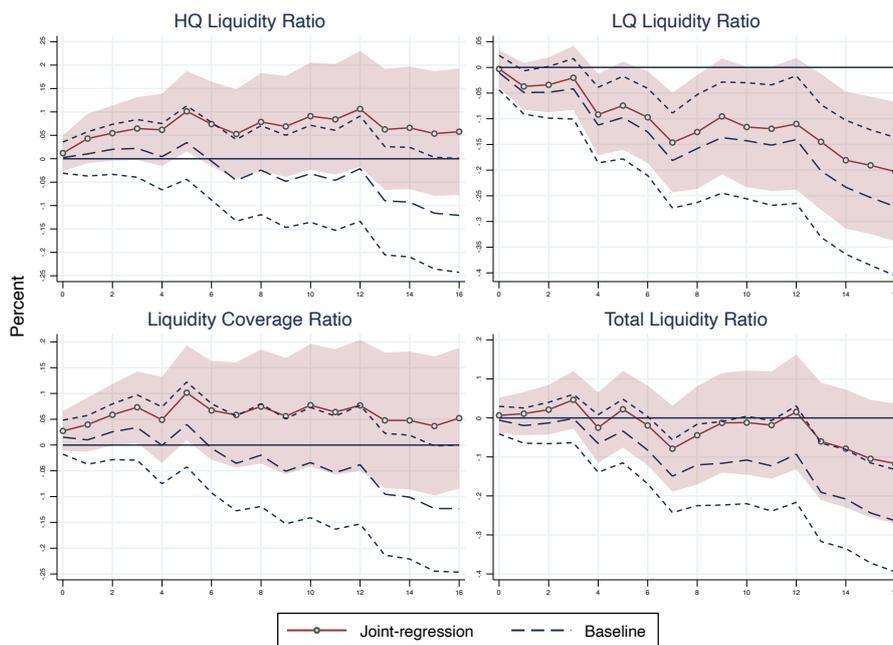
⁶³The term $mp_t\beta_i$ is included in the vector X_i , and its corresponding parameter captures the deposit channel prediction: In response to tightening monetary policy, low-beta banks increase their deposit spreads by contracting more deposit supply.

Appendix 2.D Robustness Exercises on Deposits

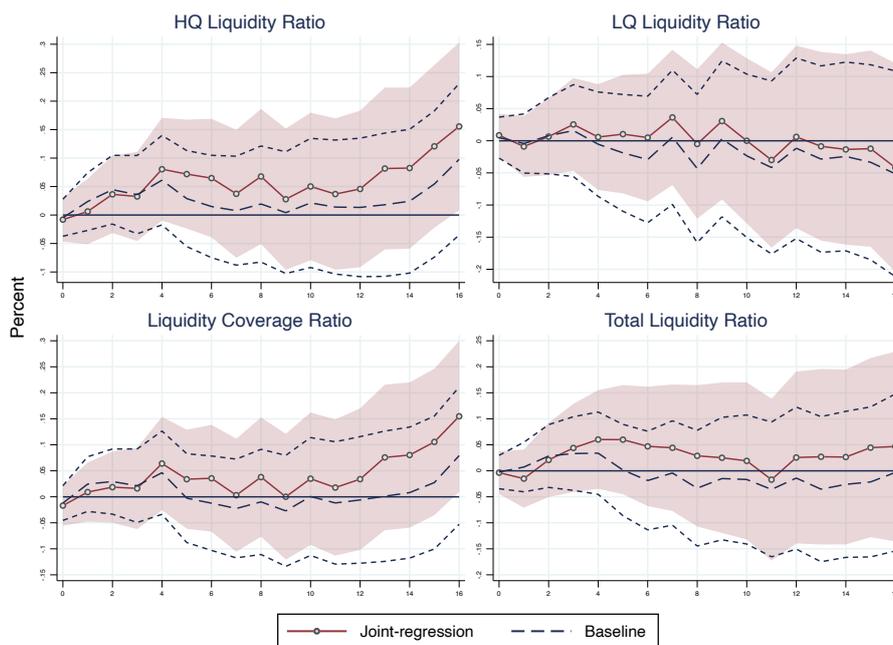
This section collects the results from all Robustness Exercise described in Section 2.5.2.

2.D.1 Different Deposit Accounts

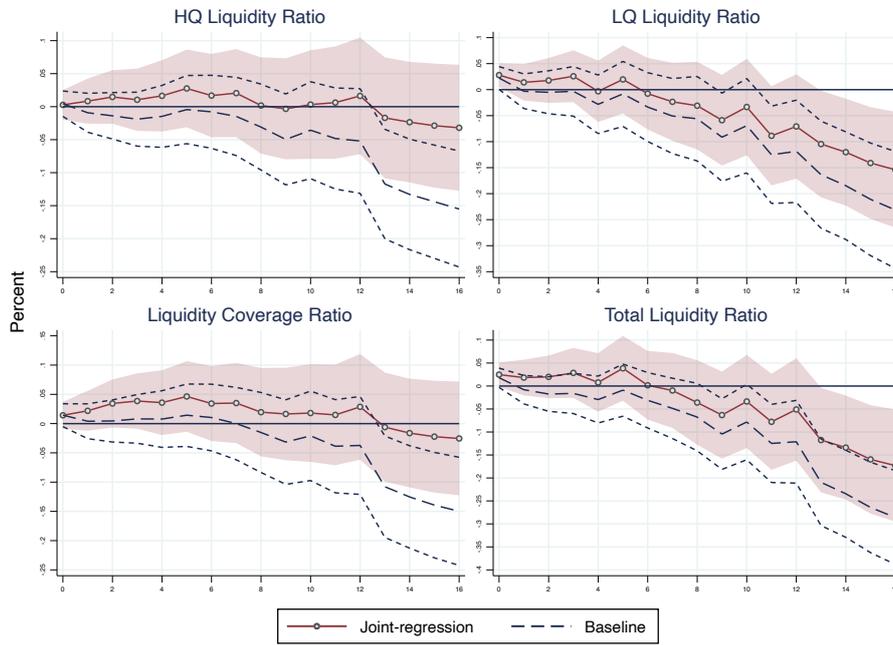
Figure 2.D.1: Monetary Tightening Shock Conditional on Liquidity: Effect on Different Deposit Accounts (Baseline)



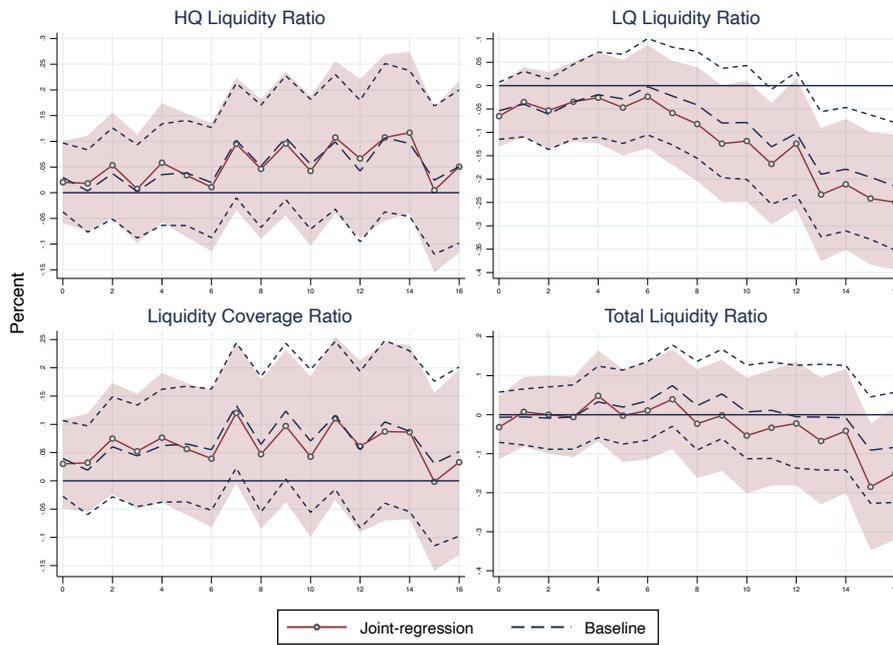
(a) Effect on Money Market Deposits Flows



(b) Effect on Other Saving Deposits Flows



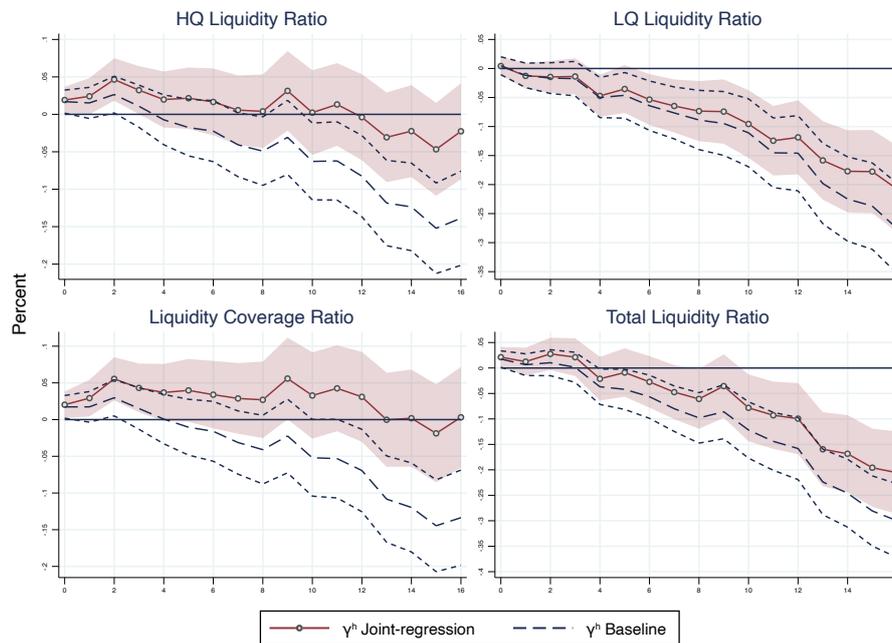
(c) Effect on Time Deposits Flows



(d) Effect on Demand Deposits Flows

Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.D.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Core Deposit Flows (Baseline)

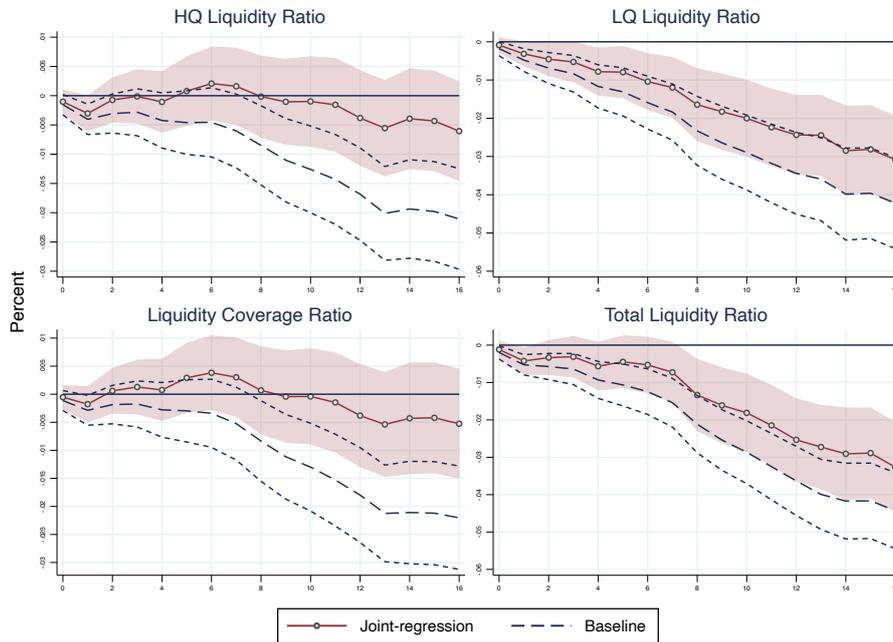


Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

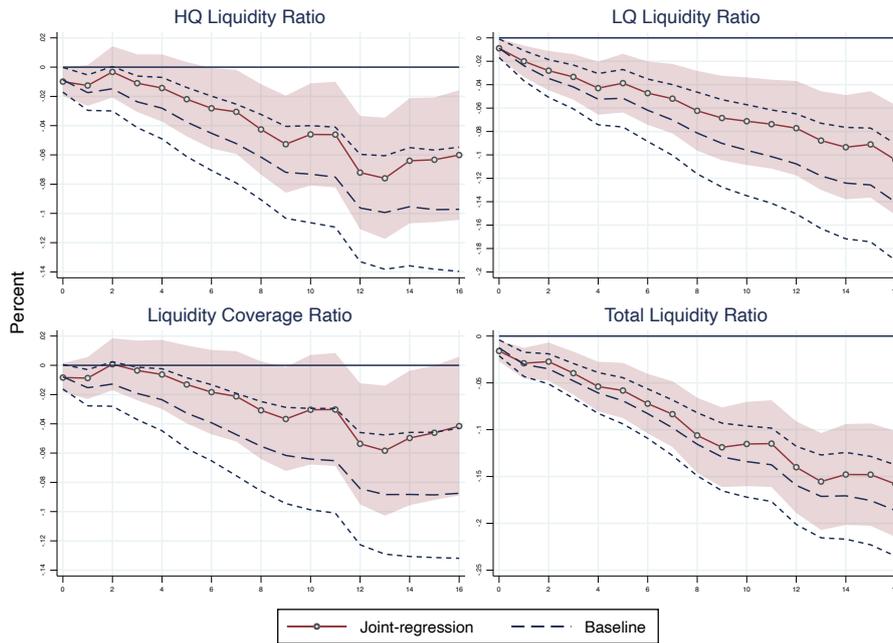
2.D.2 Alternative Monetary Shocks

Figure 2.D.3: Monetary Tightening Shock Conditional on Liquidity: Effects on Total Deposit Flows (Baseline)

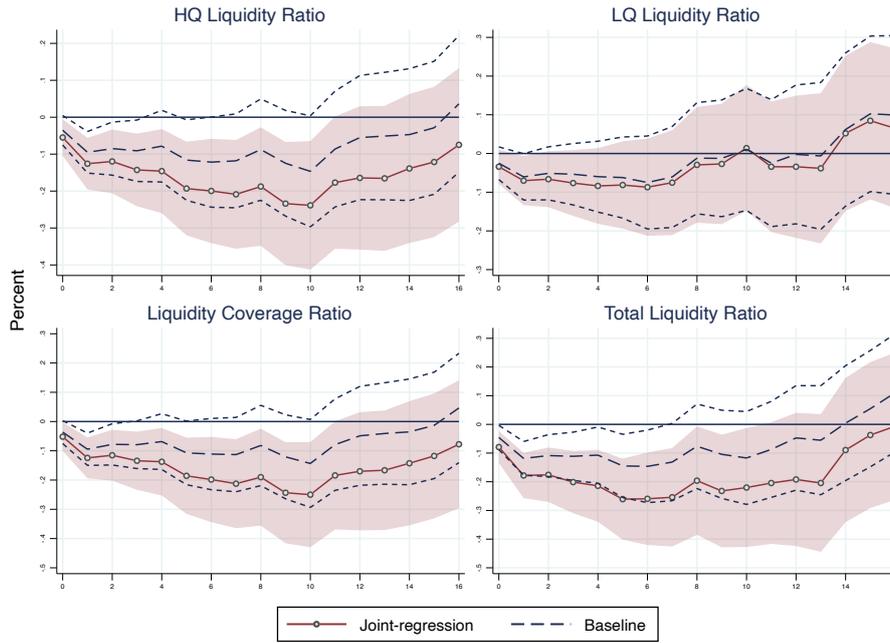
(a) (Δ Fed Funds Rate)



(b) (Bu, Rogers, and W. Wu (2021))



(c) (Acosta (2022))

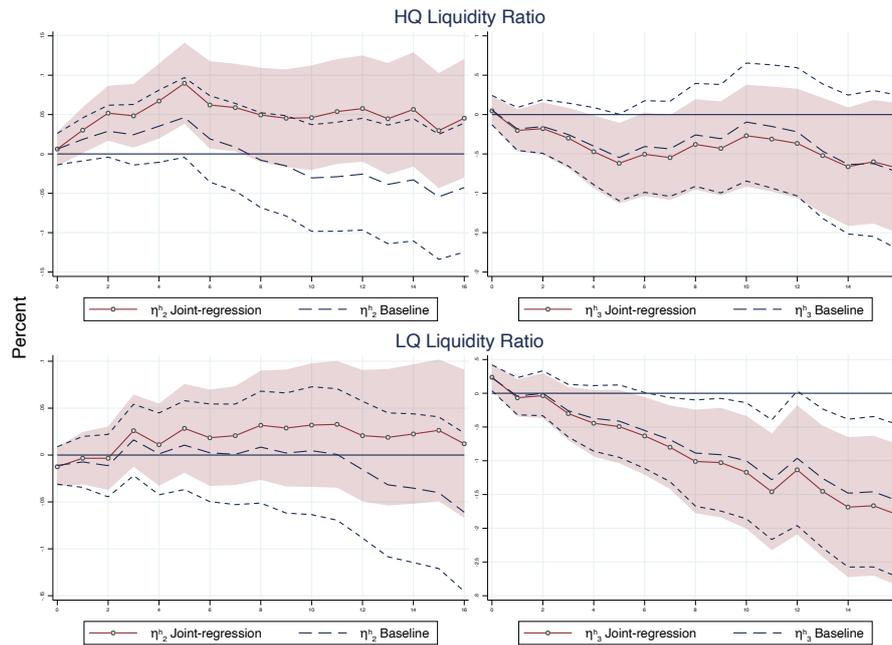


Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.D.3 Results on Alternative Specifications

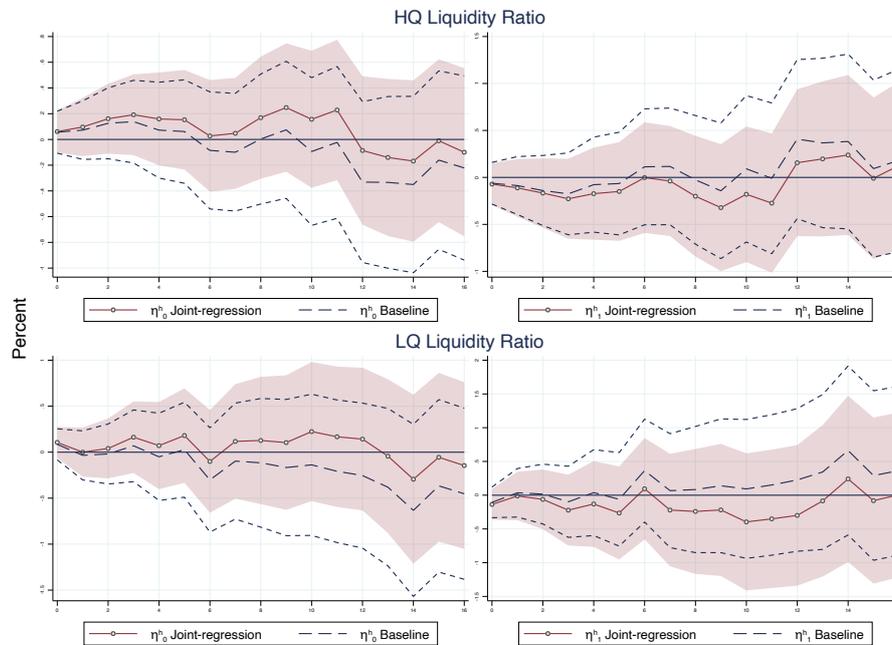
This subsection collects results based on specifications described in section 2.C.

Figure 2.D.4: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Accounting for Hedging)



Notes: The graph displays the results for η_2^h and η_3^h obtained from specification (2.6). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.D.5: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Accounting for Supply-Demand Effects)



Notes: The graph displays the results for η_0^h and η_1^h obtained from specification (2.7). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

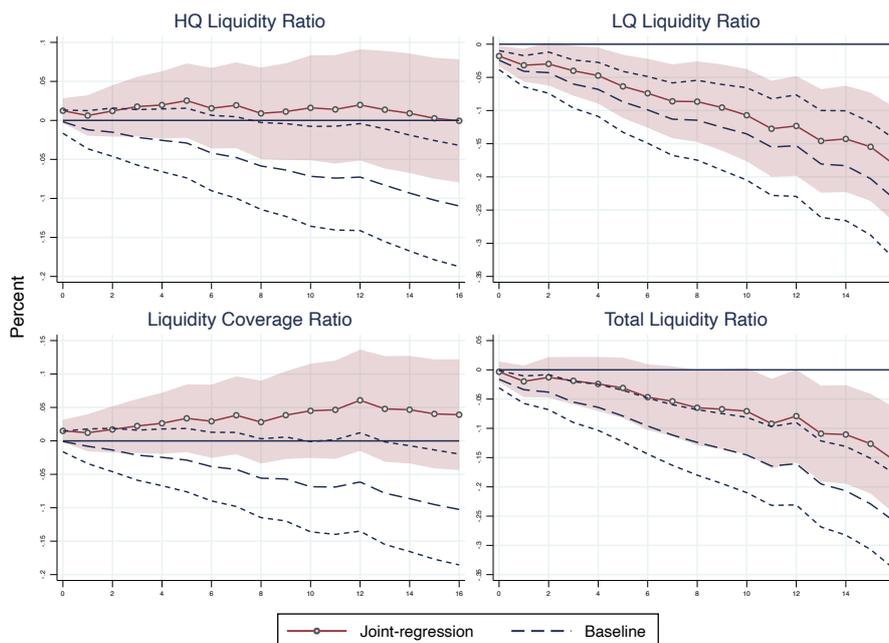
Appendix 2.E Robustness Exercises on Loans

This section collects the results from all Robustness Exercise described in Section 2.6.2.

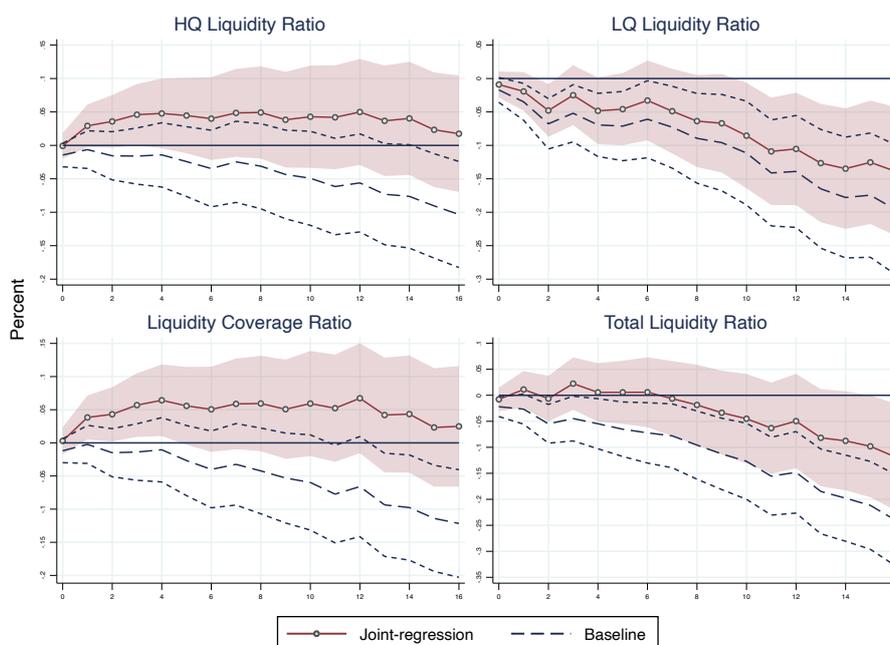
2.E.1 Compositional Effects

Figure 2.E.1: Monetary Tightening Shock Conditional on Liquidity:

(a) Effect on C&I Loans (Baseline)



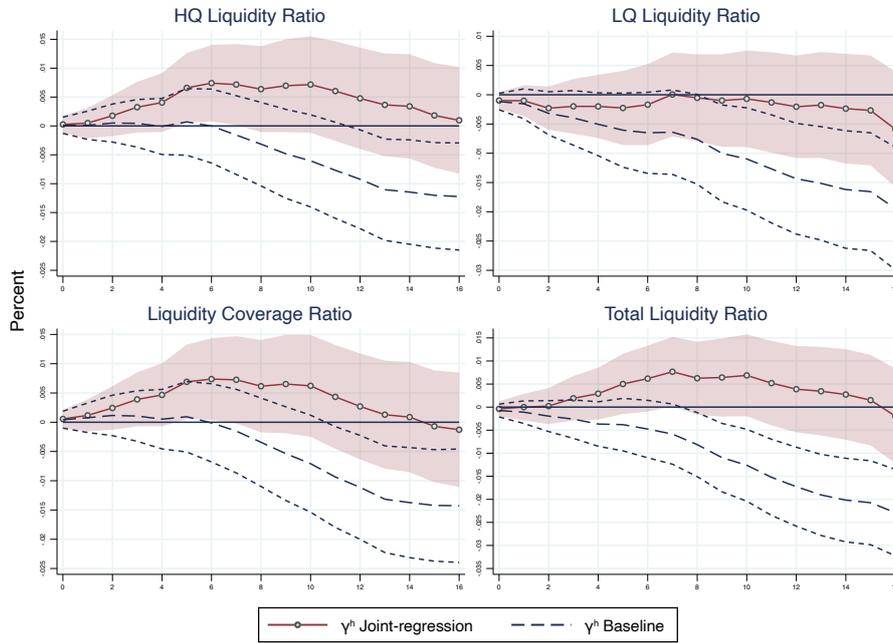
(b) Effect on Real Estate Loans (Baseline)



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

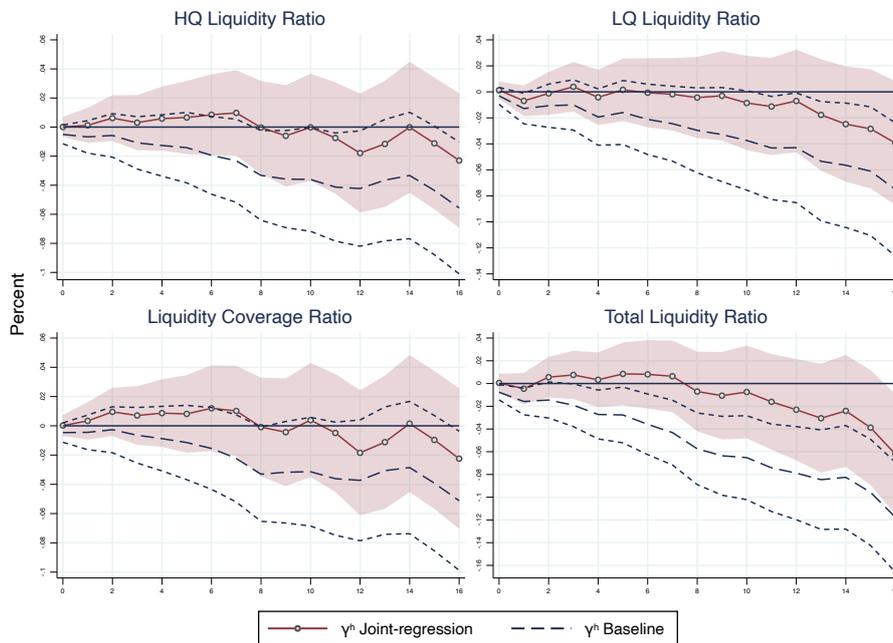
2.E.2 Alternative Monetary Shocks

Figure 2.E.2: Monetary Tightening Shock Conditional on Liquidity: Effects on Total Loans Growth (Baseline)

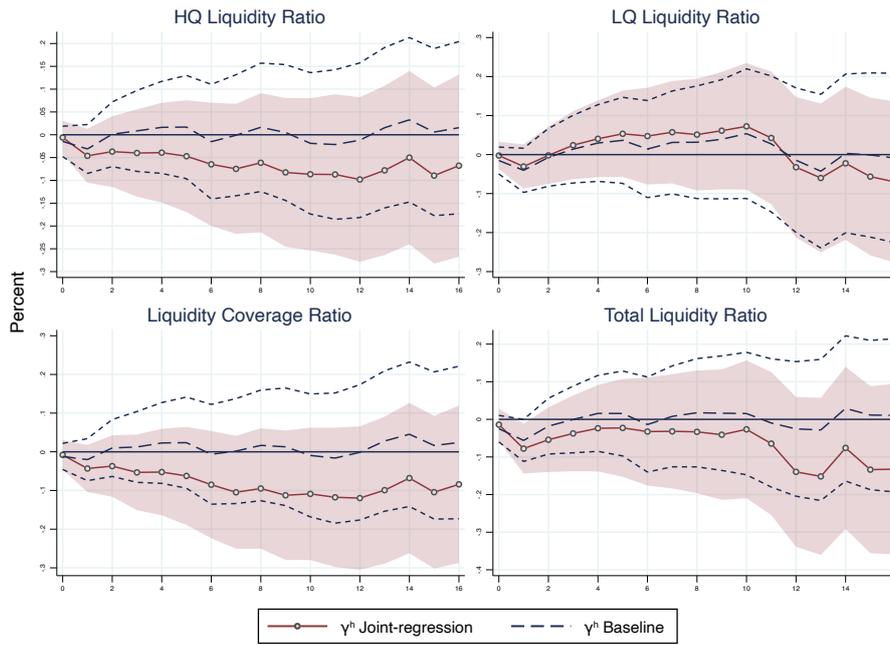


(a) (Δ Fed Funds Rate)

(b) (Bu, Rogers, and W. Wu (2021))



(c) (Acosta (2022))

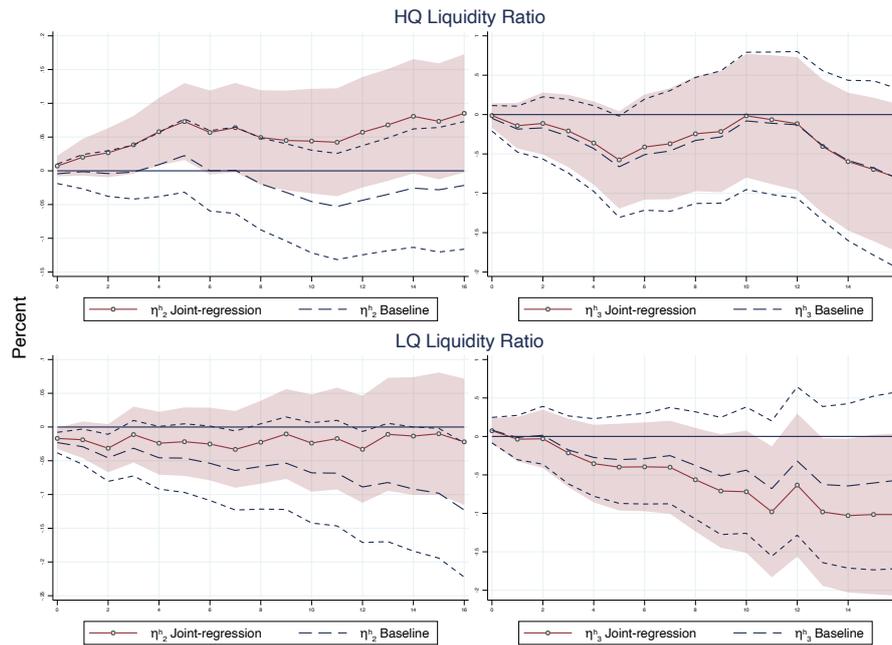


Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.E.3 Results on Alternative Specifications

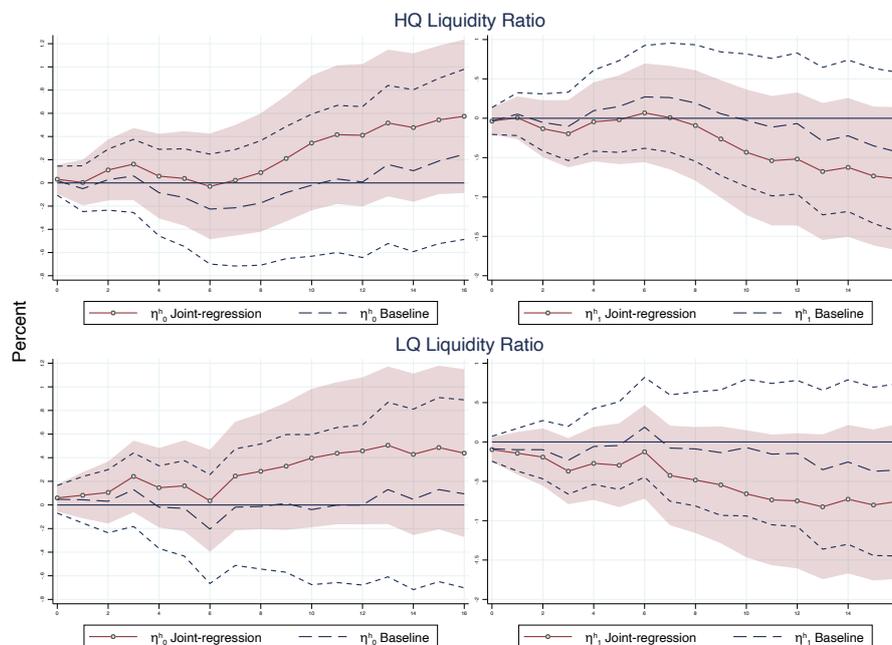
This subsection collects results based on specifications described in Section 2.C.

Figure 2.E.3: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Accounting for Hedging)



Notes: The graph displays the results for η_2^h and η_3^h obtained from specification (2.6). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.E.4: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Accounting for Supply-Demand Effects)



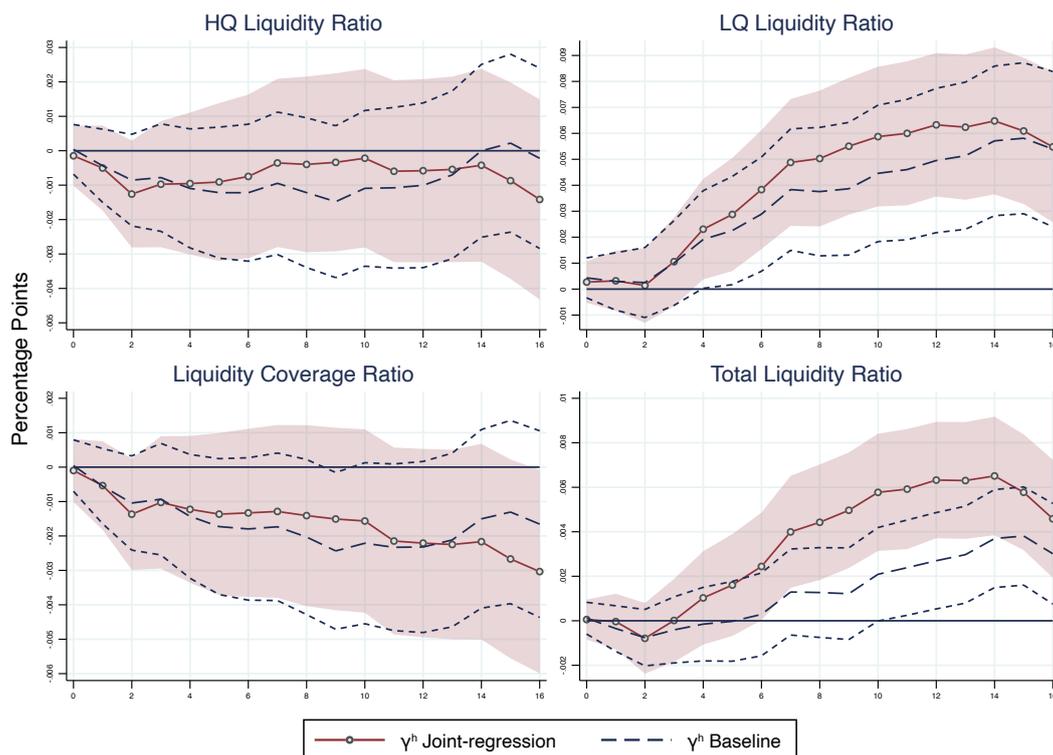
Notes: The graph displays the results for η_0^h and η_1^h obtained from specification (2.7). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Appendix 2.F Robustness Exercises on Liquidity Creation

This section collects the results from all Robustness Exercise described in Section 2.7.2.

