

Money and Banking in the Shadows: Monetary Policy and (Non)bank Finance

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I study the transmission of monetary policy through banks and nonbank financial intermediaries (NBFIs) in the United States. First, I construct a measure of nonbank lending that takes into account the complex linkages within the NBFIs sector. Then, I show empirically that following a surprise monetary policy tightening the households substitute away from bank deposits and towards nonbank-created liquidity. Bank lending to firms contracts while NBFIs' provision of credit expands. To rationalize these findings, I build a New-Keynesian model with banks and investment funds that provide liquidity to households and lending to firms. The model is able to capture both the household's portfolio rebalancing and the shift towards nonbank finance after a monetary policy tightening. Moreover, the model shows that in the absence of nonbank financial intermediation, a monetary policy tightening would lead to a deeper contraction in the economy. This suggests that the presence of nonbank financial intermediaries diminishes the effect of monetary policy.

1. Introduction

A long tradition in macroeconomics emphasizes the households' portfolio decisions as fundamental for understanding business cycles and monetary transmission mechanisms (Tobin 1969; Luetticke 2021). Relatedly, a strand of the banking literature stresses liquidity transformation, i.e. the dual role of commercial banks in issuing liquid claims (bank deposits) to households to fund lending to firms (Diamond and Dybvig 1983; Drechsler et al. 2017). Yet, the modern financial system includes entities beside traditional banks that may similarly fulfill this role. Nonbank financial intermediaries (NBFIs) offer alternative chains of intermediation in parallel to the banking sector. With its accelerated growth after the global financial crisis, the nonbank financial sector now accounts for almost 50% of global financial assets (Pascual et al. 2023).

Although much attention has been paid to the significance of NBFIs for financial stability issues, the relationship between monetary policy and the nonbank financial sector remains underexplored. In particular, nonbank liquidity transformation may have important implications for the efficacy of monetary policy both directly and via its connections with the banking sector. In this paper, I study the transmission of monetary policy, through its impact on bank and nonbank financial intermediation, in the United States.

The nonbank financial sector is understood to be a collection of intermediaries that perform bank-like activities and provide services traditionally associated with banks. Examples of NBFIs include money market funds, mutual funds, government-sponsored enterprises, asset-backed security issuers, insurance companies, and pension funds. Previous literature has emphasized the difficulty of measuring nonbank lending to the productive sector due to the entangled linkages among the NBFIs (Pozsar et al. 2010; Gallin 2013; Durdu and Zhong 2023). Therefore, I construct a dataset on bank and nonbank lending to nonfinancial firms using the Financial Accounts (FAs) of the United States. I use the methodologies of Gallin (2013) and Herman et al. (2017) to net out financial interconnections and to overcome the lack of counterparty information in the FAs.

To facilitate comparisons with traditional banks, I choose money market funds and mutual funds as the NBFIs of focus. I refer to these funds collectively as investment funds. This choice is motivated first by the fact that money market funds and mutual funds both issue liabilities that provide liquidity services to investors in ways similar to bank deposits (Krishnamurthy and Li 2023; Ma et al. 2021). Therefore, I denote

the equity shares issued by investment funds as “nonbank deposits” to highlight their characteristics as demandable and liquid claims (Xiao 2020; Begenau and Landvoigt 2022). Moreover, investment funds intermediate a significant amount of funding to nonfinancial firms both directly through holdings of firm debt and indirectly through funding of other NBFIs. Thus, investment funds compete with traditional banks on both ends of the liquidity transformation process.

I estimate the empirical effect of monetary policy shocks on financial intermediation and economic activity by means of local projections (Jordà 2005). Monetary policy shocks are identified by the narrative approach (Romer and Romer 2004) and I rely on the extended series constructed by Miranda-Agrippino and Rey (2020). I find that after a one standard deviation monetary policy shock, U.S. households’ holdings of bank deposits fall persistently by around 1.4%. Banks, in turn, reduce their lending to firms by 1% after about one year. Interestingly, nonbank financial intermediation expands. Households’ nonbank deposits increase persistently by more than 4% after three years, while nonbank lending to firms increases by about 3%. In other words, I observe credit leakage towards the less regulated nonbank financial sector in the U.S. after monetary policy tightenings.

I study the drivers of the empirical results in a New-Keynesian model with two types of financial intermediaries, banks and investment funds, that engage in liquidity transformation. Recent literature identifies two channels of monetary transmission where the households’ portfolio choices take the central stage: the “deposits channel” (Drechsler et al. 2017) and the “shadow banking channel” (Xiao 2020). According to the deposits channel, a monetary tightening induces banks with market power to increase their deposit spreads, the opportunity cost of deposit products, and consequently deposits flow out of the banking sector and bank lending contracts. At the same time, the shadow banking channel proposes that the proceeds from deposit outflows move instead into “shadow bank deposits” (i.e. money market fund shares) and the nonbank financial sector, which then expands its credit provision. In this paper, I build a simple New-Keynesian model that is able to capture both the household’s portfolio rebalancing and the shift towards nonbank finance after a monetary policy tightening.

In the model, I take a liquidity-centric view of financial intermediation similar to that of Piazzesi et al. (2022) and Niepelt (2024). The financial sector provides liquidity services to households in the forms of bank deposits issued by commercial banks and nonbank deposits (equity shares) issued by investment funds. The households are assumed to value a combination of both types of liquid assets and make portfolio

choices between them. Importantly, banks and investment funds differ in their ability to issue liabilities. Banks are assumed to face a liquidity constraint that limits their ability to issue debt (deposits). A restriction is placed on the banks' liquidity ratio (i.e. reserves-to-deposits ratio), which can capture explicit regulatory constraints such as reserve requirements or more generally the increasing marginal cost of issuing debt (Piazzesi et al. 2022; Rogers 2023). Investment funds, on the other hand, do not face the same liquidity constraint because they do not rely on debt-issuance to finance themselves. This is in line with the current financial system where nonbank institutions performing bank-like activities are often less regulated or altogether unregulated (Begenau and Landvoigt 2022).

In the model, a monetary policy tightening increases the banks' opportunity cost of holding reserves and, in turn, their marginal cost of issuing deposits. The bank deposit spread widens as banks keep the deposit rates relatively low even as the policy rate increases. At the same time, in the absence of any constraint to issue liabilities, investment funds keep the nonbank deposit spread constant. Thus, investment funds pass on the increase in the policy rate in its entirety to the households. The difference in the sensitivity of deposit spreads to monetary policy then induces the household to shift away from holding bank deposits towards nonbank liabilities. Consequently, bank credit to firms shrinks while nonbank financial intermediation expands. Moreover, I show that in the absence of nonbank financial intermediation, the economic contraction following a monetary tightening is deeper. This is because without the household's portfolio rebalancing towards nonbank liabilities, there is no increase in nonbank credit to firms which would have dampened the fall in investment and output. This suggests that the presence of investment funds diminishes the effect of monetary policy.

In this paper, I contribute to the empirical and theoretical literature on the impact of NBFIs on business cycle fluctuations and monetary policy transmission. Following the early seminal work by Pozsar et al. (2010), a series of papers have sought to clarify the inner workings of the nonbank financial sector. Pozsar (2014) builds on Pozsar et al. (2010) and provides an accounting framework for measuring the sources and uses of short-term funding among NBFIs. Gallin (2013) develops a method for netting out financial interconnections and shows how to derive estimates of nonbank lending to nonfinancial firms, households and government. Herman et al. (2017) complements the earlier work and propose a simple procedure to derive estimates of "whom-to-whom" lending among actors in the financial markets using the FAs. The authors then illustrate the historical development of and the differences between bank and nonbank credit

cycles.

Combining the methods of [Gallin \(2013\)](#) and [Herman et al. \(2017\)](#), I build a dataset to explore the responses of nonbank financial intermediation to monetary policy shocks. [Xiao \(2020\)](#) offers one of the earliest studies on the relationship between NBFIs and monetary policy in the U.S. Using proprietary industry data, the author finds that shadow bank money (money market fund shares) creation expands after monetary tightenings and thus dampens the impact of monetary policy. Similarly, using loan-level data, [Peydró et al. \(2021\)](#) show that higher policy rates shifts credit supply from banks to nonbanks. [Hodge and Weber \(2023\)](#) take advantage of high-frequency data and show that contractionary monetary policy shocks reduce the assets of nonbanks reliant on long-term funding, while increasing those of nonbanks reliant on short-term funding. The main advantage of the method I employ in this paper is its ability to take into account the various linkages between financial intermediaries. In this way, I reduce the usual risk of overestimating nonbank lending, which is often ignored in other empirical work. The other advantage is the use of the FAs, which are publicly available and typically cover a longer time period than various proprietary data sources.

On the theoretical front, [Meeks et al. \(2017\)](#) and [Moreira and Savov \(2017\)](#) are early examples of incorporating a nonbank financial sector into macroeconomic models to shed light on its role for financial stability. [Begenau and Landvoigt \(2022\)](#) estimate a quantitative general equilibrium model and find that bank capital regulation has unintended positive consequences by reducing the riskiness of the nonbank financial sector. [Iasio et al. \(2022\)](#) study macroprudential policies targeting nonbanks and find that the lack of liquidity regulation for investment funds decreases the economy's resilience to financial shocks. [Fève et al. \(2022\)](#) build a DSGE model featuring heterogeneous banks and argue that the collapse of shadow banking contributed significantly to the slow recovery after the financial crisis in the U.S. [Becard and Gauthier \(2023\)](#) analyze European business and financial cycles by focusing on the ability of traditional banks to offload credit risk to nonbank financial institutions. This paper shares the focus on credit intermediation with [Durdu and Zhong \(2023\)](#), which analyze the structural drivers of bank and nonbank credit cycles and sectoral shocks.

The rest of the paper is organized as follows. Section 2 describes the data and presents the empirical results. Section 3 describes the elements of the New-Keynesian model. Section 4 shows the baseline calibration. Section 5 analyzes the transmission of monetary policy. Section 6 summarizes the results and concludes.

2. Empirical Evidence

This section documents the transmission of monetary policy shocks to the wider economy via banks and NBFIs. First, I describe the institutional background of the nonbank financial sector and the construction of the data on financial intermediation and economic activity. Then, I present the baseline empirical specification and the main results.

2.1. Institutional Background

Despite the lack of a precise definition, the nonbank financial sector can be understood as a collection of financial intermediaries which, while not defined as banks, perform many bank-like activities. Unlike traditional banks, which perform liquidity transformation, i.e. issue short-term liquid claims to fund long-term illiquid assets, under one roof, the nonbank financial sector split the process into several parts. Thus, different NBFIs perform different functions on the financial intermediary chain. For instance, money market funds and mutual funds issue shares that are (under normal circumstances) easily redeemable and thus comparable to various forms of bank deposits. Money market funds, in turn, pass down the proceeds to downstream NBFIs such as finance companies and broker-dealers that originate commercial loans. Mutual funds, on the other hand, tend to invest directly in corporate bonds and bypass downstream entities. Here, I consider a larger class of intermediaries than what earlier literature referred to as “shadow banks.”

There is a lack of readily available data on the financial flows intermediated by NBFIs to the nonfinancial sector. Indeed, the literature has long emphasized the difficulty of measuring nonbank financial intermediation ([Pozsar et al. 2010](#); [Gallin 2013](#); [Durdu and Zhong 2023](#)). In particular, previous works on the NBFIs’ provision of credit to the wider economy often ignore the flows of funds and the entangled linkages within the nonbank financial sector itself.¹ This may drastically overstate the size of nonbank lending and obscure its cyclical properties ([Durdu and Zhong 2023](#)).

2.2. Data

I use the Financial Accounts (FAs) of the United States to construct measures of bank and nonbank financial intermediation. The FAs provide a comprehensive overview of the financial assets and liabilities of sectors of the U.S. economy (e.g. households,

¹See [Pozsar et al. \(2010\)](#) for an early attempt at mapping the NBFIs sector.

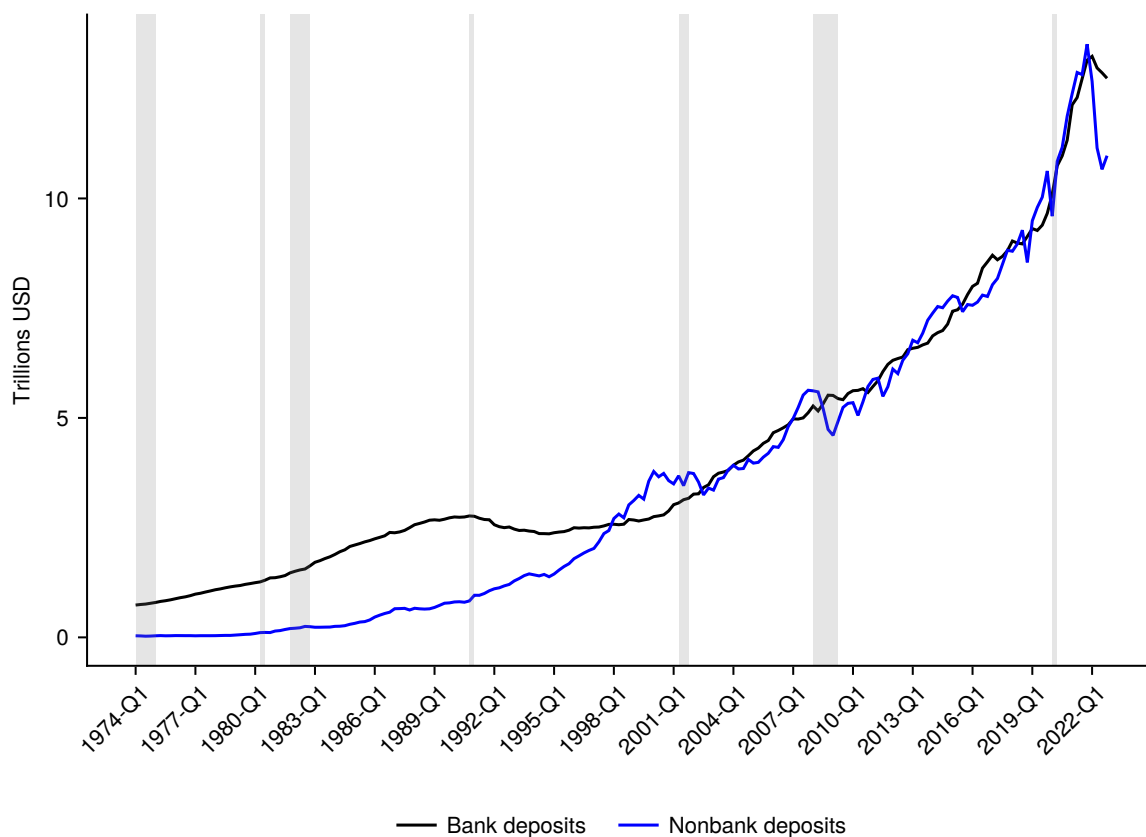
nonfinancial business, financial intermediaries), broken down into various financial instruments (e.g. deposits, corporate bonds, mortgages).