2.F.1 Alternative Monetary Shocks

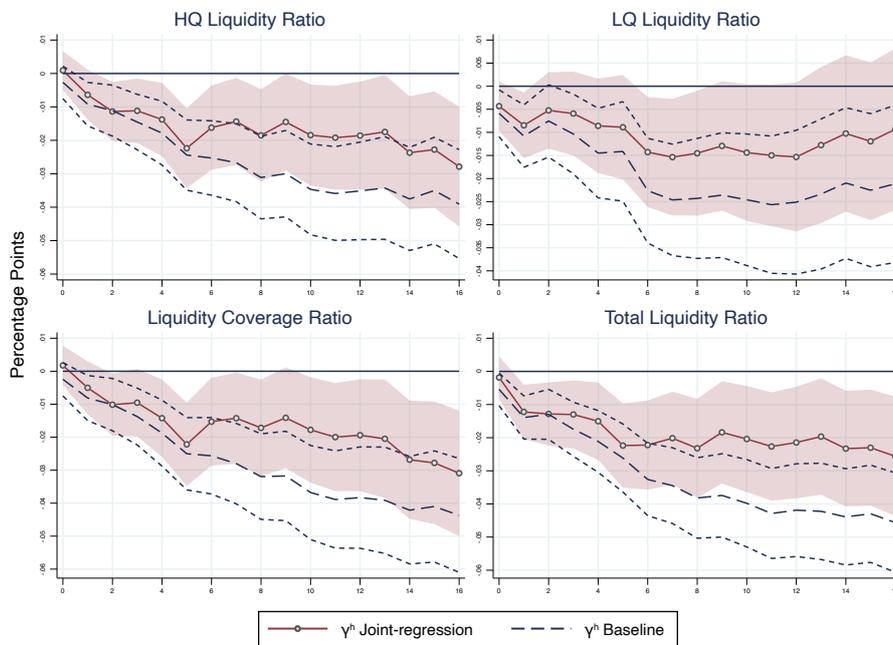
Figure 2.F.1: (Δ Fed Funds Rate)



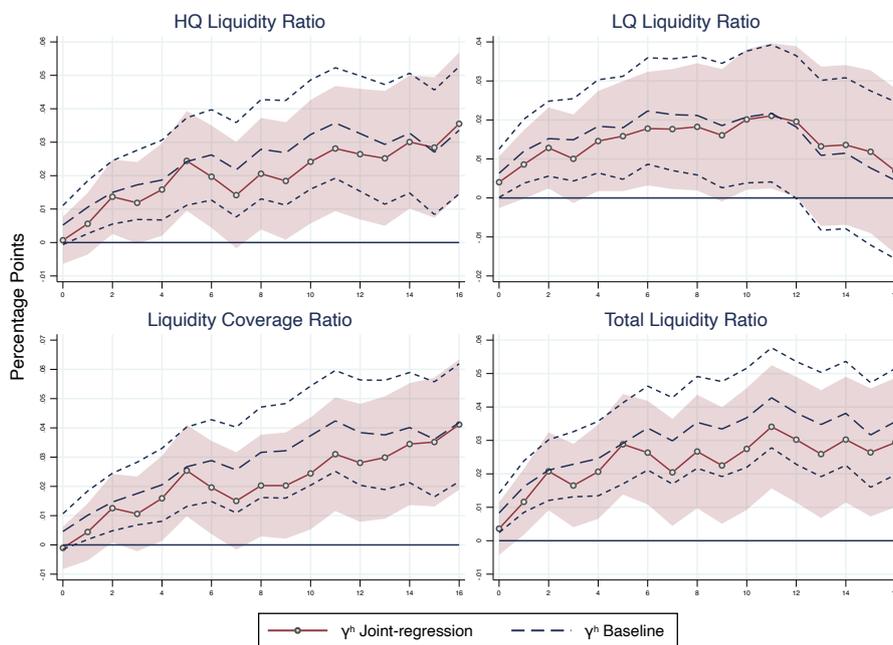
Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.F.2 Component of the liquidity creation

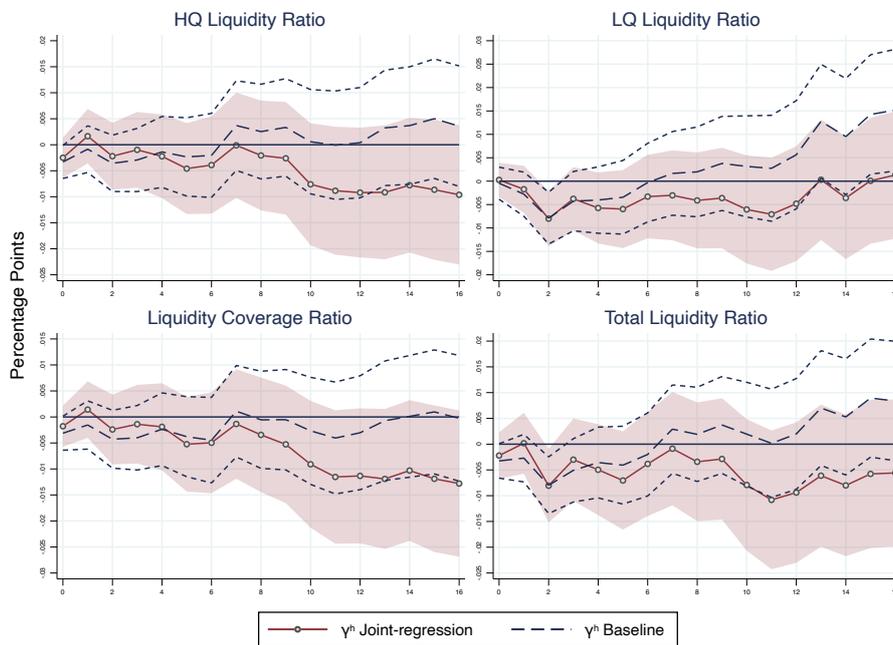
Figure 2.F.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Baseline)



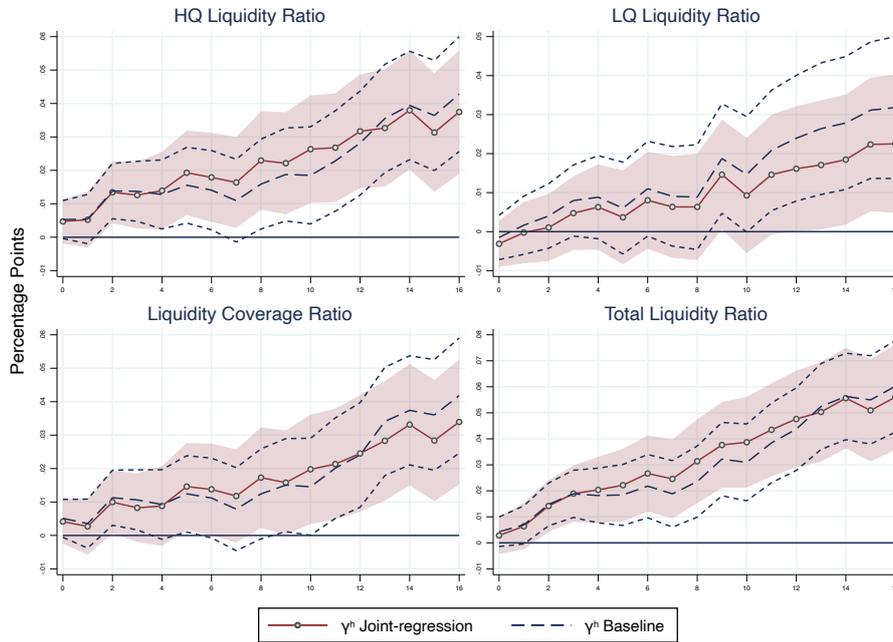
(a) Effect on Illiquid Assets



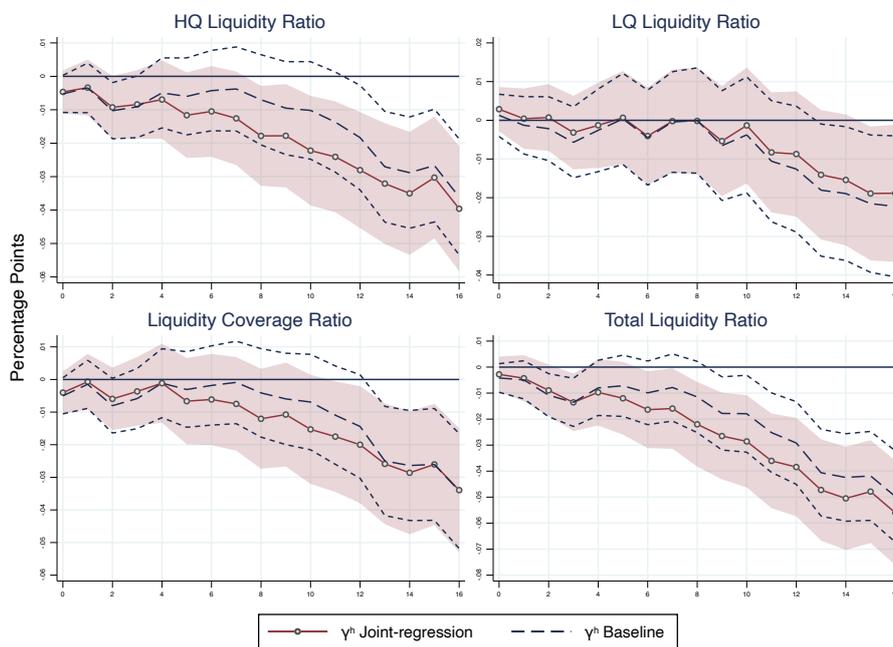
(b) Effect on Liquid Assets



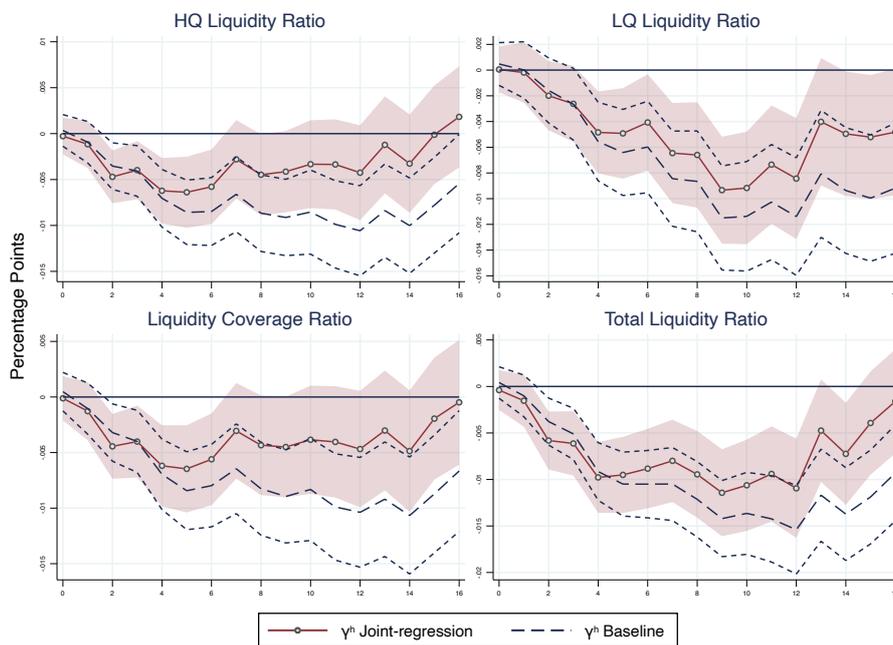
(c) Effect on Semi-liquid Assets



(d) Effect on Liquid Liabilities



(e) Effect on Semi-liquid Liabilities



(f) Effect on Illiquid Liabilities

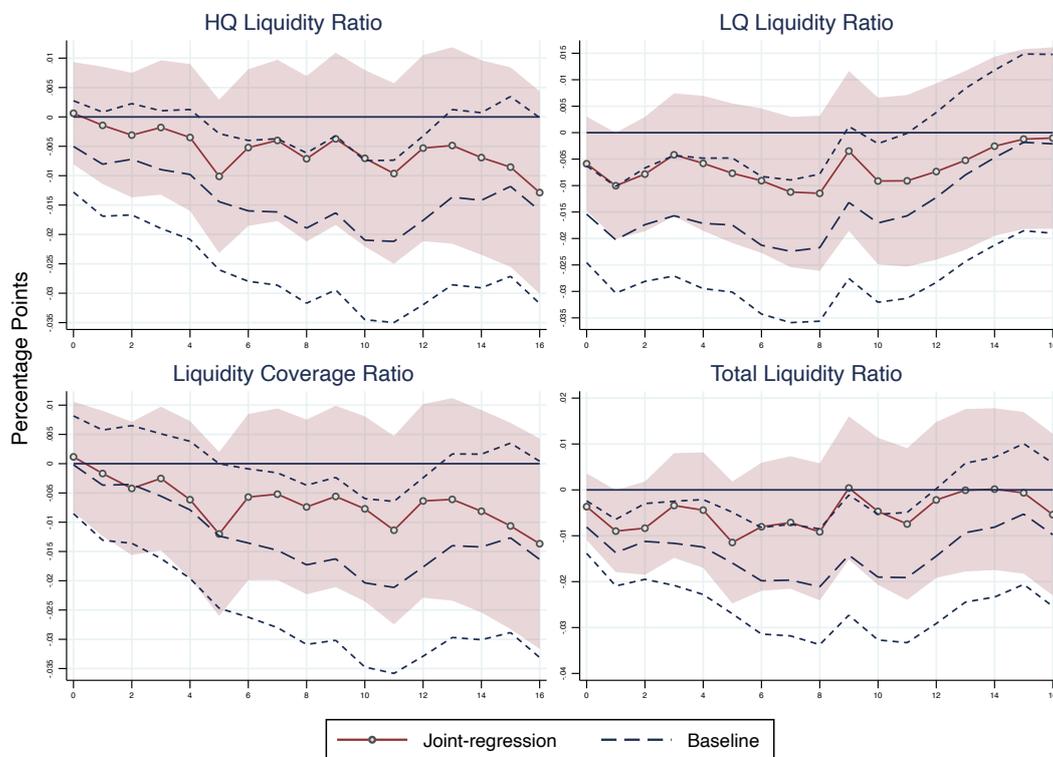
Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.F.3 Excluding HQ-liquid Assets from the liquidity creation measure

This alternative measurement does not penalize banks for investing part of their liabilities in HQ-liquid assets at the reference period $t - 1$. As a result, the measured amount of liquidity creation is higher for all banks, and this increase is greatest for banks that hold more HQ-liquid assets. The results suggest that findings are robust to excluding HQLA from the reference period.

Alternatively, I reestimate equation (2.3) replacing the dependent variable by $\Delta_h \widetilde{LIQR}_{i,t+h} \equiv LIQR_{i,t+h} - \widetilde{LIQR}_{i,t-1}$ where $\widetilde{LIQR}_{i,t-1}$ excludes all liquid assets (high and low quality). Instead of affecting banks with significant HQ assets, this measurement will generally affect all banks.

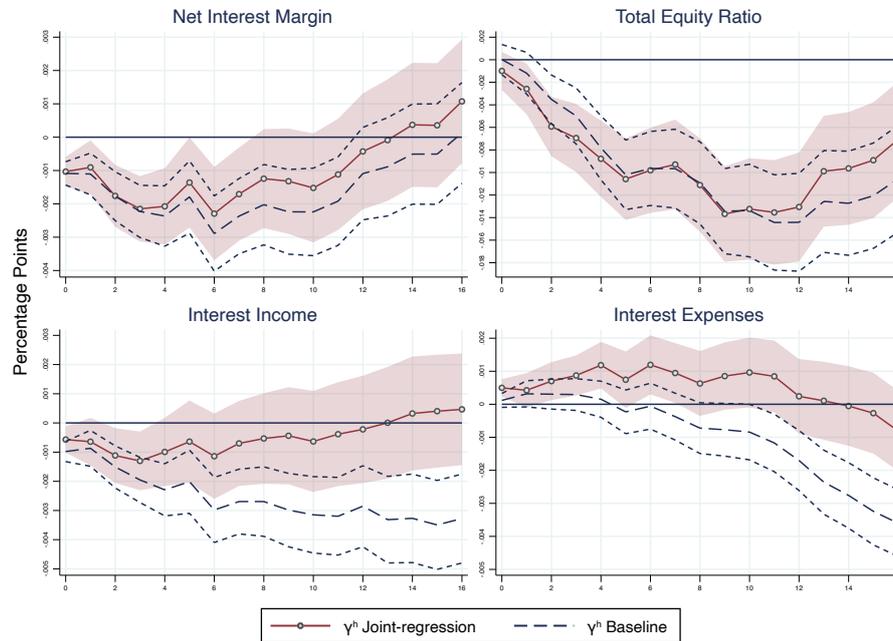
Figure 2.F.3: Removing Liquid Assets



Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Appendix 2.G Robustness Exercises on Profitability

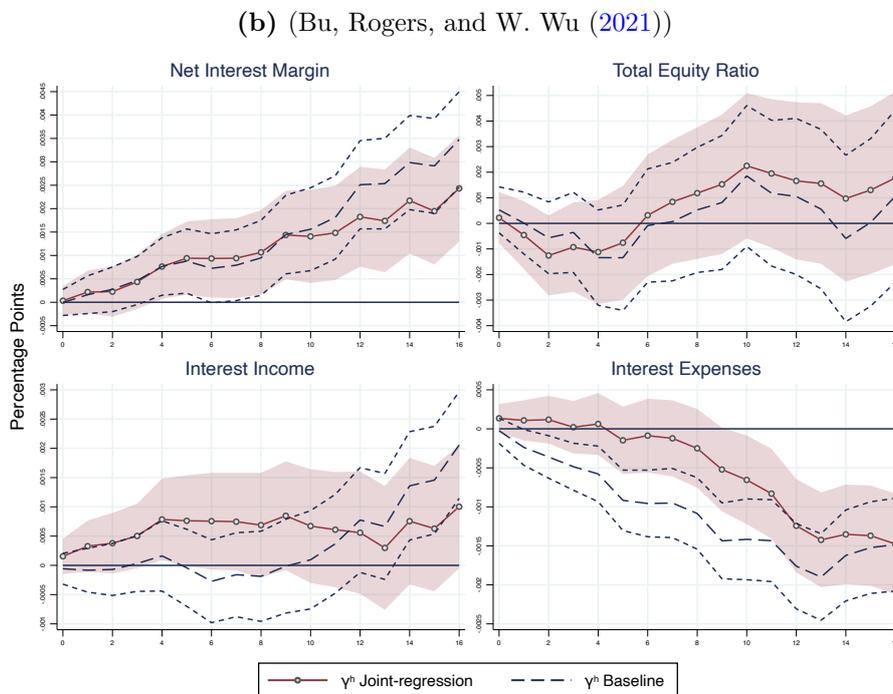
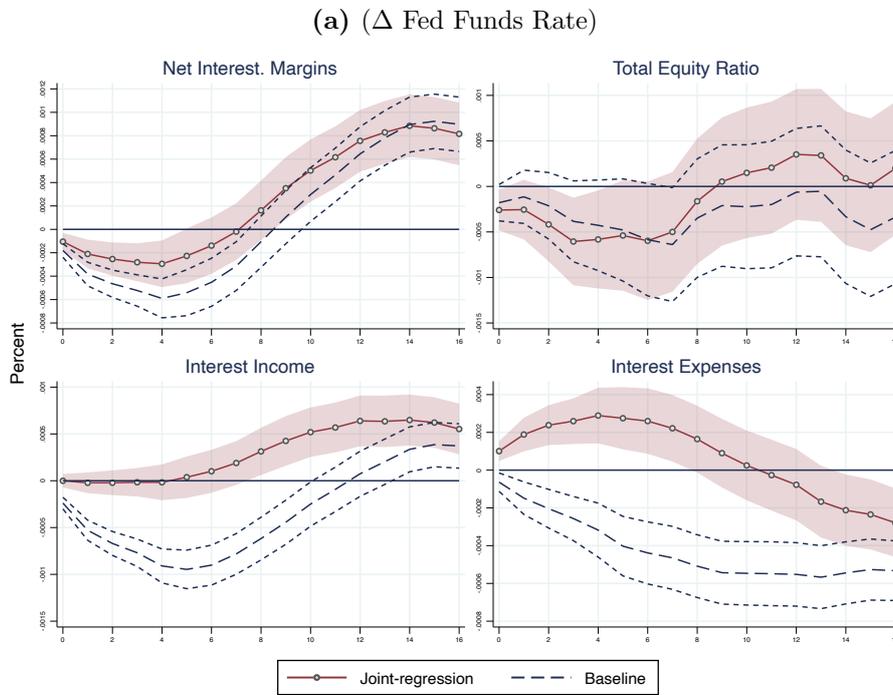
Figure 2.G.1: Monetary Tightening Shock Conditional on Total Liquidity: Effect on Profit Margins (Baseline)



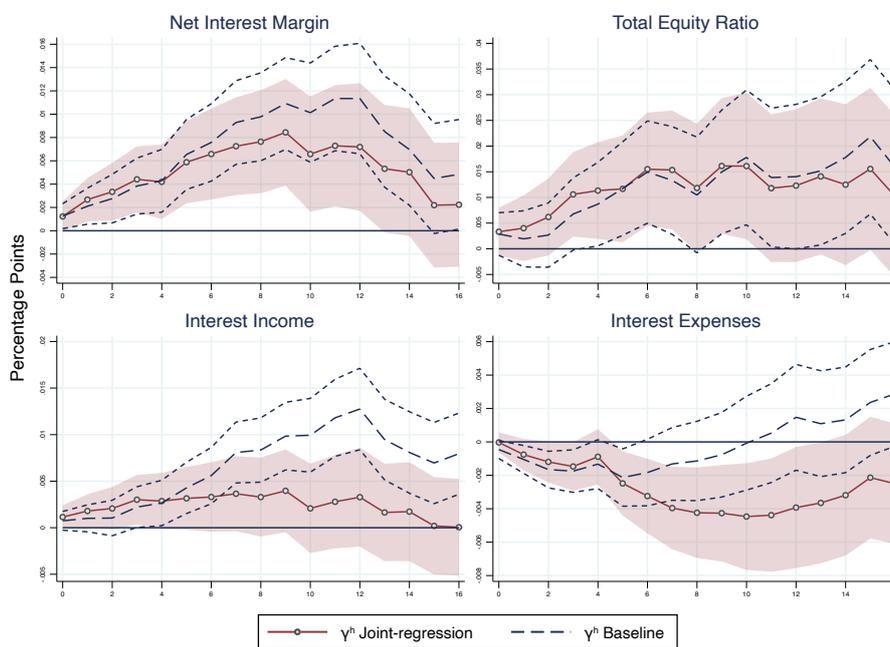
Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

2.G.1 Alternative Monetary Shocks

Figure 2.G.2: Monetary Tightening Shock Conditional on HQ-Liquidity: Effects on Profit Margins (Baseline)



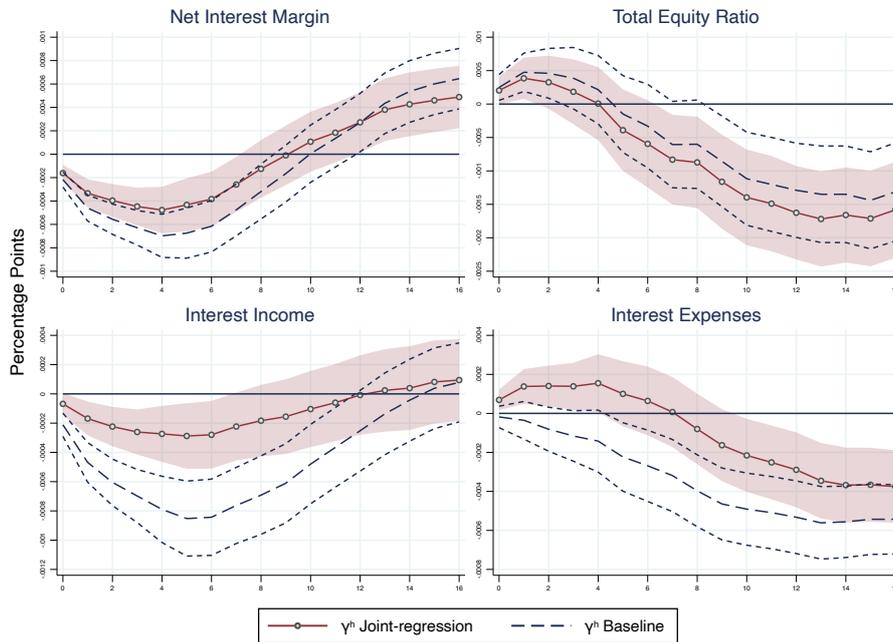
(c) (Acosta (2022))



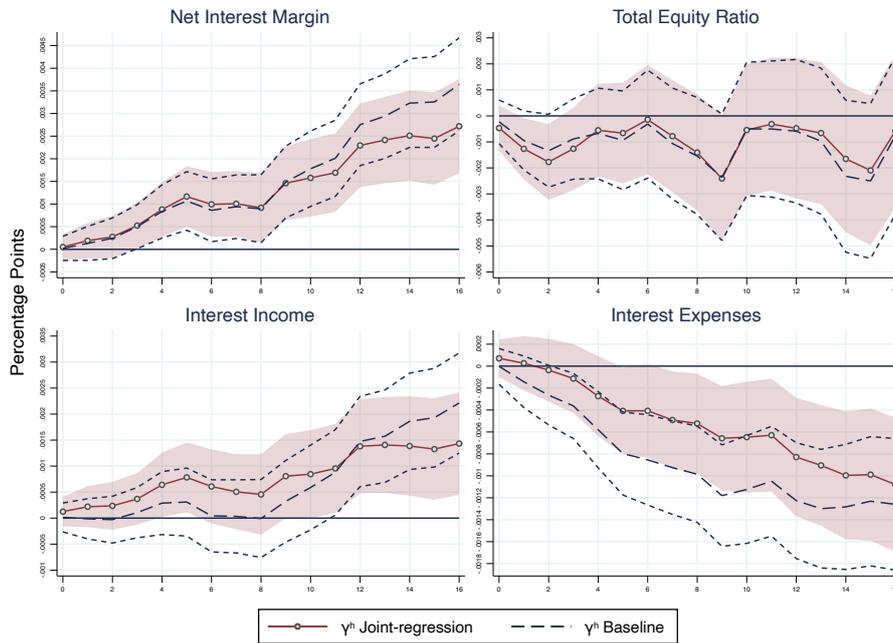
Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 2.G.3: Monetary Tightening Shock Conditional on LQ-Liquidity: Effects on Profit Margins (Baseline)

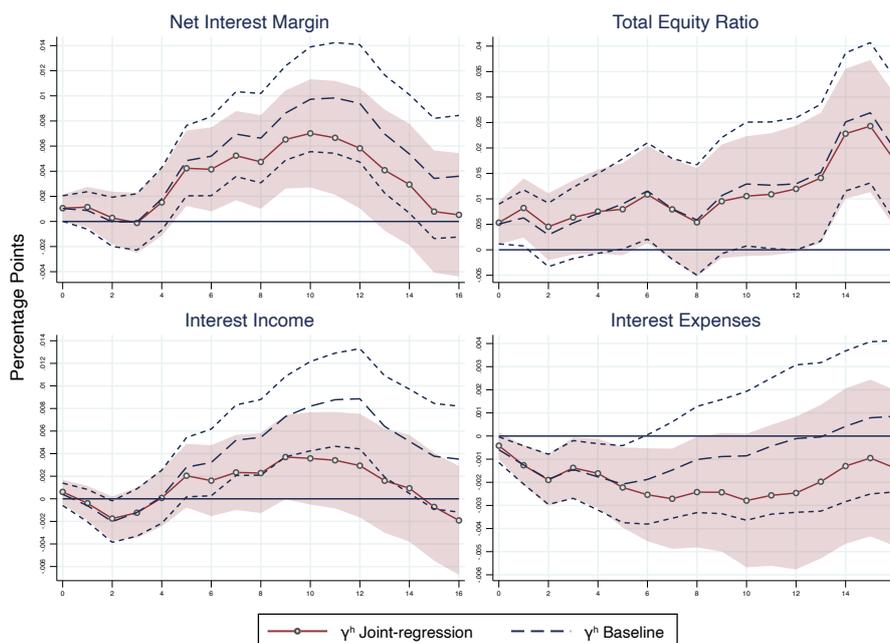
(a) (Δ Fed Funds Rate)



(b) (Bu, Rogers, and W. Wu (2021))



(c) (Acosta (2022))

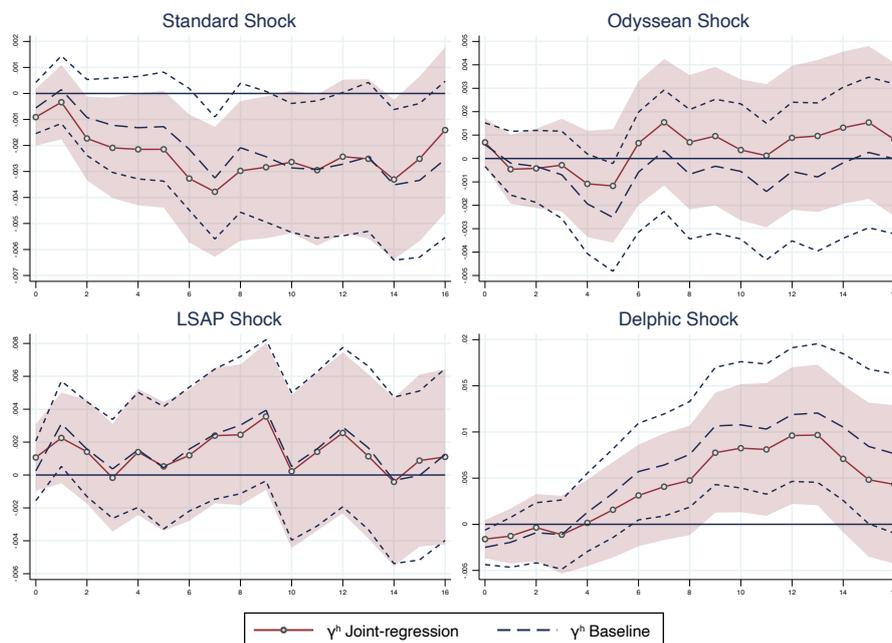


Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

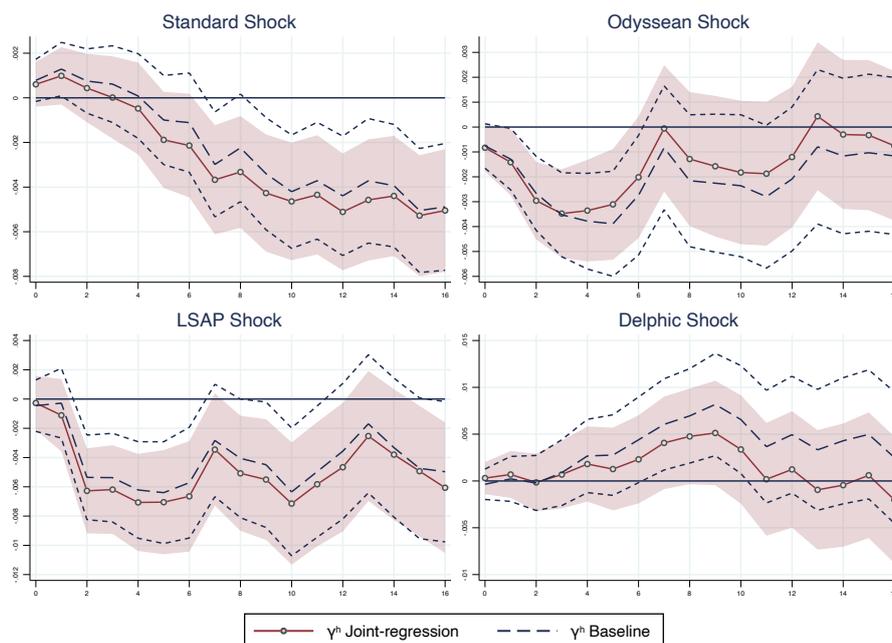
Appendix 2.H Unconventional Monetary Policy Shocks

To disentangle the nature of monetary policy shocks, Jarociński (2021) exploits characteristics of the distribution of financial market reactions to FOMC announcements. Intuitively, there is a high chance that only a small subset of the structural shocks drives the significant market reaction to an FOMC announcement (fat-tailed shocks). By detecting the unique patterns of responses characterizing individual shocks, he can categorize shocks between conventional and unconventional shocks.

Figure 2.H.1: Monetary Tightening Conditional on Liquidity: Effect on Total Equity Ratio (Baseline using Unconventional Shocks)



(a) Heterogeneity Induced by HQ liquidity



(b) Heterogeneity Induced by LQ liquidity

Notes: The graph displays the results for γ^h obtained from specification (2.3). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

References

- [1] Miguel Acosta. “The Perceived Causes of Monetary Policy Surprises”. In: *Working Paper* (2022), pp. 1–82.
- [2] Gara Afonso, Kyungmin Kim, Antoine Martin, Ed Nosal, Simon Potter, and Sam Schulhofer-Wohl. “Monetary Policy Implementation with an Ample Supply of Reserves”. In: *FRB of New York Staff Report*, No. 910.Rev. July 2023 (2020), pp. 1–47. DOI: [10.2139/ssrn.3524621](https://doi.org/10.2139/ssrn.3524621).
- [3] Pierre-Richard Agénor and Karim El Aynaoui. “Excess liquidity, bank pricing rules, and monetary policy”. In: *Journal of Banking & Finance*, 34.5 (2010), pp. 923–933. DOI: [10.1016/j.jbankfin.2009.10.003](https://doi.org/10.1016/j.jbankfin.2009.10.003).
- [4] Ryan N. Banerjee and Hitoshi Mio. “The impact of liquidity regulation on banks”. In: *Journal of Financial Intermediation*, 35 (2018), pp. 30–44. DOI: [10.1016/j.jfi.2017.05.008](https://doi.org/10.1016/j.jfi.2017.05.008).
- [5] Juliane Begenau, Monika Piazzesi, and Martin Schneider. “Banks’ Risk Exposures”. In: *NBER Working Paper Series*, WP 21334 (2015), pp. 1–47.
- [6] Hamid Beladi, May Hu, Jason Park, and Janice How. “Liquidity creation and funding ability during the interbank lending crunch”. In: *International Review of Financial Analysis*, 67 (2020), pp. 1–14. DOI: [10.1016/j.irfa.2019.101433](https://doi.org/10.1016/j.irfa.2019.101433).
- [7] Marco Bellifemine, Rustam Jamilov, and Tommaso Monacelli. “Monetary Policy with Heterogeneous Banks”. In: *CEPR Discussion Paper*, DP17129 (2022), pp. 1–68.
- [8] Allen Berger and Christa Bouwman. “Bank Liquidity Creation”. In: *Review of Financial Studies*, 22.9 (2009), pp. 3779–3837. DOI: [10.1093/rfs/hhn104](https://doi.org/10.1093/rfs/hhn104).
- [9] Allen Berger and Christa Bouwman. “Bank liquidity creation, monetary policy, and financial crises”. In: *Journal of Financial Stability*, 30 (2017), pp. 139–155. DOI: [10.1016/j.jfs.2017.05.001](https://doi.org/10.1016/j.jfs.2017.05.001).
- [10] Allen Berger, Christa Bouwman, Thomas Kick, and Klaus Schaeck. “Bank liquidity creation following regulatory interventions and capital support”. In: *Journal of Financial Intermediation*, 26 (2016), pp. 115–141. DOI: [10.1016/j.jfi.2016.01.001](https://doi.org/10.1016/j.jfi.2016.01.001).
- [11] Allen Berger, Omrane Guedhami, Hugh H. Kim, and Xinming Li. “Economic policy uncertainty and bank liquidity hoarding”. In: *Journal of Financial Intermediation*, 49 (2022), pp. 1–15. DOI: [10.1016/j.jfi.2020.100893](https://doi.org/10.1016/j.jfi.2020.100893).
- [12] Allen Berger and John Sedunov. “Bank liquidity creation and real economic output”. In: *Journal of Banking & Finance*, 81 (2017), pp. 1–19. DOI: [10.1016/j.jbankfin.2017.04.005](https://doi.org/10.1016/j.jbankfin.2017.04.005).
- [13] BIS. *Liquidity Coverage Ratio: High-quality liquid assets (LCR30)*. Tech. rep. Basel Committee on Banking Supervision, 2019, pp. 1–26.
- [14] John C. Bluedorn, Christopher Bowdler, and Christoffer Koch. “Heterogeneous Bank Lending Responses to Monetary Policy: New Evidence from a Real-Time Identification”. In: *International Journal of Central Banking*, 13.1 (2017), pp. 95–149.
- [15] Frédéric Boissay and Russell Cooper. “The Collateral Composition Channel”. In: *American Economic Journal: Macroeconomics*, 12.1 (2020), pp. 41–75. DOI: [10.1257/mac.20170097](https://doi.org/10.1257/mac.20170097).