Banks are defined as the collection of U.S.-chartered depository institutions and credit unions, following [Durdu and Zhong \(2023\)](#). I choose money market funds and mutual funds, which I refer to collectively as investment funds, as the NBFIs of focus. The reason is that investment funds are the only NBFIs that compete with banks at both ends of the liquidity transformation process. As will be clear in the following, investment funds not only provide liquidity to households and thus compete with bank deposits, they also intermediate substantial amount of funding to nonfinancial firms both directly and through funding of other NBFIs. I exclude foreign banking entities and mutual funds investing exclusively in foreign markets as I am primarily concerned with U.S. domestic financial intermediation.

The households' holdings of bank liabilities is measured by the sum of checkable, time and savings deposits issued by banks as defined above. Nonbank liabilities are defined as the sum of shares issued by money market funds and mutual funds held by the household sector. Recent literature in finance highlights the money-like attributes of liquid claims issued by money market funds and mutual funds. [Krishnamurthy and Li \(2023\)](#) find that money market fund shares, similar to bank-created money, satisfy the investors' demand for liquidity (see also [Xiao \(2020\)](#); [Begenau and Landvoigt \(2022\)](#)). [Ma et al. \(2021\)](#) show that equity-issuing mutual funds provide liquidity by insuring against idiosyncratic liquidity risks in ways similar to debt-issuing banks (see also [Chernenko and Doan \(2022\)](#); [Agarwal et al. \(2023\)](#)). Although money market fund and mutual fund shares are equity, I follow the literature and refer to them as nonbank "deposits" (see e.g. [Xiao \(2020\)](#) and [Begenau and Landvoigt \(2022\)](#)). This designation highlights their properties as demandable and liquid claims, and facilitates comparisons to bank deposits. For instance, in the U.S., money market funds offer intraday redemption, while mutual funds offer redemption within a week.

Figure 1 shows the U.S. household sector's holdings of bank and nonbank deposits in nominal USD between 1974 Q1 to 2022 Q4. Since the late 1990s, the households' demand for nonbank-created liquidity has been on par with bank deposits, with several periods during which nonbank deposits have exceeded their bank counterparts. Although, nonbank deposits have been somewhat more volatile over time with a standard deviation of 3.5, while it is 3.1 for bank deposits. As can be seen in Figure A2, much of the volume and the volatility of nonbank deposits after the late 1990s are driven by the development of the households' mutual fund assets.

FIGURE 1. Households' bank and nonbank deposits



Note: This figure shows the U.S. household sector's holdings of bank and nonbank deposits in nominal trillions USD from 1974 Q1 to 2022 Q4. Bank deposits are defined as the sum of checkable, time and savings deposits issued by U.S.-chartered depository institutions and credit unions. Nonbank deposits are defined as the sum of money market fund shares and mutual fund shares. The data are taken from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

To construct measures of lending, I follow [Gallin \(2013\)](#) and [Herman et al. \(2017\)](#) to identify the amount of credit provided to nonfinancial firms that can be traced, through the intermediation chains, back to banks and investment funds. [Gallin \(2013\)](#) categorizes financial intermediaries in the FAs database into upstream and downstream entities.² Upstream intermediaries are those who generally take proceeds from the nonfinancial sector (e.g. households) and fund both other financial intermediaries and nonfinancial sector borrowers (e.g. firms). Among upstream intermediaries are banks and investment funds. Downstream intermediaries, on the other hand, do not borrow from households directly but rely on market funding (e.g. from upstream intermediaries) to make loans to firms. Finance companies, asset-backed securities issuers and broker-dealers are examples of downstream intermediaries. Figure A1 shows a stylized representation of the funding of nonfinancial firms through upstream and downstream intermediaries. Thus, banks and investment funds provide credit to nonfinancial firms both directly and indirectly. The direct funding of firms is simply measured by the amount of firm debt held by banks and investment funds. The indirect funding is found by allocating all firm debt held by downstream intermediaries to banks and investment funds, proportional to the amount of downstream intermediaries' liabilities they hold.³

Figure 2 plots bank and nonbank lending to nonfinancial firms in the U.S. over time. Unsurprisingly, banks provide the largest share of lending to firms. Nevertheless, investment funds intermediate a substantial amount of credit to the productive sector. At the highest, investment funds' lending to firms corresponds to 38% of what banks provide. In recent years, that share has fluctuated between 30% to 35% with the average over the whole sample period being about 20%. Figure A3 compares lending to firms from all upstream financial intermediaries as categorized by [Gallin \(2013\)](#), grouped into banks, investment funds and other NBFIs. The total lending from other NBFIs stands closer to that of banks. This is the result of the considerable amount of corporate bonds held by insurance companies and pension funds.⁴ I choose to exclude those intermediaries because their roles in the financial sector and the services they provide to the households are notably different from those of banks and investment funds.

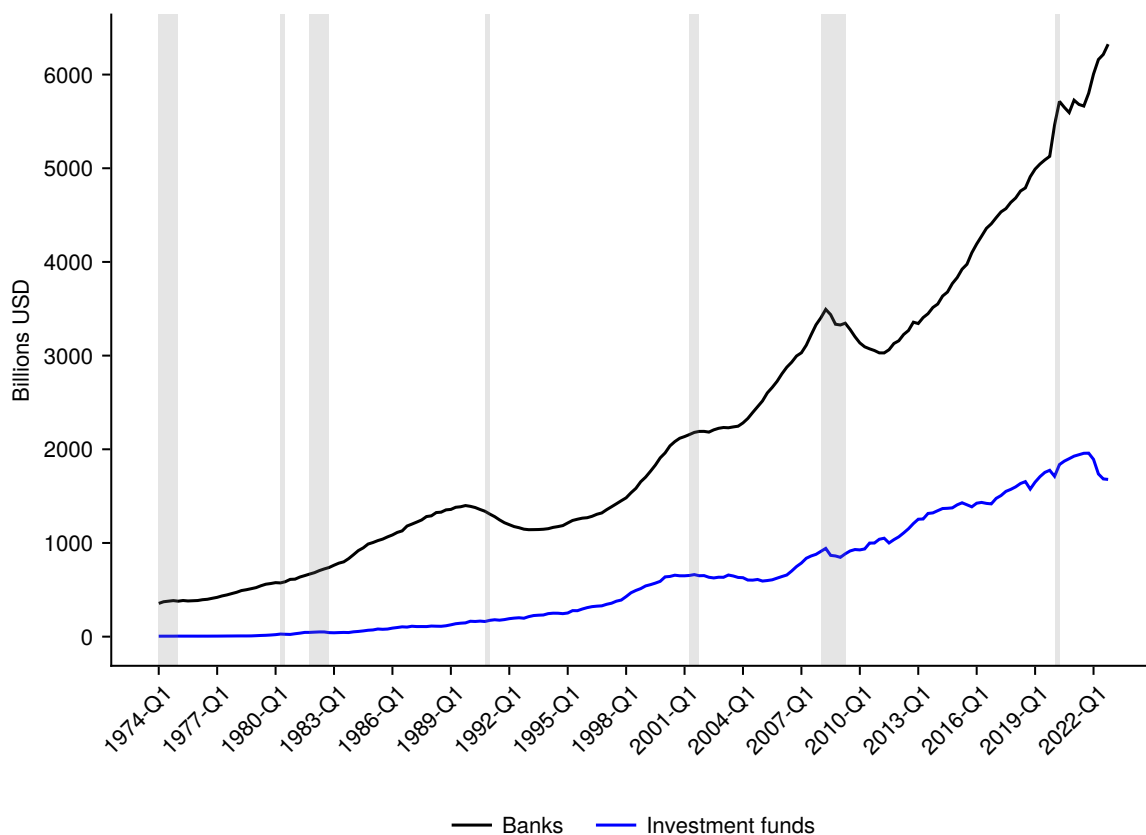
The procedure proposed by [Gallin \(2013\)](#) provides a more accurate measure bank and nonbank credit intermediation to nonfinancial firms. Figure A5 contrasts the amount of lending by investment funds, as identified using the methodology of [Gallin \(2013\)](#),

²[Gallin \(2013\)](#) denotes upstream intermediaries as terminal funders and downstream intermediaries as intermediate funders.

³For a description of how the lending data is constructed, see Appendix A.1.

⁴See Figure A4 for a breakdown of upstream NBFIs' lending.

FIGURE 2. Bank and nonbank lending to nonfinancial firms



Note: This figure shows lending to U.S. nonfinancial firms from banks and NBFIs in nominal billions USD from 1974 Q1 to 2022 Q4. Banks are defined as U.S.-chartered depository institutions and credit unions. Investment funds are defined as money market funds and mutual funds. The lending data is constructed using the methods of [Gallin \(2013\)](#) and [Herman et al. \(2017\)](#), with data from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

with their holding of (non-government) debt instruments. Because of the financial interconnections between investment funds and the rest of the financial sector, using the quantity of debt instruments on the funds' balance sheet as a proxy for their lending would severely overestimate their credit provision to the productive sector. Moreover, there is a significant difference between banks and investment funds in the share of credit to firms that is provided indirectly through the nonbank financial sector. Figure A6 shows that the majority of bank lending is done through banks' direct holdings of firm debt. Banks' funding of downstream NBFIs, which in turn is passed down to firms, has been persistently low over time. On the other hand, investment funds intermediate a sizeable share of its lending through downstream NBFIs, as indicated by Figure A7. This was especially the case during the run-up to the global financial crisis of 2007. After the financial crisis, investment funds' indirect lending plateaued while their direct holdings of firm debt rose rapidly.

Lastly, economic activity is represented by aggregate output, consumption and investments. All aggregate quarterly economic variables are obtained from the FRED database of the Federal Reserve Bank of St. Louis. Consumption is measured by real personal consumption expenditures and investments by real gross private investments. Output is calculated as the sum of consumption, investment and government purchases.

2.3. Empirical Responses to Monetary Shocks

I estimate the effect of monetary policy shocks on household portfolios, bank and nonbank lending to firms and economic activity by means of local projections (Jordà 2005). I restrict the sample to between 1974 Q1 to 2007 Q4 to include the popularization of money market funds in the U.S. in the early 1970s, and to avoid the zero lower bound and the unconventional monetary policy brought about by the global financial crisis.

Monetary policy shocks are identified by the narrative approach (Romer and Romer 2004). Specifically, I use the extended monetary policy shock series constructed by Miranda-Agrippino and Rey (2020). The empirical specification closely follows Lueticke (2021)

$$y_{t+j} = \beta_{0,j} + \beta_{1,j}D_t + \beta_{2,j}\bar{\epsilon}_t + \beta_{3,j}\mathbf{x}_{t-1} + v_{t+j}, \quad j = 0, \dots, 15, \quad (1)$$

where y_{t+j} is the endogenous variable of interest at horizon j , D_t is a time trend, $\bar{\epsilon}_t$ is the monetary shock normalized by its standard deviation, \mathbf{x}_{t-1} are lagged controls.⁵ The

⁵For the local projections, I rely on a package written by Chen (2022).

vector \mathbf{x}_{t-1} includes lagged values of output, consumption, investments, effective Fed funds rate, and monetary policy shocks. All quantity variables are real and in log levels. The coefficient $\beta_{2,j}$ captures the response of endogenous variable y_{t+j} at horizon j to the monetary policy shock occurring at time t .

Figure 3 shows the responses of economic activity, effective Fed funds rate, bank- and nonbank-created liquidity to households, and bank and nonbank lending to firms to a one standard deviation monetary shock. The monetary policy tightening pushes up the effective Fed funds rate for about three years. Output and consumption fall by around 0.7% and 0.6%, respectively, after ten quarters before recovering. Investment falls by a much larger margin, with the decrease reaching about 3% after nine quarters. Bank deposits fall persistently by around 1.4% and banks reduce their lending to firms by 1% after about one year. The responses of bank deposits and lending to firms are consistent with the deposits channel proposed by [Drechsler et al. \(2017\)](#). Interestingly, nonbank financial intermediation expands. Households' nonbank deposits increases persistently by more than 4% after three years, while nonbank lending to firms increases by about 3%. In other words, I observe a flight from bank deposits as households seek alternative sources of liquidity and saving opportunities. Consequently, there is a "credit leakage" towards the less regulated nonbank financial sector in the U.S. after monetary policy tightenings.

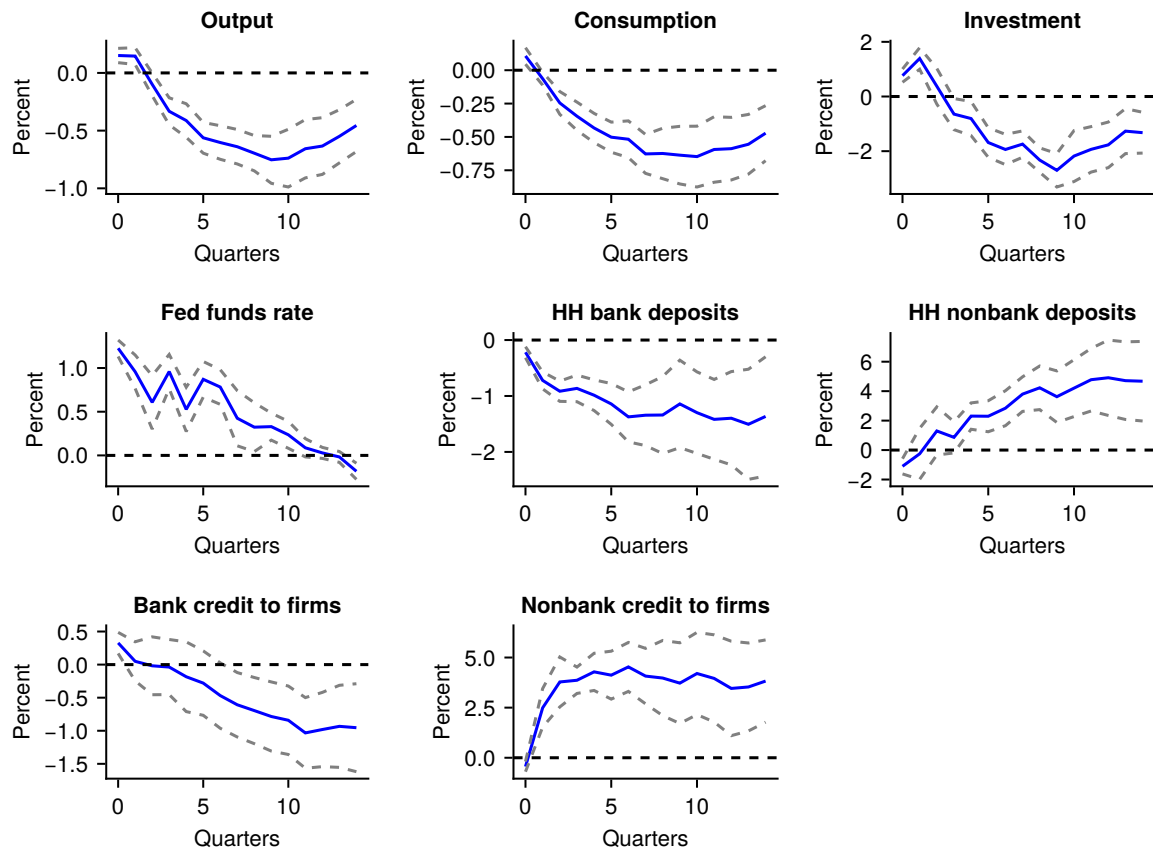
Figure A8 shows the same impulse responses with the addition of the response of NBFIs' holding of debt instruments. As already seen in the previous section, the usual way of using the quantity of NBFIs' holding of debt instruments as a measure of nonbank credit to firms might overstate its size. Figure A8 shows that it might also overestimate the response of nonbank credit to monetary policy shocks. The response of nonbank debt instruments is somewhat higher, although less persistent, than that of nonbank credit as identified by the method of [Gallin \(2013\)](#).

3. A New-Keynesian Model with (Non)banks

To interpret the empirical evidence in the last section, I build a New-Keynesian model with two types of financial intermediaries, banks and investment funds, that engage in liquidity transformation.

I take a liquidity-centric view of financial intermediation similar to that of [Piazzesi et al. \(2022\)](#) and [Niepelt \(2024\)](#). Financial intermediaries issue liquid savings, in the forms of bank and nonbank deposits, that are valued by the households. Banks are

FIGURE 3. Impulse responses to monetary policy shock



Note: This figure shows the estimated response to one standard deviation monetary policy shock, as identified in [Miranda-Agrippino and Rey \(2020\)](#). The gray dotted lines show the 66% confidence bounds, calculated using Eicker-Huber-White heteroskedasticity-robust variance-covariance estimator.

subject to a liquidity constraint that limits their ability to issue debt, which can be satisfied by holding central bank reserves. Nonbank deposits, i.e. investment fund shares, on the other hand, are equities. Investment funds are thus not affected by the constraint and they do not have access to reserves.

Production firms use capital and labor as inputs to produce intermediate goods, and purchase capital from specialized capital producers. Following [Gertler and Karadi \(2011\)](#), firms finance their capital acquisition by issuing financial claims on capital to banks and nonbanks in a competitive credit market. Retailers costlessly differentiate intermediate goods and face a quadratic price adjustment cost, following [Rotemberg \(1982\)](#), when selling the differentiated goods to the final good producer.

3.1. Household Sector

Consider a representative household whose preferences are defined over consumption c_t , liquidity services z_t , and hours worked l_t , represented by the utility function

$$u(c_t, z_t, l_t) = \frac{(c_t - hc_{t-1})^{1-\sigma}}{1-\sigma} + \nu \frac{z_t^{1-\psi}}{1-\psi} - \xi \frac{l_t^{1+\iota}}{1+\iota}, \quad (2)$$

where $\sigma, \psi > 0$ are the inverse intertemporal elasticities of substitution, h captures consumption habit formation, ν denotes the utility benefit of liquidity services, $\iota > 0$ is the inverse Frisch elasticity, and ξ is the disutility of labor.

In the modern financial system, many financial assets may fill the roles traditionally associated with money and provide liquidity services to households. In this paper, liquidity is understood as services provided by financial assets as a medium of transaction and a safe store of value. As mentioned in the previous sections, recent literature in finance shows that investment funds' liabilities satisfy agents' demand for liquidity in ways similar to bank deposits ([Krishnamurthy and Li 2023](#); [Ma et al. 2021](#)). Therefore, I assume in the model that liquidity services z_t are derived from bank deposits d_t and investment fund shares, which I denote as "nonbank deposits" s_t . I employ a constant elasticity of substitution (CES) aggregator similar to the ones used by [Krishnamurthy and Li \(2023\)](#)

$$z_t = \left(\gamma d_t^{1-\epsilon} + (1-\gamma) s_t^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}, \quad (3)$$

where $\gamma \in (0, 1)$ measures the liquidity of bank deposits relative to that of nonbank deposits and $\epsilon \geq 0$ is the inverse elasticity of substitution between the two assets.

Following [Gerali et al. \(2010\)](#), I model bank deposit d_t and nonbank deposit s_t as composite goods issued by a continuum of financial intermediaries. For each asset $j \in \{d, s\}$, the household values a bundle of differentiated deposit products

$$j_t = \left(\int_0^1 (j_t^i)^{1-\eta_j} di \right)^{\frac{1}{1-\eta_j}}, \quad (4)$$

where j_t^i is the deposits in bundle j issued by intermediary i and $\eta_j \geq 0$ is the inverse elasticity of substitution between deposit products in bundle j . One common objection to the way the aggregate bank/nonbank deposits are defined using a CES aggregator is that it is implausible that all households hold deposits from all banks/nonbanks. [Drechsler et al. \(2017\)](#) justify a similar setup by interpreting the representative household as an aggregation of many individual households with diverse preferences for holding deposits at different institutions. [Ulate \(2021\)](#) shows that a heterogeneous depositor approach with stochastic utility and extreme value shocks can work as microfoundation for such CES aggregators.

Moreover, equation (4) implies that banks and investment funds enjoy some degree of market power in their respective markets. This choice is first motivated by the extensive research in banking and finance that documents and studies the prevalence and implications of bank market power ([Drechsler et al. 2017](#); [Corbae and D'Erasmus 2020](#); [Wang et al. 2022](#)). Secondly, in recent years, U.S. money market funds have experienced substantial consolidation. By the end of 2024, the market share of the top five U.S. money market fund managers, measured in assets under management, has increased to over 50% ([Office of Financial Research 2025](#)).

Besides deposits, the household can invest in government bonds b_t which do not provide liquidity services. The household's period budget constraint, in real terms, is given by

$$c_t + \int_0^1 d_t^i di + \int_0^1 s_t^i di + b_t + \tau_t = w_t l_t + div_t + \int_0^1 \frac{d_{t-1}^i R_t^{d,i}}{\pi_t} di + \int_0^1 \frac{s_{t-1}^i R_t^{s,i}}{\pi_t} di + \frac{b_{t-1} R_t}{\pi_t}, \quad (5)$$

where τ_t is the lump-sum tax net of government transfer, w_t is the wage rate, div_t is profits from firms, banks and funds owned by the household, $R_t^{d,i}$ is the nominal gross interest rate on deposits at bank i , $R_t^{s,i}$ is the nominal gross interest rate on nonbank

deposits at investment fund i , R_t is the nominal gross interest rate on bonds, $\pi_t = p_t/p_{t-1}$ is the gross rate of inflation between $t - 1$ and t , and p_t is the price of the consumption good. I assume that the nominal returns on deposits and bonds are risk-free. The household maximizes the discounted sum of life-time utility

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j u(c_{t+j}, z_{t+j}, l_{t+j}), \quad (6)$$

subject to a sequence of flow budget constraints (5), by choosing sequences of consumption, labor supply, deposits, and bonds.

I now turn to the first-order conditions implied by the household program. For each of the liquid asset $j \in \{d, s\}$, the household allocates between different intermediaries according to

$$j_t^i = j_t \left(\frac{\chi_{t+1}^{j,i}}{j} \right)^{-\frac{1}{\eta_j}}, \quad (7)$$

where

$$\chi_{t+1}^{j,i} = \frac{R_{t+1} - R_{t+1}^{j,i}}{R_{t+1}}, \quad (8)$$

$$\chi_{t+1}^j = \left(\int_0^1 \left(\chi_{t+1}^{j,i} \right)^{\frac{\eta_j-1}{\eta_j}} di \right)^{\frac{\eta_j}{\eta_j-1}}. \quad (9)$$

Equation (8) shows the forgone interests when holding deposits at intermediary i relative to bonds, $R_{t+1} - R_{t+1}^{j,i} > 0$, discounted by the bond rate. The return differential is discounted because it is realized in period $t+1$. In other words, holding deposits is costly for the household because of the lower return and $\chi_{t+1}^{j,i}$ represents the cost of deposits at intermediary i . The household is willing to pay such a cost due to the liquidity benefits deposits provide, and I refer to this cost as the *deposit spread*. Then, χ_{t+1}^j is an index of the deposit spreads associated with one unit of deposit bundle j_t , $j \in \{d, s\}$, and it can be interpreted as the cost of one unit of the deposit bundle. Hence, equation (7) shows that the household's relative share of deposits at intermediary i , j_t^i/j_t , depends negatively on the relative cost, $\chi_{t+1}^{j,i}/\chi_{t+1}^j$. Intuitively, when the deposit products at intermediary i are more expensive relative to the total cost, the share of total deposits held at intermediary i is reduced.

The marginal rates of substitution between consumption and each of the liquid assets must be equal to their respective cost, χ_{t+1}^d and χ_{t+1}^s . This implies that the marginal rate of substitution between consumption and aggregate liquidity z_t must be equal to the *average cost of liquidity*, given by

$$\chi_{t+1}^z = \frac{\chi_{t+1}^d \chi_{t+1}^s}{\left((1-\gamma)^{\frac{1}{\epsilon}} (\chi_{t+1}^d)^{\frac{1-\epsilon}{\epsilon}} + \gamma^{\frac{1}{\epsilon}} (\chi_{t+1}^s)^{\frac{1-\epsilon}{\epsilon}} \right)^{\frac{\epsilon}{1-\epsilon}}}. \quad (10)$$

This gives rise to an expression for the household's demand for aggregate liquidity

$$z_t = \left(\frac{\nu}{M_t \chi_{t+1}^z} \right)^{\frac{1}{\psi}}, \quad (11)$$

where M_t is the marginal utility of consumption given by

$$M_t = (c_t - hc_{t-1})^{-\sigma} - \beta h \mathbb{E}_t [(c_{t+1} - hc_t)^{-\sigma}]. \quad (12)$$

Equation (11) shows that the household's demand for liquidity is decreasing in its average cost χ_{t+1}^z , the marginal utility of consumption M_t and the elasticity of liquidity demand, and increasing in the utility weight ν . In the special case where the household does not exhibit habit formation ($h = 0$) and the intertemporal elasticities of substitution are identical ($\sigma = \psi$), consumption velocity is simply given by $c_t/z_t = (\chi_{t+1}^z/\nu)^{1/\psi}$. Given the demand for aggregate liquidity, the demand for bank and nonbank deposits are found as

$$d_t = z_t \left(\gamma \frac{\chi_{t+1}^z}{\chi_{t+1}^d} \right)^{\frac{1}{\epsilon}}, \quad (13)$$

$$s_t = z_t \left((1-\gamma) \frac{\chi_{t+1}^z}{\chi_{t+1}^s} \right)^{\frac{1}{\epsilon}}. \quad (14)$$

The demand functions for deposits show that the relative demand for each type of asset is increasing in its liquidity benefit, γ or $1-\gamma$, and decreasing in its cost relative to the average cost. Combining equations (13) and (14), we see that the household demands more bank deposits relative to nonbank deposits (higher d_t/s_t) if the nonbank deposits are relatively more expensive (higher $\chi_{t+1}^s/\chi_{t+1}^d$). Lastly, the household's Euler equation

and labor supply condition are standard

$$M_t = \beta \mathbb{E}_t \left[M_{t+1} \frac{1}{\Pi_{t+1}} \right] R_{t+1}, \quad (15)$$

$$\xi(1 - x_t)^l = w_t M_t, \quad (16)$$

where M_t is given by equation (12).