- [16] Chunya Bu, John Rogers, and Wenbin Wu. “A unified measure of Fed monetary policy shocks”. In: *Journal of Monetary Economics*, 118 (2021), pp. 331–349. DOI: [10.1016/j.jmoneco.2020.11.002](https://doi.org/10.1016/j.jmoneco.2020.11.002).
- [17] Sergio Correia. “A Feasible Estimator for Linear Models with Multi-Way Fixed Effects”. In: *Working Paper* (2017), pp. 1–19.
- [18] Piotr Danisewicz, Danny McGowan, Enrico Onali, and Klaus Schaeck. “The real effects of banking supervision: Evidence from enforcement actions”. In: *Journal of Financial Intermediation*, 35 (2018), pp. 86–101. DOI: [10.1016/j.jfi.2016.10.003](https://doi.org/10.1016/j.jfi.2016.10.003).
- [19] Denis Davydov, Zuzana Fungáčová, and Laurent Weill. “Cyclicality of bank liquidity creation”. In: *Journal of International Financial Markets, Institutions and Money*, 55 (2018), pp. 81–93. DOI: [10.1016/j.intfin.2018.02.014](https://doi.org/10.1016/j.intfin.2018.02.014).
- [20] Denis Davydov, Sami Vähämaa, and Sara Yasar. “Bank liquidity creation and systemic risk”. In: *Journal of Banking & Finance*, 123 (2021), p. 106031. DOI: [10.1016/j.jbankfin.2020.106031](https://doi.org/10.1016/j.jbankfin.2020.106031).
- [21] Marco Di Maggio, Amir Kermani, Benjamin J. Keys, Tomasz Piskorski, Rodney Ramcharan, Amit Seru, and Vincent Yao. “Interest Rate Pass-Through: Mortgage Rates, Household Consumption, and Voluntary Deleveraging”. In: *American Economic Review*, 107.11 (2017), pp. 3550–3588. DOI: [10.1257/aer.20141313](https://doi.org/10.1257/aer.20141313).
- [22] Sebastian Di Tella and Pablo Kurlat. “Why Are Banks Exposed to Monetary Policy?” In: *American Economic Journal: Macroeconomics*, 13.4 (2021), pp. 295–340. DOI: [10.1257/mac.20180379](https://doi.org/10.1257/mac.20180379).
- [23] Douglas W. Diamond and Philip H. Dybvig. “Bank Runs, Deposit Insurance, and Liquidity”. In: *Journal of Political Economy*, 91.3 (1983), pp. 401–419.
- [24] Piti Disyata. “The Bank Lending Channel Revisited”. In: *Journal of money, Credit and Banking*, 43.4 (2011), pp. 711–734. DOI: [10.1111/j.1538-4616.2011.00394.x](https://doi.org/10.1111/j.1538-4616.2011.00394.x).
- [25] Itamar Drechsler, Alexi Savov, and Philipp Schnabl. “Banking on Deposits: Maturity Transformation without Interest Rate Risk”. In: *The Journal of Finance*, 76.3 (2021), pp. 1091–1143. DOI: [10.1111/jofi.13013](https://doi.org/10.1111/jofi.13013).
- [26] Itamar Drechsler, Alexi Savov, and Philipp Schnabl. “The Deposits Channel of Monetary Policy”. In: *The Quarterly Journal of Economics*, 132.4 (2017), pp. 1819–1876. DOI: [10.1093/qje/qjx019](https://doi.org/10.1093/qje/qjx019).
- [27] Itamar Drechsler, Alexi Savov, Philipp Schnabl, and Olivier Wang. “Banking on Uninsured Deposits”. In: *NBER Working Paper Series*, WP 31138 (2023), pp. 1–36. DOI: [10.3386/w31138](https://doi.org/10.3386/w31138).
- [28] William B. English, Skander J. Van Den Heuvel, and Egon Zakrajšek. “Interest rate risk and bank equity valuations”. In: *Journal of Monetary Economics*, 98 (2018), pp. 80–97. DOI: [10.1016/j.jmoneco.2018.04.010](https://doi.org/10.1016/j.jmoneco.2018.04.010).
- [29] Joshua J. Evans and Mamiza Haq. “Does bank capital reduce liquidity creation?” In: *Global Finance Journal* (2021), p. 100640. DOI: [10.1016/j.gfj.2021.100640](https://doi.org/10.1016/j.gfj.2021.100640).
- [30] Zuzana Fungacova, Rima Turk, and Laurent Weill. “High liquidity creation and bank failures”. In: *Journal of Financial Stability*, 57 (2021), pp. 1–11. DOI: [10.1016/j.jfs.2021.100937](https://doi.org/10.1016/j.jfs.2021.100937).
- [31] Anderson Gareth and Cesa-Bianchi Ambrogio. “Crossing the Credit Channel: Credit Spreads and Firm Heterogeneity”. In: *IMF Working Paper*, WP/20/267 (2020), pp. 1–67.

- [32] Pedro Gete and Michael Reher. “Mortgage Securitization and Shadow Bank Lending”. In: *The Review of Financial Studies*, 34.5 (2021). Ed. by Itay Goldstein, pp. 2236–2274. DOI: [10.1093/rfs/hhaa088](https://doi.org/10.1093/rfs/hhaa088).
- [33] Isabel Gödl-Hanisich. “Bank Concentration and Monetary Policy Pass-Through”. In: *FDIC Center for Financial Research Paper*, No. 2022-06 (2022), pp. 1–76. DOI: [10.2139/ssrn.4149637](https://doi.org/10.2139/ssrn.4149637).
- [34] Matthieu Gomez, Augustin Landier, David Sraer, and David Thesmar. “Banks’ exposure to interest rate risk and the transmission of monetary policy”. In: *Journal of Monetary Economics*, 117 (2021), pp. 543–570. DOI: [10.1016/j.jmoneco.2020.03.011](https://doi.org/10.1016/j.jmoneco.2020.03.011).
- [35] Edward P. Herbst and Benjamin K. Johannsen. “Bias in Local Projections”. In: *Finance and Economics Discussion Series*, 2020.010r1 (2021), pp. 1–62. DOI: [10.17016/FEDS.2020.010r1](https://doi.org/10.17016/FEDS.2020.010r1).
- [36] Han Hong, Jing-Zhi Huang, and Deming Wu. “The information content of Basel III liquidity risk measures”. In: *Journal of Financial Stability*, 15 (2014), pp. 91–111. DOI: [10.1016/j.jfs.2014.09.003](https://doi.org/10.1016/j.jfs.2014.09.003).
- [37] Jane Ihrig, Edward Kim, Ashish Kumbhat, Cindy Vojtech, and Gretchen C. Weinbach. “How Have Banks Been Managing the Composition of High-Quality Liquid Assets?” In: *Finance and Economics Discussion Series*, 2017.092 (2017), pp. 1–29. DOI: [10.17016/FEDS.2017.092](https://doi.org/10.17016/FEDS.2017.092).
- [38] Marek Jarociński. “Estimating the Fed’s Unconventional Policy Shocks”. In: *ECB Working Paper*, No. 2585 (2021), pp. 1–51.
- [39] Marek Jarociński and Peter Karadi. “Deconstructing Monetary Policy Surprises—The Role of Information Shocks”. In: *American Economic Journal: Macroeconomics*, 12.2 (2020), pp. 1–43. DOI: [10.1257/mac.20180090](https://doi.org/10.1257/mac.20180090).
- [40] Priit Jeenas. “Monetary Policy Shocks, Financial Structure, and Firm Activity: A Panel Approach”. In: *SSRN Electronic Journal* (2018). DOI: [10.2139/ssrn.3043579](https://doi.org/10.2139/ssrn.3043579).
- [41] Òscar Jordà. “Estimation and Inference of Impulse Responses by Local Projections”. In: *American Economic Review*, 95.1 (2005), pp. 161–182. DOI: [10.1257/0002828053828518](https://doi.org/10.1257/0002828053828518).
- [42] Supriya Kapoor and Oana Peia. “The impact of quantitative easing on liquidity creation”. In: *Journal of Banking & Finance*, 122 (2021), p. 105998. DOI: [10.1016/j.jbankfin.2020.105998](https://doi.org/10.1016/j.jbankfin.2020.105998).
- [43] Anil K. Kashyap and Jeremy C. Stein. “What Do a Million Observations on Banks Say About the Transmission of Monetary Policy?” In: *American Economic Review*, 90.3 (2000), pp. 407–428. DOI: [10.1257/aer.90.3.407](https://doi.org/10.1257/aer.90.3.407).
- [44] Ruby P. Kishan and Timothy P. Opiela. “Bank Size, Bank Capital, and the Bank Lending Channel”. In: *Journal of Money, Credit and Banking*, 32.1 (2000), pp. 121–141. DOI: [10.2307/2601095](https://doi.org/10.2307/2601095).
- [45] John Krainer and Pascal Paul. “Monetary Transmission through Bank Securities Portfolios”. In: *Federal Reserve Bank of San Francisco*, Working Paper 2023-18 (2023). DOI: [10.24148/wp2023-18](https://doi.org/10.24148/wp2023-18).
- [46] Lei Li, Elena Loutskina, and Philip E. Strahan. “Deposit market power, funding stability and long-term credit”. In: *Journal of Monetary Economics*, 138 (2023), pp. 14–30. DOI: [10.1016/j.jmoneco.2023.04.004](https://doi.org/10.1016/j.jmoneco.2023.04.004).

- [47] Emi Nakamura and Jón Steinsson. “High-Frequency Identification of Monetary Non-Neutrality: The Information Effect*”. In: *The Quarterly Journal of Economics*, 133.3 (2018), pp. 1283–1330. DOI: [10.1093/qje/qjy004](https://doi.org/10.1093/qje/qjy004).
- [48] Thach Vu Hong Nguyen, Shamim Ahmed, Thanaset Chevapatrakul, and Enrico Onali. “Do stress tests affect bank liquidity creation?” In: *Journal of Corporate Finance*, 64 (2020), p. 101622. DOI: [10.1016/j.jcorpfin.2020.101622](https://doi.org/10.1016/j.jcorpfin.2020.101622).
- [49] Pascal Paul. “Banks, maturity transformation, and monetary policy”. In: *Journal of Financial Intermediation*, 53 (2023), pp. 1–14. DOI: [10.1016/j.jfi.2022.101011](https://doi.org/10.1016/j.jfi.2022.101011).
- [50] Peter Paz. “Bank Capitalization heterogeneity and monetary policy”. In: *Working Paper Series Banco de España*, No. 2234 (2022), pp. 1–59. DOI: [10.2139/ssrn.4252563](https://doi.org/10.2139/ssrn.4252563).
- [51] Alberto Polo. “Imperfect pass-through to deposit rates and monetary policy transmission”. In: *Bank of England Working Paper*, No. 933 (2021), pp. 1–69. DOI: [10.2139/ssrn.3900542](https://doi.org/10.2139/ssrn.3900542).
- [52] Arisyi F. Raz, Danny McGowan, and Tianshu Zhao. “The dark side of liquidity regulation: Bank opacity and funding liquidity risk”. In: *Journal of Financial Intermediation*, 52 (2022), pp. 1–13. DOI: [10.1016/j.jfi.2022.100990](https://doi.org/10.1016/j.jfi.2022.100990).
- [53] Daniel Roberts, Asani Sarkar, and Or Shachar. “Liquidity Regulations, Bank Lending, and Fire-Sale Risk”. In: *Federal Reserve Bank of New York Staff Reports*, No. 852 (2023).
- [54] René Stulz, Alvaro Taboada, and Mathijs van Dijk. “The determinants of liquid asset holdings”. In: *NBER Working Paper Series*, WP 30340 (2022), pp. 1–73.
- [55] Suresh M. Sundaresan and Kairong Xiao. “Liquidity Regulation and Banks: Theory and Evidence”. In: *Columbia Business School Research Paper Forthcoming* (2023), pp. 1–57. DOI: [10.2139/ssrn.4020511](https://doi.org/10.2139/ssrn.4020511).
- [56] Skander Van den Heuvel. “Does Bank Capital Matter for Monetary Transmission?” In: *FRBNY Economic Policy Review* (2002), pp. 1–7.
- [57] Xingmin Zhang, Qiang Fu, Liping Lu, Qingyu Wang, and Shuai Zhang. “Bank liquidity creation, network contagion and systemic risk: Evidence from Chinese listed banks”. In: *Journal of Financial Stability*, 53 (2021), pp. 1–14. DOI: [10.1016/j.jfs.2021.100844](https://doi.org/10.1016/j.jfs.2021.100844).

Chapter 3

Robustness Assessments: Investigating Permanent Heterogeneity in Monetary Policy Transmission and Addressing Endogeneity Concerns

3.1 Introduction

Chapter 2 has established a foundation by presenting evidence of the interaction between liquidity ratios and monetary policy transmission. In this chapter, I expand upon this groundwork by addressing specific methodological concerns. The primary objective of this chapter is to enhance the reliability of the analysis through a series of rigorous tests and extensions. The focus lies on ensuring the robustness of previous findings in the face of two key issues: biases resulting from persistent differences in monetary policy transmission and endogeneity resulting from reverse causality. The two specific concerns are briefly described in the following paragraphs.

Chapter 2 employs a specification strategy to account for heterogeneity in the transmission of monetary policy arising from other time-varying bank characteristics. Moreover, the strategy uses bank fixed effects to control for *permanent differences* in outcomes— Y across banks (e.g., differences in bank business models). Nevertheless, according to Ottonello and Winberry (2020), the standard fixed effects estimator is not immune to biases produced by permanent differences in how banks respond to aggregate monetary shocks. For this reason, Section 3.2 implements alternative specifications intended to address heterogeneity in the transmission of monetary policy caused by factors of a more permanent nature.

Chapter 2 addresses endogeneity by incorporating lagged values of the four-quarter rolling average in the liquidity ratios, a commonly used strategy in the literature. However, it is noteworthy that while this approach helps mitigate endogeneity (arising from observed characteristics), it may not eliminate endogeneity related to unobserved characteristics or reverse causality. For this reason, Section 3.3 addresses other sources of endogeneity

by instrumenting liquidity ratios with a Bartiks-like instrumental variable approach.

To my knowledge, no other related studies perform the same exercises; hence, by addressing these methodological intricacies, I seek to contribute a more solid empirical basis for understanding how liquidity ratios impact the complex dynamics of monetary policy transmission.

3.2 Consequences of Permanent Heterogeneity in the Transmission Channel

To understand the motivation for the exercise, let's consider the argument in Ottonello and Winberry (2020). Assume that the following process generates the bank's outcome- Y

$$\Delta_h Y_{i,t+h} = \beta_i^h mp_t + \gamma^h mp_t LR_{i,t-1} + (\Psi^h + \Gamma^h mp_t) X_{i,t-1} + f_i^h + f_{t+h}^h + u_{i,t+h}^h \quad (3.1)$$

The elements in specification (3.1) remain consistent with those in the previous chapter, with the sole exception being the inclusion of the *permanent responsiveness* term β_i^h . This term indicates the presence of permanent bank-specific characteristics that induce permanent heterogeneity in the transmission of monetary policy shocks mp_t .

Consider that $\beta_i^h = f(\mathbb{B}^h \mathbb{W}_i)$, where $\mathbb{B} = b_1, b_2, \dots, b_l$ is a vector of coefficients, and \mathbb{W}_i is a vector of unobserved characteristics inducing permanent heterogeneity in policy transmission. For the estimation of the parameters of interest γ^h , a source of bias might be that the characteristics within β_i^h correlate with the liquidity ratios, $Corr(LR_{i,t-1}, \mathbb{W}_i) \neq 0$.

This section controls for two factors that cause the correlation between the permanent heterogeneity factor and the liquidity ratios. The first specification tackles permanent heterogeneity caused by permanent cross-sectional differences in liquidity ratios. The strategy follows the within-bank estimation approach (or direct orthogonalization) of Ottonello and Winberry (2020), which is thoroughly explained in section 3.2.1. The second specification tackles permanent heterogeneity in the transmission due to permanent differences in how banks adjust their liquidity ratios in response to monetary shocks. This issue is addressed in section 3.2.2 and consists of mixing Ottonello and Winberry (2020) with the state-dependent local projections approach of Cloyne, Jordà, and Taylor (2023).

3.2.1 Controlling for Within Bank Liquidity Variation

Consider the case when the average value of the bank's liquidity position is proportional to the permanent heterogeneity in responsiveness β_i , in other words, $\beta_i^h = b_1^h E_i[LR_{i,t}]$. In the context of this thesis, banks may be ex-ante heterogeneous in how they respond to monetary policy due to cross-sectional differences in liquidity ratios for various reasons: For example, low-beta-banks are permanently less exposed to monetary policy and more likely to have permanently lower liquidity ratios.

Under this assumption, a high value of LR_{it} in the cross-section may influence how the bank responds to the aggregate shock: a) through the coefficient of interest γ or b) through the permanent responsiveness term. In the absence of variables controlling for the permanent responsiveness term, Ottonello and Winberry (2020) proposes to construct regressors that are by construction orthogonal to the omitted terms. This approach yields

the following specifications:

$$\Delta_h Y_{i,t+h} = \gamma_{wb}^h m p_t \widetilde{LR}_{i,t-1} + \Psi_{wb}^h Z_{i,t-1} + \Gamma_{wb}^h m p_t \widetilde{X}_{i,t-1} + f_i^h + f_{t+h}^h + u_{i,t+h}^h \quad (3.2)$$

Unlike specification (2.3), equation (3.2) includes an interaction term that measures liquidity ratios relative to the average liquidity position, denoted as $\widetilde{LR}_{i,t-1} \equiv LR_{i,t-1} - \mathbb{E}_i[LR_{i,t}]$ ¹. By construction, $\widetilde{LR}_{i,t-1}$ is uncorrelated with $\mathbb{E}_i[LR_{i,t}]$; hence results are less likely to be driven by permanent heterogeneity in monetary policy responsiveness across banks.

For the baseline specification, the vector $\widetilde{X}_{i,t-1}$ is empty while $Z_{i,t-1}$ is a vector including only the level of the liquidity ratio $LR_{j,t-1}$. For the joint-regressions approach, the vector $\widetilde{X}_{i,t-1}$ includes demeaned control variables while $Z_{i,t-1}$ contains the levels of these control variables plus the level of the liquidity ratio. The selection of variables in $\widetilde{X}_{i,t-1}$ is unchanged compared to the ones used in Chapter 2. Finally, the right-hand side variables are winsorized at 1% and then standardized by subtracting the sample mean and dividing by the sample standard deviation of each respective variable.

The primary coefficients of interest, denoted as γ_{wb}^h , quantify the sensitivity of outcome- Y to monetary shocks based on the heterogeneity in within-bank variations in the liquidity ratios. For interpretability, these coefficients indicate how a bank's response to a monetary policy shock is influenced by the fact that the bank is more or less liquidity relative to its typical level. Once again, results in the following sections represent equilibrium outcomes.

3.2.1.1 Effect on Deposit Flows

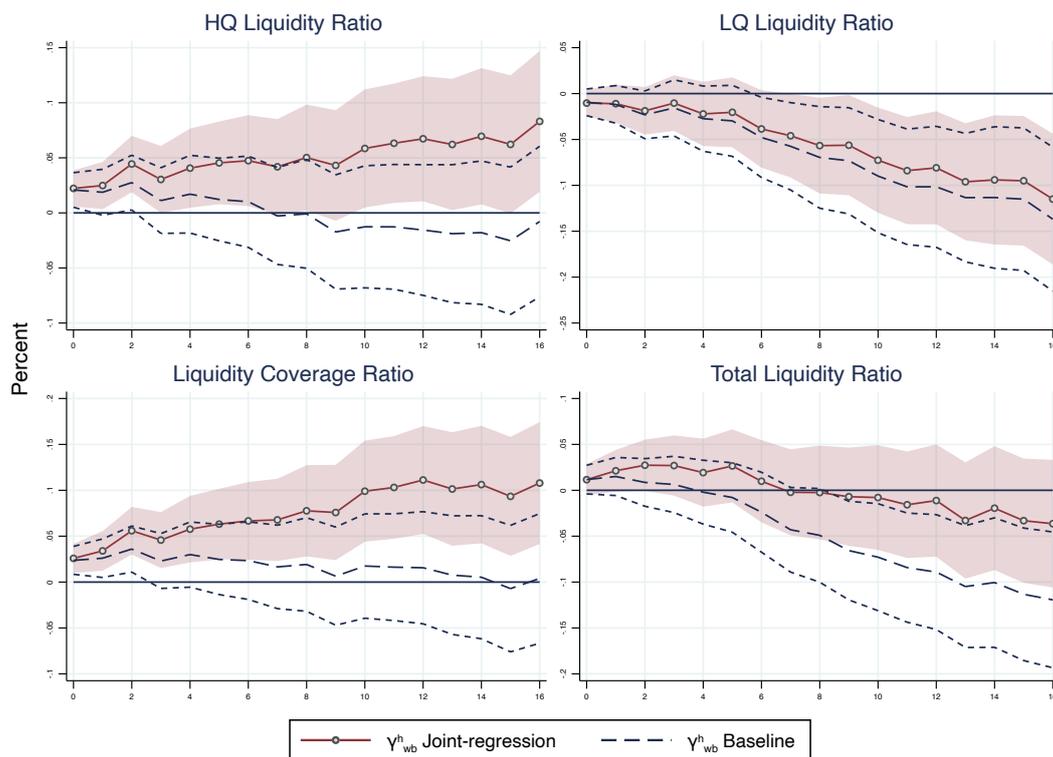
Figure 3.2.1 displays the estimates of γ_{wb}^h in specification (3.2), where the dependent variable is the logarithmic change in total deposits. Once considering the impact of persistent heterogeneity in liquidity ratios, the exercise highlights the following results.

First, when examining the joint-regression estimates, those banks having more than usual HQ liquidity ratios before the monetary shock² exhibit more significant deposit growth rates. This observation aligns with the findings presented in Figure 2.5.1, which demonstrate how HQ liquidity aids banks in stabilizing their deposits during periods of monetary tightening. The primary difference lies in the fact that when I account for the removal of permanent heterogeneity in HQ liquidity, the magnitudes of these effects are amplified, and their impact appears to be more enduring over time.

¹ $\mathbb{E}_i[LR_{i,t}]$ denotes the average value the liquidity ratio for a given bank over the sample.

²Banks positioned one standard deviation above the mean of the distribution of within-bank changes in HQ liquidity ratios

Figure 3.2.1: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Within Variation)



Notes: The graph displays the results for γ_{wb}^h obtained from specification (3.2). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Second, the dynamics concerning heterogeneity induced by differences in LQ liquidity mirror almost exactly the ones in Figure 2.5.1, Chapter 2. That is, LQ liquidity destabilizes more deposit flows in response to monetary shocks. Once again, removing permanent differences in LQ liquidity ratios increases the absolute value of the parameters. Finally, looking at the dynamics induced by total liquidity, the positive stabilization effect of HQ liquidity seems to dominate the negative effect of LQ liquidity.

Overall, the results closely align with those discussed in Section 2.5. However, one notable difference is that when we control for a source of permanent heterogeneity in monetary policy, the coefficients' magnitudes γ_{wb}^h increase and the stabilizing influence of HQ liquidity becomes more pronounced.

3.2.1.2 Effect on Loans Growth

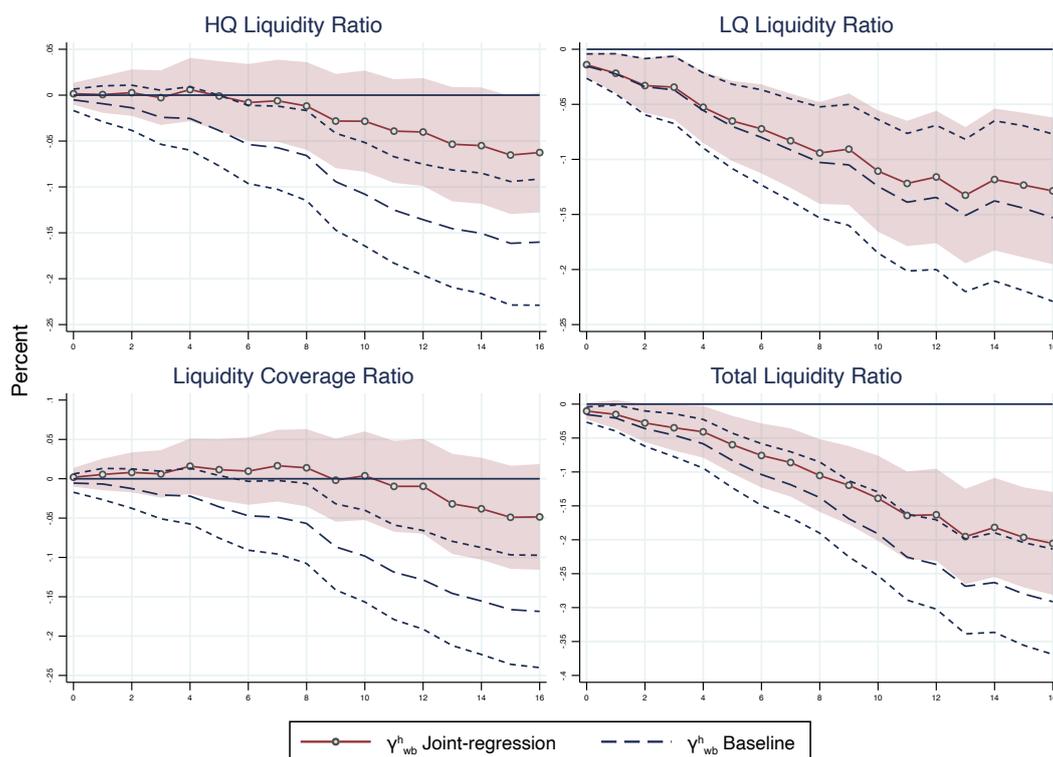
Figure 3.2.2 displays the estimates of γ_{wb}^h in specification (3.2), where the dependent variable is the logarithmic change in total loans. The exercise highlights the following equilibrium conditions.

First, when examining the joint-regression estimates, those banks having more than usual HQ liquidity ratios before the monetary shock do not exhibit significant differences regarding loan growth rates. Like evidence presented in Figure 2.6.1, HQ liquidity does not amplify the decrease in loans as suggested by the baseline point estimates. Once

controlling for income and duration gaps, HQ liquidity does not seem to have differential effects during monetary cycles.

Second, banks having more than usual LQ liquidity ratios before the monetary shock experience significantly lower loan growth rates, mirroring almost exactly the results in Figure 2.6.1. Coefficients fall around the same magnitudes, implying that four years after a monetary shock that induces a 1bp increase in the Fed fund future rate, banks with higher LQ ratios experience weaker loan growth of around -0.15%.

Figure 3.2.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Within Variation)



Notes: The graph displays the results for γ_{wb}^h obtained from specification (3.2). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

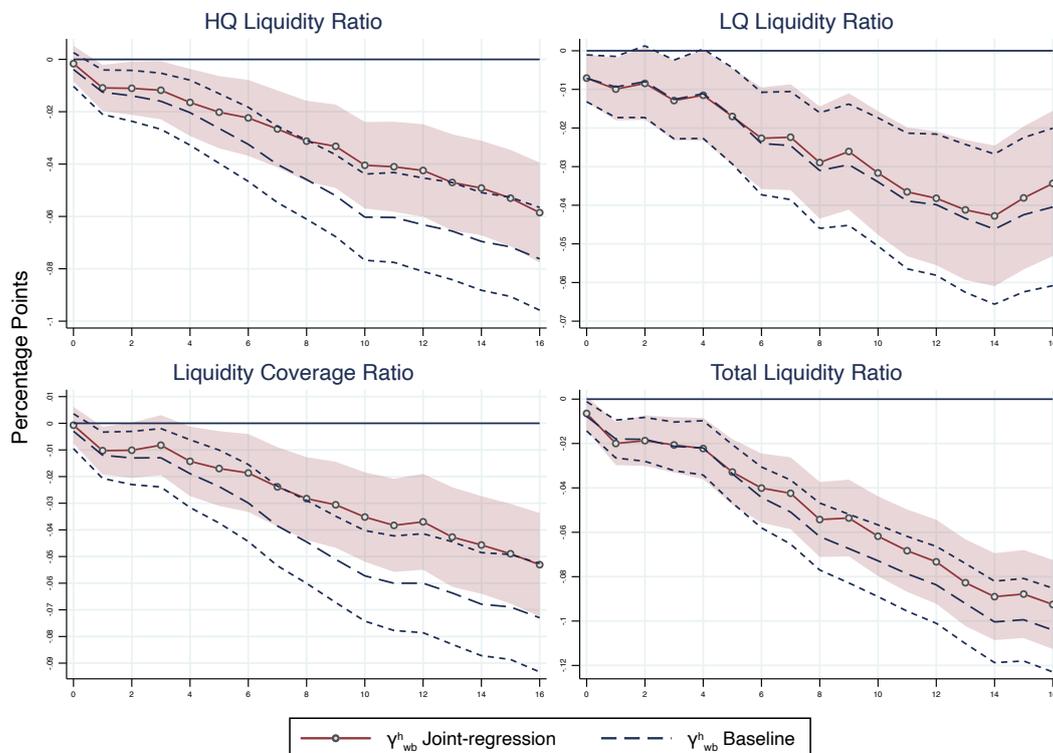
Overall, these dynamics follow relatively close to the ones in 2.6, Chapter 2. Remarkably, the heterogeneity identified here is more precisely estimated (narrower confidence intervals), indicating that permanent heterogeneity in responsiveness is quantitatively relevant in the sample.

3.2.1.3 Effect on Liquidity Creation

Figure 3.2.3 displays the estimates of γ_{wb}^h in specification (3.2). The findings are in line with the results presented in Figure 2.7.1, which showed that a bank with a liquidity ratio one standard deviation above its average creates less liquidity following a monetary tightening shock. What's particularly noteworthy is that the differences in the effects are more pronounced, persist over longer time horizons, and are statistically significant. This pattern holds for all four liquidity measures, suggesting that having higher ex-ante

liquidity does not necessarily grant banks a greater ability to generate liquidity during periods of monetary tightening.

Figure 3.2.3: Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Within Variation)



Notes: The graph displays the results for γ_{wb}^h obtained from specification (3.2). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

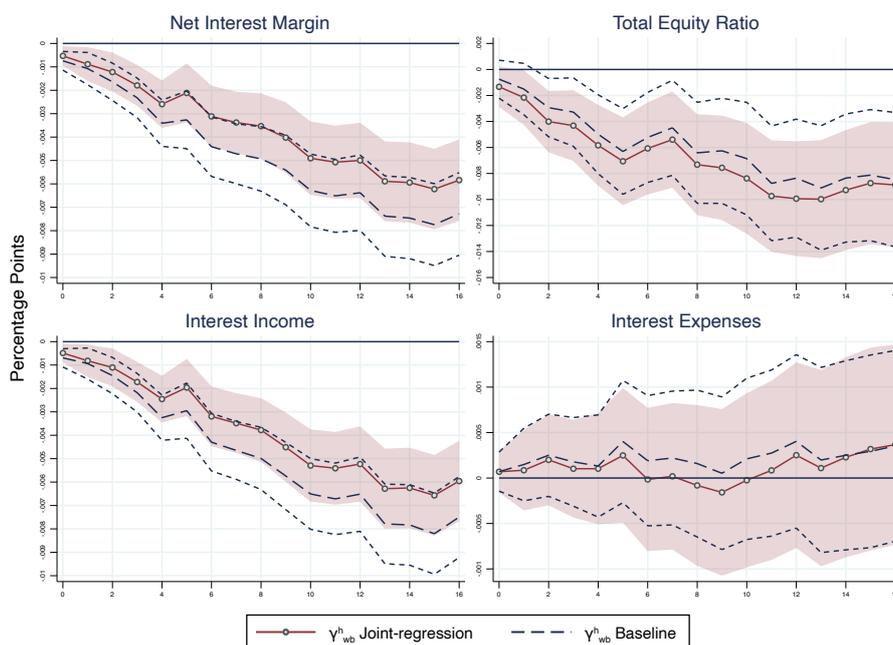
3.2.1.4 Effect on Profit Margins

Figure 3.2.4 displays the estimates of γ_{wb}^h in specification (3.2), focusing on HQ liquidity (Panel a) and LQ liquidity (Panel b). The exercise highlights significant differences compared to the results in Section 2.8, Chapter 2.

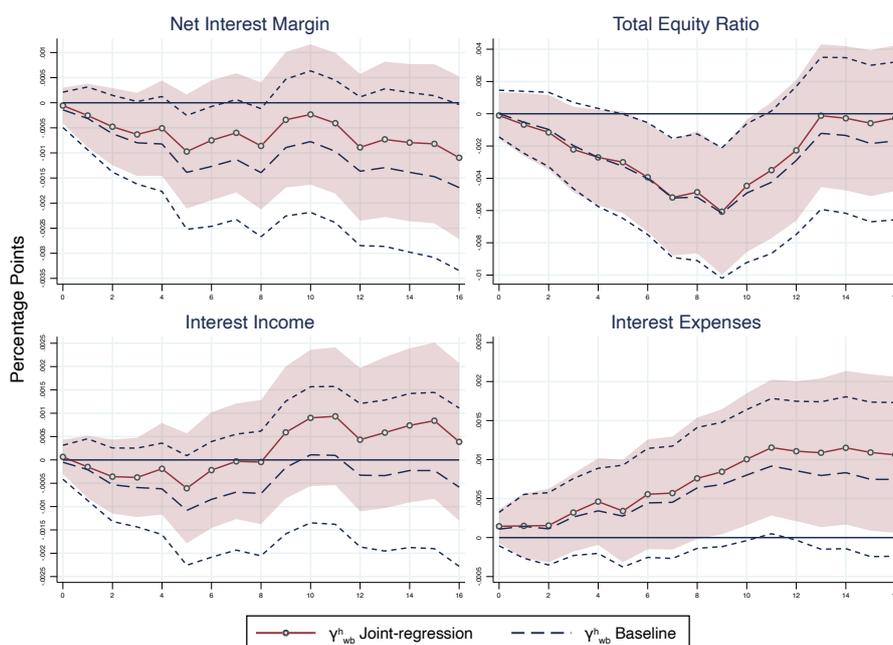
First, it remains true that higher liquidity ratios are associated with lower net interest income in response to a monetary tightening shock. However, this result persists over an even longer horizon and is statistically significantly different from zero.

Focusing on the point estimates from the joint regression, net interest margins of banks standing one standard deviation above the HQ-liquidity distribution are about 0.006 percentage points lower in response to the monetary shock. The dynamics of policy-induced variations in interest rate income primarily explain these differences. In contrast, heterogeneity in interest expenses is not observed. Furthermore, the book value of banks' capital as a percentage of total assets drops by about 0.01 percentage points in response to the same monetary shock. Overall, after eliminating permanent heterogeneity in the transmission channel, the adverse impact of HQ liquidity on profit margins and equity appears to be larger and persists for a longer duration.

Figure 3.2.4: Monetary Tightening Conditional on Liquidity: Effect on Profit Margins (Within Variation)



(a) Heterogeneity Induced by HQ Liquidity



(b) Heterogeneity Induced by LQ Liquidity

Notes: The graph displays the results for γ_{wb}^h obtained from specification (3.2). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

3.2.2 Controlling for Permanent Adjustments in Liquidity Ratios

Banks may be ex-ante heterogeneous in how they adjust their liquidity ratios in response to monetary policy. Similar to the previous section, these policy-induced adjustments can be a source of bias if they convey permanent effects on monetary policy transmission. In that sense, consider the case when permanent heterogeneity in responsiveness β_i^h is explained by changes in the expected liquidity ratio, such that $\beta_i^h = b_2^h \mathbb{E}_i[\Delta_h LR_{i,t}]$. This section aims to identify if estimates are less likely to be driven by permanent heterogeneity in banks' liquidity adjustments in response to monetary policy.