3.2. Financial Sector

3.2.1. Banks

There is a continuum of banks that fund themselves with bank deposits and equity. Each bank i purchases financial claims on physical capital $a_t^{b,i}$ at the price q_t , and invests in central bank reserves r_t^i . The balance sheet of a typical bank, in real terms, is

$$q_t a_t^{b,i} + r_t^i = d_t^i + e^i, \quad (17)$$

where e^i is a fixed endowment of bank equity. I interpret the financial claims that the bank holds as credit provided to nonfinancial firms. Banks are subject to a liquidity constraint that limits their ability to issue debt, i.e. they need sufficient collateral to back deposits. The liquidity constraint reads

$$d_t^i \leq \zeta r_t^i, \quad (18)$$

where $\zeta \geq 1$ puts an upper bound on the quantity of deposits relative to reserves. The liquidity constraint simply states that the banks' reserves-to-deposits ratio, or liquidity ratio r_t/d_t , must be greater or equal to $1/\zeta$. This constraint can be interpreted as an explicit regulatory constraint or alternatively as a way to model an increasing marginal cost of debt (Piazzesi et al. 2022; Rogers 2023).

Bank credit earns a real stochastic return R_t^k and the nominal risk-free interest rate on reserves is R_t^r . Furthermore, I assume liquidity transformation is costly for the banks. For each unit of liquid deposits a bank issues, it faces a linear cost of θ_b which is identical across banks. The real profit a bank i , $div_t^{b,i}$, consists of the returns on last-period lending and reserves, net of financing costs and liquidity transformation

costs

$$div_t^{b,i} = q_{t-1} a_{t-1}^{b,i} R_t^k + r_{t-1}^i \frac{R_t^r}{\pi_t} - d_{t-1}^i \frac{R_t^{d,i}}{\pi_t} - e^i - \theta_b d_t^i. \quad (19)$$

Each bank is infinitely-lived and seeks to maximize expected discounted profits

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} div_{t+j}^{b,i}, \quad (20)$$

subject to the household's demand schedule (7) for its deposits, the balance sheet constraint (17), and the liquidity constraint (18). The bank chooses the quantities of capital claims, reserves and deposits, and discounts its profits by the household's real stochastic discount factor $\Lambda_{t,t+j} = \beta^j M_{t+j}/M_t$.

The first-order conditions with respect to capital claims is

$$\mathbb{E}_t \left[\Lambda_{t,t+1} \left(R_{t+1}^k - \frac{R_{t+1}}{\pi_{t+1}} \right) \right] = 0. \quad (21)$$

With perfect credit/capital markets, there is no risk adjusted premium on bank loans, i.e. the real return on loans must equal the real rate in expectation. The first-order condition with respect to reserves yields

$$\lambda_t = \frac{\chi_{t+1}^r}{\zeta}, \quad (22)$$

where λ_t is the Lagrange multiplier associated with the liquidity constraint and χ_{t+1}^r is the bank's discounted forgone interests for each unit of reserves it holds

$$\chi_{t+1}^r = \frac{R_{t+1} - R_{t+1}^r}{R_{t+1}}. \quad (23)$$

Similar to the interpretations of deposit spreads, χ_{t+1}^r represents the bank's opportunity cost of holding reserves and I denote it the *reserve spread*. Equation (22) shows that the marginal value of relaxing the liquidity constraint is equal to the opportunity cost of reserves, adjusted for the bound on bank debt. In other words, χ_{t+1}^r/ζ is the shadow value of reserves. We also see that a larger ζ , i.e. a less restrictive liquidity constraint, means a lower shadow value of reserves.

The first-order condition with respect to deposits gives rise to a classical pricing

equation that determines the equilibrium bank deposit spread for bank i

$$\chi_{t+1}^{d,i} = \left(\frac{\partial d_t^i}{\partial R_{t+1}^{d,i}} \frac{R_{t+1}^{d,i}}{d_t^i} \right)^{-1} \frac{R_{t+1}^{d,i}}{R_{t+1}} + \lambda_t + \theta_b. \quad (24)$$

The term $\lambda_t + \theta_b$ on the right-hand side of equation (24) constitutes the bank's marginal cost of issuing deposits. This cost consists of the shadow value of reserves λ_t , since investments in reserves are needed to satisfy the liquidity constraint, and the unit cost of liquidity creation θ_b . The leftmost term on the right-hand is a markup term over the marginal cost, which is inversely related to the demand elasticity for bank deposits. Banks are able to charge a markup due to the non-competitive nature of the banking sector. All banks are identical and I focus on a symmetric industry equilibrium. Then, equation (24) can be expressed as it applies to a representative bank

$$\chi_{t+1}^d = \frac{\chi_{t+1}^r / \zeta + \theta_b}{1 - \eta_d}, \quad (25)$$

where η_d is the inverse elasticity of substitution between deposits at different banks. Monopolistically competitive banks then charge a markup $1/(1 - \eta_d)$ over their marginal cost $\chi_{t+1}^r / \zeta + \theta_b$. In the special case in which the household substitutes perfectly between banks, i.e. $\eta_d = 0$, then the banking sector becomes perfectly competitive. The bank deposit spread is simply equal to banks' marginal cost

$$\chi_{t+1}^d = \frac{\chi_{t+1}^r}{\zeta} + \theta_b. \quad (26)$$

Lastly, note that a positive deposit spread indicates that the bank's cost of funding is lower than the reference nominal rate in the economy. Hence, deposits are a cheap source of funding and in equilibrium the bank will issue deposits until the liquidity constraint (18) holds with equality.

3.2.2. Investment funds

There is a continuum of investment funds that issue “nonbank deposits”, i.e. fund equities, to finance the purchases of financial claims on capital. Each investment fund i purchases claims $a_t^{s,i}$ at the price q_t . Similar to banks, I interpret the funds' holding of these claims as credits extended to nonfinancial firms. The balance sheet of a typical

investment fund i is

$$q_t a_t^{s,i} = s_t^i. \quad (27)$$

Since the investment fund does not issue debt, it is not subject to the liquidity constraint that banks face. Like banks, the fund faces costs associated with liquidity provision. For each share it issues, it incurs a cost of θ_f which is identical across funds. I assume that the fund participate in the same competitive credit market as banks, and firms do not distinguish between bank and nonbank credit. Hence, nonbank credit earns the same rate of return R_{t+1}^k as the banks. The real profit of an investment fund is the difference between the return on its previously intermediated assets and its financing costs and the liquidity transformation cost

$$div_t^{s,i} = q_{t-1} a_{t-1}^{s,i} R_t^k - s_{t-1}^i \frac{R_t^{s,i}}{\pi_t} - \theta_f s_t^i. \quad (28)$$

The fund maximizes the expected discounted profits, by choosing the size of its balance sheet s_t^i ,

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} div_{t+j}^{s,i}, \quad (29)$$

subject to the household's demand schedule (7) for its deposits and its balance sheet constraint (27), and discounts its profits by the household's real stochastic discount factor $\Lambda_{t,t+j}$.

The first-order condition of the investment fund yields a pricing equation that determines the nonbank deposit spread

$$\chi_{t+1}^{s,i} = \left(\frac{\partial s_t^i}{\partial R_{t+1}^{s,i}} \frac{R_{t+1}^{s,i}}{s_t^i} \right)^{-1} \frac{R_{t+1}^{s,i}}{R_{t+1}} + \theta_f. \quad (30)$$

Note that equation (30) mirrors that of the banks'. The monopolistically competitive investment fund is also able to charge a markup, which is inversely related to the demand elasticity for nonbank deposits, over the marginal cost of issuing nonbank deposits. Importantly, unlike banks, the fund's marginal cost does not include the shadow value of reserves. Naturally, this is because the fund is neither subject to the liquidity constraint nor have access to reserves. Given a symmetric industry equilibrium we arrive at an

expression for the nonbank deposit spread as it applies to a representative investment fund

$$\chi_{t+1}^s = \frac{\theta_f}{1 - \eta_s}. \quad (31)$$

Similar to the banks, the constant markup term depends on the inverse elasticity of substitution between nonbank deposits at different funds, η_s . However, the marginal costs of the investment funds only consists of the cost of liquidity transformation, θ_f , which is also constant. Then, equation (31) implies that the investment funds set the returns on nonbank deposits such that there is a constant spread between them and the nominal risk-free rate R_{t+1} .

3.3. Production Sector

3.3.1. Production Firms

Competitive production firms produce common intermediate goods y_t^m using a constant return to scale technology, with capital and labor as inputs. A firm has a production function of the form

$$y_t^m = k_{t-1}^\alpha l_t^{1-\alpha}, \quad (32)$$

where k_{t-1} is the quantity of capital carried over from the previous period, l_t is the current demand for labor, and α is the capital share of output. In the current period, the firm purchases capital k_t at price q_t from specialized capital producers to be brought into the next period. The firm has to finance its capital acquisition in its entirety by obtaining funds from financial intermediaries. It issues financial claims to capital a_t , priced at q_t , that equals the value of capital to be acquired

$$q_t a_t = q_t k_t. \quad (33)$$

Intermediate goods are eventually sold to retailers at price p_t^m . At the end of each period, the firm acquires new capital and sells its stock of undepreciated capital to capital producers. The real profit of the firm consists of the value of its output, plus capital sales, net of capital financing cost and labor cost

$$\text{div}_t^p = y_t^m \frac{p_t^m}{p_t} + (q_t - \delta)k_{t-1} - q_{t-1}a_{t-1}R_t^k - w_t l_t, \quad (34)$$

where δ is the rate of capital depreciation. In each period, the firm chooses its current labor demand and next-period quantity of capital to maximize expected discounted profits, given its production technology

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \text{div}_{t+j}^p. \quad (35)$$

The first-order condition with respect to labor yields the firm's labor demand

$$w_t = mc_t(1 - \alpha) \left(\frac{k_{t-1}}{l_t} \right)^\alpha, \quad (36)$$

where $mc_t = p_t^m / p_t$. The first-order condition with respect to capital implies a relation determining the firm's demand for capital

$$R_t^k = \frac{mc_t \alpha \left(\frac{k_{t-1}}{l_t} \right)^{\alpha-1} + q_t - \delta}{q_{t-1}}. \quad (37)$$

3.3.2. Retailers and Final Good Producer

A continuum of monopolistically competitive retailers buy intermediate goods from the production firms, costlessly differentiate them, and sell the differentiated goods to a final good producer.

Each retailer i transforms the intermediate goods y_t^m into its variety simply according to $y_t^i = y_t^m$. The final good producer aggregates the varieties into the final output y_t

$$y_t = \left(\int_0^1 (y_t^i)^{1-\varphi} di \right)^{\frac{1}{1-\varphi}}, \quad (38)$$

where φ is the inverse elasticity of substitution between good varieties. The real profit of the final good producer is

$$\text{div}_t^f = y_t - \int_0^1 \frac{p_t^i}{p_t} y_t^i di, \quad (39)$$

where p_t^i is the price of variety i . The demand for variety i is derived from the static

profit maximization problem of the final good producer

$$y_t^i = y_t \left(\frac{p_t^i}{p_t} \right)^{-\frac{1}{\varphi}}. \quad (40)$$

Using the last equation, an expression for the price level in the economy in terms of intermediate goods can be found

$$p_t = \left(\int_0^1 (p_t^i)^{\frac{\varphi-1}{\varphi}} di \right)^{\frac{\varphi}{\varphi-1}}. \quad (41)$$

The real profit of a retailer consists of the value of its output net of the cost of purchasing intermediate goods and a quadratic price adjustment cost following [Rotemberg \(1982\)](#)

$$div_t^{r,i} = \frac{p_t^i}{p_t} y_t^i - mc_t y_t^i - \frac{\theta_p}{2\varphi} \left(\ln \left(\frac{p_t^i}{p_{t-1}^i} \right) \right)^2 y_t, \quad (42)$$

where mc_t is the real marginal cost of the retailer, y_t^i is given by (40), and $\theta_p > 0$ determines the magnitude of the price adjustment cost. The retailer sets its price to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} div_{t+h}^{r,j}. \quad (43)$$

The first-order condition generates the New-Keynesian Phillips curve

$$\ln \pi_t = \frac{1}{\theta_p} (mc_t - (1 - \varphi)) + \mathbb{E}_t \left[\Lambda_{t,t+1} \ln \pi_{t+1} \frac{y_{t+1}}{y_t} \right]. \quad (44)$$

3.3.3. Capital Good Producers

Competitive capital good producers purchase undepreciated capital from firms after production, repair depreciated capital and build new capital.

A capital producer values both new and repaired capital at price q_t . I assume there are adjustment costs when making investment decisions. Let I_t^n denote net capital investment, or newly created capital, and $k_t = k_t^h + k_t^c$ be the total stock of capital. Depreciated capital δk_{t-1} is refurbished in its entirety. The gross capital investment,

denoted by I_t , is given by

$$I_t = I_t^n + \delta k_{t-1}. \quad (45)$$

The profit of the capital producer at time t is then

$$q_t k_t - (q_t - \delta) k_{t-1} - (I_t^n + \delta k_{t-1}) - f\left(\frac{I_t^n + I}{I_{t-1}^n + I}\right) (I_t^n + I), \quad (46)$$

where $f(\cdot)$ is the adjustment cost function given by

$$f(x) = \frac{\theta_c}{2} (\ln(x))^2, \quad (47)$$

$\theta_c \geq 0$ controls the magnitude of the adjustment cost, and I is the steady state level of gross investment. The profit of the capital producer can be rewritten in terms of I_t^n

$$div_t^c = (q_t - 1) I_t^n - f\left(\frac{I_t^n + I}{I_{t-1}^n + I}\right) (I_t^n + I). \quad (48)$$

The capital producer maximizes expected discounted profits by choosing the level of net investment I_t^n , subject to the investment adjustment cost,

$$\mathbb{E}_t \sum_{h=0}^{\infty} \Lambda_{t,t+h} div_{t+h}^c. \quad (49)$$

The first-order condition of the capital producer yields an expression for the price of capital, q_t ,

$$q_t = 1 + \frac{\theta_c}{2} \left(\ln \left(\frac{I_t^n + I}{I_{t-1}^n + I} \right) \right)^2 + \theta_c \ln \left(\frac{I_t^n + I}{I_{t-1}^n + I} \right) - \mathbb{E}_t \left[\Lambda_{t,t+1} \theta_c \ln \left(\frac{I_{t+1}^n + I}{I_t^n + I} \right) \frac{I_{t+1}^n + I}{I_t^n + I} \right]. \quad (50)$$

3.4. Consolidated Government

The consolidated central bank and fiscal authority issues reserves to banks and bonds to the household, and collects lump-sum taxes to fund its interest payments. It has the

following budget constraint:

$$b_t + r_t + \tau_t = b_{t-1} \frac{R_t}{\pi_t} + r_{t-1} \frac{R_t^r}{\pi_t}, \quad (51)$$

where r_t is the aggregate supply of reserves to banks. The government sets the interest rates on bonds and reserves and the lump-sum tax, and elastically supplies bonds and reserves to meet demand. In the baseline, I assume that reserves are non-interest bearing in all periods. The reserve rate is then

$$R_t^r = R^r = 1, \forall t. \quad (52)$$

The government has as its monetary policy instrument the interest rate on government bonds R_{t+1} . Monetary policy is set according to a Taylor rule that seeks to stabilize inflation and output

$$\begin{aligned} \log(R_{t+1}) = & (1 - \rho) \log(R) + \rho \log(R_t) \\ & + (1 - \rho) \left(\phi_\pi \log\left(\frac{\pi_t}{\pi}\right) + \phi_y \log\left(\frac{y_t}{y_{t-1}}\right) \right) + v_t, \end{aligned} \quad (53)$$

where R is the steady state nominal rate, π is the inflation target, ρ captures monetary policy inertia, ϕ_π measures the inflation response, ϕ_y measures the output response, and v_t is the exogenous monetary policy shock.

3.5. Market Clearing and Aggregate Resource Constraint

Clearing in the markets for bank and nonbank deposits requires that the household's total demand for deposits equals the supply of deposits

$$d_t = \int_0^1 d_t^i di, \quad (54)$$

$$s_t = \int_0^1 s_t^i di, \quad (55)$$

The banks' demand for reserves must equal the government's supply

$$r_t = \int_0^1 r_t^i di. \quad (56)$$

The balance sheet relation of the banking sector must hold

$$q_t \int_0^1 a_t^{b,i} di + r_t = d_t + \int_0^1 e^i di. \quad (57)$$

The balance sheet relation of the investment funds must hold

$$q_t \int_0^1 a_t^{s,i} di = s_t. \quad (58)$$

Credit market clearing requires that the production firms' issuance of financial claims equals the sum of the financial intermediaries' holding of claims

$$a_t = \int_0^1 a_t^{b,i} di + \int_0^1 a_t^{s,i} di, \quad (59)$$

which in turn must equal the value of capital purchase from capital producers, as already mentioned in the previous section. Lastly, the total profit distributed to the household in every period equals the sum of profits from banks, funds, production firms, retailers, final good producer, and capital producers

$$div_t = \int_0^1 div_t^{b,i} di + \int_0^1 div_t^{s,i} di + div_t^P + \int_0^1 div_t^{r,i} di + div_t^f + div_t^c. \quad (60)$$

The aggregate resource constraint is found by combining budget constraints of the household and the government, market clearing conditions, and total profits

$$c_t + I_t = y_t - \frac{\theta_c}{2} \left(\ln \left(\frac{I_t^n + I}{I_{t-1}^n + I} \right) \right)^2 (I_t^n + I), \quad (61)$$

where output is

$$y_t = k_{t-1}^\alpha l_t^{1-\alpha} \quad (62)$$

gross investment I_t is as defined in equation (45), and the law of motion for capital is given by

$$k_t = k_{t-1} + I_t^n. \quad (63)$$

Following [Hagedorn et al. \(2019\)](#) and [Fernández-Villaverde et al. \(2023\)](#), I assume that

the retailers’ price adjustment costs and the financial intermediaries’ liquidity transformation costs are “virtual”. This means that while these costs affect the pricing decision of the agents, they do not result in the transfer of real resources. Thus, these costs do not show up in the aggregate resource constraint.

4. Calibration

I calibrate the model to the U.S. economy. Each period in the model is interpreted as a quarter. Table 1 summarizes the parameters and the chosen targets. I use variables without time subscripts to denote their steady state values.

4.1. Household sector

The household’s time discount factor is set to $\beta = 0.99$. I set the inverse intertemporal elasticities of substitution σ and ψ to the standard values of 1. The habit parameter h is set to 0.815 following [Gertler and Karadi \(2011\)](#). The inverse Frisch elasticity ι is set to 1 to be in line with the estimates of [Chetty et al. \(2011\)](#). The disutility of labor $\xi = 7.07$ is set such that the labor supply is 1/3 in steady state. I calibrate the utility weight of liquidity $\nu = 0.07$ to match the ratio of liquid assets to output of 2.81.⁶ I calibrate the relative liquidity benefit of bank deposits $\gamma = 0.60$ to match the ratio of nonbank credit to bank credit of 0.21. The inverse elasticity of substitution between bank and nonbank deposits is set to $\epsilon = 0.13$, in line with the estimates of [Krishnamurthy and Li \(2023\)](#). I assume that elasticities of substitution between bank deposit products and between nonbank deposit products are also the same, i.e. $\eta_d = \eta_s = 0.13$.

4.2. Financial sector

The financial intermediaries’ per unit cost of issuing deposits, θ_b and θ_f , are both set to 0.01. This is the midpoint of the range of values calculated by [Niepelt \(2024\)](#) for U.S. banks. I calibrate the upper bound on bank debt $\zeta = 6.43$ to match a steady state bank liquidity ratio (reserves-to-deposits ratio) of 0.1556, as estimated by [van Binsbergen et al. \(2022\)](#). I set the total fixed bank equity to 0.13 such that the ratio of bank equity to total asset is 0.045, which is the minimum CET1 capital ratio requirement in the U.S.

⁶Liquidity assets are the sum of bank deposits, money market fund shares and mutual fund shares held by the household sector, in line with the definition in the empirical analysis.

TABLE 1. Baseline calibration

Parameters	Description	Value	Target/Source
Household sector			
β	Discount factor	0.99	Standard value
σ	Inv. intertemporal elasticity of substitution	1	Standard value
ψ	Inv. intertemporal elasticity of substitution	1	Standard value
h	Habit parameter	0.815	Gertler and Karadi (2011)
ι	Inv. Frisch elasticity	1	Chetty et al. (2011)
ξ	Disutility of labor	7.07	$l = 1/3$
ν	Utility weight of liquidity	0.07	$z/y = 2.81$
γ	Liquidity benefit of bank deposits	0.60	$k^s/k^b = 0.21$
ϵ	Inv. elasticity of substitution s and d	0.13	Krishnamurthy and Li (2023)
η_d	Inv. elasticity of substitution d^i	0.13	$\eta_d = \epsilon$
η_s	Inv. elasticity of substitution s^i	0.13	$\eta_s = \epsilon$
Financial sector			
θ_b	Bank deposit issuance cost	0.01	Niepelt (2024)
θ_f	Nonbank deposit issuance cost	0.01	$\theta_f = \theta_b$
ζ	Bound on bank debt	6.43	$r/d = 0.1556$
e	Fixed bank equity	0.13	$e/(e + d) = 0.045$
Production sector			
α	Capital share of output	0.3	Standard value
δ	Capital depreciation rate	0.025	Standard value
θ_c	Capital adjustment cost	10	Standard value
θ_p	Price stickiness	20	Calvo price duration 5 quarter
φ	Inv. elasticity of substitution y^i	0.05	Markup 5%
Government			
ρ	Interest smoothing	0.8	Standard value
ϕ_π	Inflation response	1.25	Standard value
ϕ_y	Inflation response	0.125	Standard value
Π	Inflation target	1	Zero steady state inflation

Note: This table shows the baseline calibration. Variables without time subscripts denote steady state values.

4.3. Production sector

The capital share of output $\alpha = 0.3$ and the capital depreciation rate $\delta = 0.025$ are standard. The capital adjustment cost parameter θ_c is set to 10. The parameter capturing price stickiness, θ_p , is set to 20 to match a price duration of 5 quarters in the Calvo setting. To match a steady state markup of 5%, I set the inverse elasticity of substitution between intermediate good varieties φ to 0.05.

4.4. Government

The inertia in the nominal rate setting, indicated by ρ , is assumed to be 0.8. The government's responses to inflation and output, ϕ_π and ϕ_y , take on the conventional values of 1.25 and 0.125, respectively. I assume that the government targets zero inflation in steady state, i.e. $\pi = 1$.

5. Monetary transmission

Figure 4 shows the impulse responses, as deviation from steady state, to a monetary policy shock of 25 basis points. The solid black lines show the baseline specification in which the household values both bank and nonbank deposits. In the alternative specification, shown by the dotted blue lines, the household does not value nonbank deposits, i.e. $\gamma = 1$. This is a simple way of simulating a scenario where investment funds are not in competition with banks and there is no nonbank financial intermediation.

After the shock, the monetary policy rate R_{t+1} reaches to a level about 20 basis points higher than in steady state. It is less than the size of the initial shock because of the feedback mechanism in the Taylor-rule (53). The reserve spread χ_{t+1}^r widens by the same magnitude as the policy rate, since the government keeps the interest rate on reserves fixed. Recall from the banks' problem that a higher (opportunity) cost of reserves raises their shadow value as it becomes more expensive for the banks to satisfy the liquidity constraint (18). The banks' marginal cost of issuing debt increases and, according to the bank pricing equation (25), the bank spread χ_{t+1}^d widens as a result. A wider bank spread then implies that the banks keep their deposit rates relatively low after a monetary policy tightening.

The investment funds, on the other hand, keep the nonbank spread χ_{t+1}^s constant (and therefore it is not plotted in Figure 4). Recall that investment funds do not rely on debt-issuance to finance themselves. Therefore, they do not face the same liquidity

constraint that limits the banks' ability to issue liabilities (beyond the liquidity transformation costs). As a result, according to their pricing equation (31), the funds' marginal cost of issuing nonbank deposits and the equilibrium nonbank spread are not altered by monetary policy. In other words, the investment funds set the returns on nonbank deposits such that the increase in the policy rate is passed on to the household in its entirety.

The differential responses of the spreads mean that, after a monetary policy tightening, bank deposits become more expensive for the household as a source of liquidity. The deposits demand equations (13) and (14) show that the ratio of bank to nonbank deposits d_t/s_t is decreasing the relative cost $\chi_{t+1}^d/\chi_{t+1}^s$. The flight from bank deposits and the inflows into nonbank liabilities are observed in Figure 4. The household's portfolio rebalancing is also in line with the empirical results shown in section 2.

In turn, banks reduce the amount of credit they extend to nonfinancial firms. The reasons for this are twofold. First, in the model, the banks cannot make up for the loss of deposit funding with other sources. In practice, of course, banks have other sources of funding other than household deposits. However, as shown by [Wang et al. \(2022\)](#), there are substantial costs for banks associated with non-deposit debt financing. Deposits are, in this sense, "special" for commercial banks as they generally cannot compensate large deposit outflows fully with other forms of market financing. In the model, the lack of other sources of funding for banks is a simple way of capturing this feature of the financial markets. Second, although the decreased deposit funding frees up a portion of the banks' balance sheets by reducing the need for reserves, the balance sheets shrink by more than the reserves. For every unit of lost deposit funding, the reserves necessary to satisfy the liquidity constraint fall by only $1/\zeta = 0.1556$. The rest of the reduction in funding must then be mirrored by a fall in the banks' investments of credit to nonfinancial firms. In contrast, the investment funds expand their balance sheets and channel more of the household's savings to the firms. Then, the structure of the financial sector (at least the parts examined here) changes after a monetary policy shock. The nonbank financial sector expands while banks play a lesser role in credit intermediation.

This suggests that the existence of nonbank financial intermediaries in competition with traditional banks dampens the contractionary effects of monetary policy. In Figure 4, the impulse responses in the alternative specification without nonbank deposits retain the same qualitative characters as those in the baseline. However, without the household portfolio rebalancing mechanism, investment falls by more than in the

baseline. The decrease in output and consumption are somewhat more pronounced and takes longer to recover after the initial fall. In the absence of nonbank liabilities, capital exhibits a deeper decline after a monetary tightening. This is because there is no increase in nonbank loans to firms that counteracts the (small) decline in bank credit. In the absence of competition from nonbank liabilities, banks deposits also fall by less than in the baseline.

The critical mechanism in the model that generates the household portfolio rebalancing, and the subsequent increase in nonbank finance, is the differential responses of the bank and nonbank spreads after a monetary policy tightening. These responses are in line with recent empirical evidence in the United States regarding the impact of monetary policy on bank deposit spreads and spreads on money market fund yields. [Drechsler et al. \(2017\)](#) and [Wang et al. \(2022\)](#) show evidence for a positive relationship between U.S. bank deposit spreads and the Fed funds rate. [Afonso et al. \(2023\)](#) find that the yields on U.S. money market funds tend to follow the effective Fed funds rate very closely, while the response of the average rate on retail three-month certificates of deposit (CD) is much slower. For example, between 2022 and 2023 the increase in fund yields corresponded to 97% of the increase in the effective Fed funds rate, whereas for the CD rate the pass-through was 8%.