3.2.2.1 Empirical Specification: Two-stage Local Projection Approach

To explore the consequences of this source of permanent heterogeneity, I employ an approach inspired by the Cloyne, Jordà, and Taylor (2023) approach. Their methodology consists of Kitagawa-Blinder-Oaxaca decomposition of the traditional Local projection. Precisely, the estimation consists of two-stage local projections. In stage one, I estimate the bank-specific average cumulative response of liquidity ratios to monetary shocks from the following specification:

$$\Delta_h LR_{i,t+h} = f_i^h + \Theta_i^h mp_t + \Gamma^h mp_t \widetilde{X}_{i,t-1} + \Psi^h B_{i,t-1} + \varphi^h A_{t-1} + \epsilon_{i,t+h}^h \quad (3.3)$$

The notation remains consistent with the previous section. In equation (3.3), the right-hand side represents the cumulative changes in the liquidity ratios. The vector A_{t-1} includes other state variables³. The vector B_i includes bank-specific controls⁴. Finally, the parameters of interest are Θ_i^h , which proxies the bank-specific sensitivity of their liquidity ratio(s) to the monetary tightening shocks (mp_t). Descriptive statistics on the distribution of these parameters are provided in Appendix 3.2.

In stage two, I extend the baseline panel regression (3.2) by including the estimated coefficient $\hat{\Theta}_i^h$ as follows:

$$\Delta_h Y_{i,t+h} = \beta^h mp_t + \gamma_{SP}^h mp_t \widetilde{LR}_{i,t} + \theta^h mp_t \hat{\Theta}_i^h + \gamma_{SP}^h mp_t \widetilde{X}_{i,t-1} + \Psi_{SP}^h Z_{i,t-1} + f_i^h + \varphi^h A_{t-1} + u_{i,t+h}^h \quad (3.4)$$

the parameters of interest are γ_{SP}^h , which do not capture the indirect effects of monetary shocks on bank-specific liquidity ratios.

One clarification before presenting the results: State-dependent local projection methods are typically used in exercises that study state dependence, focusing on how the effect of policy varies with some lagged state variables, like the lagged output gap. However, I am not directly estimating the state-dependent impulse response function in this section. The empirical specification here is simply inspired by these methodologies. Furthermore, endogeneity issues are not expected to be addressed by including the estimated coefficient $\hat{\Theta}_i^h$. I still use four-quarter moving averages in this section to control for possible reverse causality.

³The set of time-variant controls includes quarter dummies and four lags of the national unemployment rate, real GDP growth, CPI inflation, market expectations of near-term volatility conveyed by stock index option prices (VIX), and the change in the fed funds rate to capture persistence in the policy rate.

⁴The set of bank-specific controls consists of the lagged change in the liquidity ratio to capture persistence in liquidity adjustments, size and leverage, local deposit concentration, the repricing/maturity gap, the income gap, z-scores, and the ratio of non-performing loans.

3.2.2.2 Results

Figures 3.2.5 to 3.2.8 summarize the γ_{SP}^h estimates from the OLS estimation of (3.4). For brevity, I only present the estimation results for the log change in total deposits and loans, the change in liquidity creation ratios, the change in profit margins, and the change in equity ratios, respectively. The estimated dynamics do not fully match those observed in previous chapters⁵; however, the main conclusions remain virtually unchanged compared to the OLS regression in Chapter 2.

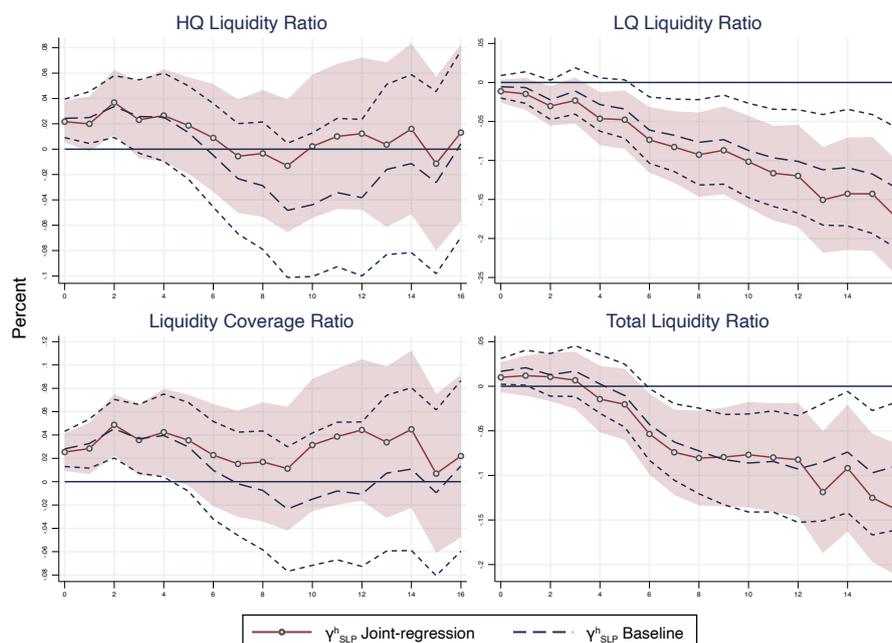
First, HQ liquidity stabilizes deposit flows at short-term horizons, between 0 and 6 quarters. While in the middle- and long-term horizons, LQ liquidity negatively and permanently affects deposit growth (fig. 3.2.5). Overall, it is still the case that high liquid asset holdings are associated with lower deposit growth after a contractionary monetary policy shock.

Secondly, banks with larger liquidity ratios –of any type– tend to experience lower loan growth during monetary tightening cycles (fig. 3.2.6). This finding aligns with the predictions made in Bluedorn, Bowdler, and Koch (2017). However, when considering joint-regression estimates, liquidity appears to have no differential effect on loan growth. In other words, factors such as income and duration gaps, which capture banks' exposure to interest rate risk, seem to absorb the negative impact of liquidity. This observation is consistent with the evidence in Kashyap, Rajan, and Stein (2002). Similar results if looking at a bank's capacity to create liquidity (fig. 3.2.7). From the joint-regression point estimates, liquidity seems to play no role in the transmission channel.

Finally, larger HQ- and LQ liquidity ratios harm banks' profitability (fig. 3.2.8). Remarkably, banks with higher HQ liquidity ratios permanently experience lower net interest rate margins.

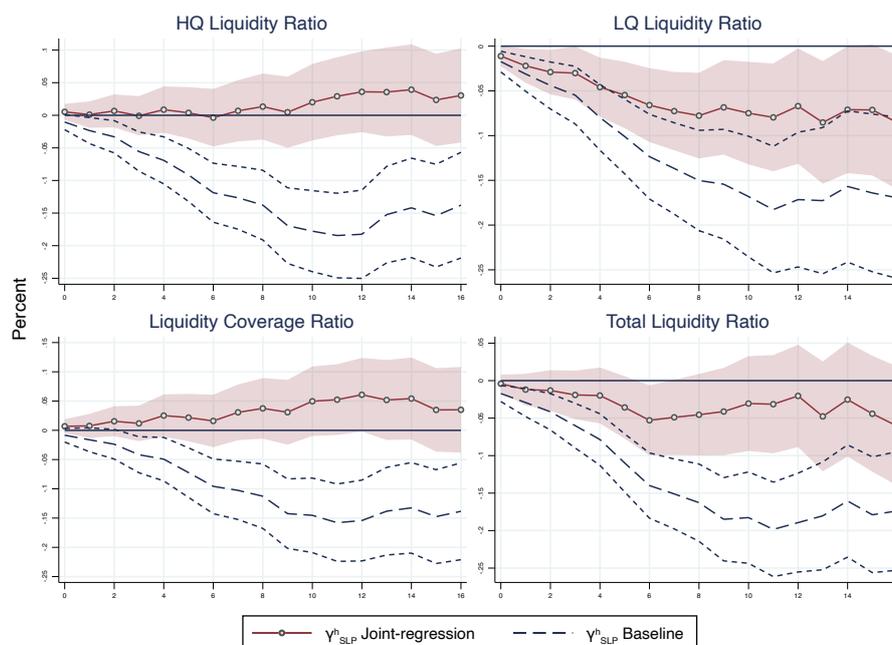
⁵The magnitudes of the coefficients remain within the range estimated in Chapter 2, while confidence intervals are wider in the joint-regressions.

Figure 3.2.5: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (State-dependent LP)



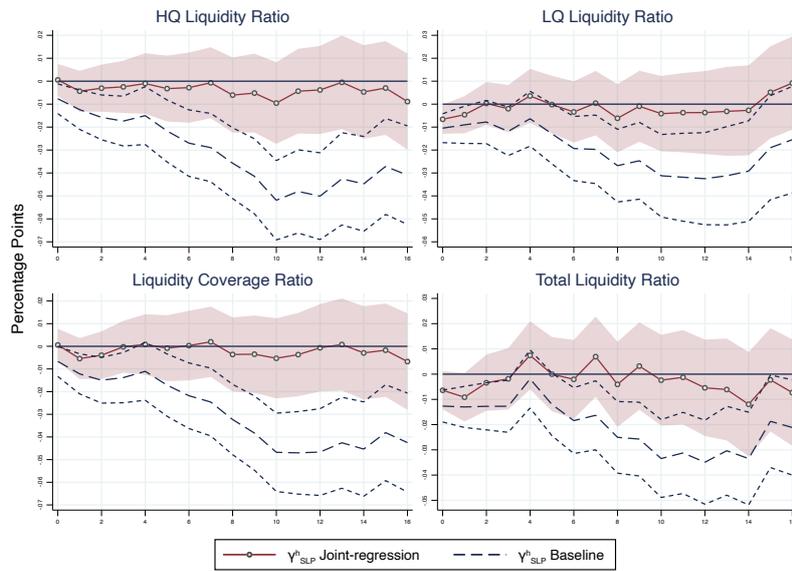
Notes: The graph displays the results for γ_{SLP}^h obtained from specification (3.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.2.6: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (State-dependent LP)



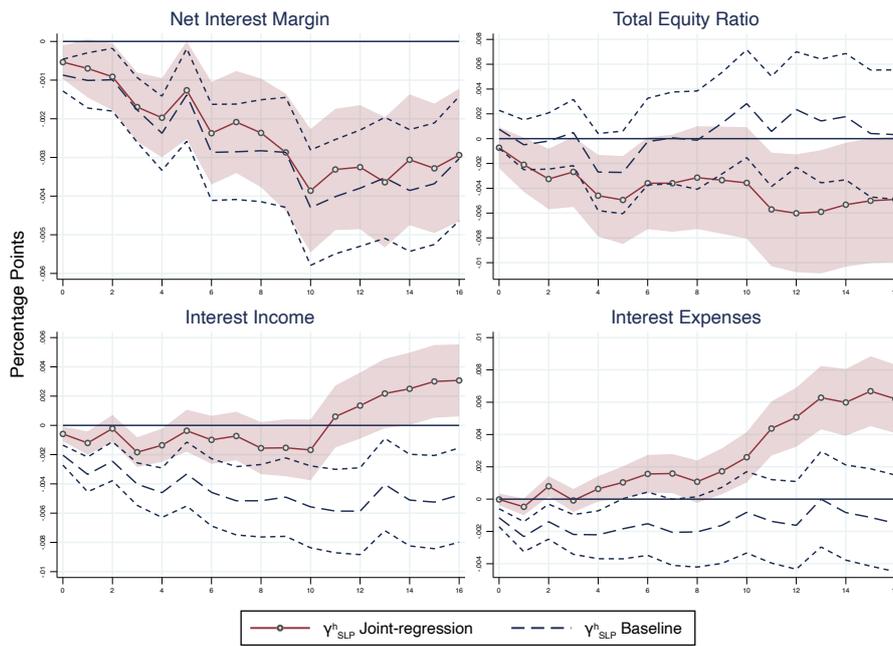
Notes: The graph displays the results for γ_{SLP}^h obtained from specification (3.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.2.7: Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (State-dependent LP)

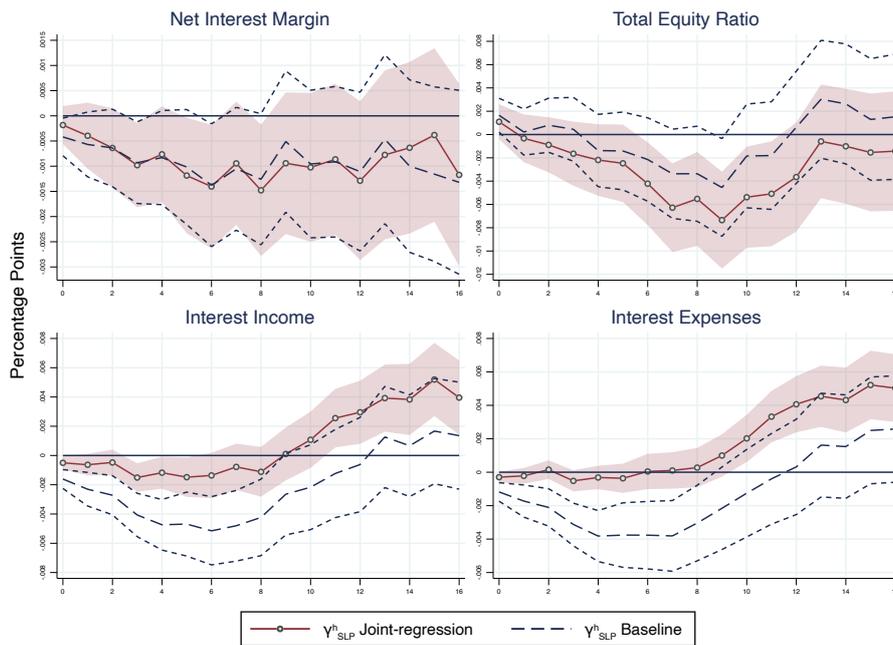


Notes: The graph displays the results for γ_{SLP}^h obtained from specification (3.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.2.8: Monetary Tightening Shock Conditional on Liquidity: (State-dependent LP)



(a) HQ Liquidity Portfolio



(b) LQ Liquidity Portfolio

Notes: The graph displays the results for γ_{SLP}^h obtained from specification (3.4). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

3.3 Consequences of Endogeneity - Reverse Causality

3.3.1 Bartik's Instruments

This subsection provides the foundational understanding of the Bartik approach. The Bartik approach in this study is used to decompose the cross-sectional heterogeneity in liquidity ratios $LR_{i,t-1}$ (the treatment variation) between a (plausibly) exogenous component and an endogenous component. The objective is to build instruments that capture the cross-sectional heterogeneity of high- and low-quality liquidity ratios explained by exogenous factors.

To decompose the liquidity ratios, the method suggests focusing on the individual components of each liquidity category, named asset- $a \in LR^j$. These categories are summarized in Chapter 2 Appendix 2.A.1. Based on these categories, the dollar value of each asset- a is disaggregated between a) a bank-specific portfolio share of asset- a and b) a bank-specific accumulation of asset- a . The decomposition begins with the following identity⁶

$$\frac{\Delta LR_{i,t}}{LR_{i,t-1}} \equiv \sum_{a \in LR} w_{i,t-1}^a \times \tilde{g}_{i,t}^a \quad (3.5)$$

where $w_{i,t}^a$ is the bank-specific share of asset- a in the liquidity category (LR-portfolio), and $\tilde{g}_{i,t}^a$ is the rate of growth of a specific asset- a from $t - 1$ to t , relative to the rate of growth in total assets (LR-trend). It is noteworthy that equation (3.5) is a decomposition for the changes in liquidity ratios.

Following Breuer (2021), identity (3.5) can be rewritten as follows

$$\frac{\Delta LR_{i,t}}{LR_{i,t-1}} = \sum_{a \in LR} w_i^a \tilde{g}_t^a + (w_{i,t-1}^a - w_i^a) \tilde{g}_t^a + (\tilde{g}_{i,t}^a - \tilde{g}_t^a) w_i^a + (w_{i,t-1}^a - w_i^a) (\tilde{g}_{i,t}^a - \tilde{g}_t^a) \quad (3.6)$$

In equation (3.6), the term $(w_{i,t-1}^a - w_i^a)$ accounts for the variations in the rate of growth of liquidity ratios across banks in quarter t resulting from the endogenous changes in a bank's portfolio shares. The term $(\tilde{g}_{i,t}^a - \tilde{g}_t^a)$ accounts for the variations in changes of liquidity ratios across banks in quarter t due to endogenous bank-specific trends. The remaining term $w_i^a \tilde{g}_t^a$ corresponds to Bartik's since it is the (more plausible) exogenous component explaining the heterogeneity of interest.

$$z_{i,t}^{BTk} \equiv \sum_{a \in LR} w_i^a \tilde{g}_t^a \quad (3.7)$$

The instrument is composed of two elements. w_i^a is the *predetermined* share of asset- a in banks' portfolio of LR-liquidity, which captures bank-specific portfolio composition (stationary allocation). While \tilde{g}_t^a is the *aggregate change* of asset- a from $t - 1$ to t relative to total assets, which captures asset-specific common trends in the banking system (aggregate shocks). The interaction of both terms ($z_{i,t}^{BTk}$) accounts for a fraction of the cross-sectional heterogeneity in the relative growth rate of liquidity in quarter t explained by exogenous factors. This is because, by construction, $z_{i,t}^{BTk}$ is orthogonal to banks' endogenous changes in the portfolio composition and endogenous changes in the rate of accumulation of assets.

⁶See Appendix 3.B.1.

3.3.1.1 Measurement Procedure

I build one instrument $z_{i,t}^j$ for each of the liquidity categories of interest, where j corresponds to the liquidity categories: high- or low-quality. Since the procedure is the same for each liquidity category, I omit index j to simplify the notation. The computation of each component in $z_{i,t}$ goes as follows:

1. **Bank-specific predetermined portfolio composition (w_i^a):** Measured as the share of liquid asset type- a in the liquidity portfolio- j for bank- i . Following the literature, the predetermined quarter corresponds to 2013q2 as the reference date since this date is a referent in other related works (e.g., Ihrig et al., 2017).
2. **Common time-varying component ($\tilde{g}_{i,t}^a$):** Measured as the aggregate rate growth of asset- a relative⁷ to aggregate total assets by size group.

The instrument's characteristics and components are left in Appendix 3.B.1.

3.3.2 Empirical Specification: IV Approach

This section implements the Bartik Instruments following the basic idea of the instrumental variable approach. The estimation employs two-stage least squares. In stage one, $(mp_t \times z_{i,t}^j)$ and $z_{i,t}^j$ are used as instruments for $mp_t \times LR_{i,t}^j$ and $LR_{i,t}^j$. The first stage estimation goes as follows

$$\begin{aligned} mp_t \cdot LR_{i,t}^j &= f_i + f_t + \beta_1 (mp_t \times z_{i,t}^j) + \beta_2 z_{i,t}^j + \Gamma' mp_t X_{i,t-1} + \Psi' Z_{i,t-1} + \epsilon_{i,t} \\ LR_{i,t}^j &= f_i + f_t + \beta_3 (mp_t \times z_{i,t}^j) + \beta_4 z_{i,t}^j + \Gamma' mp_t X_{i,t-1} + \Psi' Z_{i,t-1} + \epsilon_{i,t} \end{aligned} \quad (3.8)$$

The second stage consists of estimating the following specifications

$$\Delta_h Y_{i,t+h} = f_i^h + f_{t+h}^h + \gamma_{iv}^h \widehat{(mp_t \cdot LR_{i,t})} + \Gamma'_h mp_t X_{i,t-1} + \Psi'_h Z_{i,t-1} + u_{i,h,t+h} \quad (3.9)$$

where $\widehat{mp_t \cdot LR_{i,t}}$ is the instrumented treatment obtained in stage-one⁸. As for how I include the sets of financial conditioning variables $X_{i,t-1}$, I repeat the same strategy as in the OLS regressions from the previous sections. I consider the relevance of the liquidity ratio separately (baseline regression) and finally jointly (joint regression). For the joint regressions, I limit the set of controls to three main control variables: capitalization, income gaps, and maturity mismatch⁹.

3.3.3 Results

Figures 3.3.1 to 3.3.5 summarize the γ_{iv}^h estimates from the 2SLS estimation of (3.9). For brevity, I only present the estimation results for the log change in total deposits and loans, the change in liquidity creation ratios, the change in net interest rate margins, and the change in equity ratios, respectively¹⁰.

⁷See a related mathematical expression in equation (3.B.1).

⁸ $\widehat{LR_{i,t}}$ is included in the Z_i vector.

⁹In this respect, I limit the set of control variables because the joint-regressions estimates are not stable when including a large number of controls. However, the instruments are more likely to be uncorrelated with unobserved bank-quarter characteristics, thereby improving control for confounding factors.

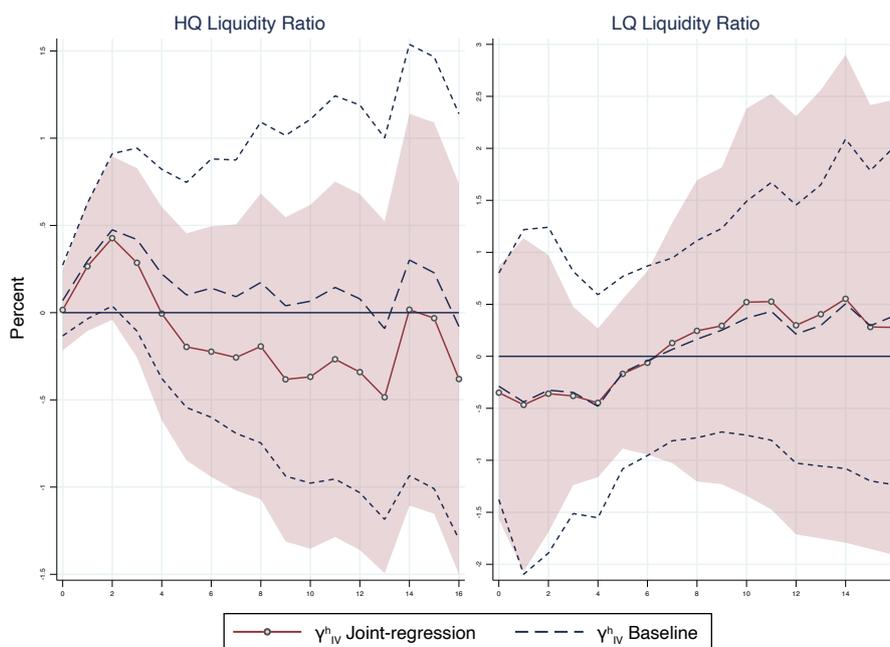
¹⁰The implications of using the IV approach for other outcome variables- Y are available upon request.

Regarding HQ liquidity, the IV estimates largely align with the previous findings. When examining the short-term effects (between 0 and 8 quarters after the shock), the conclusions are similar to those obtained in the OLS regression. Higher HQ liquidity ratios continue to exhibit a stabilizing effect on deposit outflows and loan growth. However, they also correspond to lower profit margins, although this effect does not directly translate into equity. Interestingly, the impact on liquidity creation is opposite to the evidence presented in Chapter 2 and Section 3.2.1.

In contrast, the effects of LQ liquidity in the IV approach are more nuanced. Previous evidence in Chapter 2 suggested that LQ liquidity played a destabilizing role in the transmission mechanism. However, the IV results present a less clear-cut picture.

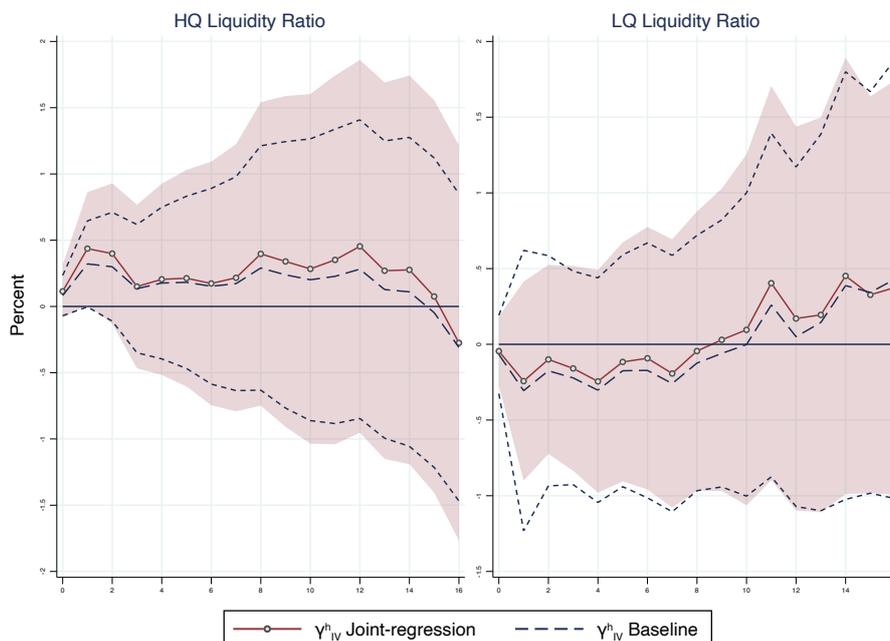
Two key takeaways emerge from this exercise. First, the magnitudes of the point estimates obtained in the IV approach fall within the ranges estimated in previous sections. However, it is essential to note that the confidence intervals in the IV approach tend to be larger. This can be attributed to the low cross-sectional heterogeneity in the instruments, as seen in Figure 3.B.1. This observation indicates that the variations in liquidity ratios across banks are predominantly driven by the banks' endogenous, with exogenous responses playing a minor role. One potential interpretation of this finding is that the Bartik instruments might not be the most effective tools for instrumenting liquidity ratios.

Figure 3.3.1: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Domestic Deposit Flows (Bartik-IV)



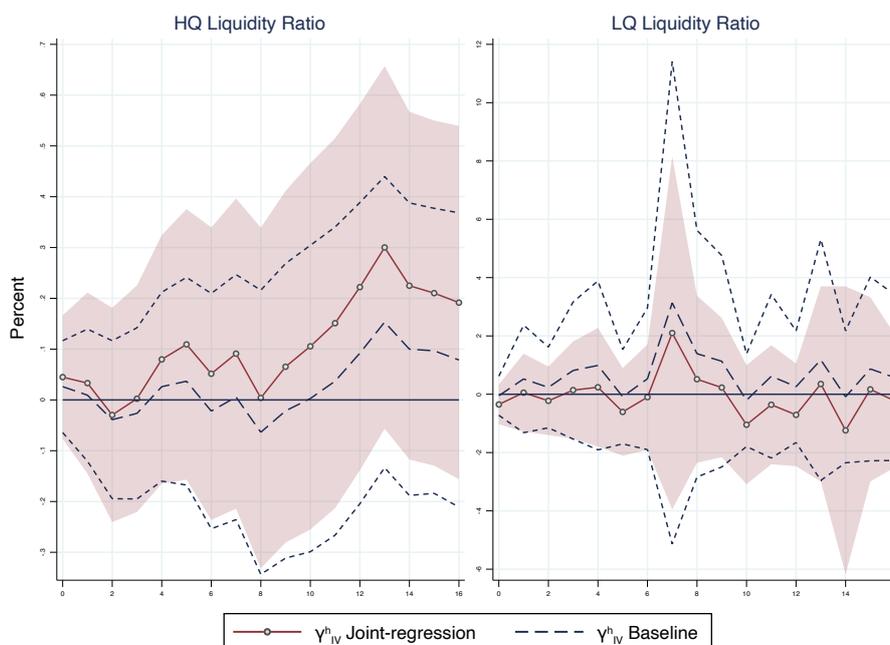
Notes: The graph displays the results for γ_{iv}^h obtained from specification (3.9). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.3.2: Monetary Tightening Shock Conditional on Liquidity: Effect on Total Loans Growth (Bartik-IV)



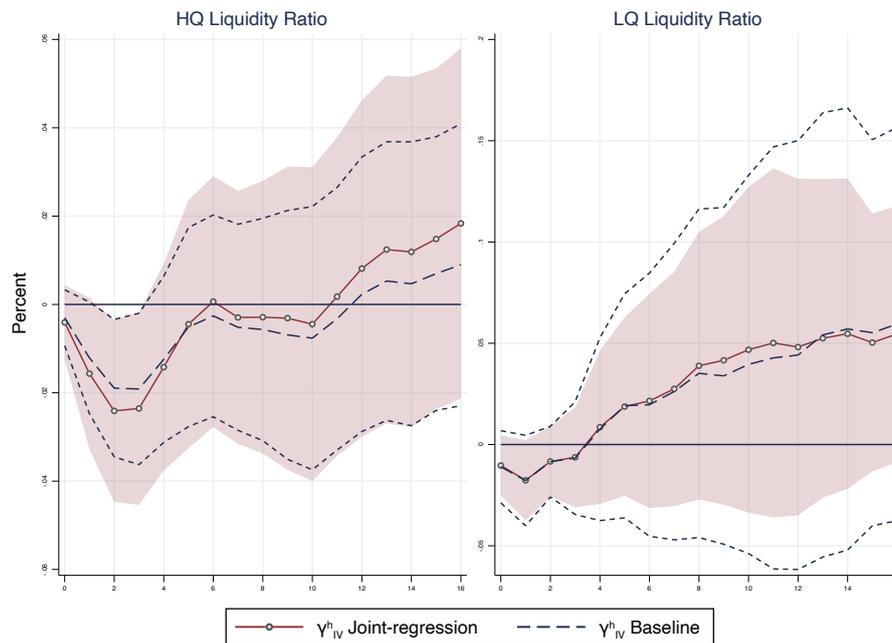
Notes: The graph displays the results for γ_{iv}^h obtained from specification (3.9). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.3.3: Monetary Tightening Shock Conditional on Liquidity: Effect on Liquidity Creation (Bartik-IV)



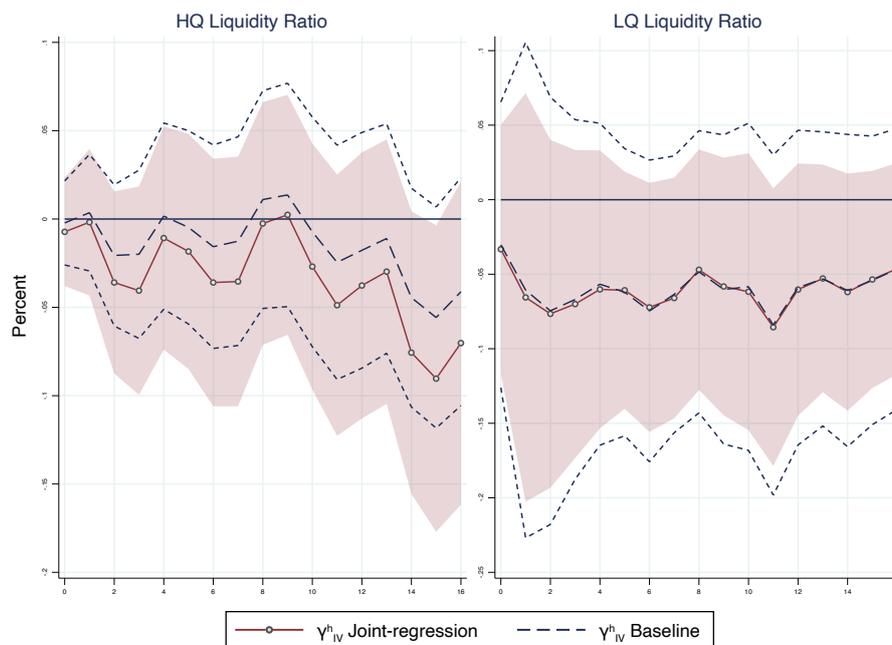
Notes: The graph displays the results for γ_{iv}^h obtained from specification (3.9). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.3.4: Monetary Tightening Shock Conditional on Liquidity: Effect on Net Interest Margins (Bartik-IV)



Notes: The graph displays the results for γ_{iv}^h obtained from specification (3.9). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

Figure 3.3.5: Monetary Tightening Shock Conditional on Liquidity: Effect on Equity Value (Bartik-IV)



Notes: The graph displays the results for γ_{iv}^h obtained from specification (3.9). The solid lines represent the joint-regression estimates incorporating control variables. Confidence intervals at 90% are constructed based on Newey-West robust standard errors to account for correlation within banks and within quarters.

3.4 Conclusion

This chapter assesses the robustness of the findings presented in Chapter 2 from two distinct angles: by studying potential biases stemming from persistent differences in monetary policy transmission and by considering issues related to endogeneity–reverse causality.

In Section 3.2, the robustness analysis accounts for biases product of permanent heterogeneity in monetary policy transmission. These biases might arise from two sources: a) differences in banks’ holdings of liquid assets (Section 3.2.1) and b) differences in the adjustment of liquidity (Section 3.2.2). From a methodological perspective, I estimate the dynamic and heterogeneous response using standard and state-dependent local projections.

In Section 3.2.1, a key distinction lies in the orthogonalization of liquidity ratios before estimation. This method directly addresses the issue of permanent heterogeneity in monetary policy resulting from sustained differences in liquidity ratios across banks. Overall, the findings in Section 3.2.1 align with those in Chapter 2. However, a noteworthy difference is the quantitative relevance of permanent heterogeneity in liquidity ratios, impacting the estimates’ magnitude. This impact is particularly evident when examining profit margins and liquidity creation. Specifically, the negative effect of liquidity ratios on profits is significantly amplified, indicating that banks with larger holdings of liquidity experience a greater reduction in profit margins. Moreover, the capacity of these banks to create liquidity is diminished. Concerning deposit flows, the stabilizing effect of HQ liquidity becomes more pronounced. In contrast, the conclusions regarding loan growth remain broadly consistent with the OLS regression results.

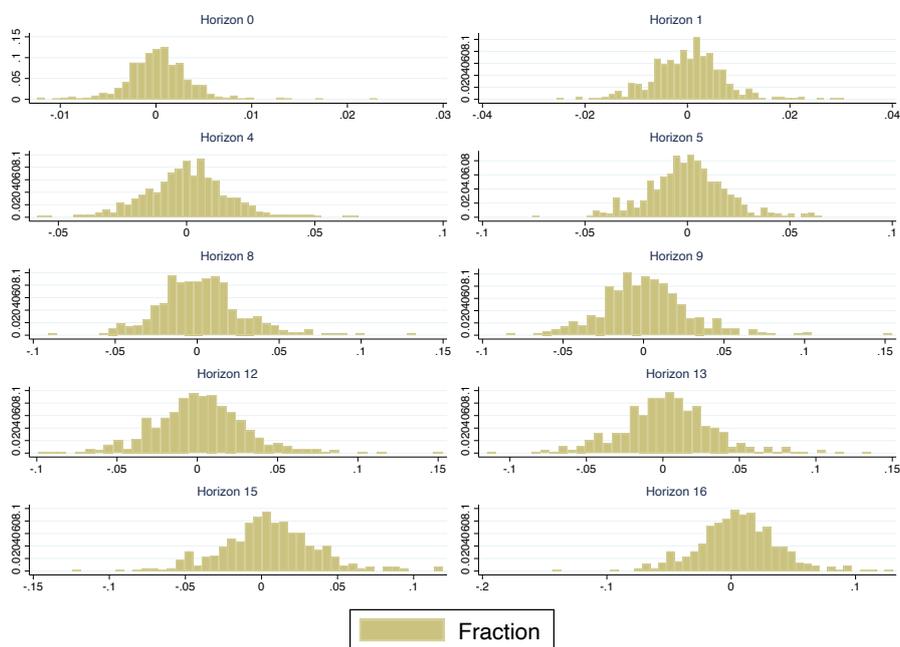
In Section 3.2.2, the critical distinction is that it accounts for bank-specific adjustments in liquidity ratios in response to monetary shocks. The methodology is inspired by the state-local projection approach of Cloyne, Jordà, and Taylor (2023). In the first stage, I estimate the expected sensitivity of banks’ liquidity ratios to monetary shocks, and in the second stage –where the conditional effect of monetary policy is estimated– I control for these permanent policy-driven adjustments in liquidity. Results closely mirror the short-term dynamics of the estimates in Chapter 2.

In Section 3.3, I conducted a robustness analysis to address concerns about reverse causality arising from endogenous bank-specific choices. The evidence obtained from the IV approach presents a more nuanced picture than the results of OLS regressions in Chapter 2 and Section 3.2. While HQ liquidity continues to act as a stabilizer in the short term, the evidence regarding LQ liquidity ratios does not align with the dynamics observed in previous sections. Notably, the exercise highlights a potential limitation: the exogenous factors obtained from the Bartik decomposition do not seem to provide sufficient variation in liquidity ratios; therefore, their statistical power might be inadequate to serve as proper instruments for liquidity ratios. Further research should explore alternative identification strategies or alternative methods to construct more suitable instruments for liquidity ratios.

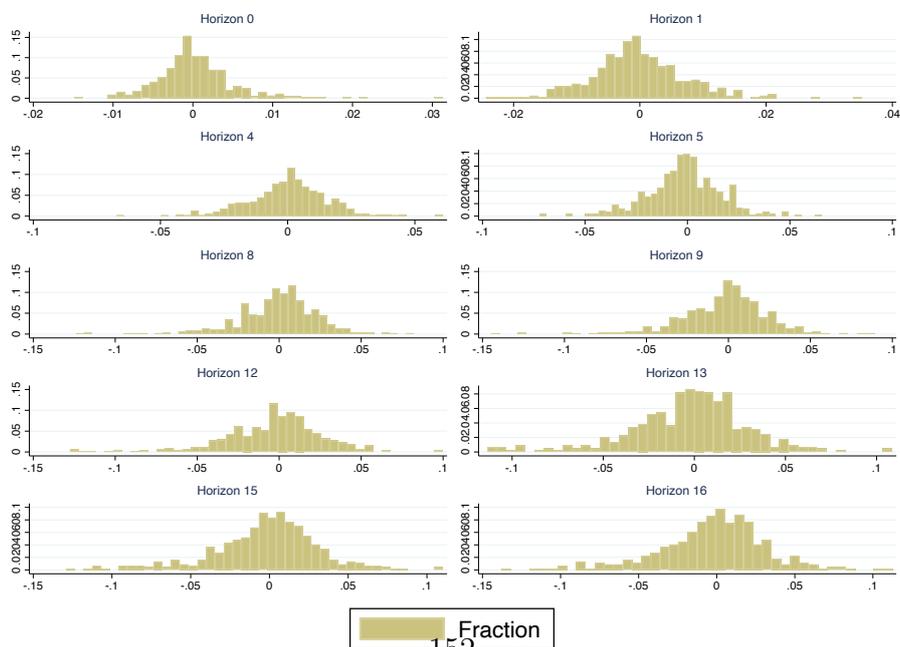
Appendix

Appendix 3.A Appendix Section 3.2

Figure 3.A.1: Heterogeneity in the Response of Liquidity Ratios to Monetary Shocks



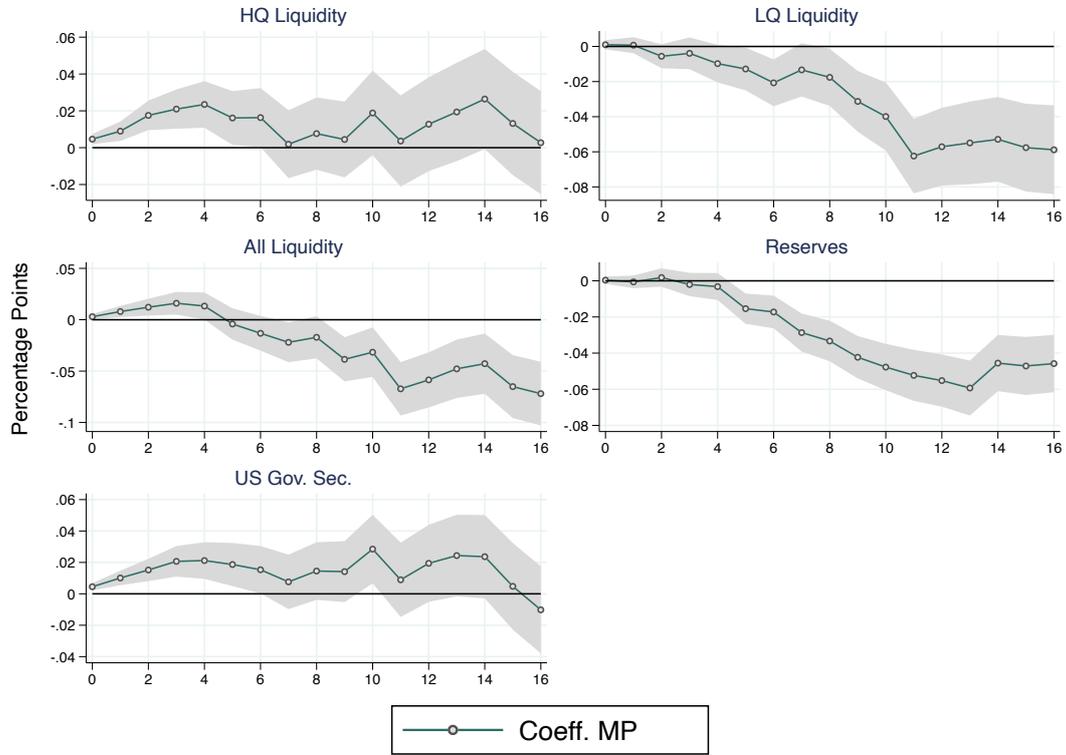
(a) HQ Liquidity Portfolio



(b) LQ Liquidity Portfolio

$$\Delta_h LR_{i,t+h}^j = f_i^h + \theta^h mp_t + \Gamma^h mp_t \tilde{X}_{i,t-1} + \Psi^h B_{i,t-1} + \varphi^h A_{t-1} + \epsilon_{i,t+h}^h \quad (3.10)$$

Figure 3.A.2: Unconditional Effect of Monetary Tightening Shocks into Liquidity Ratios



Notes: The graph shows estimated coefficients θ^h from specification (3.10). It represents the average response of the sample to monetary tightening shocks.

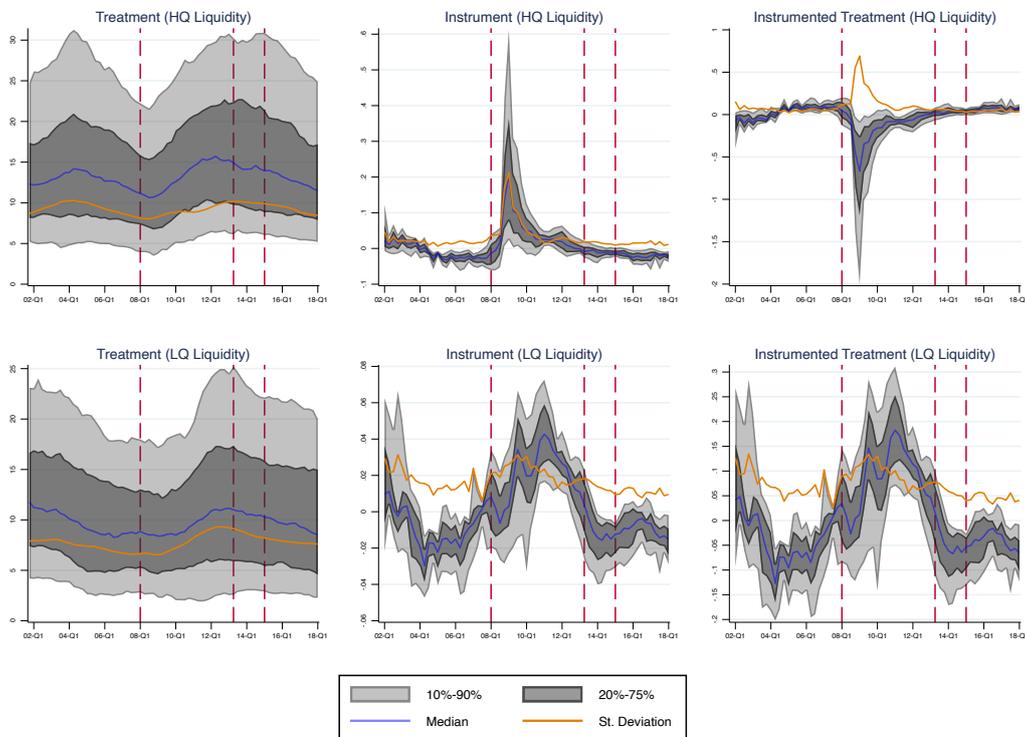
Appendix 3.B Appendix Section 3.3

3.B.1 Descriptive Statistics on the Bartik's Instruments

3.B.1.1 Heterogeneity in the Instruments

Does the instrumented treatment still provide enough variation across banks? Figure 3.B.1 presents cross-sectional heterogeneity of the liquidity ratios (Column 1), their instruments (Column 2), and the instrumented treatment (Column 3). Heterogeneity in Bartik's instruments (Column 2) indicates that asset-specific aggregate shocks affect total liquidity ratios differently. Intuitively, a bank with a predetermined portfolio allocation responds differently to asset-specific aggregate shocks.

Figure 3.B.1: Heterogeneity in Treatment, Instrument and Instrumented Treatment



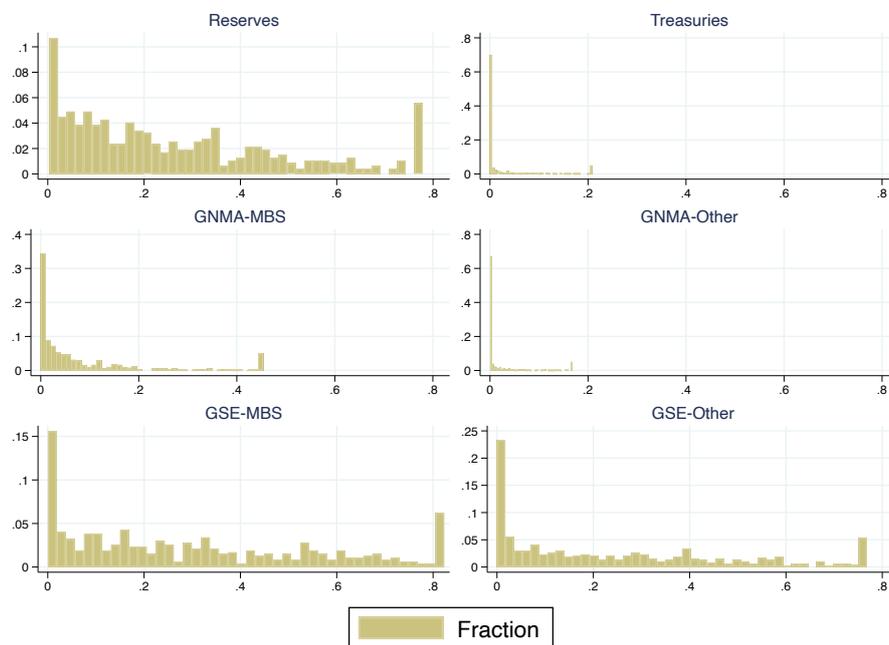
Notes: The graph shows the evolution of the 10, 25, 50, 75, and 90 percentiles and the standard deviation across No-LCR commercial banks for 2001q4-2018q1. Column 1 represents the liquidity ratios $LR_{i,t}^j$. Column 2 represents the Bartik instrument $z_{i,t}^j$ where the predetermined portfolio shares correspond to 2013q2. Column 3 is obtained regressing $LR_{i,t}^j$ on $z_{i,t}^j$ and bank-quarter-fixed effects. Vertical dashed lines indicate 2008q4, 2013q2, and 2015q1.

3.B.1.2 Relevance Condition

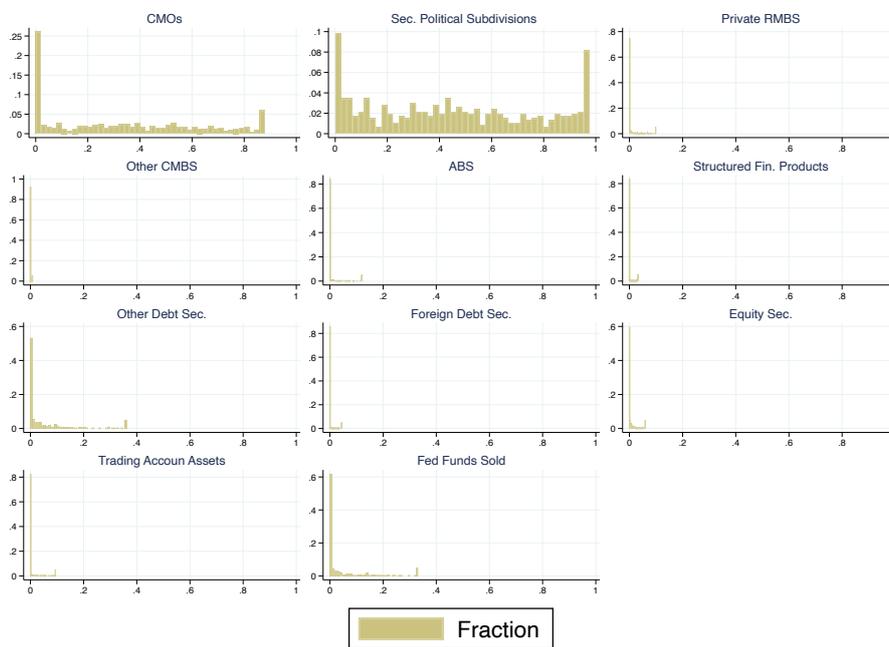
In line with the standard instrumental variable approach, a necessary condition for the validity of the instrument is that $\mathbb{E} [LR_{i,t}^j \cdot z_{i,t}^j | f_i, f_t] \neq 0$. Following Breuer (2021), this condition essentially requires:

Degree of persistence in the pre-determined shares: Figure 3.B.3 depicts the

Figure 3.B.2: Cross Sectional Heterogeneity in Predetermined Shares of Assets in 2013q2



(a) HQ Liquid Assets



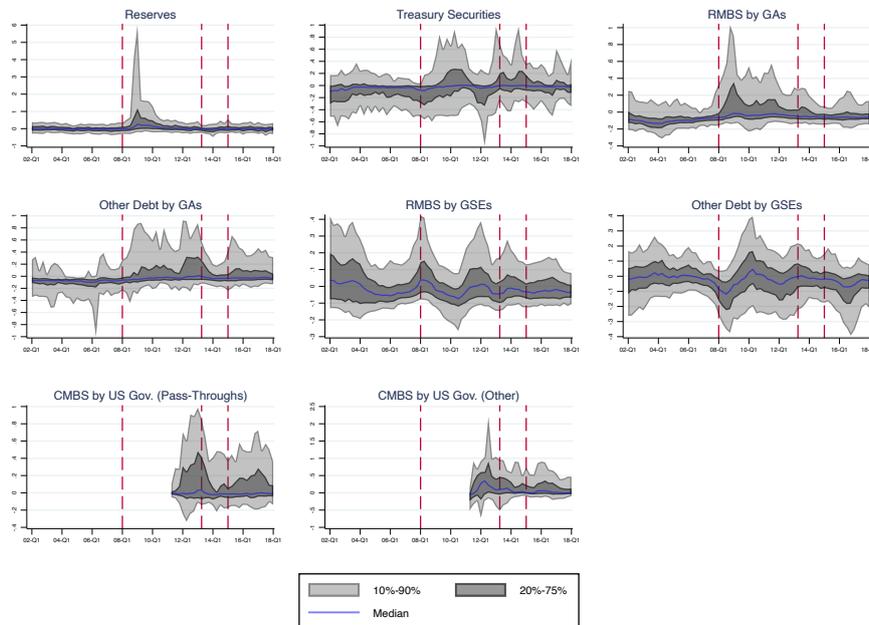
(b) HQ Liquid Assets

Notes: This figure depicts the predetermined shares of assets- a (w_i^a). The quarter of reference is 2013q2.

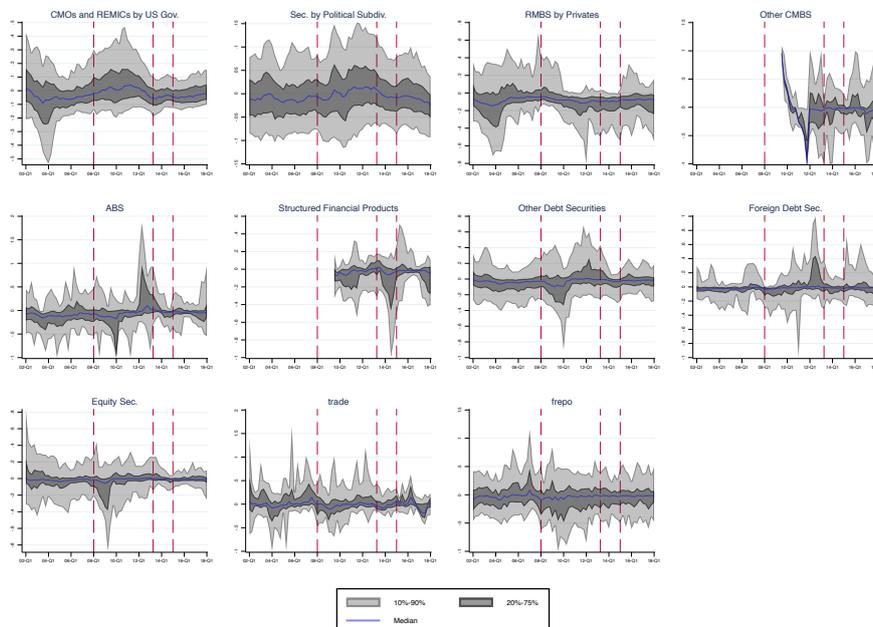
evolution of the portfolio shares for each asset type¹¹.

Commonality in the trend across units: Figure 3.B.4 depicts the cross-sectional heterogeneity in the growth rate of each asset- a (relative to the growth of total assets). Similarly, the common trend must predict the trend observed in individual units.

Figure 3.B.4: Cross-sectional Heterogeneity in Relative Growth Rates



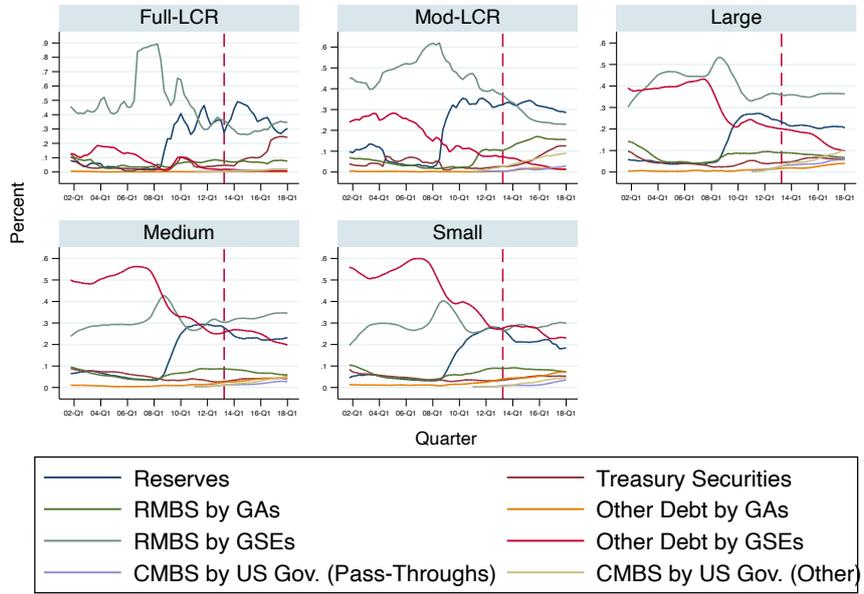
(a) HQ Liquidity Portfolio



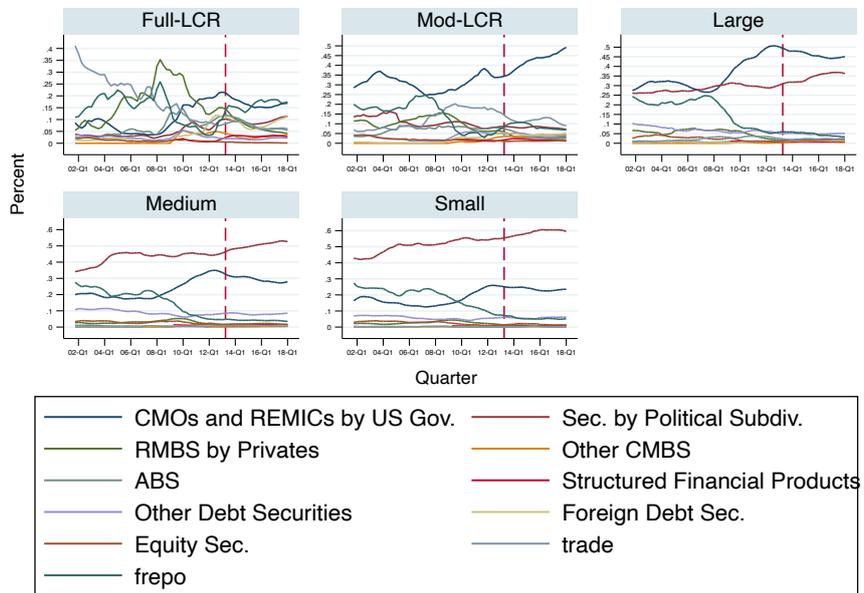
(b) LQ Liquidity Portfolio

¹¹In particular, the pre-determined shares must predict the actual shares during the sample period for the Bartik instrument to be relevant. Literature suggests not adjusting for limited persistence or commonality using the actual instead of the predetermined shares as the right-hand-side variation.

Figure 3.B.3: Time Series of the Liquidity Portfolio Shares by Bank Size



(a) HQ Liquidity Portfolio



(b) LQ Liquidity Portfolio

Proof 3.B.1 (Bartik Decomposition for Liquidity Ratios) *The treatment variation corresponds to the different liquidity ratios $j = \{HQLA, LQLA\}$. A decomposition for changes in liquidity ratios goes as follows:*

$$\frac{LA_{i,t}^j}{GTA_{i,t}} \equiv LR_{i,t}^j = \sum_{a \in LA^j} \frac{a_{i,t}}{GTA_{i,t}}$$

Subtracting $LR_{i,t-1}^j$,

$$\begin{aligned} LR_{i,t}^j - LR_{i,t-1}^j &= \sum_{a \in LA^j} \frac{a_{i,t}}{GTA_{i,t}} - \frac{a_{i,t-1}}{GTA_{i,t-1}} \\ \Delta LR_{i,t}^j &= \sum_{a \in LA^j} \frac{a_{i,t}}{GTA_{i,t}} - \frac{a_{i,t-1}}{GTA_{i,t-1}} \frac{GTA_{i,t}}{GTA_{i,t}} \\ &= \sum_{a \in LA^j} [a_{i,t} - a_{i,t-1}(1 + g_{i,t}^{GTA})] \frac{1}{GTA_{i,t}} \\ &= \sum_{a \in LA^j} [a_{i,t} - a_{i,t-1} - a_{i,t-1}g_{i,t}^{GTA}] \frac{1}{GTA_{i,t}} \\ &= \sum_{a \in LA^j} [a_{i,t-1}g_{i,t}^a - a_{i,t-1}g_{i,t}^{GTA}] \frac{1}{GTA_{i,t}} \\ &= \sum_{a \in LA^j} [a_{i,t-1} (g_{i,t}^a - g_{i,t}^{GTA})] \frac{1}{GTA_{i,t}} \end{aligned}$$

Dividing by $LR_{i,t-1}^j$,

$$\begin{aligned} \frac{\Delta LR_{i,t}^j}{LR_{i,t-1}^j} &= \frac{GTA_{i,t-1}}{LA_{i,t-1}^j} \sum_{a \in LA^j} [a_{i,t-1} (g_{i,t}^a - g_{i,t}^{GTA})] \frac{1}{GTA_{i,t}} \\ &= \sum_{a \in HQ} \frac{a_{i,t-1}}{LA_{i,t-1}^j} \frac{g_{i,t}^a - g_{i,t}^{GTA}}{1 + g_{i,t}^{GTA}} \\ &= \sum_{a \in LA^j} w_{i,t-1}^a \times \left(\frac{g_{i,t}^a - g_{i,t}^{GTA}}{1 + g_{i,t}^{GTA}} \right) \\ &= \sum_{a \in LA^j} w_{i,t-1}^a \times \tilde{g}_{i,t}^a \end{aligned}$$

where $\frac{g_{i,t}^a - g_{i,t}^{GTA}}{1 + g_{i,t}^{GTA}}$ is the rate of growth of asset- a relative to the rate of growth of total assets.

Bibliography

- [1] John C. Bluedorn, Christopher Bowdler, and Christoffer Koch. “Heterogeneous Bank Lending Responses to Monetary Policy: New Evidence from a Real-Time Identification”. In: *International Journal of Central Banking*, 13.1 (2017), pp. 95–149.
- [2] Matthias Breuer. “Bartik Instruments: An Applied Introduction”. In: *Journal of Financial Reporting, forthcoming* (2021). DOI: [10.2139/ssrn.3786229](https://doi.org/10.2139/ssrn.3786229).
- [3] James S. Cloyne, Òscar Jordà, and Alan M. Taylor. “State-Dependent Local Projections: Understanding Impulse Response Heterogeneity”. In: *Federal Reserve Bank of San Francisco, Working Paper Series*, 2023.05 (2023), pp. 1–58. DOI: [10.24148/wp2023-05](https://doi.org/10.24148/wp2023-05).
- [4] Jane Ihrig, Edward Kim, Ashish Kumbhat, Cindy Vojtech, and Gretchen C. Weinbach. “How Have Banks Been Managing the Composition of High-Quality Liquid Assets?” In: *Finance and Economics Discussion Series*, 2017.092 (2017), pp. 1–29. DOI: [10.17016/FEDS.2017.092](https://doi.org/10.17016/FEDS.2017.092).
- [5] Marek Jarociński and Peter Karadi. “Deconstructing Monetary Policy Surprises—The Role of Information Shocks”. In: *American Economic Journal: Macroeconomics*, 12.2 (2020), pp. 1–43. DOI: [10.1257/mac.20180090](https://doi.org/10.1257/mac.20180090).
- [6] Anil K. Kashyap, Raghuram Rajan, and Jeremy C. Stein. “Banks as Liquidity Providers: An Explanation for the Coexistence of Lending and Deposit-taking”. In: *The Journal of Finance*, 57.1 (2002), pp. 33–73. DOI: [10.1111/1540-6261.00415](https://doi.org/10.1111/1540-6261.00415).
- [7] Pablo Ottonello and Thomas Winberry. “Financial Heterogeneity and the Investment Channel of Monetary Policy”. In: *Econometrica*, 88.6 (2020), pp. 2473–2502. DOI: [10.3982/ECTA15949](https://doi.org/10.3982/ECTA15949).

Chapter 4

Liquidity Provision in a Simple Banking Model with Entry Barriers

4.1 Introduction

The Basel III regulatory framework introduces significant innovations that address liquidity management-related risks. Notably, two critical instruments, namely the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR), have been incorporated into the framework. These instruments aim to confront a behavior within the banking industry: banks systematically operate with substantial maturity mismatches, usually resulting in situations where they provide insufficient liquidity.

This characteristic is frequently called the “overinvestment problem,” a concept notably articulated in the classic trade-off presented by Diamond and Dybvig (1983). This trade-off involves choosing between short-term low-yielding assets and longer-term higher-yielding assets that may lack liquidity in the short run. Individuals grappling with this trade-off typically end up with suboptimal liquidity insurance. The causes of this suboptimality can vary and may stem from pecuniary externalities present in competitive markets (Geanakoplos and Walsh, 2018), sluggish payment systems under nominal contracts (Liu and Xie, 2021), moral hazard (Cooper and Ross, 1998) among other factors.

Different models have proposed various liquidity policies to address the overinvestment problem in the banking industry. For instance, some suggest that imposing liquidity ratios to limit long-term investments can be a welfare-improving intervention under certain conditions (e.g., Geanakoplos and Walsh, 2018). However, most policy recommendations have predominantly focused on enhancing the liquidity available through financial products. Often, there has been limited consideration of how these improvements, which could potentially increase the operational costs of financial institutions, might inadvertently reduce access to financial services. This leads to a fundamental question: Do the conventional strategies aimed at enhancing liquidity within the financial system push individuals to explore alternative savings options that might provide less favorable liquidity insurance?

This chapter is dedicated to exploring optimal liquidity provision in competitive economies, particularly emphasizing the impact of policies on access to banking services. I propose a model encompassing maturity mismatches, entry barriers, and systemic liquidity shocks

to achieve this. My approach builds upon the framework introduced by Cooper and Corbae (2002), incorporating aspects of maturity transformation as in Diamond and Dybvig (1983) and systemic liquidity shocks akin to Geanakoplos and Walsh (2018, among others).

Within this model, households with different levels of wealth experience preference shocks and must choose among two types of savings vehicles. They can save in cash, which functions as both a savings vehicle and a medium of exchange for consumption goods outside the traditional banking system. Alternatively, households use liquidity services offered by depository institutions. These services take the form of state-contingent claims on future consumptions. Ex-ante, cash does not provide worse liquidity insurance to households than deposits. However, access to the banking system might be beneficial because a) depository institutions have access to higher returns on investment, and b) households might lose purchasing power using cash.

Depository institutions act as credit intermediaries that raise funds through competitive deposit markets. To attract depositors, they must provide enticing, ex-ante, welfare-improving liquidity services. They achieve this by investing collected deposits in profitable lending opportunities and liquid assets. I assume an allocation rule such that each depositor receives equal consumption claims regardless of their initial wealth. Altogether, it implies that depository institutions in competitive markets must limit the entry of households into the banking system.

Two sources of inefficient liquidity provision emerge in the competitive economy under study. The first characterizes the efficiency of the banking system itself. Ex-ante liquidity provision of deposit contracts is sub-optimal due to aggregate uncertainty and market competition (in line with Geanakoplos and Walsh, 2018). The second one characterizes the efficiency outside of the banking system. Incentive compatibility constraints and market competition restrict the provision of deposit contracts, leading to the exclusion of a portion of the population, which must rely on the (limited) liquidity services offered by cash. In the model, the exclusion of some households from accessing banking services makes deposit contracts attractive for those with access to the financial system. Consequently, these individuals benefit from improved liquidity services through deposit contracts, while households lacking access resort to cash savings and are exposed to inflation.

In this chapter, I provide the proof of existence and the characterization of the incentive-compatible deposit contracts in the absence of runs in a competitive equilibrium framework. This framework should provide valuable insights into how some liquidity provision policies might enhance the liquidity insurance provided by the banking system while affecting the liquidity insurance available to households outside the banking system. The policy implications of these results have not yet been drawn but are briefly discussed in the conclusion. A proper analysis of these matters is left for further research.

Related Literature

This research relates to the literature on optimal liquidity provision by financial intermediaries. Most of the literature in this field has followed the influential work of Diamond and Dybvig (1983) in which the fundamental challenge is that investors typically seek high average returns on their investments but may face unexpected liquidity shocks, requiring

access to liquid assets before their long-term investments mature.

In Diamond and Dybvig (1983)'s framework, diverse assets enable an efficient, competitive equilibrium in which investors achieve optimal liquidity insurance. However, because liquidity needs are often private information or challenging to observe, competitive asset markets of this nature are likely to be limited. To tackle this issue, Diamond and Dybvig (1983) demonstrated that a standard bank deposit contract is incentive-compatible and sufficient for optimal insurance, even when liquidity needs are private information. However, their work highlighted a well-known side-effect of bank deposit contracts: multiple equilibria. While one equilibrium leads to optimal insurance, the other results in a bank run worse than financial autarky. While bank contracts solve the private information problem and improve liquidity provision, they introduce fundamental fragility in financial markets.

One branch of the literature builds upon this multiple equilibrium problem and studies bank runs or intermediary contracting problems. Cooper and Ross (2002) studies how deposit insurance is needed to avoid bank runs, while capital requirements are necessary to overcome the adverse incentive problems associated with providing deposit insurance. Other branches extend Diamond and Dybvig (1983)'s framework to highlight market conditions that can rule out the existence of an equilibrium with a bank run. For instance, in nominal economies, where nominal deposits serve as settlement tools (that is, are repayable in inside money), price adjustments in the goods market and a sufficient supply of money rule out the bank-run equilibria because funds are not drained out of the banking sector (Allen, Carletti, and Gale, 2009; Skeie, 2008). The validity of this result has been discussed in alternative nominal contract theories. For instance, Rivero-Leiva and Rodríguez-Mendizábal (2019), by incorporating endogenous money creation, shows that nominal deposit contracts are insufficient to implement the optimal amount of real liquidity. Similarly, in this line, Liu and He (2022) introduces the concept of real liquidity to highlight that payments by inside money and the consequential price-adjustment mechanism are neither sufficient to achieve socially optimal liquidity provision in the presence of real-liquidity shortages.

Beyond the bank-run equilibrium problem, another branch explores other inherent inefficiencies in competitive asset markets. For instance, Geanakoplos and Walsh (2018) provides a framework in which the overinvestment problem emerges from market incompleteness, not private information mechanism design. Alternative frameworks explore refinancing shocks and costly liquidations as the sources of inefficient precautionary liquidity holdings at banks (e.g., Holmström and Tirole, 1998; Kahn and Wagner, 2021).

4.2 Model

The economy comprises households, depository institutions (DIs), entrepreneurs, and a government. Agents live in two periods indexed by t and $t + 1$, and each period is divided into two sub-periods: day and night.

Households face two sources of uncertainty. On the one hand, they experience changes in their preference for consuming during periods 1 or 2. I assume there are two possible types of households. Early type (type-E) are impatient households who want to consume in period 1, while the late type (type-L) are patient households who prefer to consume in

period 2. Besides idiosyncratic uncertainty, a systemic component is inherent to households' preferences. I assume that there are two states of nature in the economy denoted by $s = \{1, 2\}$, such that state $s = 1$ is characterized by a larger fraction of type-E consumers relative to state $s = 2$. From a banking perspective, it can be interpreted as a systemic liquidity shock, and state $s = 1$ is the liquidity crisis state.

4.2.1 Households

Endowments

A new generation of households is born every period and lives for, at most, two periods. Each household- i is born with an endowment of $\alpha^i \in [\underline{\alpha}, \bar{\alpha}]$ units of a non-durable consumption good, which is private information and unverifiable. The distribution of endowments across the population is given by $H(\alpha)$. Denote $\hat{H}(\alpha) \equiv H(\bar{\alpha}) - H(\alpha)$.

Preferences

Households have preferences over consumption goods in only one of the two periods, and there is both idiosyncratic and aggregate uncertainty about types. Specifically, with probability π_s^E , households derive utility during the night of period t , while with probability π_s^L , households derive utility only in period $t + 1$. The probabilities of becoming early and late types change over the states of nature. The probability of observing aggregate state s is denoted by $\Pi_s \geq 0$. All in all, the preferences of households in generation t are given by:

$$\pi_s^E u\left(c_s^E\right) + \pi_s^L u\left(c_s^L\right) \quad (4.1)$$

where c_s^E and c_s^L are the consumption levels for early and late consumers, respectively, and $u(\cdot)$ represents the utility function over consumption. Assume that it is strictly increasing in consumption and (quasi) concave.

Saving choice

In the day of period t , all households have two ways of saving. They can deposit their endowment into a DI or store it until night, knowing they can transfer it using cash until the next period. Households who sign a deposit contract are named deposit holders, and those keeping their endowments are called non-deposit holders. Households will allocate their endowment before knowing their preferences so that their problem during the day of period t consists of choosing whether to deposit their endowments into the DIs to maximize their expected utility.

$$V_t^H(\alpha_t^i) = \max\{V_t^M(\alpha_t^i), V_t^D(\alpha_t^b)\} \quad (4.2)$$

where $V_t^M(\alpha_t^i)$ and $V_t^D(\alpha_t^b)$ are defined below.

4.2.1.1 Non-deposit Holders

Any household i not saving in a DI keeps its endowment until the night of period t . After its consumption preferences are revealed, type-E households immediately consume storage goods $C_{s,i}^{\text{NDE}} \leq \alpha^i$. In contrast, type-L non-depositors born at t sell their endowment at night in a decentralized (anonymous) goods market at a price p_t in exchange for cash. The cash received allows them to buy goods at price p_{t+1} during the following night goods

market. Hence, they consume $C_{s,i}^{\text{NDL}} \leq \alpha^i \frac{p_t}{p_{t+1}} \equiv \varphi \alpha^i$. Notice that cash is being held by type-L non-depositors born at $t - 1$. Finally, a non-depositor i born at time t choosing to save through the holding of cash has the following ex-ante lifetime utility:

$$V^M(\alpha^i) = \sum_{s=1}^S \Pi_s \left[\pi_s^E u\left(C_{s,i}^{\text{NDE}}\right) + \pi_s^L u\left(C_{s,i}^{\text{NDL}}\right) \right] \quad (4.3)$$

4.2.1.2 Deposit Holders

For a household- i choosing to deposit its initial endowment into a DI, it agrees to state and type contingent consumption contracts: $\mathcal{C}_s = \left(C_s^{\text{DE}}, C_s^{\text{DL}}\right) \forall s \in S$. Deposit contracts are real claims on future consumption that are not household-specific. These contracts can be attractive because they allow households to invest in profitable entrepreneurial projects. By themselves, monitoring entrepreneurs is too costly.