The relevant theoretical mechanisms in my model are, however, somewhat different than those in e.g. [Drechsler et al. \(2017\)](#). In [Drechsler et al. \(2017\)](#), the deposit spread depends on the presence of bank market power. If banks were competitive, monetary policy would have no impact on the deposit spread in that model.⁷ In my model there is always a positive spread between the monetary policy rate and the bank deposit rates, because the household derive utility from bank deposits.⁸ While bank market power modulates the response of the bank spread to monetary policy, its absence would not lead to a fixed spread as in [Drechsler et al. \(2017\)](#). As described in the model section, even when banks are competitive they are nevertheless bound by the liquidity constraint (18), and their marginal cost dependent on the shadow value of reserves. In this way, monetary policy has an impact on the bank spread regardless of the structure of the banking sector.

Recall, from the bank spread equation (25), that the extent to which a higher monetary policy rate leads to a wider bank spread depends on the restrictiveness of liquidity

⁷In fact, in the absence of bank market power there would be no spread between the policy rate and the deposit rate at all.

⁸For instance, as the bank deposit spread goes to zero, the household's demand for bank deposits goes to infinity.

constraint, captured by ζ , and the degree of differentiation between bank deposit products, captured by η_d . Here, I choose to focus on the liquidity constraint since it reflects (at least to some degree) a feature of the banking sector that policymakers more likely could affect. Figure 5 compares the baseline to a specification in which the banks face a stricter liquidity constraint while nonbank financial intermediation is active. The tightened liquidity constraint could reflect some increased regulatory requirement such as a higher minimum reserve requirement or more generally an increased cost of issuing debt. Specifically, I lower the parameter ζ to about 2.86 (compared to $\zeta = 6.43$ in the baseline) which corresponds to a higher liquidity ratio of 0.35 (compared to 0.1556 in the baseline).

Figure 5 illustrates that with a more restrictive liquidity constraint, the bank spread rises by substantially more after a monetary policy increase. It is clear from equation (25) that a lower ζ makes the bank spread more reactive to monetary policy, through the reserve spread χ_{t+1}^r . It is because the more restrictive constraint raises the banks' marginal cost of issuing debt for any given level of the reserve spread. Moreover, the magnitude of the household's portfolio rebalancing towards nonbank deposits is also larger due to the larger difference between the bank spread and the (constant) nonbank spread after the shock. Interestingly, the responses of output, capital and investment do not differ much between the specifications. This is because although bank credit experiences a deeper fall when banks face the stricter liquidity constraint, the corresponding increase in nonbank credit is also larger.

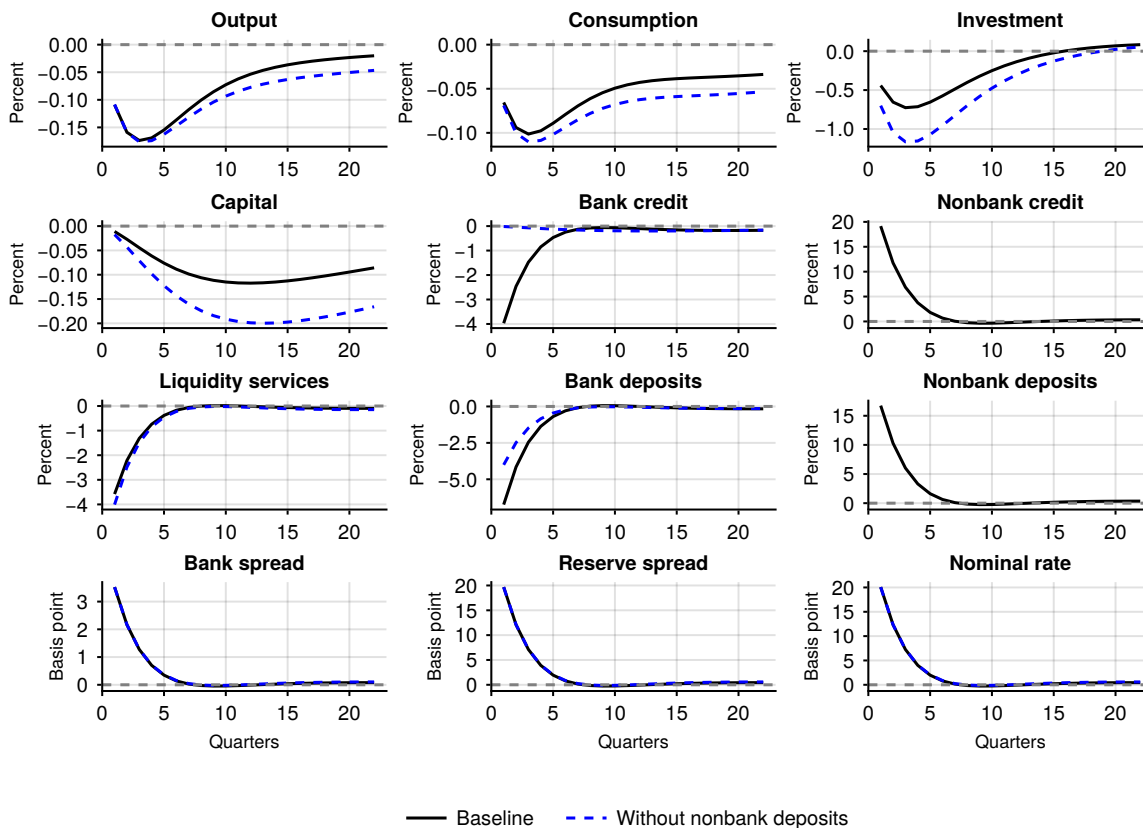
This is in stark contrast to Figure A9, which shed light on the impact of a stricter liquidity constraint when there is no nonbank financial intermediation. Figure A9 shows that without nonbank financial intermediation, a more restrictive liquidity constraint leads to a deeper contraction in the economy after a monetary policy tightening. It is because in that case there is nothing to counteract the effects of the larger increase in the bank spread induced by the tightened liquidity requirement. This further illustrates the result that the presence of nonbank financial intermediation dampens the impact of monetary policy.

6. Conclusion

In this paper, I study the transmission of monetary policy, through its impact on bank and nonbank financial intermediation, in the United States.

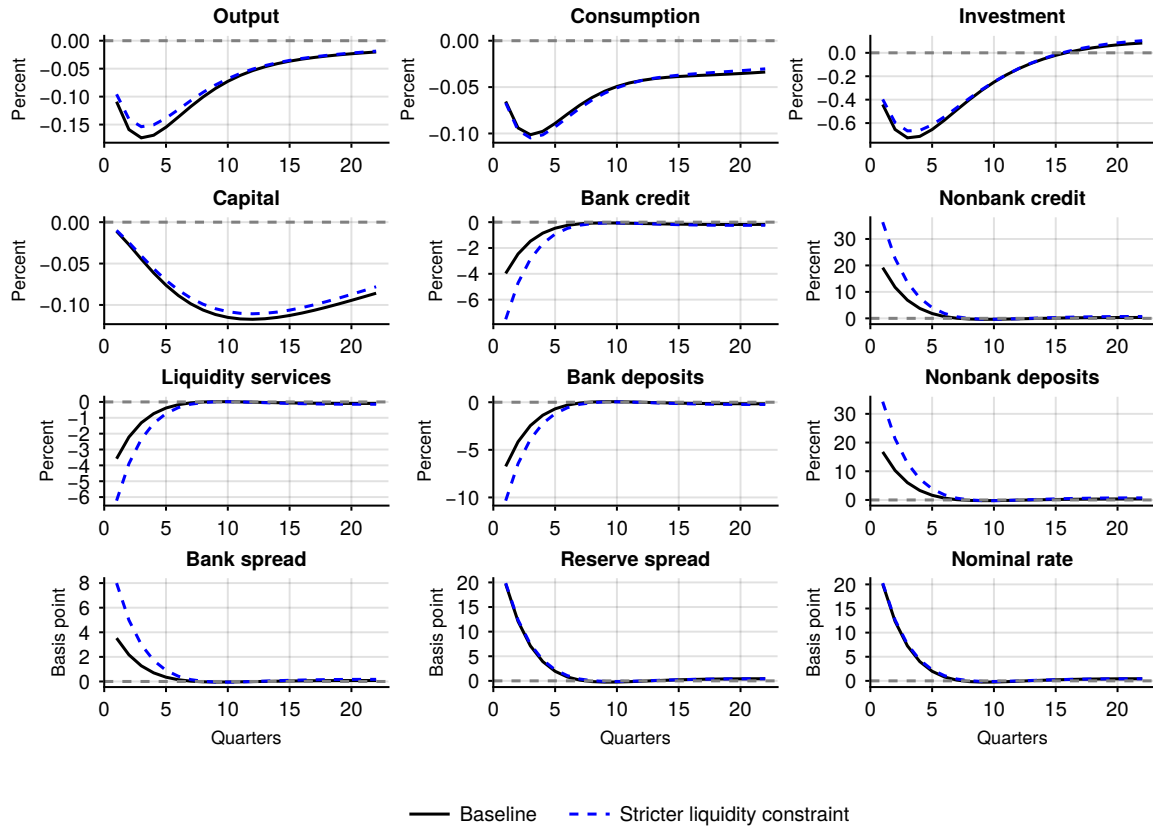
I begin by documenting the empirical response of household portfolios, bank and

FIGURE 4. Impulse responses to a monetary policy shock of 25 basis points



Note: This figure shows the impulse responses, as deviations from steady state, to a monetary policy shock of 25 basis points. The solid black lines show the baseline specification in which the household values both bank and nonbank deposits. The dotted blue lines show a specification in which the household does not value nonbank deposits for liquidity purposes, i.e. $\gamma = 1$.

FIGURE 5. Impulse responses to a monetary policy shock of 25 basis points



Note: This figure shows the impulse responses, as deviations from steady state, to a monetary policy shock of 25 basis points. In both specifications, the household values bank and nonbank deposits. The solid black lines show the baseline in which $\zeta = 6.43$, which corresponds to a liquidity ratio of 0.1556. The dotted blue lines show a specification in which the banks face a stricter liquidity constraint, i.e. $\zeta = 2.8571$ which corresponds to a liquidity ratio of 0.35.

nonbank lending, and economic activity to monetary policy surprises. I use the Financial Accounts to construct measures of bank and nonbank financial intermediation. By employing methods for netting out financial interconnections between financial market participants, I reduce the usual risk of overestimating nonbank credit intermediation in the construction of my dataset. I find that following a surprise monetary policy tightening U.S. households substitute away from bank deposits and increase holdings of nonbank liabilities. In turn, bank lending to nonfinancial firms contracts and economic activity falls. NBFIs, on the other hand, expand credit intermediation and increase lending to firms.

To rationalize the empirical results, I introduce banks and investment funds into an otherwise standard New-Keynesian model. Financial intermediaries issue claims, valued by the households for their liquidity services, to fund loans to the productive sector. Restrictions on the banks' ability to issue debt make the cost of bank deposits more sensitive to monetary policy relative to nonbank deposits. The change in relative prices after a monetary tightening gives rise to the portfolio shifts and increased nonbank finance in the model. Consequently, in the absence of the nonbank financial sector investment would fall by more and the economy experiences a deeper contraction since, in this case, the decrease in bank lending is not compensated by the increased nonbank credit to firms. Thus, nonbank financial intermediaries act as a conduit for the flight from bank deposits during monetary tightening and nonbank credit intermediation dampen the effect of monetary policy.

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Appendix A. Empirical Appendix

A.1. Constructing lending data using the Financial Accounts

The Financial Accounts (FAs) provide a comprehensive overview of the financial assets and liabilities of sectors of the U.S. economy (e.g. households, nonfinancial business, financial intermediaries), broken down into various financial instruments (e.g. deposits, corporate bonds, mortgages). Here, I focus on the flows between financial intermediaries and nonfinancial businesses via debt instruments. Table A1 shows the complete list of debt instruments and financial intermediaries used when constructing the data.

First, I categorize all financial intermediaries into upstream and downstream intermediaries, following [Gallin \(2013\)](#). Upstream intermediaries are those who generally take proceeds from the households and fund both other financial intermediaries and the firms. Downstream intermediaries are those who do not interact with the household sector but rely on market funding from upstream intermediaries. The aim is to determine the amount of funding that the upstream intermediaries provide to nonfinancial firms. The upstream intermediaries provide funding to firms in two ways: (1) holding firm debt directly and (2) fund downstream intermediaries who in turn invest in firm debt.

In order to achieve this, counterparty information is needed to determine whom-to-whom lending. However, the FAs lack this information. For example, Table L.213 shows that, as of 2022Q4, of the total outstanding corporate bonds, \$6.7 trillion had been issued by nonfinancial corporate businesses. The table also shows that \$0.78 trillion worth of corporate bonds were held by U.S.-chartered depository institutions. But there is no information on how much of corporate bonds held by depository institutions was issued by nonfinancial corporate businesses (or by any other issuers). To overcome this issue, I follow [Herman et al. \(2017\)](#) and assume that, for each debt instrument, the whom-to-whom lending is proportional to each intermediary's asset holdings of that debt instrument. Continuing with the previous example, in 2022Q4 U.S.-chartered depository institutions' holdings of corporate bonds (\$0.78 trillion) accounted for 5.8% of the total (\$13.4 trillion). Therefore, I assume that 5.8% of the corporate bonds issued by nonfinancial corporate businesses are held by U.S.-chartered depository institutions. That is, the estimated funding of firms that comes from depository institutions via corporate bonds is $\$6.7 \text{ trillion} * 0.058 \approx \0.39 trillion . I can repeat this procedure for every debt instrument that the nonfinancial firms issue, and arrive at an estimate of how much of the firms' balance sheet is funded by depository institutions.