Once night arrives, consumption preferences are revealed, and type-E depositors obtain C_s^{DE} units of goods delivered by the DI. In contrast, type-L depositors claim C_s^{DL} units of consumption at time $t + 1$. Any depositor- i born at time t choosing to save through a DI has the following ex-ante lifetime utility:

$$V^D(\alpha^b) = \sum_{s=1}^S \Pi_s \left[\pi_s^E u\left(C_s^{\text{DE}}\right) + \pi_s^L u\left(C_s^{\text{DL}}\right) \right] \quad \forall i \quad (4.4)$$

where α^b is the endowment of the household- b with the lowest endowment accepted in a DI, which refers to the size of the financial intermediary.

4.2.2 Depository Institutions

A new generation of depository institutions is formed every period and lives for two periods. The DIs have no endowments, but unlike households, they can collect endowments from multiple households during the day and, by assumption, credibly commit to paying off. Given the preference shocks previously described, portfolio and contract decisions must be made without knowing the distribution of types at night of period t .

The DIs collect deposits $D_{\alpha^b} \equiv \int_{\alpha^b}^{\bar{\alpha}} \alpha^i dH(\alpha^i)$ from households in competitive markets during the day. Households simultaneously decide whether or not to deposit their endowments in exchange for a deposit contract. These contracts are real claims stipulating a type-specific and state-specific return of $\mathcal{C}_s \equiv \left(C_s^{\text{DE}}, C_s^{\text{DL}}\right)$ for any state of nature $s \in S$.

Once the DIs collect deposits, they allocate resources between two types of investments. First, short-term liquid investment is denoted by \mathcal{X} , which gives a risk-free real return of $R^{\mathcal{X}} = 1$ at night (storage capacity)¹. Second, the DIs can finance entrepreneur's projects, which are long-term illiquid investments denoted by \mathcal{Y} . Lending to entrepreneurs returns $R^{\mathcal{Y}} > 1$ in period $t + 1$. In particular, this investment is risky since entrepreneurs' profits are private information, so loans are defaultable. However, if DIs incur a monitoring cost Γ , the DIs ensure that entrepreneurs do not claim investment failures to avoid obligations

¹Since deposits are completely invested at $t = 0$ (no initial consumption), it is without loss of generality to fix the short-term return at 1 (see Geanakoplos and Walsh, 2018)

to the intermediary. Finally, besides these two investment opportunities, the DIs own a transferring technology denoted by \mathcal{X}'_s that allows them to reallocate resources freely across periods. Specifically, after the state of the economy is revealed, the DIs can use gains from the liquid asset and transfer them to the next day.

The DIs compete for endowments in a competitive market, maximizing depositors' utility in equilibrium to attract them. Given the collected amount of deposits, monitoring costs, the returns on investments, and deposit contracts offered by other DIs, each DI must maximize the depositors' expected utility by offering consumption contracts C_s^{DE} and C_s^{DL} and choosing the optimal portfolio $(\mathcal{X}, \mathcal{X}'_s, \mathcal{Y})$. The DIs optimization problem is as follows

$$V^D(\alpha^b) = \underset{\{C_s^E, C_s^L, \mathcal{X}'_s\}_{s=1}^S, \mathcal{X}, \mathcal{Y}}{\text{maximize}} \sum_{s=1}^S \Pi_s [\pi_s^E u(C_s^{\text{DE}}) + \pi_s^L u(C_s^{\text{DL}})] \quad (4.5a)$$

subject to

$$\pi_s^E C_s^{\text{DE}} \hat{H}(\alpha^b) + \mathcal{X}'_s \leq \mathcal{X} \quad \forall s, \quad (4.5b)$$

$$\pi_s^L C_s^{\text{DL}} \hat{H}(\alpha^b) \leq R^y \mathcal{Y} + \mathcal{X}'_s \quad \forall s, \quad (4.5c)$$

$$\mathcal{X}'_s \geq 0 \quad ; \quad \mathcal{X} \geq 0 \quad ; \quad \mathcal{Y} \geq 0, \quad (4.5d)$$

$$D_{\alpha^b} = \int_{\alpha^b}^{\bar{\alpha}} \alpha^i dH(\alpha) = \mathcal{X} + \mathcal{Y} + \Gamma \quad (4.5e)$$

The solution to the DI's problem is summarized in the following lemma.

Lemma 4.2.1 (The DIs' Optimal Choice) *For any given DI's size α^b ,*

1. *The DIs' optimal investment in short-term liquid assets \mathcal{X}^\bullet is determined within the regions:*

$$\mathcal{X}^\bullet = \begin{cases} 0 < \mathcal{X} \leq \Omega_2 & \text{iff } R^y \geq \hat{R}^y \\ \Omega_2 < \mathcal{X} < D_{\alpha^b} - \Gamma & \text{iff } R^y < \hat{R}^y \end{cases} \quad (4.6)$$

with $\Omega_s \equiv \frac{D_{\alpha^b} - \Gamma}{1 + \frac{\pi_s^L}{\pi_s^E} \frac{1}{R^y}} \forall s$ and \hat{R}^y solving equation (4.48).

(a) *In the region $\mathcal{X}^\bullet = (0, \Omega_2]$, the optimal liquidity \mathcal{X}^\bullet is determined by*

$$u' \left(\frac{\mathcal{X}^\bullet}{\pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_1^L \hat{H}(\alpha^b)} \right) = \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{\mathcal{X}^\bullet}{\pi_2^E \hat{H}(\alpha^b)} \right) \quad (4.7)$$

and consumption contracts

$$C_1^{\text{DE}} < C_2^{\text{DE}} \leq C_2^{\text{DL}} < C_1^{\text{DL}} \quad (4.8)$$

holding with equality if and only if $\mathcal{X}^\bullet = \Omega_2$.

(b) *In the region $\mathcal{X}^\bullet = (\Omega_2, \Omega_1)$, the optimal liquidity \mathcal{X}^\bullet is determined by*

$$u' \left(\frac{\mathcal{X}^\bullet}{\pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_1^L \hat{H}(\alpha^b)} \right) = \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{R^y (D_{\alpha^b} - \Gamma) - \mathcal{X}^\bullet (R^y - 1)}{\hat{H}(\alpha^b)} \right) \quad (4.9)$$

the optimal transferring in liquidity abundant state ($s=2$) is

$$\mathcal{X}_2^\bullet = (1 + \pi_2^E(R^y - 1))(\mathcal{X}^\bullet - \Omega_2) > 0 \quad (4.10)$$

and consumption contracts

$$C_1^{DE} < C_2^{DE} = C_2^{DL} < C_1^{DL} \quad (4.11)$$

2. DIs' optimal investment in long-term assets is:

$$\mathcal{Y}^\bullet = D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet \quad (4.12)$$

Proof 4.2.1 See Appendix 4.B

Lemma 4.2.1 defines the optimal strategy of depository institutions in this economy. The DIs' solution consists of an investment strategy that balances the gains from offering consumption smoothing in response to preference shocks (smoothing effect) and the gains from increasing total returns by investing in the profitable illiquid asset (wealth effect). This trade-off depends on the return on long-term assets R^y . When R^y is relatively low, the smoothing effect dominates. The best the DIs can do is invest enough liquid assets to cover all type-E depositors in the liquidity shortage state ($s=1$). Hence, in case state 2 realizes, the DIs use the transferring technology. In contrast, when the return on lending is sufficiently high, the wealth effect dominates. Therefore, the DIs never use the transferring technology in any state and, in contrast, choose an investment strategy in which all of the proceeds from liquid assets are distributed among type-E depositors and all the proceeds from illiquid assets among type-L depositors².

Finally, as shown in Appendix 4.B.5, when the wealth effect dominates, the optimal DI size is determined by the condition $D_{\alpha^\bullet} - \Gamma = \alpha^\bullet \hat{H}(\alpha^\bullet)$. Notice that the optimal deposit amount is independent of the investment strategy. Moreover, by the Markov inequality, the total net deposits are lower than the average endowment in the economy μ_α .

Timing of Events

The timing of events of the model (summarized in Figure 4.2.1) is as follows.

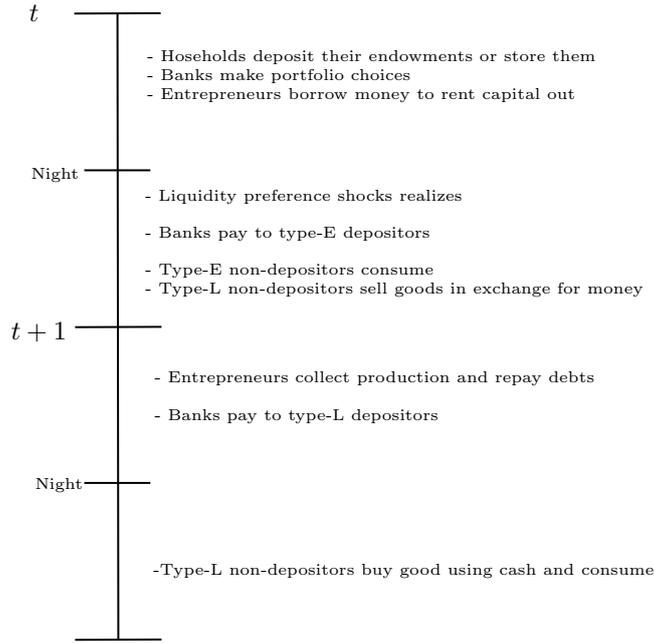
Period t - Morning: The DIs offer the deposit contract to households. Households decide whether to deposit their endowments into DIs or store them until night. This use collected endowments to invest in long-term projects \mathcal{Y} or their storable technology \mathcal{X} . Entrepreneurs finance production using loanable funds from the DIs.

Period t - Night: Households preferences are realized (uncertainty is resolved). Impatient (type-E) depositors claim consumption goods from deposit contracts, and the DIs honor early-type contracts using resources saved through the storable technology. Impatient non-depositors consume their stored endowments. The government makes decisions. Patient (type-L) non-depositors sell their endowments in the goods market at price p_t .

Period $t + 1$ - Night: Return on long-term projects R^y is realized. Patient depositors claim consumption from deposit contracts. Patient non-depositors buy consumption goods in the goods market at price p_{t+1} .

²The solution of DIs' problem coincides with the socially optimal allocation of Liu and Xie (2021) for a version of their model in which the same liquidity shocks are included.

Figure 4.2.1: Time of Events



4.2.3 Entrepreneur

There is a representative risk-neutral entrepreneur born at t . The entrepreneur buys k_t units of raw capital at time t from foreign capital producers at the exogenous price p_t^k . She uses capital at time t to produce $f(k_t)$ units of final good at the beginning of period $t + 1$. Production occurs with a lag, so the entrepreneur must obtain funds from the DIs at the interest rate $R^y > 1$. If the entrepreneur succeeds in obtaining the funds, she produces and honors its debt at period $t + 1$. Entrepreneur's profits are private information, so loans are defaultable unless the investor pays a monitoring cost Γ .

Entrepreneurs maximize profits obtained at period $t + 1$:

$$\max_{k_t} f(k_t) - R^y p_t^k k_t \quad (4.13)$$

The entrepreneur consumes the excess from production in the end, and due to perfect competition, profits are null.

4.2.4 Government

During the night of period t and after preferences of generation t are revealed, the government can intervene in the goods market. The government can issue or withdraw cash and uniformly distribute it among type-L non-depositors of generation $t - 1$. In case of a monetary expansion, the government injects cash proportional to the amount held by generation $t - 1$ late non-depositors: $g_t(s^t) M_{t-1}^s$. In a monetary contraction, the government withdraws cash from type-L non-depositors of generation $t - 1$. A passive government intervention is defined as $g_t = 0 \forall t$. The government's budget constraint is

$$T_t(s^t) = \frac{g_t(s^t) M_{t-1}^s}{p_t} \quad (4.14)$$

4.2.5 Market Clearing Conditions

In the capital market, the clearing condition is defined by $k_t^d = k_t^s$, which implies that:

$$p_t^k = \frac{f'(\bar{K})}{R^y} \quad (4.15)$$

In the credit market, lending supply is defined by the DIs' optimal choice, while entrepreneurs' behavior defines lending demand. Hence, the condition for clearing is $p_t^k k_t^d = \mathcal{Y}_t$, which implies:

$$R^y = \frac{f'(\bar{K})\bar{K}}{D_{\alpha^b} - \Gamma - \mathcal{X}} > 1 \quad (4.16)$$

In the goods market, at night of period t , a fraction $\pi^L(s^t)$ of non-depositors sell their goods in the goods market at price p_t . The total cash supply during night- t will be $M_t^s = (1 + g_t(s^t))M_{t-1}^s$, where M_{t-1}^s is cash held by type-L non-depositors of generation $t - 1$ after the government intervention. The market clearing condition in the good markets is

$$p_t = \frac{M_t^s}{\pi^L(s^t) \int_1^{\alpha_{bt}} \alpha^i dH(\alpha)} \quad (4.17)$$

Computations are left in Appendix 4.C.

4.2.6 Equilibrium with Passive Government

I focus on interior steady states equilibrium in which money is held and the DIs exist. The set of equilibrium analyzed is characterized by no incentives to run, optimism about the capacity of DIs to collect deposits, and passive government intervention.

Definition 4.2.1 (Competitive Optimistic No-run Equilibrium) *A competitive equilibrium is a collection of deposit contracts $\{C_s^{\text{DE}*}, C_s^{\text{DL}*}\}$, prices $\mathbf{p}_t \equiv \{p_t, p_{t+1}, R^y, p^k\}$, and a banking size α_t^* such that:*

1. *The portfolio allocation $(\mathcal{Y}^*, \mathcal{X}^*)$, the deposit contracts $(C_s^{\text{DE}*}, C_s^{\text{DL}*}) \forall s \in S$ and the optimal size α^* :*
 - (a) *Solve the DIs' problem (4.5).*
 - (b) *Incentive compatible: There exists at least one $\alpha^b = \alpha^*$ such that $V^D(\alpha^*) \geq V^M(\alpha^i) \forall i \in [\alpha^*, \bar{\alpha}]$.*
 - (c) *No-runs: Patient depositor has no incentives to claim early type consumption contracts $\frac{p_t}{p_{t+1}} C_s^{\text{DE}*} \leq C_s^{\text{DL}*} \forall s$*
2. *Markets clear*
 - (a) *The price p^k clear the capital market for all $s \in S$: $k_t^d = k_t^s$*
 - (b) *The rate R^y clears the credit market for all $s \in S$: $p_t^k k_t^d = \mathcal{Y}_t^*$, and $R^y > 1$.*
 - (c) *Price p_t clears the goods market $\forall t$.*

Definition 4.2.1 tells that an optimal investment portfolio $(\mathcal{X}^*, \mathcal{Y}^*)$ and the size of the banking sector α^* must be consistent with all optimality conditions, markets clearance, and the no-run condition. Furthermore, it has to be compatible with the outside option of depositors so that banks can credibly promise contracts that attract the optimal amount of depositors³.

Notice that a solution in the region $\mathcal{X}^\bullet > \Omega_2$ is never optimal when the gap between π_2^E and π_1^E is small ($\pi_2^E \rightarrow \pi_1^E \Leftrightarrow \pi_2^L \rightarrow \pi_1^L$) (See Appendix 4.B.3). Henceforth, in the further analysis, I focus on the situation in which π_2^E and π_1^E are close, and thus the optimal investment always falls in the regions $\mathcal{X}^\bullet \leq \Omega_2$.

Proposition 4.2.1 (Existence) *A competitive equilibrium exists in region $\mathcal{X}^\bullet \in (0, \Omega_2]$.*

Proof 4.2.2 *See Appendix (4.D.1) ■*

Intuitively, Proposition 4.2.1 stems from the following. The DIs collect deposits up to the optimal amount and invest net deposits in liquid and illiquid assets following the optimal strategies in Lemma 4.2.1. The loan interest rate adjusts for a given portfolio allocation until the credit market clears. The optimal portfolio allocation denoted $\{\mathcal{X}^\bullet, \mathcal{Y}^\bullet, \alpha^\bullet\}$ generates the maximum ex-ante utility that a DI can provide in the competitive equilibrium. However, this solution's feasibility depends on whether the deposit contracts are incentive-compatible with the outside option: cash. To prove this is enough to show that the DIs' optimal deposit collection α^\bullet is a size that respects the compatibility constraint, that is $V^D(\alpha^\bullet) \geq V^M(\bar{\alpha})$. This condition is fulfilled for sufficiently high values of the interest rate relative to the inflation rate. In other words, the deposit contracts provide better insurance than cash. Finally, as shown in Appendix 4.D.1.2, the existing equilibrium satisfies the non-run condition.

Two characteristics of this economy are worth noting. First, even if DIs provide better insurance than cash, deposit contracts in the competitive equilibrium are ex-ante constrained inefficient, and all DIs could be better off by collectively allocating more to the short-term asset (See Appendix 4.D.2). As in Geanakoplos and Walsh (2018), the source of inefficiency results from a classic overinvestment problem. The DIs facing aggregate uncertainty invest too much in illiquid assets; therefore, the equilibrium interest rate is low⁴.

Second, since households are optimistic about the DIs formation, profit-maximizing criteria under perfect competition is the fundamental force determining the optimal size of the banking sector. In proposition 4.2.1, the optimal size α^\bullet is incentive-compatible when lending is profitable. However, that proposition does not rule out other sizes $\tilde{\alpha} \geq \alpha^\bullet$ that can also be incentive-compatible $V^D(\tilde{\alpha}) \geq V^M(\bar{\alpha})$. This distinction is particularly relevant for the analysis of optimal liquidity.

Suppose, for instance, that deposit contracts are still incentive compatible for a smaller size $\tilde{\alpha} < \alpha^\bullet$. At this hypothetical compatible size, the economy will gather a larger fraction of households relative to the competitive solution. Although the DIs never choose this $\tilde{\alpha}$ due to market competition, operating with $\tilde{\alpha}$ can be socially optimal since fewer households will rely on cash as a saving vehicle. Since the size is still incentive-compatible

³Notice that black dots denote DIs' optimal quantities, while stars denote competitive equilibrium quantities.

⁴The reader can find the DIs problem without aggregate uncertainty in Appendix 4.F.

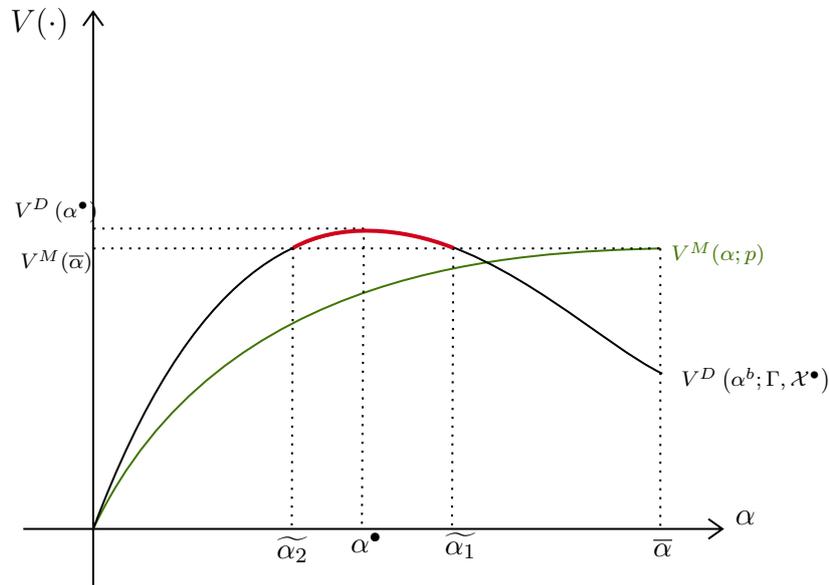
for all depositors, the welfare gains might come since a larger fraction of households benefit from the better liquidity insurance offered by the DIs.

To illustrate this point, consider the case when a log-utility function defines preferences. Corollary 4.2.1 summarized the optimal solutions under this case. First, equation (4.18) and (4.19) determines the optimal DI's investment decision. The optimal fraction of the collected deposits net of fixed cost invested in liquid assets equals the expected fraction of type-E depositors. Notably, due to constant relative risk aversion, if the DIs experience an increase in net deposits, they will choose to keep the fraction of the portfolio in liquid assets unchanged. Under this investment strategy, a DI can offer consumption contracts in equations (4.20), which yields the ex-ante utility in (4.21).

In equilibrium, the market interest rate is determined by $R^y = \frac{f'(\bar{K})\bar{K}}{\bar{\pi}^L(D_{\alpha^\bullet} - \Gamma)}$, which implies that the ex-ante utility of depositors is determined by the left-hand-side of equation (4.22). This equilibrium incentive compatibility condition is depicted in Figure 4.2.2 and illustrates the main characteristic of this model. While the solution α^\bullet yields the maximum incentive-compatible utility that a DI can offer depositors, other sizes might also be incentive-compatible.

For instance, consider a DI collecting deposits up to $D_{\tilde{\alpha}_2}$. This size allows DIs to provide a level of utility equivalent to $V^D(\tilde{\alpha}_2) = V^M(\bar{\alpha})$, which is lower than the one determined in competitive equilibrium $V^D(\alpha^\bullet)$. Although this size yields lower welfare for depositors in $[\alpha^\bullet, \bar{\alpha}]$, households between $[\tilde{\alpha}_2, \alpha^\bullet)$ experience welfare improvements due to access to the financial system.

Figure 4.2.2: Incentive Compatible Deposit Contracts



Note: This figure illustrates the intuition of the existence of the competitive equilibrium when the log-utility function represents preferences. α^\bullet is the optimal size chosen by the bank. $\tilde{\alpha}$ is a size that makes indifferent the richest households join the DI. Both can coincide in equilibrium depending on the parameters.

Corollary 4.2.1 (Log-Utility Example) *Suppose log-utility function, the DIs' optimal solution in the region $\mathcal{X}^\bullet \in (0, \Omega_2]$ are*

1. Optimal investment is

$$\mathcal{X}^\bullet = \bar{\pi}^E (D_{\alpha^\bullet} - \Gamma) \quad (4.18)$$

2. Optimal size is determined by

$$\Gamma = D_{\alpha^\bullet} - \alpha^\bullet \hat{H}(\alpha^\bullet) \quad (4.19)$$

3. Consumption contracts are

$$C_t^{\text{DE}}(s^t) = \frac{\bar{\pi}^E}{\pi_s^E} \alpha^\bullet; \quad C_{t+1}^{\text{DL}}(s^t) = \frac{\bar{\pi}^L}{\pi_s^L} R^y \alpha^\bullet \quad (4.20)$$

4. Ex-ante utility is

$$V^D(\alpha^\bullet; R^y) = \log(\alpha^\bullet) + \bar{\pi}^L \log(R^y) + \sum_{s=1}^S \Pi_s \left\{ \pi_s^E \log\left(\frac{\bar{\pi}^E}{\pi_s^E}\right) + \pi_s^L \log\left(\frac{\bar{\pi}^L}{\pi_s^L}\right) \right\} \quad (4.21)$$

5. The incentive compatibility condition in equilibrium $V^D(\alpha^\bullet; \Gamma, \mathcal{X}^\bullet) \geq V^M(\alpha^i; \varphi)$

$$\begin{aligned} \bar{\pi}^E \log(\alpha^\bullet) - \bar{\pi}^L \log(\hat{H}(\alpha^\bullet)) + \sum_{s=1}^S \Pi_s \left\{ \bar{\pi}^L \log\left(\frac{f'(\bar{K})\bar{K}}{\bar{\pi}^L}\right) + \pi_s^E \log\left(\frac{\bar{\pi}^E}{\pi_s^E}\right) + \pi_s^L \log\left(\frac{\bar{\pi}^L}{\pi_s^L}\right) \right\} \\ \geq \log(\bar{\alpha}) + \bar{\pi}^L \log(\varphi) \end{aligned} \quad (4.22)$$

Proof 4.2.3 See Appendix (4.E) ■

4.3 Conclusion

This chapter proposes a model in which the liquidity efficiency of financial markets interacts with the limited access to financial services. Depository institutions provide incentive-compatible deposit contracts that improve the welfare of households within the financial system. However, the benefits of deposit contracts are only extended to a fraction of the population due to market competition. Households outside the financial system use cash, a saving vehicle that provides ex-ante worse liquidity insurance.

This model is well-suited for analyzing how specific policy interventions can enhance the liquidity insurance provided by depository institutions and how these enhancements intersect with access to financial systems. In this regard, this work leaves several interesting avenues for future research. The following is a list of remarks and potential extensions that could enrich the contribution of this research.

Policy Analysis

The next natural step will be to study the implications of different policy implementations through the lenses of the baseline model.

On the one hand, as traditional in the literature, I can explore the policies that can improve the ex-ante welfare of depositors. This can be reached by including reserves requirements in the model $M^b \geq \delta D_{\alpha^b}$, or liquidity coverage ratios $\frac{M^b + \mathcal{X}}{\delta D_{\alpha^b}} \geq 1$, where δ is the fraction of deposits must be held in reserves (cash) or high-quality liquid assets. By altering the trade-off between profiting from investing in illiquid assets (lending) and incurring greater liquidity risk, from Geanakoplos and Walsh (2018), I expect deposit contracts to improve welfare.

A more challenging direction might be considering policies that improve ex-ante welfare by reducing consumption inequality between cash holders and depositors. In that sense, the objective will be to consider liquidity provisions beyond financial products' liquidity efficiency. The ultimate aim will be to determine whether some government interventions can improve the welfare properties of the deposit contract and simultaneously limit or enhance access to depository institutions.

Optimistic Equilibrium

In the baseline setting, I abstract from the coordination problems by assuming that households are always optimistic about the DIs' capacity to collect enough deposits to provide enough ex-ante utility (to become profitable). Therefore, α^b in equilibrium reflects DIs' decisions and market rates. An interesting extension would be to consider a version of the model where participation in the DIs is driven by the coordination of households and their confidence in the DIs. Notably, in this model, this might emerge due to the timing of the collection of deposits. Households deposit their endowments without knowing how many deposits the bank operates. Therefore, beliefs about the ability of banks to attract depositors might generate strategic complementarities among depositors.

Cooper and Corbae (2002) studies this case where the size of a "coalition of agents" is determined through non-cooperative games in equilibrium. Under this form of the game, the coalition's capacity to reach the optimal size is determined by sunspots.

Non-zero Profits

Notice that because the DIs propose state-contingent consumption claims, they distribute all revenues among depositors (zero profits) in all states: the liquidity-abundant and the liquidity-shortage state.

Nevertheless, a potential scenario where profits could arise involves a situation where DIs can operate at a smaller scale compared to the optimal size that remains incentive compatible ($\tilde{\alpha} > \alpha^\bullet$). Due to market competition, this case is typically ruled out. Yet, let's consider a scenario where DIs have the option to deviate from the competitive norm and "cooperate." In this case, the DIs can collect deposits equivalent to D_{α^\bullet} and generate $V^D(\alpha^\bullet)$ in value; however, they only redistribute consumption equivalent to $V^D(\tilde{\alpha})$. Under these circumstances, the DIs can extract a surplus of $\mathcal{SP} \equiv V^D(\alpha^\bullet) - V^D(\tilde{\alpha}) > 0$.

Appendix

Appendix 4.A Assumptions

Assumption 4.A.1 (Liquidity-shortage state) *State 1 is defined as the liquidity shortage state*

$$\pi_1^E > \pi_2^E \Rightarrow \Omega_2 < \Omega_1$$

.

Assumption 4.A.2 (Distribution of Patient and Impatient Households) $\bar{\pi}^E < \bar{\pi}^L$; with $\bar{\pi}^E \equiv \mathbb{E}_s \pi_s^E = \sum_{s=1}^S \Pi_s \pi_s^E$.

From assumptions 4.A.1 and 4.A.2 imply that $\pi_2^E < \frac{1}{2}$.

Proof 4.A.1

$$\begin{aligned} \mathbb{E}_s \pi_s^E &< \mathbb{E}_s \pi_s^L \\ \mathbb{E}_s \pi_s^E &< \mathbb{E}_s(1 - \pi_s^E) \\ \mathbb{E}_s \pi_s^E &< \frac{1}{2} \\ \Pi_1(\pi_1^E - \pi_2^E) &< \frac{1}{2} - \pi_2^E \end{aligned} \tag{4.23}$$

Given that $\pi_1^E > \pi_2^E$, hence $\frac{1}{2} > \pi_2^E$ ■.

Assumption 4.A.3 $u(\cdot)$ has the following properties:

$$u'(c) > 0, \quad u''(c) < 0, \quad \lim_{c \rightarrow 0} u'(c) = \infty, \quad \lim_{c \rightarrow \infty} u'(c) = 0$$

and the coefficient of relative risk aversion:

$$\varepsilon = -c \frac{u''(c)}{u'(c)} \geq 1$$

Appendix 4.B Solution of the DI's Problem

Rewriting the DI's problem

$$V^D(\alpha^b) = \underset{\{C_s^E, C_s^L, \mathcal{X}'_s\}_{s=1}^S, \mathcal{X}, \mathcal{Y}}{\text{maximize}} \quad \sum_{s=1}^S \Pi_s [\pi_s^E u(C_s^{\text{DE}}) + \pi_s^L u(C_s^{\text{DL}})] \quad (4.24a)$$

subject to

$$\pi_s^E C_s^{\text{DE}} \hat{H}(\alpha^b) + \mathcal{X}'_s \leq \mathcal{X} \quad \forall s, \quad (4.24b)$$

$$\pi_s^L C_s^{\text{DL}} \hat{H}(\alpha^b) \leq R^y \mathcal{Y} + \mathcal{X}'_s \quad \forall s, \quad (4.24c)$$

$$\mathcal{X}'_s \geq 0 \quad ; \quad \mathcal{X} \geq 0 \quad ; \quad \mathcal{Y} \geq 0, \quad (4.24d)$$

$$D_{\alpha^b} = \int_{\alpha^b}^{\bar{\alpha}} \alpha^i dH(\alpha) = \mathcal{X} + \mathcal{Y} + \Gamma \quad (4.24e)$$

The proof of lemma 4.2.1 consist on three regions in which the DIs are willing to operate. In order to characterize these regions, let's first define the optimality conditions of problem (4.5):

$$\begin{aligned} \mathcal{L} = \sum_{s=1}^S \Pi_s \{ & \pi_s^E u(C_s^{\text{DE}}) + \pi_s^L u(C_s^{\text{DL}}) \\ & + \lambda_s^E [\mathcal{X} - \pi_s^E \hat{H}(\alpha^b) C_s^{\text{DE}} - \mathcal{X}'_s] \\ & + \lambda_s^L [R(D_{\alpha^b} - \mathcal{X} - \Gamma) + \mathcal{X}'_s - \pi_s^L \hat{H}(\alpha^b) C_s^{\text{DL}}] + \Lambda_s \mathcal{X}'_s \} \end{aligned}$$

The first-order conditions are:

$$[C_s^{\text{DE}}] \quad u'(C_s^{\text{DE}}) = \lambda_s^E \hat{H}(\alpha^b) \quad \forall s \quad (4.25)$$

$$[C_s^{\text{DL}}] \quad u'(C_s^{\text{DL}}) = \lambda_s^L \hat{H}(\alpha^b) \quad \forall s \quad (4.26)$$

$$[\mathcal{X}] \quad \sum_{s=1}^S \Pi_s (\lambda_s^E - \lambda_s^L R^y) = 0 \quad (4.27)$$

$$[\mathcal{X}'_s] \quad \lambda_s^E - \lambda_s^L = \Lambda_s \quad \forall s \quad (4.28)$$

The budget and resource constraints (binding)

$$\pi_s^E C_s^{\text{DE}} \hat{H}(\alpha^b) + \mathcal{X}'_s = \mathcal{X} \quad (4.29)$$

$$\pi_s^L C_s^{\text{DL}} \hat{H}(\alpha^b) = R^y \mathcal{Y} + \mathcal{X}'_s \quad (4.30)$$

$$D = \mathcal{X} + \mathcal{Y} + \Gamma \quad (4.31)$$

Finally the KKT conditions:

$$\Lambda_s \geq 0 \quad \forall s \quad ; \quad \Lambda_s \mathcal{X}'_s = 0 \quad \forall s \quad (4.32)$$

Combining the constraints ($\mathcal{X} > 0$), we obtain:

$$(\pi_s^L C_s^{DL} + \pi_s^E R^y C_s^{DE}) (1 - H(\alpha^b)) = R^y(D - \Gamma) - (R^y - 1) \mathcal{X}'_s \quad \forall s \quad (4.33)$$

Combining the FOCs (4.27) and (4.28),

$$(R^y - 1) \sum_{s=1}^S \Pi_s \lambda_s^L = \sum_{s=1}^S \Pi_s \Lambda_s \quad (4.34)$$

Equation (4.27) tells that the optimal investment in liquid assets must be such that the ratio between the expected marginal utility of type-E depositors and the expected marginal utility of type-L depositors equalize the rate of return of illiquid assets.

Proposition 4.B.1 (Interior Solution) *DIs always allocate some resources among the risky-investment. In equilibrium, there is an interior solution for liquidity: $\mathcal{X}^* \in (0, D_{\alpha^b} - \Gamma)$.*

- **Proof 4.B.1** *Due to INADA conditions (assumptions 4.A.3) $\mathcal{X} > 0$. Moreover, as $\mathcal{X} \rightarrow D_{\alpha^b} - \Gamma$, the return on illiquid assets goes to infinity, encouraging high investment in \mathcal{Y} . By continuity, there exists an intermediate \mathcal{X}^* that constitutes an optimal solution to the DI's problem.*

Furthermore, by the concavity of the problem and Proposition 4.B.1, the FOCs hold in equilibrium.

To characterize the optimal interior solution, notice that in the case where $R^y \leq 1$ DIs would prefer to invest all net deposits into the short-term investment ($D - \Gamma = \mathcal{X} \Rightarrow \mathcal{Y} = 0$) and use their transferring technology after the realization of aggregate shocks. In contrast, when $R^y > 1 \Rightarrow \sum_{s=1}^S \Pi_s \Lambda_s > 0$. Hence, three cases are possible:

Region 1 $\Lambda_1 > 0$ and $\Lambda_2 > 0$ implying that $\mathcal{X}'_1 = 0$ and $\mathcal{X}'_2 = 0$

Region 2 $\Lambda_1 > 0$ and $\Lambda_2 = 0$ implying that $\mathcal{X}'_1 = 0$ and $\mathcal{X}'_2 = 0$

Region 3 $\Lambda_1 > 0$ and $\Lambda_2 = 0$ implying that $\mathcal{X}'_1 = 0$ and $\mathcal{X}'_2 > 0$

Region 4 $\Lambda_1 = 0$ and $\Lambda_2 > 0$ implying that $\mathcal{X}'_1 \geq 0$ and $\mathcal{X}'_2 = 0$

As proven below, **Region 1** and **Region 2** correspond to the cases where DIs do not use the transferring technology between periods $t=1$ and $t=2$. In **Region 3**, the DIs use the transferring technology in the liquidity-abundant state ($s=2$) but not in the liquidity-shortage state ($s=1$). Finally, **Region 4** can be ruled out due to assumption (4.A.1).

4.B.1 Characterization Region 1

The DIs are unwilling to transfer period one resource into period two; thus, $\mathcal{X}'_s = 0 \quad \forall s$. Therefore, from the budget constraints (4.5b) and (4.5c), deposit contracts become:

$$C_s^{DE} = \frac{\mathcal{X}}{\pi_s^E \hat{H}(\alpha^b)}; \quad C_s^{DL} = \frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X})}{\pi_s^L \hat{H}(\alpha^b)} \quad (4.35)$$

with $\hat{H}(\alpha^b) \equiv 1 - H(\alpha^b)$.