The abovementioned procedure is then applied to find: (1) the amount of direct funding that upstream intermediaries provide to nonfinancial firms through the direct holdings of firm debt, (2) the amount of funding upstream intermediaries provide to downstream intermediaries by holding debt issued by downstream entities, and (3) the amount of funding that downstream intermediaries provide to nonfinancial firms through their holdings of firm debt. A stylized depiction of the chains of intermediation is shown in Figure A1. Next, I allocate all firm debt held by the downstream intermediaries to upstream intermediaries, proportional to the amount of downstream intermediaries' liabilities the upstream entities hold. For example, suppose brokers/dealers hold \$500 million of firm debt, and that in turn 50% of their liabilities are held by mutual funds. Then, $\$500 \text{ million} * 0.5 = \250 million of the firm debt held brokers/dealers are counted as if they are held by mutual funds. In this way, I reallocate all firm debt held by the downstream intermediaries back to upstream entities. This is then the indirect funding that the upstream intermediaries provide to nonfinancial firms.

The sum of the direct and the indirect funding of nonfinancial firms from upstream intermediaries is basis of the empirical analysis in the main text. Note that I focus on four of the upstream intermediaries in particular; U.S.-chartered depository institutions and credit unions, which constitute “commercial banks”, and mutual funds and money market funds, which constitute “investment funds”.

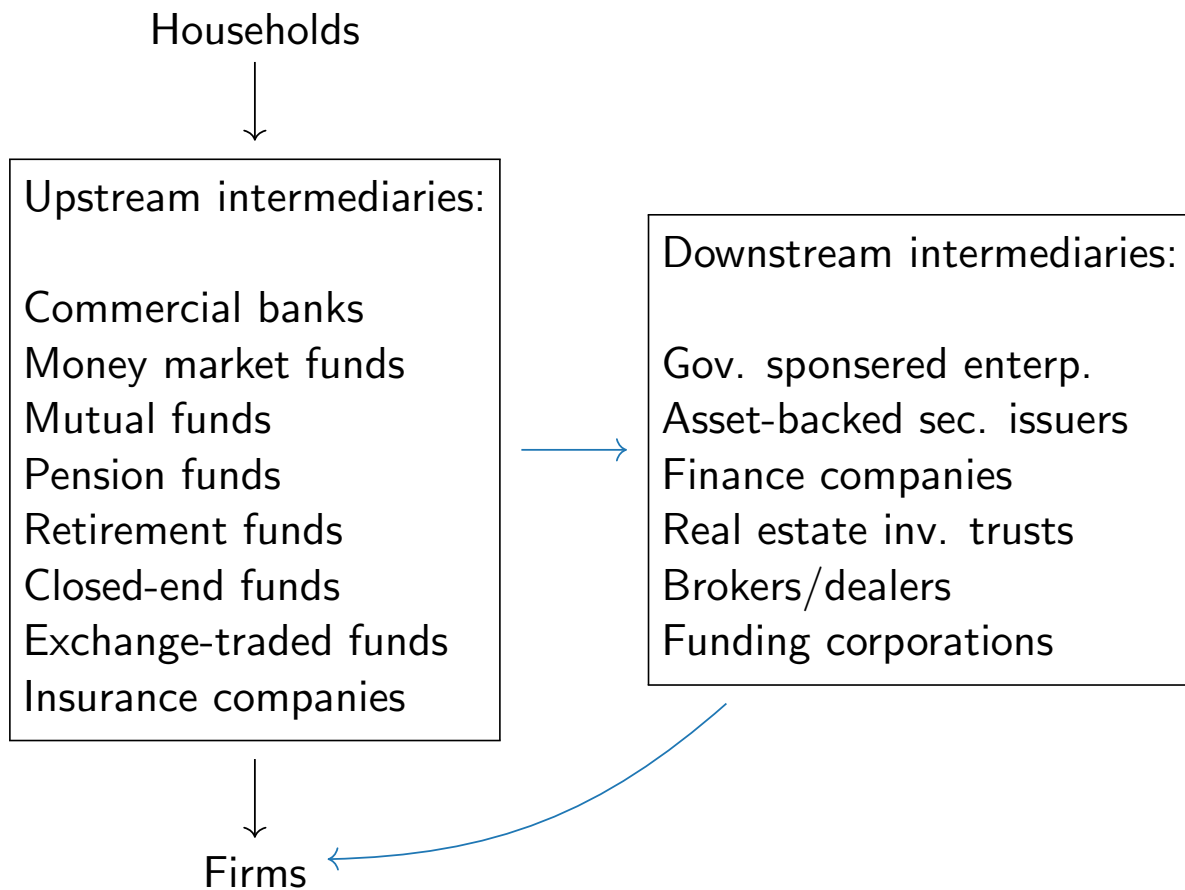
TABLE A1. Tables in Financial Accounts

Table number	Description
Debt instruments	
L.205	Time and savings deposit
L.207	Federal funds and security repurchase agreements
L.209	Open market papers
L.211	Agency- and GSE-backed securities
L.212	Municipal securities
L.213	Corporate and foreign bonds
L.215	Depository institution loans not elsewhere classified
L.216	Other loans and advances
L.218	Home mortgages
L.219	Multifamily residential mortgages
L.220	Commercial mortgages
L.221	Farm mortgages
Financial intermediaries	
L.111	U.S.-chartered depository institutions (u)
L.114	Credit unions (u)
L.115	Property insurance companies (u)
L.116	Life insurance companies (u)
L.118	Private pension funds (u)
L.119	Federal government retirement funds (u)
L.120	State and local government retirement funds (u)
L.121	Money market funds (u)
L.122	Mutual funds (u)
L.123	Closed-ended funds (u)
L.124	Exchange-traded funds (u)
L.125	Government-sponsored enterprises (d)
L.126	Agency- and GSE-backed mortgage pools (d)
L.127	Issuers of asset-backed securities (d)
L.128	Finance companies (d)
L.129	Real estate investment trust (d)
L.130	Brokers and dealers (d)
L.132	funding corporations (d)

Note: This tables shows the list of debt instruments and financial intermediaries used when constructing the lending data. Municipal bonds are included here because local government could use them to raise funds for businesses. Following [Gallin \(2013\)](#), intermediaries marked with “u” are classified as upstream intermediaries while those marked with “d” are the downstream ones.

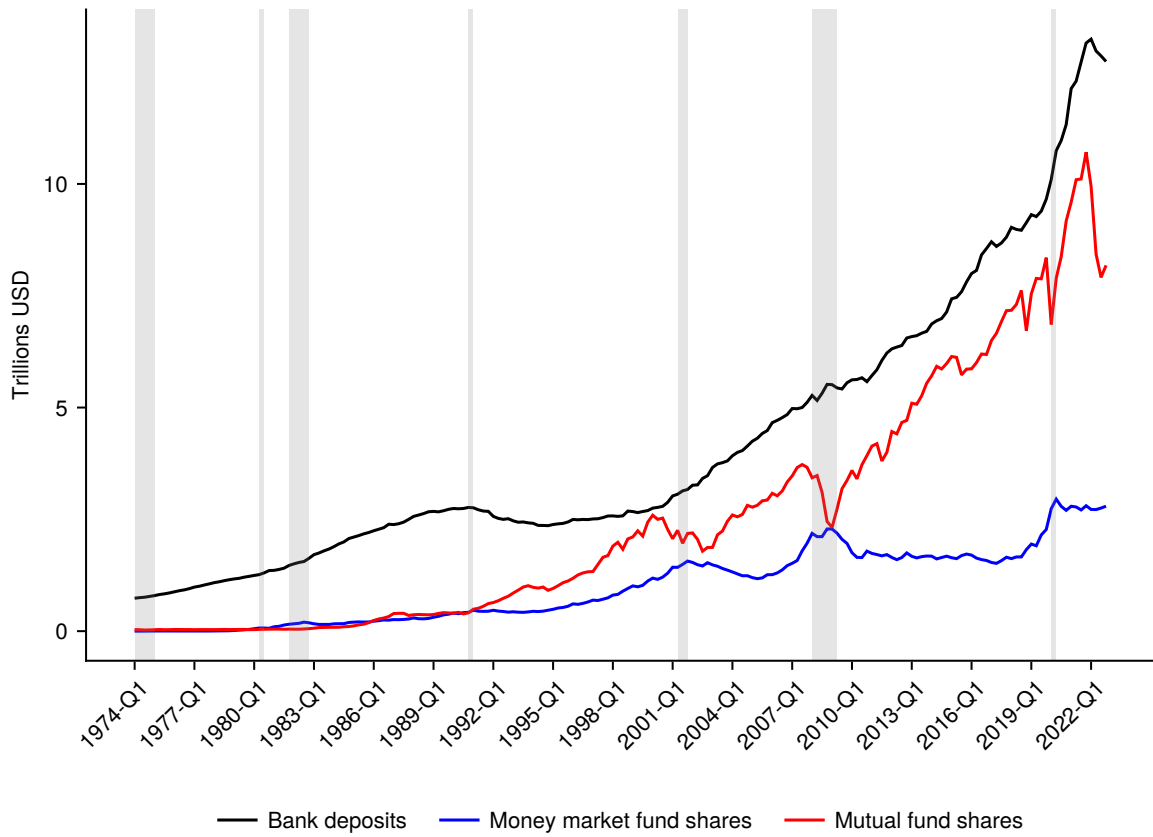
A.2. Additional Figures

FIGURE A1. Upstream and downstream intermediaries' funding of nonfinancial firms



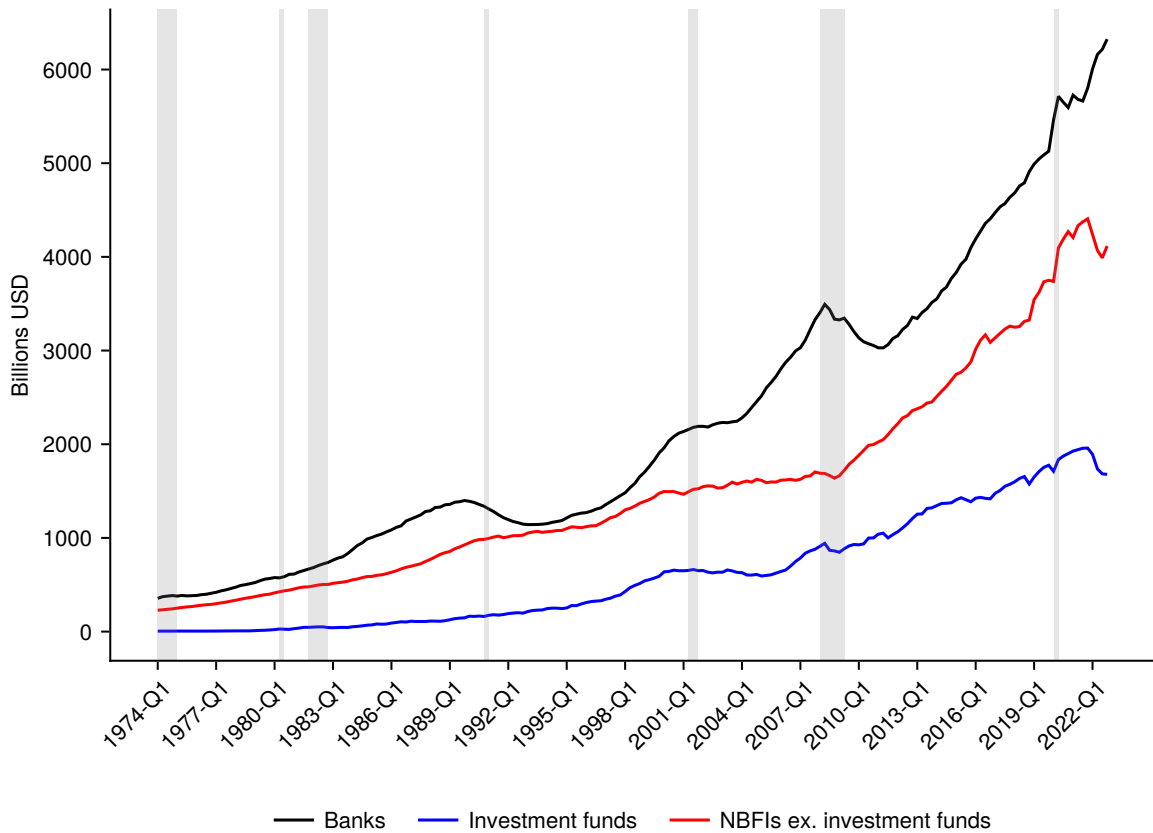
Note: This figure shows the financial intermediaries' funding of nonfinancial firms according to the classification of [Gallin \(2013\)](#). The black line shows the upstream intermediaries' direct funding of firms. The blue lines show upstream intermediaries' funding through downstream intermediaries.