Furthermore, the FOCs (4.28) are satisfied if $\lambda_2^E > \lambda_2^L$ and $\lambda_1^E > \lambda_1^L$. This implies that deposit contracts are ordered $C_2^{\text{DE}} < C_2^{\text{DL}}$ and $C_1^{\text{DE}} < C_1^{\text{DL}}$, respectively. Thus, budget constraints (4.35) holds if and only if:

$$\mathcal{X}^\bullet < \Omega_s = \min\{\Omega_2, \Omega_1\} \quad (4.36)$$

with

$$\Omega_s \equiv \frac{R^y \pi_s^E}{1 + \pi_s^E (R^y - 1)} (D_{\alpha^b} - \Gamma) = \frac{1}{1 + \frac{\pi_s^L}{\pi_s^E} \frac{1}{R^y}} (D_{\alpha^b} - \Gamma) \quad (4.37)$$

Due to assumption 4.A.1, $\min\{\Omega_2, \Omega_1\} = \Omega_2$, where Ω_2 is net deposits weighted by the the ratio between the expected marginal utility of type-E depositors in state two to the total expected marginal utility of all depositors in state two⁵.

The order of consumption claims is the following.

$$C_1^{\text{DE}} < C_2^{\text{DE}} < C_2^{\text{DL}} < C_1^{\text{DL}} \quad (4.38)$$

The DIs operate in the region $\mathcal{X}^\bullet \in (0, \Omega_2)$, and the optimal investment in liquid assets is determined by the FOC (4.27)

$$\sum_{s=1}^S \Pi_s \left(u' \left(\frac{\mathcal{X}^\bullet}{\pi_s^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_s^L \hat{H}(\alpha^b)} \right) \right) = 0 \quad (4.39)$$

Equivalent to

$$u' \left(\frac{\mathcal{X}^\bullet}{\pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_1^L \hat{H}(\alpha^b)} \right) = \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{\mathcal{X}^\bullet}{\pi_2^E \hat{H}(\alpha^b)} \right) \quad (4.40)$$

Remark 4.B.1 (Properties of the FOCs) Given D_{α^b} and R^y , equation (4.39) has unique solution in \mathcal{X} because $\lim_{\mathcal{X} \rightarrow 0} \frac{\partial V^D(\alpha^b)}{\partial \mathcal{X}} = \infty$, $\lim_{\mathcal{X} \rightarrow D - \Gamma} \frac{\partial V^D(\alpha^b)}{\partial \mathcal{X}} = -\infty$ and also it is monotonically decreasing in \mathcal{X} since $u''(c) < 0$.

$$\begin{aligned} \frac{\partial^2 V^D(\alpha^b)}{\partial \mathcal{X} \partial \mathcal{X}} &= \sum_{s=1}^S \Pi_s \left[\frac{1}{\pi_s^E \hat{H}(\alpha^b)} u'' \left(\frac{\mathcal{X}}{\pi_s^E \hat{H}(\alpha^b)} \right) + \frac{R^{y2}}{\pi_s^L \hat{H}(\alpha^b)} u'' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X})}{\pi_s^L \hat{H}(\alpha^b)} \right) \right] < 0 \\ &= -\varepsilon \left[\frac{D_{\alpha^b} - \Gamma}{\mathcal{X} (D_{\alpha^b} - \Gamma - \mathcal{X})} \right] \sum_{s=1}^S \Pi_s u' \left(\frac{\mathcal{X}}{\pi_s^E \hat{H}(\alpha^b)} \right) < 0 \end{aligned} \quad (4.41)$$

where ε is the coefficient of relative risk aversion defined in 4.A.3.

Remark 4.B.2

$$\frac{\partial^2 V^D(\alpha^b)}{\partial \mathcal{X} \partial R^y} = \sum_{s=1}^S \Pi_s u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_s^L \hat{H}(\alpha^b)} \right) (\varepsilon - 1) \geq 0 \quad (4.42)$$

with equality if $\varepsilon = 1$

⁵Replacing FOC (4.27) in Ω_2 yields $\Omega_2 \equiv \frac{\pi_2^E \mathbb{E}_s u' \left(C_s^{\text{DE}} \right)}{\pi_2^E \mathbb{E}_s u' \left(C_s^{\text{DE}} \right) + \pi_2^L \mathbb{E}_s u' \left(C_s^{\text{DL}} \right)} (D_{\alpha^b} - \Gamma)$.

4.B.2 Characterization Region 2

In **Region 2**, DIs do not use their transferring technology in any state ($\mathcal{X}'_2 = \mathcal{X}'_1 = 0$). Hence, from equations (4.5b) and (4.5c), consumption contracts must be equal to equations (4.35).

Furthermore, when $\Lambda_2 = 0$ and $\Lambda_1 > 0$, equations (4.28) can be satisfied if $\lambda_2^E = \lambda_2^L$ and $\lambda_1^E > \lambda_1^L$. This implies that $C_2^{DE} = C_2^{DL} \equiv C_2$ and $C_1^{DE} < C_1^{DL}$, respectively. For this ordering to hold, optimal investment in liquid assets must be $\mathcal{X}^\bullet \leq \Omega_s \forall s$. Given assumption 4.A.1, a necessary condition for optimality is:

$$\mathcal{X}^\bullet = \frac{\pi_2^E R^y}{1 + \pi_2^E (R^y - 1)} (D_{\alpha^b} - \Gamma) \equiv \Omega_2 \quad (4.43)$$

Proof 4.B.2 Make $C_2^{DE} = C_2^{DL}$ from (4.35) and solve for \mathcal{X} . ■

Given the optimal level of investment in liquid assets $\mathcal{X}^\bullet = \Omega_2$, deposit contracts are determined by

$$C_2 = \frac{R^y}{1 + \pi_2^E (R^y - 1)} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \quad (4.44)$$

$$C_1^{DE} = C_2 \frac{\pi_2^E}{\pi_1^E} < C_2 \quad (4.45)$$

$$C_1^{DL} = C_2 \frac{\pi_2^L}{\pi_1^L} > C_2 \quad (4.46)$$

which implies

$$C_1^{DE} < C_2^{DE} = C_2 = C_2^{DL} < C_1^{DL} \quad (4.47)$$

Proof 4.B.3 Replacing $\mathcal{X}^\bullet = \Omega_2$ into BCs (4.35), and BCs (4.35) ■

The DIs operating with $\mathcal{X}^\bullet = \Omega_2$ must be consistent with the FOC (4.27). Denoting \hat{R}^y the interest rate that solves (4.48). Hence, the optimal investment $\mathcal{X}^\bullet = \Omega_2$ is optimal if and only if $R^y = \hat{R}^y$.

$$u' \left(\frac{\Omega_2}{\pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \Omega_2)}{\pi_1^L \hat{H}(\alpha^b)} \right) = \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{\Omega_2}{\pi_2^E \hat{H}(\alpha^b)} \right) \quad (4.48)$$

Proof 4.B.4 (Uniqueness) Given the optimal investment $\mathcal{X}^\bullet = \frac{\pi_2^E R^y}{1 + \pi_2^E (R^y - 1)} (D_{\alpha^b} - \Gamma) \equiv \Omega_2$,

$$\begin{aligned} \frac{\partial V^D(\alpha^b)}{\partial \mathcal{X}} \Big|_{\mathcal{X}^\bullet = \Omega_2} &= \sum_{s=1}^S \Pi_s \left[u' \left(\frac{\mathcal{X}^\bullet}{\pi_s^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_s^L \hat{H}(\alpha^b)} \right) \right] \\ &= \sum_{s=1}^S \Pi_s \left[u' \left(\frac{\pi_2^E D_{\alpha^b} - \Gamma}{\pi_s^E \hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E (R^y - 1)} \right) - R^y u' \left(\frac{\pi_2^L D_{\alpha^b} - \Gamma}{\pi_s^L \hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E (R^y - 1)} \right) \right] = 0 \end{aligned} \quad (4.49)$$

To show that only one $R^y \in (1, \infty)$ solves equation (4.49).

First, $\lim_{R^y \rightarrow 1} \frac{\partial V^D(\alpha^b)}{\partial \mathcal{X}} \Big|_{\mathcal{X}^\bullet = \Omega_2} = \Pi_1 \left[u' \left(\frac{\pi_2^E}{\pi_s^E} (D_{\alpha^b} - \Gamma) \right) - u' \left(\frac{\pi_2^L}{\pi_s^L} (D_{\alpha^b} - \Gamma) \right) \right] > 0$. Second, $\frac{\partial}{\partial R^y} \left(\frac{\partial V^D(\alpha^b)}{\partial \mathcal{X}} \Big|_{\mathcal{X} = \Omega_2} \right)$ is monotonically decreasing in R^y .

Differentiating (4.49) with respect to R^y yields,

$$- \left[u' \left(\frac{\pi_2^L}{\pi_s^L} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) + R^y \frac{\pi_2^L}{\pi_s^L} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{\pi_2^L}{1 + \pi_2^E(R^y - 1)} u'' \left(\frac{\pi_2^L}{\pi_s^L} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) \right] \\ - \sum_{s=1}^S \Pi_s \frac{\pi_2^E}{\pi_s^E} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{\pi_2^L}{1 + \pi_2^E(R^y - 1)} u'' \left(\frac{\pi_2^E}{\pi_s^E} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) \quad (4.50)$$

Using the relative risk aversion definition,

$$\sum_{s=1}^S \Pi_s \left[- \frac{\epsilon \pi_2^L}{R^y} u' \left(\frac{\pi_2^E}{\pi_s^E} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) \right. \\ \left. - \left[u' \left(\frac{\pi_2^L}{\pi_s^L} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) - \epsilon \pi_2^L u' \left(\frac{\pi_2^L}{\pi_s^L} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) \right] \right] \quad (4.51)$$

$$- \sum_{s=1}^S \Pi_s \left[\frac{\epsilon \pi_2^L}{R^y} u' \left(\frac{\pi_2^E}{\pi_s^E} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) + u' \left(\frac{\pi_2^L}{\pi_s^L} \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} \frac{R^y}{1 + \pi_2^E(R^y - 1)} \right) (1 - \epsilon \pi_2^L) \right] \quad (4.52)$$

which is always negative if $\frac{1}{\pi_2^L} > \epsilon$.

For instance, this condition is always respected with constant RRA ($\epsilon = 1$). Hence, the equation is monotonically decreasing in R^y . It implies that solution $\mathcal{X}^\bullet = \Omega_2$ is only optimal for $R^y = \hat{R}^y$.

■

4.B.3 Characterization Region 3

This case represents the scenario where the DIs find it optimal to use the transferring technology, $\mathcal{X}'_2 > 0$. In other words, the DIs allocate resources from the liquid assets to patient depositors in the liquidity-abundant state ($s=2$).

From the BCs (4.5b) and (4.5c) consumption contracts will be:

$$C_2^{DE} = \frac{\mathcal{X} - \mathcal{X}'_2}{\pi_2^E \hat{H}(\alpha^b)}; \quad C_2^{DL} = \frac{R^y(D - \Gamma - \mathcal{X}) + \mathcal{X}'_2}{\pi_2^L \hat{H}(\alpha^b)} \quad (4.53)$$

Equations (4.28) can be satisfied if $\lambda_2^E = \lambda_2^L$ and $\lambda_1^E > \lambda_1^L$. This implies that $C_2^{DE} = C_2^{DL} = C'_2$ and $C_1^{DE} < C_1^{DL}$, respectively. Thus, budget constraints hold if and only if

$$\mathcal{X} = \frac{R^y \pi_2^E (D_{\alpha^b} - \Gamma) + \mathcal{X}'_2}{1 + \pi_2^E (R^y - 1)} \quad (4.54)$$

$$\mathcal{X} = \Omega_2 + \frac{\mathcal{X}'_2}{1 + \pi_2^E(R^y - 1)} < \Omega_1 \quad (4.55)$$

Replacing (4.55) into (4.53), we obtain consumption contracts in state 2:

$$C'_2 = \frac{R^y(D_{\alpha^b} - \Gamma) - \mathcal{X}'_2(R^y - 1)}{(1 + \pi_2^E(R^y - 1))\hat{H}(\alpha^b)} \quad (4.56)$$

$$C'_2 = C_2 - \frac{R^y - 1}{1 + \pi_2^E(R^y - 1)} \frac{\mathcal{X}'_2}{\hat{H}(\alpha^b)} \quad (4.57)$$

Rewriting in term of \mathcal{X} ,

$$\begin{aligned} C'_2 &= \frac{R^y(D_{\alpha^b} - \Gamma) - [(1 + \pi_2^E(R^y - 1))\mathcal{X} - R^y \pi_2^E(D_{\alpha^b} - \Gamma)](R^y - 1)}{(1 + \pi_2^E(R^y - 1))\hat{H}(\alpha^b)} \\ C'_2 &= \frac{R^y(D_{\alpha^b} - \Gamma) - \mathcal{X}(R^y - 1)}{\hat{H}(\alpha^b)} \end{aligned} \quad (4.58)$$

Likewise, plugging equation (4.55) into budget constraints (4.35) at state 1 we obtain:

$$C_1^{DE} = C'_2 - \frac{R^y(D - \Gamma)(\pi_1^E - \pi_2^E) - \mathcal{X}'_2(1 + \pi_1^E(R^y - 1))}{\pi_1^E(1 + \pi_2^E(R^y - 1))} \quad (4.59)$$

$$C_1^{DL} = C'_2 + \frac{R^y(D - \Gamma)(\pi_1^E - \pi_2^E) - \mathcal{X}'_2(1 + \pi_1^E(R^y - 1))}{(1 - \pi_1^E)(1 + \pi_2^E(R^y - 1))} \quad (4.60)$$

Therefore,

$$C_1^{DE} < C'_2 < C_1^{DL} \quad (4.61)$$

For \mathcal{X}'_2 positive, $\mathcal{X}^\bullet > \Omega_2$. Therefore, due to assumption 4.A.1, the DIs must operate in the region $\Omega_2 < \mathcal{X}^\bullet < \Omega_1$. The optimal investment in liquid assets and transferring technology must follow:

For the transferring technology,

$$0 < \mathcal{X}'_2 < \frac{R^y(D - \Gamma)(\pi_1^E - \pi_2^E)}{1 + \pi_1^E(R^y - 1)} \quad (4.62)$$

The optimal investment in liquid assets is determined by (4.27)

$$\frac{\lambda_1^E - R^y \lambda_1^L}{\lambda_2} = \frac{\Pi_2}{\Pi_1} (R^y - 1) \quad (4.63)$$

which is equivalent to

$$u' \left(\frac{\mathcal{X}^\bullet}{\pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y(D_{\alpha^b} - \Gamma - \mathcal{X}^\bullet)}{\pi_1^L \hat{H}(\alpha^b)} \right) = \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{R^y(D_{\alpha^b} - \Gamma) - \mathcal{X}^\bullet(R^y - 1)}{\hat{H}(\alpha^b)} \right) \quad (4.64)$$

Remark 4.B.3 First, notice that (4.64) is decreasing in \mathcal{X} . Second, suppose equation (4.64) evaluated in $\mathcal{X}^\bullet = \Omega_2$. If negative, then DIs are not better off increasing \mathcal{X} beyond Ω_2 . Hence, the DI is better off reducing \mathcal{X} below Ω_2 .

$$\begin{aligned} & u' \left(\frac{\frac{\pi_2^E R^y}{1+\pi_2^E(R^y-1)}(D_{\alpha^b} - \Gamma)}{\pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y(D_{\alpha^b} - \Gamma) - \frac{\pi_2^E R^y}{1+\pi_2^E(R^y-1)}(D_{\alpha^b} - \Gamma)}{\pi_1^L \hat{H}(\alpha^b)} \right) \\ &= \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{R^y(D_{\alpha^b} - \Gamma) - \frac{\pi_2^E R^y}{1+\pi_2^E(R^y-1)}(D_{\alpha^b} - \Gamma)(R^y - 1)}{\hat{H}(\alpha^b)} \right) \end{aligned} \quad (4.65)$$

$$\begin{aligned} & u' \left(\frac{\pi_2^E R^y (D_{\alpha^b} - \Gamma)}{(1 + \pi_2^E (R^y - 1)) \pi_1^E \hat{H}(\alpha^b)} \right) - R^y u' \left(\frac{R^y (D_{\alpha^b} - \Gamma) \pi_2^L}{(1 + \pi_2^E (R^y - 1)) \pi_1^L \hat{H}(\alpha^b)} \right) \\ &= \frac{\Pi_2}{\Pi_1} (R^y - 1) u' \left(\frac{R^y (D_{\alpha^b} - \Gamma)}{(1 + \pi_2^E (R^y - 1)) \hat{H}(\alpha^b)} \right) \end{aligned} \quad (4.66)$$

when π_2^E converges to π_1^E ,

$$-(R^y - 1) u' \left(\frac{R^y (D_{\alpha^b} - \Gamma)}{(1 + \pi^E (R^y - 1)) \hat{H}(\alpha^b)} \right) < 0 \quad (4.67)$$

■

4.B.4 Characterization Region 4

Region 4 with $\mathcal{X}'_1 = 0$ is not optimal, because $\mathcal{X} = \Omega_1$ and $\mathcal{X} < \Omega_2$ cannot be both satisfied, due to Assumption 4.A.1. Likewise, **Region 4** with $\mathcal{X}'_1 > 0$ is not optimal, because $\mathcal{X} > \Omega_1$ and $\mathcal{X} < \Omega_2$ cannot be both satisfied due to Assumption 4.A.1 ■

4.B.5 Optimal Level of Deposits

The DIs face a trade-off between having a higher level of deposits versus distributing profits among a higher mass of depositors. Notice that the FOC of problem (4.5) with respect to α^b is:

$$h(\alpha^b) \sum_{s=1}^S \Pi_s \left\{ \lambda_s^E \left[\pi_s^E C_s^{DE} \right] + \lambda_s^L \left[\pi_s^L C_s^{DL} - R^y \alpha^b \right] \right\} = 0 \quad (4.68)$$

An increase in α^b (i.e., accepting fewer households in the DI) increases the per-capita value of a deposit contract. It comes at the cost of reducing the deposits available to invest in liquid and illiquid assets and a higher monitoring cost per capita.

Using (4.25) and (4.26), equation (4.68) can be re-written as follows:

$$\frac{h(\alpha^b)}{\hat{H}(\alpha^b)} \sum_{s=1}^S \Pi_s \left\{ u' \left(C_s^{DE} \right) \left[\pi_s^E C_s^{DE} \right] + u' \left(C_s^{DL} \right) \left[\pi_s^L C_s^{DL} - R^y \alpha^b \right] \right\} = 0 \quad (4.69)$$

Solving for α^b

$$\alpha^b = \frac{\sum_{s=1}^S \Pi_s \left\{ \pi_s^E u' \left(C_s^{\text{DE}} \right) C_s^{\text{DE}} + \pi_s^L u' \left(C_s^{\text{DL}} \right) C_s^{\text{DL}} \right\}}{\sum_{s=1}^S \Pi_s \left\{ R^y u' \left(C_s^{\text{DL}} \right) \right\}} \quad (4.70)$$

Then, the optimal level of depositors has to be equal to the ratio between the marginal cost of increasing the number of depositors and the marginal benefit of increasing the level of deposits. Using FOC (4.27),

$$\alpha^b = \frac{\sum_{s=1}^S \Pi_s \left\{ \pi_s^E u' \left(C_s^{\text{DE}} \right) C_s^{\text{DE}} + \pi_s^L u' \left(C_s^{\text{DL}} \right) C_s^{\text{DL}} \right\}}{\sum_{s=1}^S \Pi_s u' \left(C_s^{\text{DE}} \right)} \quad (4.71)$$

For **Region 1** and **Region 2**, replacing consumption contracts (4.35) in equation (4.71)

$$\alpha^b = \frac{\sum_{s=1}^S \Pi_s \left\{ u' \left(\frac{\mathcal{X}}{\pi_s^E \hat{H}(\alpha^b)} \right) \frac{\mathcal{X}}{\hat{H}(\alpha^b)} + u' \left(\frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X})}{\pi_s^L \hat{H}(\alpha^b)} \right) \frac{R^y (D_{\alpha^b} - \Gamma - \mathcal{X})}{\hat{H}(\alpha^b)} \right\}}{\sum_{s=1}^S \Pi_s u' \left(\frac{\mathcal{X}}{\pi_s^E \hat{H}(\alpha^b)} \right)} \quad (4.72)$$

Simplifying and using FOC (4.27),

$$\Gamma = D_{\alpha^b} - \alpha^b \hat{H}(\alpha^b) \quad (4.73)$$

Condition (4.73) determines the optimal level of deposits by the DIs. Defining an α^\bullet that solves $\Gamma = D_{\alpha^\bullet} - \alpha^\bullet \hat{H}(\alpha^\bullet)$. For a given $\Gamma > 0$, Markov's inequality implies that net deposits are: $D_{\alpha^\bullet} - \Gamma < \mu_{\alpha^\bullet}$. This gives an upper bound on deposits collected by the DIs.

Remark 4.B.4 (Properties of Optimal Deposit Collection) For $\alpha^b \in [\underline{\alpha}, \bar{\alpha}]$

First, $\lim_{\alpha^b \rightarrow \bar{\alpha}} RHS = \bar{\alpha} \ll \Gamma$, and $\lim_{\alpha^b \rightarrow \underline{\alpha}} RHS = \int_{\underline{\alpha}}^{\bar{\alpha}} \alpha^i dH(\alpha^i) - \underline{\alpha} > \Gamma$ For a given $\Gamma > 0$, $\alpha^\bullet \in [\underline{\alpha}, \bar{\alpha}]$ exist by continuity.

Second, it is monotonically decreasing in α^b

$$-\alpha^b h(\alpha_b) - [\hat{H}(\alpha^b) - \alpha^b h(\alpha^b)] = -(1 - H(\alpha^b)) < 0 \quad (4.74)$$

For a given $\Gamma > 0$, $\alpha^\bullet \in [\underline{\alpha}, \bar{\alpha}]$ exist and is unique.

Appendix 4.C Markets Clearing Conditions

4.C.1 Capital Market

Entrepreneurs' demand for capital under perfect competition implies that marginal productivity of capital must equalize the marginal cost of capital, that is, $f'(k_t) = R^y p_t^k$.

Assuming that capital supply is fixed and equal to \bar{K} , market clearing implies $k_t^d = k_t^s$. Hence, the price of capital in equilibrium is determined by

$$p_t^k = \frac{f'(\bar{K})}{R^y} \quad (4.75)$$

which implies that the price of capital in equilibrium is equal to the ratio between the marginal productivity of capital and the cost of lending.

Assuming that $f(k_t) = Ak_t^\xi$, the equilibrium condition becomes

$$p_t^k = \frac{\bar{K}^{\xi-1} A \xi}{R^y} = \frac{\xi}{R^y} \frac{f(\bar{K})}{\bar{K}} \quad (4.76)$$

4.C.2 Credit Market

Market clearing in the credit market implies that $p_t^k k_t^d = \mathcal{Y}$

$$p_t^k k_t^d = D_{\alpha^b} - \Gamma - \mathcal{X} \quad (4.77)$$

Together with the capital market clearing conditions, the return on long-term investment in equilibrium is determined by

$$R^y = \frac{f'(\bar{K})\bar{K}}{D_{\alpha^b} - \Gamma - \mathcal{X}} \quad (4.78)$$

Assuming $f(k_t) = Ak_t^\xi$, the equilibrium condition becomes:

$$R^y = \frac{f(\bar{K})\xi}{D_{\alpha^b} - \Gamma - \mathcal{X}} \quad (4.79)$$

4.C.3 Goods Market

In the goods market, at night of period t , a fraction $\pi^L(s^t)$ of non-depositors will sell their goods in the goods market at price p_t .

$$\pi^L(s^t) \int_1^{\alpha_{b_t}} \alpha^i dH(\alpha) = \frac{M_{t-1}^s}{p_t} + \frac{g_t(s^t)M_{t-1}^s}{p_t} \quad (4.80)$$

The amount of goods consumed depends on the realization of the systemic liquidity shock as the prices can adjust with the realization of the liquidity shocks.

If DIs choices are static, $\alpha_{b_t} = \alpha^b$ for any t , we have that:

$$\frac{p_t}{p_{t+1}} = \frac{M_t^s}{M_{t+1}^s} \frac{\pi^L(s^{t+1})}{\pi^L(s^t)} \quad (4.81)$$

Replacing by the government

$$\frac{p_t}{p_{t+1}} = \frac{1}{1 + g_{t+1}(s^{t+1})} \frac{\pi^L(s^{t+1})}{\pi^L(s^t)} \quad (4.82)$$

For a given initial price $p'_0 > 0$, recursively we obtain,

$$p_t = p'_0 \frac{\pi^L(s^0)}{\pi^L(s^t)} (1 + g_t(s^t)) \prod_{j=0}^{t-1} 1 + g_j(s^j) \quad (4.83)$$

In equilibrium, expected inflation at time t equal to

$$\begin{aligned} \mathbb{E}_t \left[\frac{p_t}{p_{t+1}} \right] &= \Pi_1^2 \frac{M_t^1}{M_{t+1}^1} + \Pi_1 \Pi_2 \frac{M_t^1}{M_{t+1}^2} \frac{\pi_2^L}{\pi_1^L} + \Pi_1 \Pi_2 \frac{M_t^2}{M_{t+1}^1} \frac{\pi_1^L}{\pi_2^L} + \Pi_2^2 \frac{M_t^2}{M_{t+1}^2} \\ &= \Pi_1^2 \frac{1}{1 + g_{t+1}^1} + \Pi_1 \Pi_2 \left(\frac{1}{1 + g_{t+1}^2} \frac{\pi_2^L}{\pi_1^L} + \frac{1}{1 + g_{t+1}^1} \frac{\pi_1^L}{\pi_2^L} \right) + \Pi_2^2 \frac{1}{1 + g_{t+1}^2} \end{aligned} \quad (4.84)$$

Appendix 4.D Equilibrium

4.D.1 Proof of Proposition 4.2.1

Consider an equilibrium in which the DIs operate within **Region 1** or **Region 2**. First, given Γ , the DIs collect deposits ($\alpha^b = \alpha^\bullet$) up to the amount such that condition (4.73) is satisfied $D_{\alpha^\bullet} - \alpha^\bullet \hat{H}(\alpha^\bullet) = \Gamma$.

Subsequently, the DIs operating in these regions optimally invest in liquidity within the interval $\mathcal{X}^\bullet \in (0, \Omega_2]$. Given the equilibrium interest rate R^y from condition (4.16), the optimal interval of investment in liquid assets becomes

$$\mathcal{X}^\bullet \in \left(0, \frac{\pi_2^E}{\pi_2^L} f'(\bar{K}) \bar{K} \right] \quad (4.85)$$

The DIs offer deposit contracts $C_1^E < C_2^E \leq C_2^L < C_1^L$. Given $D_{\alpha^\bullet} - \Gamma$, the optimal investment of liquid assets at equilibrium is determined by

$$\mathcal{X}^\bullet = (D_{\alpha^\bullet} - \Gamma) - f'(\bar{K}) \bar{K} \cdot \frac{\sum_{s=1}^S \Pi_s u' \left(\frac{f'(\bar{K}) \bar{K}}{\pi_s^E \hat{H}(\alpha^*)} \right)}{\sum_{s=1}^S \Pi_s u' \left(\frac{\mathcal{X}^\bullet}{\pi_s^E \hat{H}(\alpha^\bullet)} \right)} \quad (4.86)$$

Finally, to prove the existence in equilibrium, for a given optimal investment and the DIs' optimal size $(\mathcal{X}^\bullet, \alpha^\bullet)$, ex-ante utility from deposits must respect the outside option of all households. Since V^D is the utility generated by deposit contracts when DIs collect the endowments from households $\alpha_i \in [\alpha^\bullet, \bar{\alpha}]$ with $\{\alpha^\bullet \leq \dots \leq \bar{\alpha}\}$; compatibility of deposit contracts is achieved if $V^D(\alpha^\bullet; R^y) \geq V^M(\alpha_i; \mathbf{p}_t) \quad \forall \alpha_i \in [\alpha^\bullet, \bar{\alpha}]$. However, as the utility of holding cash is strictly decreasing with the level of endowment, it is sufficient to show that the wealthiest household- $\bar{\alpha}$ prefers the deposit contract $V^D(\alpha^\bullet; R^y) \geq V^M(\bar{\alpha}; \mathbf{p}_t)$, where $V^M(\bar{\alpha}; \mathbf{p}_t)$ is the utility of the richest household if it decides to keep its endowment until night. Figure 4.2.2 illustrates the intuition for the solution.

$$\sum_{s=1}^S \Pi_s \left[\pi_s^E u \left(\frac{\mathcal{X}^\bullet}{\pi_s^E \hat{H}(\alpha^\bullet)} \right) + \pi_s^L u \left(\frac{f'(\bar{K}) \bar{K}}{\pi_s^L \hat{H}(\alpha^\bullet)} \right) \right] \geq \sum_{s=1}^S \Pi_s \left[\pi_s^E u(\bar{\alpha}) + \pi_s^L u(\varphi \cdot \bar{\alpha}) \right] \quad (4.87)$$

Notice that to guarantee an interior solution in equilibrium (i.e., $R^y > 1$), for any investment \mathcal{X}^\bullet in the range of (4.85), the amount of deposits in equilibrium must respect⁶

$$D_{\alpha^\bullet} < \frac{f'(\bar{K})\bar{K}}{\pi_2^L} + \Gamma \quad (4.88)$$

Proof 4.D.1 (Equilibrium Condition (4.85)) Replace the credit market clearing condition equation (4.16) into equation (4.43) to obtain $\Omega_2^* \equiv \frac{f'(\bar{K})\bar{K} \pi_2^E (D_{\alpha^b} - \Gamma)}{(D_{\alpha^b} - \Gamma - \mathcal{X}^*) \pi_2^L + f'(\bar{K})\bar{K} \pi_2^E}$. Then $\mathcal{X} = \Omega_2^*$ and solve for \mathcal{X}^* ■.

Proof 4.D.2 (Equilibrium Condition (4.86)) Replace the credit market clearing condition equation (4.16) into the DIs' optimality conditions equations (4.25)-(4.27) ■.

4.D.1.1 Region 2

For given $\bar{\alpha}$, \bar{K} , the probabilities; a solution in **Region 2** is feasible in equilibrium if the optimal investment in liquid assets $\mathcal{X}^\bullet = \frac{\pi_2^E}{\pi_2^L} f'(\bar{K})\bar{K}$ yields the higher expected utility for the depositors.

$$\left(\frac{D_{\alpha^\bullet} - \Gamma}{f'(\bar{K})\bar{K}} - \frac{\pi_2^E}{\pi_2^L} \right) \sum_s \Pi_s u' \left(\frac{\pi_2^E}{\pi_s^E} \frac{f'(\bar{K})\bar{K}}{\pi_2^L \hat{H}(\alpha^\bullet)} \right) = \sum_s \Pi_s u' \left(\frac{f'(\bar{K})\bar{K}}{\pi_s^L \hat{H}(\alpha^\bullet)} \right) \quad (4.89)$$

$$D_{\alpha^\bullet} - \alpha^\bullet \hat{H}(\alpha^\bullet) = \Gamma \quad (4.90)$$

$$\sum_{s=1}^S \Pi_s \left[\pi_s^E u \left(\frac{\pi_2^E}{\pi_s^E} \frac{f'(\bar{K})\bar{K}}{\pi_2^L \hat{H}(\alpha^\bullet)} \right) + \pi_s^L u \left(\frac{f'(\bar{K})\bar{K}}{\pi_s^L \hat{H}(\alpha^\bullet)} \right) \right] \geq \sum_{s=1}^S \Pi_s \left[\pi_s^E u(\bar{\alpha}) + \pi_s^L u(\varphi \cdot \bar{\alpha}) \right] \quad (4.91)$$

If α^* exists, then competitive equilibrium exists.

From condition (4.91), let's consider situations in which the expected utility of depositors might be lower than the expected utility of households- $\bar{\alpha}$:

Case a. Deposits for sure better than Cash A deposit contract such that the consumption offered to impatient depositors in state 1 offers higher consumption than cash for any positive inflation, any $\bar{\alpha}$. Given the ordering of contracts, this is obtained whenever $C_1^E = \frac{\pi_2^E}{\pi_1^E} \frac{f'(\bar{K})\bar{K}}{\pi_2^L \hat{H}(\alpha^\bullet)} \geq \bar{\alpha}$, which implies that:

$$\alpha^\bullet \geq H^{-1} \left(1 - \frac{\pi_2^E}{\pi_1^E} \frac{f'(\bar{K})\bar{K}}{\pi_2^L \bar{\alpha}} \right) \equiv \alpha^N \quad (4.92)$$

It implies that for $\alpha^\bullet \geq \alpha^N$, the expected utility of depositors is always higher than that of cash. Hence, the DI successfully collects the endowment of the households- $\bar{\alpha}$, and the DIs can be formed in equilibrium. It is a sufficient condition, **but is it feasible?**

Case b. Deposits for sure worse than Cash Deposit contracts offer lower ex-ante utility than cash for any positive inflation, any $\bar{\alpha}$. Given the ordering of contracts, this

⁶This condition determines the lower bound of the solution in $\alpha^* \in (\alpha^{lb}, \cdot)$, where α^{lb} is the endowment such that $D_{\alpha^{lb}} = f'(\bar{K})\bar{K} \frac{\pi_2^E}{\pi_2^L} + \Gamma$.

is obtained whenever $C_1^L = \frac{f'(\bar{K})\bar{K}}{\pi_1^L \hat{H}(\alpha^*)} < \varphi \bar{\alpha}$, which implies that:

$$\alpha^* \leq H^{-1} \left(1 - \frac{f'(\bar{K})\bar{K}}{\pi_1^L \varphi \bar{\alpha}} \right) \equiv \alpha^\kappa \quad (4.93)$$

It implies that $\alpha^* \leq \alpha^\kappa$, the expected utility of depositors is always lower than that of cash. Hence, the DI cannot collect the endowment of the households- $\bar{\alpha}$. This cannot occur in an equilibrium.

Case c. Intermediate Cases $\alpha^\kappa < \alpha^* < \alpha^\aleph$

- Type-E deposit contract in state 1 generates less consumption than cash

$$H^{-1} \left(1 - \frac{\pi_2^E f'(\bar{K})\bar{K}}{\pi_1^E \pi_2^L \bar{\alpha}} \right) < \alpha^* < H^{-1} \left(1 - \frac{f'(\bar{K})\bar{K}}{\pi_2^L \bar{\alpha}} \right) \quad (4.94)$$

4.D.1.2 No-Runs Conditions (Region 1 and 2)

The solution in the region $\mathcal{X}^\bullet \in \left(0, \frac{\pi_2^E}{\pi_2^L} f'(\bar{K})\bar{K} \right)$ is always an equilibrium without runs for certain inflation values φ .

Lemma 4.D.1 (Non-Runs Equilibrium) *Take the non-run condition*

$$\frac{f'(\bar{K})\bar{K}}{\pi_s^L \hat{H}(\alpha^\bullet)} \geq \frac{\mathcal{X}^\bullet}{\pi_s^E \hat{H}(\alpha^\bullet)} \cdot \varphi \quad (4.95)$$

where $\frac{1}{\varphi} \equiv \frac{p_{t+1}}{p_t}$ is the inflation rate. The non-run condition ensures that type-L depositors are not incentivized to claim type-E deposit contracts and use the money to transfer resources into period $t + 1$. The condition yields

$$\mathcal{X}^\bullet \leq \frac{\pi_s^E f'(\bar{K})\bar{K}}{\pi_s^L \varphi} \quad \forall s \quad (4.96)$$

Relative to the highest level of investment in **Region 1** and **Region 2**,

$$\mathcal{X}^\bullet = \frac{\pi_2^E}{\pi_2^L} f'(\bar{K})\bar{K} \leq \frac{\pi_s^E f'(\bar{K})\bar{K}}{\pi_s^L \varphi} \quad \forall s \quad (4.97)$$

This defines the no-runs conditions.

- In the liquidity-abundant state ($s=2$), non-decreasing prices ($\varphi \leq 1$) guarantee no runs.
- In the liquidity-shortage state ($s=1$), $\varphi \frac{\pi_2^E \pi_1^L}{\pi_2^L \pi_1^E} \leq 1$ guarantees no runs.

4.D.2 Inefficiency of deposit contracts in equilibrium

Every competitive banking contract is ex-ante constrained and inefficient in a competitive banking equilibrium. In particular, all DIs could make depositors better off by collectively allocating more to short-term assets.

For any given α^b

1. $V^D(\alpha^b) : (0, D_{\alpha^b} - \Gamma) \times \mathbb{R}_{++}^S \rightarrow \mathbb{R}$ is differentiable.
2. An optimal investment $\mathcal{X}^\bullet \in (0, D_{\alpha^b} - \Gamma)$.

In order to prove that the inefficiency of the equilibrium contract, we need to show that $\left. \frac{d}{d\mathcal{X}} V^D(\mathcal{X}, R^y(\mathcal{X})) \right|_{\mathcal{X}=\mathcal{X}^\bullet} > 0$

As

$$\frac{d}{d\mathcal{X}} V^D = \frac{\partial V^D}{\partial \mathcal{X}} + \frac{\partial R^y}{\partial \mathcal{X}} \frac{\partial V^D}{\partial R^y} \quad (4.98)$$

, at $\mathcal{X} = \mathcal{X}^\bullet$ the first term on the right-hand side is 0, so

$$\left. \frac{d}{d\mathcal{X}} V^D(\mathcal{X}, R^y(\mathcal{X})) \right|_{\mathcal{X}=\mathcal{X}^\bullet} = \left. \frac{\partial R^y}{\partial \mathcal{X}} \right|_{\mathcal{X}=\mathcal{X}^\bullet} \frac{\partial}{\partial R^y} V^D(\mathcal{X}^\bullet, R^y(\mathcal{X}^\bullet)) \quad (4.99)$$

From credit market clearing condition

$$\begin{aligned} \left. \frac{d}{d\mathcal{X}} V^D(\mathcal{X}, R^y(\mathcal{X})) \right|_{\mathcal{X}=\mathcal{X}^\bullet} &= \frac{f'(\bar{K})\bar{K}}{\mathcal{Y}^\bullet \hat{H}(\alpha^b)} \sum_{s=1}^S \Pi_s u'(C_s^{\text{DL}\bullet}) \\ &= \frac{f'(\bar{K})\bar{K}}{\mathcal{Y}^\bullet (1 - H(\alpha^b))} \sum_{s=1}^S \Pi_s u'\left(\frac{f'(\bar{K})\bar{K} + \mathcal{X}'}{\pi_s^L (1 - H(\alpha^b))}\right) > 0 \end{aligned} \quad (4.100)$$

■

Appendix 4.E Economy with Log-Utility

4.E.1 The DIs' Optimal Solution

This section presents the proof Corollary (4.2.1). Suppose that banks are operating in **Region 1** or **Region 2** and $u(\cdot) = \log(\cdot)$.

First, the optimality condition (4.27) can be written as:

$$u'\left(\frac{\mathcal{X}}{\pi_1^E \hat{H}(\alpha^b)}\right) - R^y u'\left(\frac{R^y(D - \Gamma - \mathcal{X})}{\pi_1^L \hat{H}(\alpha^b)}\right) = \frac{\Pi_2}{\Pi_1} \left[R^y u'\left(\frac{R^y(D - \Gamma - \mathcal{X})}{\pi_2^L \hat{H}(\alpha^b)}\right) - u'\left(\frac{\mathcal{X}}{\pi_2^E \hat{H}(\alpha^b)}\right) \right]$$

Using $\log(\cdot)$

$$\frac{\pi_1^E \hat{H}(\alpha^b)}{\mathcal{X}} - \frac{\pi_1^L \hat{H}(\alpha^b)}{\mathcal{Y}} = \frac{\Pi_2}{\Pi_1} \left[\frac{\pi_2^L \hat{H}(\alpha^b)}{\mathcal{Y}} - \frac{\pi_2^E \hat{H}(\alpha^b)}{\mathcal{X}} \right] \quad (4.101)$$

Multiplying by \mathcal{X}

$$\pi_1^E - \pi_1^L \frac{\mathcal{X}}{\mathcal{Y}} = \frac{\Pi_2}{\Pi_1} \left[\pi_2^L \frac{\mathcal{X}}{\mathcal{Y}} - \pi_2^E \right] \quad (4.102)$$

Reordering

$$\pi_1^E + \frac{\Pi_2}{\Pi_1} \pi_2^E - \pi_1^L \frac{\mathcal{X}}{\mathcal{Y}} - \frac{\Pi_2}{\Pi_1} \pi_2^L \frac{\mathcal{X}}{\mathcal{Y}} = 0 \quad (4.103)$$

Factorizing,

$$\left(\pi_1^E + \frac{\Pi_2}{\Pi_1} \pi_2^E\right) - \frac{\mathcal{X}}{\mathcal{Y}} \left(\pi_1^L + \frac{\Pi_2}{\Pi_1} \pi_2^L\right) = 0 \quad (4.104)$$

using $\bar{\pi}^E \equiv \sum_{s=1}^S \Pi_s \pi_s^E$,

$$\left(\frac{\bar{\pi}^E}{\Pi_1}\right) - \frac{\mathcal{X}}{\mathcal{Y}} \left(\frac{\bar{\pi}^L}{\Pi_1}\right) = 0 \quad (4.105)$$

The optimal liquid-to-illiquid ratio is⁷,

$$\frac{\mathcal{X}}{\mathcal{Y}} = \frac{\bar{\pi}^E}{\bar{\pi}^L} \quad (4.108)$$

Replacing $\mathcal{Y} = D_{\alpha^b} - \Gamma - \mathcal{X}$

$$\mathcal{X}^\bullet = \bar{\pi}^E (D_{\alpha^b} - \Gamma) \quad (4.109)$$

Second, the optimal deposit from (4.71) becomes

$$\alpha^b = \frac{1}{\sum_{s=1}^S \frac{\Pi_s}{C_s^{DE}}} \quad (4.110)$$

$$\alpha^b = \frac{1}{\sum_{s=1}^S \frac{\Pi_s \pi_s^E \hat{H}(\alpha^b)}{\mathcal{X}}} \quad (4.111)$$

$$\alpha^b = \frac{\mathcal{X}}{\bar{\pi}^E \hat{H}(\alpha^b)} \quad (4.112)$$

Optimal deposit size respect

$$\mathcal{X}^\bullet = \bar{\pi}^E \alpha^b \hat{H}(\alpha^b) \quad (4.113)$$

Conditions (4.113) and (4.109) yields the condition (4.73) that determines the optimal size of the bank

$$\Gamma = D_{\alpha^b} - \alpha^b \hat{H}(\alpha^b) \quad (4.114)$$

■

4.E.2 Competitive Equilibrium

From section 4.E.1, we obtain $\mathcal{X}^\bullet = \bar{\pi}^E \alpha^\bullet \hat{H}(\alpha^\bullet)$. The equilibrium interest rate becomes $R^y = \frac{f'(\bar{K})\bar{K}}{\bar{\pi}^L \alpha^\bullet \hat{H}(\alpha^\bullet)}$. Replacing in the ex-ante value function (4.21),

$$V^D(\alpha^\bullet; R^y) = \bar{\pi}^E \log(\alpha^\bullet) - \bar{\pi}^L \log(\hat{H}(\alpha^\bullet)) + \bar{\pi}^L \log\left(\frac{f'(\bar{K})\bar{K}}{\bar{\pi}^L}\right) + \sum_{s=1}^S \Pi_s \left\{ \pi_s^E \log\left(\frac{\bar{\pi}^E}{\pi_s^E}\right) + \pi_s^L \log\left(\frac{\bar{\pi}^L}{\pi_s^L}\right) \right\} \quad (4.115)$$

⁷For a CRRA utility function, $u(c) = \frac{c^{1-\theta}-1}{1-\theta}$, then the optimality condition (4.27) yields

$$\frac{\Pi_1 \pi_1^{E\theta} + \Pi_2 \pi_2^{E\theta}}{\Pi_1 \pi_1^{L\theta} + \Pi_2 \pi_2^{L\theta}} = (R^y)^{1-\theta} \left(\frac{\mathcal{X}}{\mathcal{Y}}\right)^\theta \quad (4.106)$$

$$\left(\frac{\Pi_1 \pi_1^{E\theta} + \Pi_2 \pi_2^{E\theta}}{\Pi_1 \pi_1^{L\theta} + \Pi_2 \pi_2^{L\theta}} R^{y\theta-1}\right)^{1/\theta} = \frac{\mathcal{X}}{\mathcal{Y}} \quad (4.107)$$

If $\theta \rightarrow 1 \Rightarrow u(\cdot) \rightarrow \log(\cdot)$, then we are in the previous case with $\mathcal{X}^\bullet = \bar{\pi}^E (D_{\alpha^b} - \Gamma)$

Therefore, the incentive compatibility constraint

$$\begin{aligned} \bar{\pi}^E \log(\alpha^\bullet) - \bar{\pi}^L \log(\hat{H}(\alpha^\bullet)) + \sum_{s=1}^S \Pi_s \left\{ \bar{\pi}^L \log\left(\frac{f'(\bar{K})\bar{K}}{\bar{\pi}^L}\right) + \pi_s^E \log\left(\frac{\bar{\pi}^E}{\pi_s^E}\right) + \pi_s^L \log\left(\frac{\bar{\pi}^L}{\pi_s^L}\right) \right\} \\ \geq \log(\bar{\alpha}) + \bar{\pi}^L \log(\varphi) \end{aligned} \quad (4.116)$$

Suppose no inflation $\varphi = 1$. Hence, a necessary condition for α^\bullet to be incentive compatible is

$$\sum_{s=1}^S \Pi_s \left\{ \bar{\pi}^L \log\left(\frac{f'(\bar{K})\bar{K}}{\bar{\pi}^L}\right) + \pi_s^E \log\left(\frac{\bar{\pi}^E}{\pi_s^E}\right) + \pi_s^L \log\left(\frac{\bar{\pi}^L}{\pi_s^L}\right) \right\} > \bar{\pi}^L \log(\hat{H}(\alpha^\bullet)) \quad (4.117)$$

■

4.E.3 The DIs' Optimal Solution Region 3

For **Region 3**, the optimal level of liquidity converges to:

$$\mathcal{X}'^* = \frac{\mathcal{X}'_2 + \pi_2^E f(\bar{K})\xi}{\pi_2^L} \quad (4.118)$$

Therefore, consumption contracts converge to:

$$C_2 = \frac{f(\bar{K})\xi + \mathcal{X}'_2}{\hat{H}(\alpha^b) \pi_2^L}; \quad C_1^{\text{DE}} = \frac{\pi_2^E f(\bar{K})\xi + \mathcal{X}'_2}{\hat{H}(\alpha^b) \pi_2^L \pi_1^E}; \quad C_1^{\text{DL}} = \quad (4.119)$$

Proof 4.E.1 To obtain (4.118), replace the credit market clearing condition equation (4.16) into the DIs optimality condition equation (4.55), and solve for \mathcal{X} . The equation has two roots, but the solution $\mathcal{X} = D - \Gamma$ is not optimal. ■

Now, suppose the DIs are operating in **Region 3**. First, the optimality condition (4.27) can be written as:

$$\frac{\pi_1^E \hat{H}(\alpha^b)}{\mathcal{X}} - R^y \frac{\pi_1^L \hat{H}(\alpha^b)}{R^y(D - \Gamma - \mathcal{X})} = \Pi_{2,1}(R^y - 1) \frac{\hat{H}(\alpha^b)}{R^y(D_{\alpha^b} - \Gamma) - \mathcal{X}(R^y - 1)} \quad (4.120)$$

Simplifying,

$$\frac{\pi_1^E(D - \Gamma - \mathcal{X}) - \mathcal{X} \pi_1^L}{\mathcal{X}(D - \Gamma - \mathcal{X})} = \frac{\Pi_{2,1}(R^y - 1)}{R^y(D - \Gamma) - \mathcal{X}(R^y - 1)} \quad (4.121)$$

$$\frac{\pi_1^E \mathcal{Y} - \mathcal{X} \pi_1^L}{\mathcal{X} \mathcal{Y}} = \frac{\Pi_{2,1}(R^y - 1)}{R^y \mathcal{Y} + \mathcal{X}} \quad (4.122)$$

$$\pi_1^E - \pi_1^L \frac{\mathcal{X}}{\mathcal{Y}} = \frac{\Pi_{2,1}(R^y - 1) \mathcal{X}}{R^y + \frac{\mathcal{X}}{\mathcal{Y}}} \quad (4.123)$$

Solving for

$$\pi_1^E R^y + \pi_1^E \frac{\mathcal{X}}{\mathcal{Y}} - \pi_1^L R^y \frac{\mathcal{X}}{\mathcal{Y}} - \left(\frac{\mathcal{X}}{\mathcal{Y}}\right)^2 \pi_1^L = \Pi_{2,1}(R^y - 1) \frac{\mathcal{X}}{\mathcal{Y}} \quad (4.124)$$

Factorizing,

$$\pi_1^E R^y + [\pi_1^E - \pi_1^L R^y - \Pi_{2,1}(R^y - 1)] \frac{\mathcal{X}}{\mathcal{Y}} - \left(\frac{\mathcal{X}}{\mathcal{Y}}\right)^2 \pi_1^L = 0 \quad (4.125)$$

$$\left(\frac{\mathcal{X}}{\mathcal{Y}}\right)^2 - \frac{\pi_1^E + \Pi_{2,1} - R^y(\pi_1^L + \Pi_{2,1})}{\pi_1^L} \frac{\mathcal{X}}{\mathcal{Y}} - \frac{\pi_1^E}{\pi_1^L} R^y = 0 \quad (4.126)$$

Appendix 4.F Implications of Aggregate Uncertainty

Suppose there are no aggregate uncertainty shocks, such that Hence π^E and π^L are fixed probabilities.

Households' problem becomes

Money Holders

$$V_t^M(\alpha^i) = \pi^E u(\alpha^i) + \pi^L u\left(\alpha^i \frac{p_t}{p_{t+1}}\right) \quad (4.127)$$

Deposits Holders

$$V_t^D(\alpha^i) = \pi^E u(C_t^{\text{DE}}) + \pi^L u(C_{t+1}^{\text{DL}}) \quad (4.128)$$

The DI's problem becomes

$$V^D = \underset{C^j, \mathcal{X}_{t+h}, \alpha^b}{\text{maximize}} \quad \pi^E u(C_t^{\text{DE}}) + \pi^L u(C_{t+1}^{\text{DL}}) \quad (4.129a)$$

subject to

$$\pi^E \int_{\alpha^b}^{\bar{\alpha}} C_t^{\text{DE}} dH(\alpha) + \mathcal{X}' \leq \mathcal{X} \quad , \quad (4.129b)$$

$$\pi^L \int_{\alpha^b}^{\bar{\alpha}} C_{t+1}^{\text{DL}} dH(\alpha) \leq R^y(D - \Gamma - \mathcal{X}) + \mathcal{X}', \quad (4.129c)$$

$$\mathcal{X}' \geq 0 \quad ; \quad \mathcal{X} > 0, \quad (4.129d)$$

$$D = \int_{\alpha^b}^{\bar{\alpha}} \alpha^i dH(\alpha) = \mathcal{X} + \mathcal{Y} + \Gamma \quad (4.129e)$$

FOCs

$$[C_t^{\text{DE}}] \quad u'(C_t^{\text{DE}}) = \lambda^E \hat{H}(\alpha^b) \quad (4.130)$$

$$[C_{t+1}^{\text{DL}}] \quad u'(C_{t+1}^{\text{DL}}) = \lambda^L \hat{H}(\alpha^b) \quad (4.131)$$

$$[\mathcal{X}] \quad \lambda^E - \lambda^L R^y = 0 \quad (4.132)$$

$$[\mathcal{X}'] \quad \lambda^E - \lambda^L = \Lambda \quad (4.133)$$

$$[\alpha^b] \quad \pi^E \lambda^E C_t^{\text{DE}} + \pi^L \lambda^L C_{t+1}^{\text{DL}} = \lambda^L R^y \alpha^b \quad (4.134)$$

4.F.1 DI's Solution

From (4.132) and $R^y > 1$, $\lambda^E > \lambda^L \Rightarrow C_t^{\text{DE}} < C_{t+1}^{\text{DL}}$. This further implies that $\Lambda > 0$ so that DIs never use the transferring technology ($\mathcal{X}' = 0$). Therefore, budget constraints become:

$$C_t^{\text{DE}} = \frac{\mathcal{X}}{\pi^E \hat{H}(\alpha^b)}; \quad C_{t+1}^{\text{DL}} = \frac{R^y(D - \Gamma - \mathcal{X})}{\pi^L \hat{H}(\alpha^b)} \quad (4.135)$$

$$\mathcal{X} < \frac{R^y \pi^E}{1 + \pi^E(R^y - 1)}(D_{\alpha^b} - \Gamma) \equiv \Omega \quad (4.136)$$

The optimal level of investment in liquid assets is determined by

$$\frac{u' \left(\frac{\mathcal{X}}{\pi^E \hat{H}(\alpha^b)} \right)}{u' \left(\frac{R^y(D - \Gamma - \mathcal{X})}{\pi^L \hat{H}(\alpha^b)} \right)} = R^y \quad (4.137)$$

Following Diamond and Dybvig (1983), when $R^y > 1$ and the relative risk aversion is greater than or equal to 1, from the equation (4.137) it turns out that: $\frac{D - \Gamma}{\hat{H}(\alpha^b)} < C_t^{\text{DE}*} < C_{t+1}^{\text{DL}*} < R^y \frac{D - \Gamma}{\hat{H}(\alpha^b)}$.

Proof 4.F.1

$$u' \left(\frac{R^y(D - \Gamma) - \pi^L \hat{H}(\alpha^b) C_{t+1}^{\text{DL}}}{R^y \pi^E \hat{H}(\alpha^b)} \right) = R^y u' (C_{t+1}^{\text{DL}}) \quad (4.138)$$

Implying that:

$$\frac{R^y(D - \Gamma) - \pi^L \hat{H}(\alpha^b) C_{t+1}^{\text{DL}}}{R^y \pi^E \hat{H}(\alpha^b)} < C_{t+1}^{\text{DL}} \quad (4.139)$$

Hence, an interval for optimal type-L consumption is:

$$\frac{R^y(D - \Gamma)}{\hat{H}(\alpha^b) [1 + \pi^E(R^y - 1)]} < C_{t+1}^{\text{DL}} < \frac{R^y(D - \Gamma)}{\hat{H}(\alpha^b)} \quad (4.140)$$

Hence, an interval for optimal type-E consumption is:

$$\frac{(D - \Gamma)}{\hat{H}(\alpha^b)} < C_t^{\text{DE}} < \frac{R^y(D - \Gamma)}{\hat{H}(\alpha^b) [1 + \pi^E(R^y - 1)]} \quad (4.141)$$

■

The optimal level of deposits is obtained by substituting FOC (4.132) and BCs (4.135) into FOC (4.134). This yields

$$D_{\alpha^b} - \Gamma = \alpha^b(1 - H(\alpha^b)) \quad (4.142)$$

which is the same as in the case where aggregate uncertainty is included.

4.F.2 Equilibrium

The equilibrium conditions are,

$$\mathcal{X}^* \in \left(0, \frac{\pi^E}{\pi^L} f'(\bar{K}) \bar{K} \right) \quad (4.143)$$

$$\mathcal{X}^* = D_{\alpha^b} - \Gamma - f'(\bar{K}) \bar{K} \cdot \frac{u' \left(\frac{f'(\bar{K}) \bar{K}}{\pi^L \hat{H}(\alpha^b)} \right)}{u' \left(\frac{\mathcal{X}^*}{\pi^E \hat{H}(\alpha^b)} \right)} \quad (4.144)$$

$$D_{\alpha^b} - \Gamma = \alpha^b (1 - H(\alpha^b)) \quad (4.145)$$

$$\pi^E u \left(\frac{\mathcal{X}^*}{\pi^E \hat{H}(\alpha^b)} \right) + \pi^L u \left(\frac{f'(\bar{K}) \bar{K}}{\pi^L \hat{H}(\alpha^b)} \right) \geq \pi^E u(\alpha^i) + \pi^L u \left(\alpha^i \frac{p_t}{p_{t+1}} \right) \quad (4.146)$$

4.F.2.1 DIs' solution when Log-Utility

Remark 4.F.1 (Assume log-utility function) If $u(c) = \frac{c^{1-\theta}-1}{1-\theta}$, then equation (4.137) becomes:

$$\frac{C_{t+1}^{\text{DL}}}{C_t^{\text{DE}}} = R^y \frac{1}{\theta} \quad (4.147)$$

Hence, optimal liquidity is defined by the following:

$$\mathcal{X}^* = (D_{\alpha^b} - \Gamma) \frac{\pi^E}{\pi^E + \pi^L R^y \frac{\theta-1}{\theta}} \quad (4.148)$$

If $\theta \rightarrow 1 \Rightarrow u(\cdot) \rightarrow \log(\cdot)$, then

$$\mathcal{X}^* = \pi^E (D_{\alpha^b} - \Gamma) \quad (4.149)$$

$$C_t^{\text{DE}}(\mathcal{X}^*) = \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} = \alpha^b \quad , \quad C_{t+1}^{\text{DL}}(\mathcal{X}^*) = R^y \frac{D_{\alpha^b} - \Gamma}{\hat{H}(\alpha^b)} = R^y \alpha^b \quad (4.150)$$

The interest rate becomes

$$R^* = \frac{f'(\bar{K}) \bar{K}}{\pi^L \alpha^b \hat{H}(\alpha^b)} \quad (4.151)$$

Appendix 4.G Constrained Efficient Planner Allocation

Systemic preference shocks imply that banking contracts are inefficient in this economy (See Theorem).

What would the socially optimal allocation be?

The social planner can make all allocation decisions to maximize all households' expected utility. Allocate endowments to invest in short and long-term assets. The planner is constrained similarly to DIs but can allocate all α .

The constrained efficient allocations are defined by the solution to the following problem:

Definition 4.G.1 $(1 - H(\alpha^{sp})) \equiv \hat{H}(\alpha^{sp})$

$$\text{maximize}_{C^i, \mathcal{X}, \mathcal{X}', \alpha^{sp}} \hat{H}(\alpha^{sp}) \sum_{s=1}^S \Pi_s \left[\pi_s^E u(C_s^{\text{DE}}) + \pi_s^L u(C_s^{\text{DL}}) \right] \quad (4.152a)$$

$$+ \int_1^{\alpha^{sp}} \left[\bar{\pi}^E u(c_{i,t}^E) + \bar{\pi}^L u(c_{i,t+1}^L) \right] dH(\alpha) \quad (4.152b)$$

subject to

$$\pi_s^E \hat{H}(\alpha^{sp}) C_s^{\text{DE}} + \mathcal{X}'_s \leq \mathcal{X} \quad \forall s, \quad (4.152c)$$

$$\pi_s^L \hat{H}(\alpha^{sp}) C_s^{\text{DL}} \leq R^y \mathcal{Y} + \mathcal{X}'_s \quad \forall s, \quad (4.152d)$$

$$c_{i,t}^E \leq \alpha^i \quad \forall i, \quad (4.152e)$$

$$c_{i,t+1}^L \leq \omega^i \quad \forall i, \quad (4.152f)$$

$$\mathcal{X}'_s \geq 0 \quad ; \quad \mathcal{X} \geq 0, \quad (4.152g)$$

$$\frac{\alpha^i}{\pi^L(s^{t+1}) \int_1^{\alpha^{sp}} \alpha^i dH(\alpha)} = \omega^i, \quad (4.152h)$$

$$\int_{\alpha^{sp}}^{\bar{\alpha}} \alpha^i dH(\alpha) = \mathcal{X} + \mathcal{Y} + \Gamma \quad (4.152i)$$

$[\alpha^{sp}]$

$$\begin{aligned} & - h(\alpha^{sp}) \sum_{s=1}^S \Pi_s \left[\pi_s^E u(C_s^{\text{DE}}) + \pi_s^L u(C_s^{\text{DL}}) \right] \\ & + h(\alpha^{sp}) \left[\bar{\pi}^E u(\alpha^{sp}) + \bar{\pi}^L u(\phi \alpha^{sp}) \right] \\ & + h(\alpha^{sp}) \sum_{s=1}^S \Pi_s \lambda_s^E \left[\pi_s^E C_s^{\text{DE}} - \alpha^{sp} \right] \\ & + h(\alpha^{sp}) \sum_{s=1}^S \Pi_s \lambda_s^L \left[\pi_s^L C_s^{\text{DL}} - R^y \alpha^{sp} \right] = 0 \end{aligned}$$

$$\begin{aligned} \sum_{s=1}^S \Pi_s \left[\pi_s^E u(C_s^{\text{DE}}) + \pi_s^L u(C_s^{\text{DL}}) - \lambda_s^E [\pi_s^E C_s^{\text{DE}} - \alpha^{sp}] - \lambda_s^L [\pi_s^L C_s^{\text{DL}} - R^y \alpha^{sp}] \right] \\ = \bar{\pi}^E u(\alpha^{sp}) + \bar{\pi}^L u(\phi \alpha^{sp}) \end{aligned}$$

If α^{sp} is constant over time then changes in α^{sp} has no effects on inflation (price ratio).

$\log()$

$$\begin{aligned} \sum_{s=1}^S \Pi_s \left[\pi_s^E \log(C_s^{\text{DE}}) + \pi_s^L \log(C_s^{\text{DL}}) - \left[\pi_s^E - \frac{\alpha^{sp}}{C_s^{\text{DE}}} \right] - \left[\pi_s^L - R^y \frac{\alpha^{sp}}{C_s^{\text{DL}}} \right] \right] \\ = \log(\alpha^{sp}) + \bar{\pi}^L \log(\phi) \end{aligned}$$

$$\begin{aligned} \sum_{s=1}^S \Pi_s \left[\pi_s^E \log(C_s^{\text{DE}}) + \pi_s^L \log(C_s^{\text{DL}}) - 1 + \frac{\alpha^{sp}}{C_s^{\text{DE}}} + R^y \frac{\alpha^{sp}}{C_s^{\text{DL}}} \right] \\ = \log(\alpha^{sp}) + \bar{\pi}^L \log(\phi) \end{aligned}$$

Appendix 4.H Households' problem in autarky

Analyze the case where households can invest directly into entrepreneurs' projects. Household- i can allocate its endowment α_i among cash (liquid asset x^i) and entrepreneurs' projects (illiquid investment y^i). This decision happens during the day of period t before preferences are known.

On the one hand, for any unit of endowment invested in projects (y^i), household- i pays the fixed monitoring cost Γ . If household- i becomes type-E, it can liquidate projects and receive $(1 - \tau)$ for each unit of investment in the night of period t with $\tau \in [0, 1]^8$. On the contrary, if household- i becomes type-L, it collects the return on projects $R^y > 1$ at night of period $t + 1$. The monitoring cost is paid only if household- i invest a positive amount in projects ($\hat{\Gamma} \equiv \Gamma \times \mathbf{1}_{y>0}$). Hence, any household- i such that its endowment is insufficient to cover the monitoring cost ($\alpha^i \leq \Gamma$) never invests directly in entrepreneurs' projects ($y^i = 0$).

On the other hand, each unit of endowment not invested in projects will be kept until night (x^i). If household- i becomes type-E, it will consume x^i . Instead, if it becomes type-L, it sells at night x^i units of goods in the goods market at price p_t and buys consumption goods at night of period $t + 1$ at price p_{t+1} . Hence, the properties of the goods-cash market will remain invariant.

I assume that the gains of liquidating a project and transferring into the second period using cash are lower than the gains of waiting until the project matures $\left(\frac{p'_{st}}{p'_{s_{t+1}}} (1 - \tau) < R^y \forall s \right)$.

⁸Notice that if $\tau = 1$ we always have that $x_i > 0$, because of risk aversion. In this case, $y_i = 0$; because $y_i > 0$ is high risk.

Households' problem with endowments $\alpha^i > \Gamma$ in autarky is:

$$V_i^A(\alpha^i | \alpha^i > \Gamma) = \underset{c_t^E, c_{t+1}^L, x^i, y^i}{\text{maximize}} \quad [\bar{\pi}^E u(c_t^E) + \bar{\pi}^L u(c_{t+1}^L)] \quad (4.153a)$$

subject to

$$c_t^E = x^i + (1 - \tau)y^i, \quad (4.153b)$$

$$c_{t+1}^L = x^i \frac{p_t}{p_{t+1}'} + R^y y^i, \quad (4.153c)$$

$$x^i \geq 0 \quad ; \quad y^i \geq 0 \quad , \quad (4.153d)$$

$$\alpha^i = x^i + y^i + \Gamma \times \mathbb{1}_{y^i > 0} \quad (4.153e)$$

with Λ^{x^i} and Λ^{y^i} are the Lagrange multipliers associated to the non-negativity constraints (4.153d), respectively. The following equation defines the first-order necessary conditions of the problem:

$$\bar{\pi}^L \left(R^y - \frac{p_t}{p_{t+1}'} \right) u'(c_{t+1}^L) + \Lambda^{y^i} = \tau \bar{\pi}^E u'(c_t^E) + \Lambda^{x^i} \quad (4.154)$$

Case 1 Household invests in a mix $x^i > 0$ and $y^i > 0$. Hence, $\Lambda^{x^i} = 0$ and $\Lambda^{y^i} = 0$

Given $\alpha_i - \Gamma$, the optimal x_i is determined by

$$\tau \bar{\pi}^E u' \left((1 - \tau)(\alpha^i - \Gamma) + \tau x^i \right) = \bar{\pi}^L \left(R^y - \frac{p_t}{p_{t+1}'} \right) u' \left(R^y (\alpha^i - \Gamma) - \left(R^y - \frac{p_t}{p_{t+1}'} \right) x^i \right) \quad (4.155)$$

The ex-ante utility for $\log(\cdot)$ is

$$V_i^A(\alpha^i > \Gamma) = \bar{\pi}^E \log((1 - \tau)(\alpha^i - \Gamma) + \tau x^i) + \bar{\pi}^L \log \left(R^y (\alpha^i - \Gamma) - \left(R^y - \frac{p_t}{p_{t+1}'} \right) x^i \right) \quad (4.156)$$

Corner Solutions

Case 2 Household i will save all his endowment until night $x^i = \alpha^i$. Hence, whenever households are impatient, they consume $c_t^E = \alpha^i$, and whenever they are patient, they sell their goods to consume $c_{t+1}^L(s^t) = \alpha^i \varphi'$ in the next period.

$$V_i^A(\alpha^i > \Gamma) = \log(\alpha^i) + \bar{\pi}^L \log(\varphi') \quad (4.157)$$

Case 3 Household i will invest all his endowment net of monitoring cost in the illiquid asset $y^i = \alpha^i - \Gamma$. Hence, whenever households are impatient, liquidate projects and consume $c_t^E = (1 - \tau)(\alpha^i - \Gamma)$, and whenever they are patient, consume all the proceedings $c_{t+1}^L = R^y(\alpha^i - \Gamma)$. Both are independent of the aggregate state.

Given that $x^i = 0$ and $y^i > 0$ then $\Lambda^{x^i} \geq 0$ and $\Lambda^{y^i} = 0$.

$$V_i^A(\alpha^i > \Gamma) = \bar{\pi}^E u((1 - \tau)(\alpha^i - \Gamma)) + \bar{\pi}^L u(R^y(\alpha^i - \Gamma)) \quad (4.158)$$

For $\log(\cdot)$

$$V_i^A(\alpha^i > \Gamma) = \log(\alpha^i - \Gamma) + \bar{\pi}^L \log(R^y) + \bar{\pi}^E \log(1 - \tau) \quad (4.159)$$

Proof 4.H.1 (Consumption)

$$\begin{aligned}c_t^E &\leq c_{t+1}^L(s^t) \\ \alpha^i - \hat{\Gamma} - y^i \tau &\leq (\alpha^i - \hat{\Gamma}) \varphi'_{t,s} + y^i (\mathbb{R}^y - \varphi'_{t,s}) \\ (\alpha^i - \hat{\Gamma}) (1 - \varphi'_{t,s}) &\leq y^i (\mathbb{R}^y - \varphi'_{t,s} + \tau) \\ \frac{1 - \varphi'_{t,s}}{\mathbb{R}^y - \varphi'_{t,s} + \tau} &\leq \frac{y^i}{\alpha^i - \hat{\Gamma}}\end{aligned}\tag{4.160}$$

$$\frac{1 - \varphi'_{t,s}}{\mathbb{R}^y - \varphi'_{t,s} + \tau} \leq \frac{y^i}{\alpha^i - \hat{\Gamma}} < 1$$

$$\frac{1 - \varphi'_{t,s}}{\mathbb{R}^y - \varphi'_{t,s} + \tau} \in \left(-\infty, \frac{1}{\mathbb{R}^y + \tau}\right)$$

Given that $\varphi'_{t,s}(1 - \tau) < \mathbb{R}^y$, it is always true that:

$$\frac{1 - \varphi'_{t,s}}{\mathbb{R}^y - \varphi'_{t,s} + \tau} < \frac{1}{\tau}\tag{4.161}$$

Bibliography

- [1] Franklin Allen, Elena Carletti, and Douglas Gale. “Interbank market liquidity and central bank intervention”. In: *Journal of Monetary Economics*, 56.5 (2009), pp. 639–652. DOI: [10.1016/j.jmoneco.2009.04.003](https://doi.org/10.1016/j.jmoneco.2009.04.003).
- [2] Russell Cooper and Dean Corbae. “Financial Collapse: A Lesson from the Great Depression”. In: *Journal of Economic Theory*, 107.2 (2002), pp. 159–190. DOI: [10.1006/jeth.2001.2951](https://doi.org/10.1006/jeth.2001.2951).
- [3] Russell Cooper and Thomas W. Ross. “Bank runs: deposit insurance and capital requirements”. In: *International Economic Review*, 43.1 (2002), pp. 55–72. DOI: [10.1111/1468-2354.t01-1-00003](https://doi.org/10.1111/1468-2354.t01-1-00003).
- [4] Russell Cooper and Thomas W. Ross. “Bank runs: Liquidity costs and investment distortions”. In: *Journal of Monetary Economics*, 41.1 (1998), pp. 27–38. DOI: [10.1016/S0304-3932\(97\)00070-6](https://doi.org/10.1016/S0304-3932(97)00070-6).
- [5] Douglas W. Diamond and Philip H. Dybvig. “Bank Runs, Deposit Insurance, and Liquidity”. In: *Journal of Political Economy*, 91.3 (1983), pp. 401–419.
- [6] John Geanakoplos and Kieran James Walsh. “Inefficient liquidity provision”. In: *Economic Theory*, 66.1 (2018), pp. 213–233. DOI: [10.1007/s00199-017-1059-7](https://doi.org/10.1007/s00199-017-1059-7).
- [7] Bengt Holmström and Jean Tirole. “Private and Public Supply of Liquidity”. In: *Journal of Political Economy*, 106.1 (1998), pp. 1–40. DOI: [10.1086/250001](https://doi.org/10.1086/250001).
- [8] Charles M Kahn and Wolf Wagner. “Sources of Liquidity and Liquidity Shortages”. In: *Journal of Financial Intermediation*, 46 (2021), pp. 1–12. DOI: [10.1016/j.jfi.2020.100869](https://doi.org/10.1016/j.jfi.2020.100869).
- [9] Zehao Liu and Ping He. “Real liquidity and banking”. In: *Journal of Financial Intermediation*, 49 (2022), pp. 1–12. DOI: [10.1016/j.jfi.2020.100895](https://doi.org/10.1016/j.jfi.2020.100895).
- [10] Zehao Liu and Chengbo Xie. “Liquidity, capital requirements, and shadow banking”. In: *International Review of Economics & Finance*, 76 (2021), pp. 1379–1388. DOI: [10.1016/j.iref.2019.11.019](https://doi.org/10.1016/j.iref.2019.11.019).
- [11] David Rivero-Leiva and Hugo Rodríguez-Mendizábal. “Self-fulfilling runs and endogenous liquidity creation”. In: *Journal of Financial Stability*, 45 (2019), pp. 1–15. DOI: [10.1016/j.jfs.2019.100704](https://doi.org/10.1016/j.jfs.2019.100704).
- [12] David R. Skeie. “Banking with nominal deposits and inside money”. In: *Journal of Financial Intermediation*, 17.4 (2008), pp. 562–584. DOI: [10.1016/j.jfi.2008.05.001](https://doi.org/10.1016/j.jfi.2008.05.001).