FIGURE A2. Households' bank deposits and fund shares



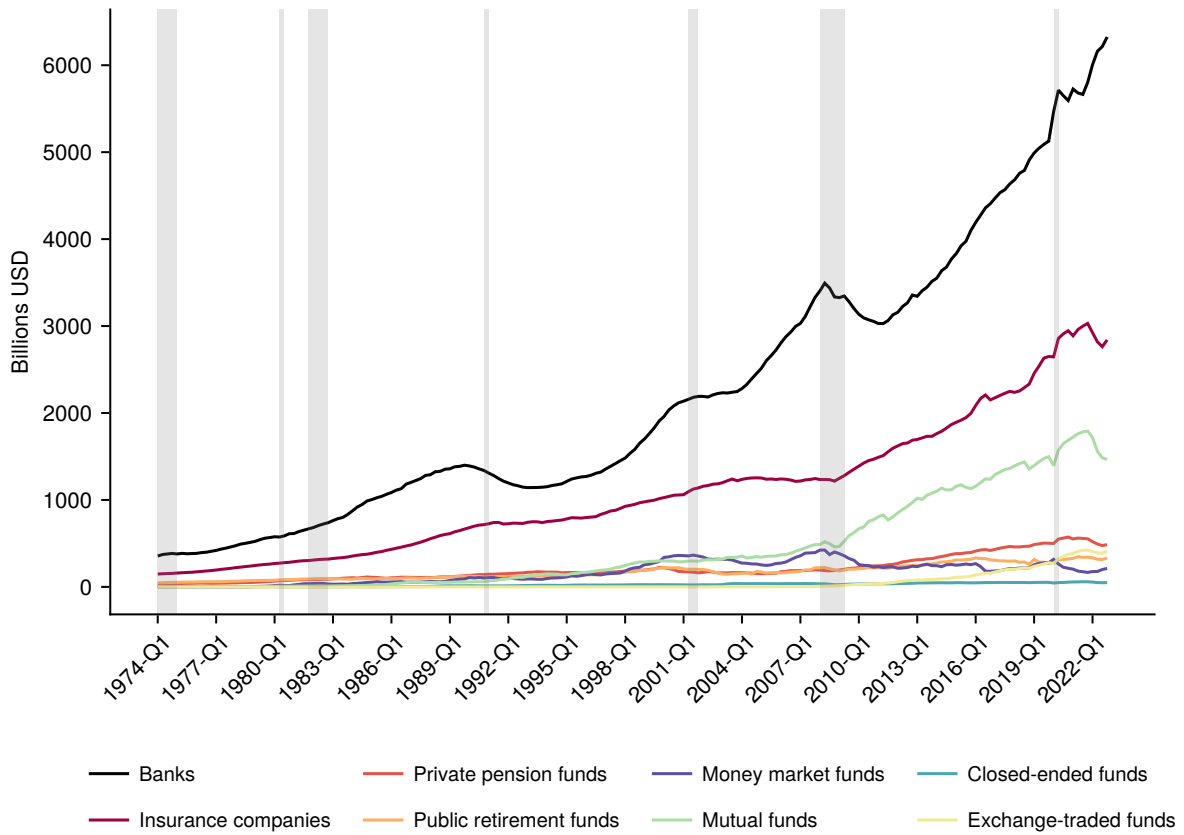
Note: This figure shows the U.S. household sector's holdings of bank deposits, money market fund shares and mutual fund shares in nominal trillions USD from 1974 Q1 to 2022 Q4. Bank deposits are defined as the sum of checkable, time and savings deposits issued by U.S.-chartered depository institutions and credit unions. The data are taken from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

FIGURE A3. Bank and nonbank lending to nonfinancial firms



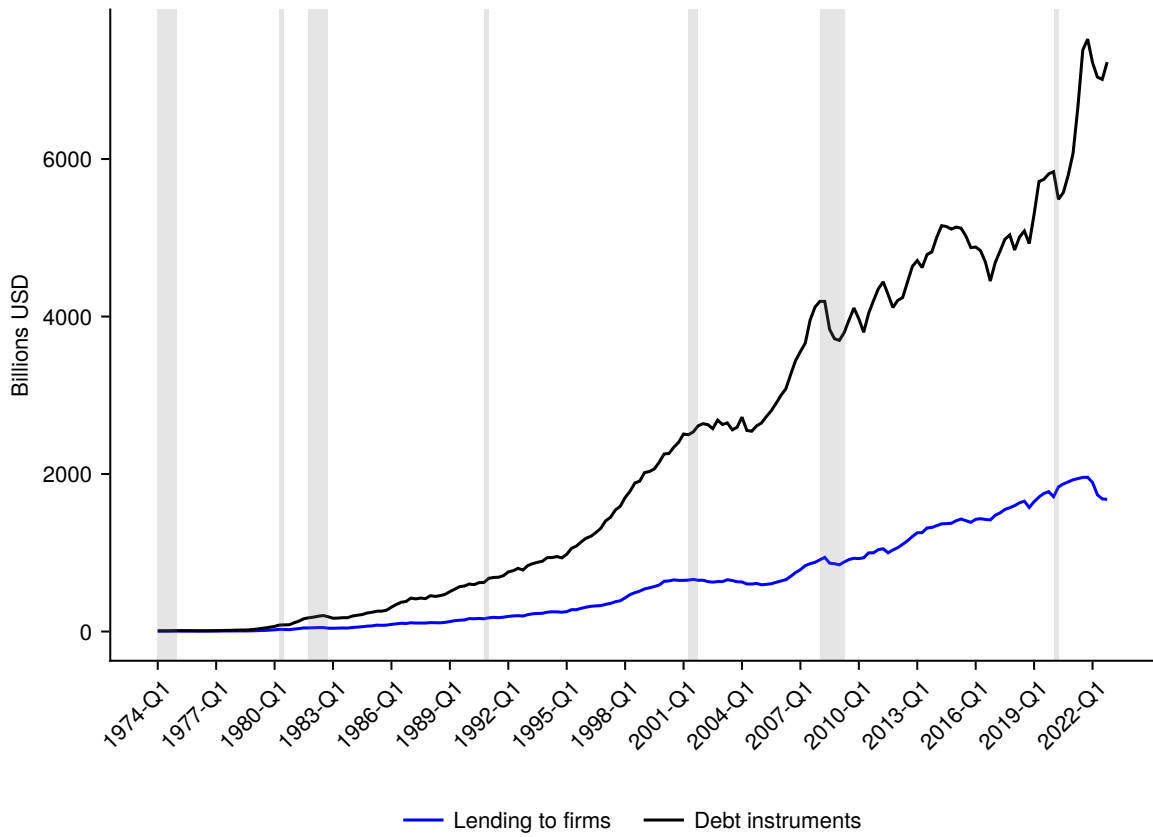
Note: This figure shows lending to U.S. nonfinancial firms from banks and various NBFIs in nominal billions USD from 1974 Q1 to 2022 Q4. Banks are defined as U.S.-chartered depository institutions and credit unions. Investment funds are the sum of money market funds and mutual funds. Other NBFIs are private pensions funds, public retirement funds, closed-ended funds, exchange-traded funds and insurance companies. The lending data is constructed using the methods of [Gallin \(2013\)](#) and [Herman et al. \(2017\)](#), with data from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

FIGURE A4. Bank and nonbank lending to nonfinancial firms



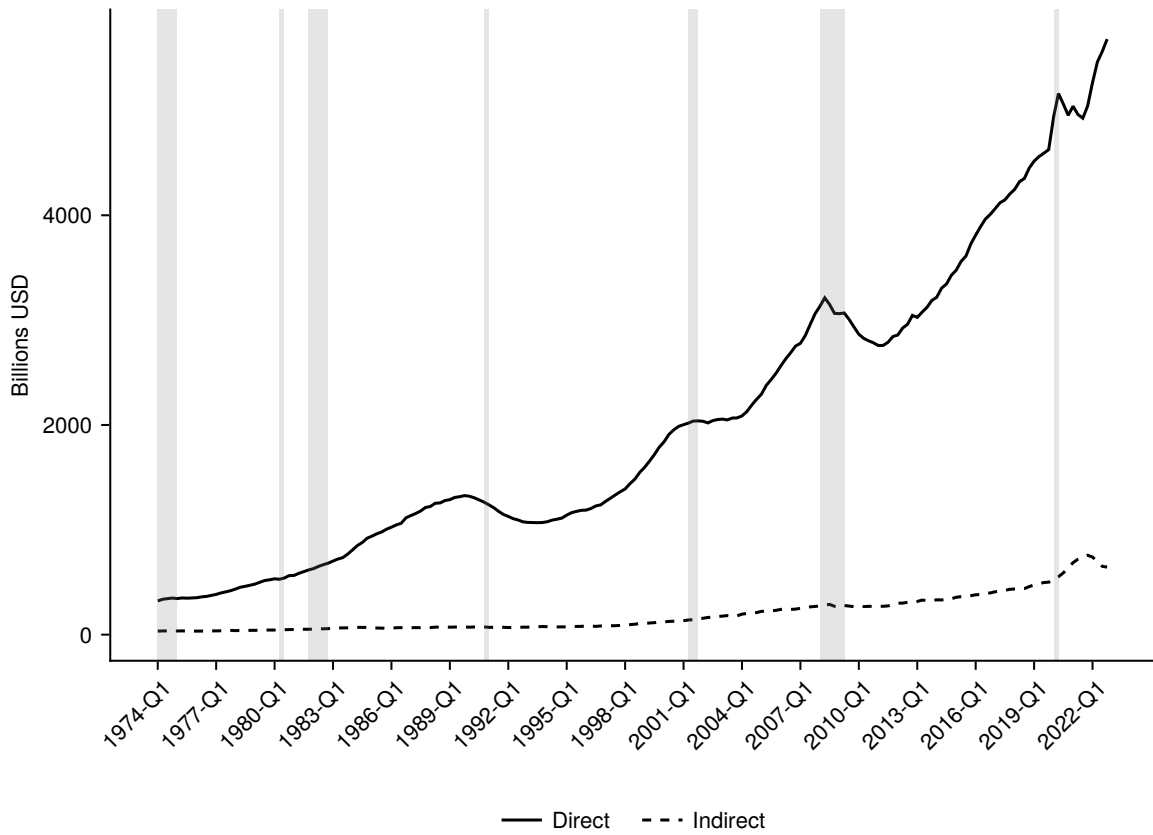
Note: This figure shows lending to U.S. nonfinancial firms from banks and various NBFIs in nominal billions USD from 1974 Q1 to 2022 Q4. Banks are defined as U.S.-chartered depository institutions and credit unions. The lending data is constructed using the methods of Gallin (2013) and Herman et al. (2017), with data from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

FIGURE A5. Investment funds' lending to firms vs. holdings of debt



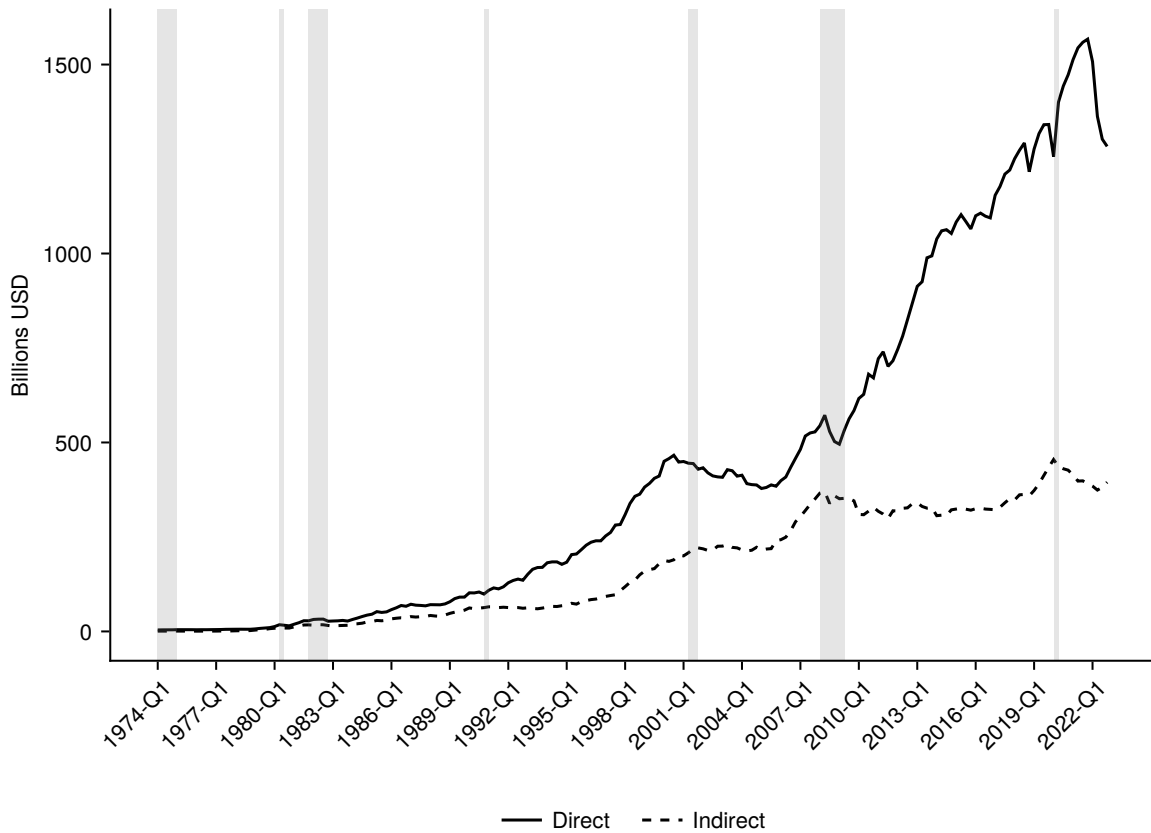
Note: This figure shows lending to U.S. nonfinancial firms from investment funds, as identified using the methods of [Gallin \(2013\)](#) and [Herman et al. \(2017\)](#), and investment funds' holding of non-government debt in nominal billions USD from 1974 Q1 to 2022 Q4. Investment funds are defined as money market funds and mutual funds. The data is taken from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

FIGURE A6. Direct and indirect bank lending to nonfinancial firms



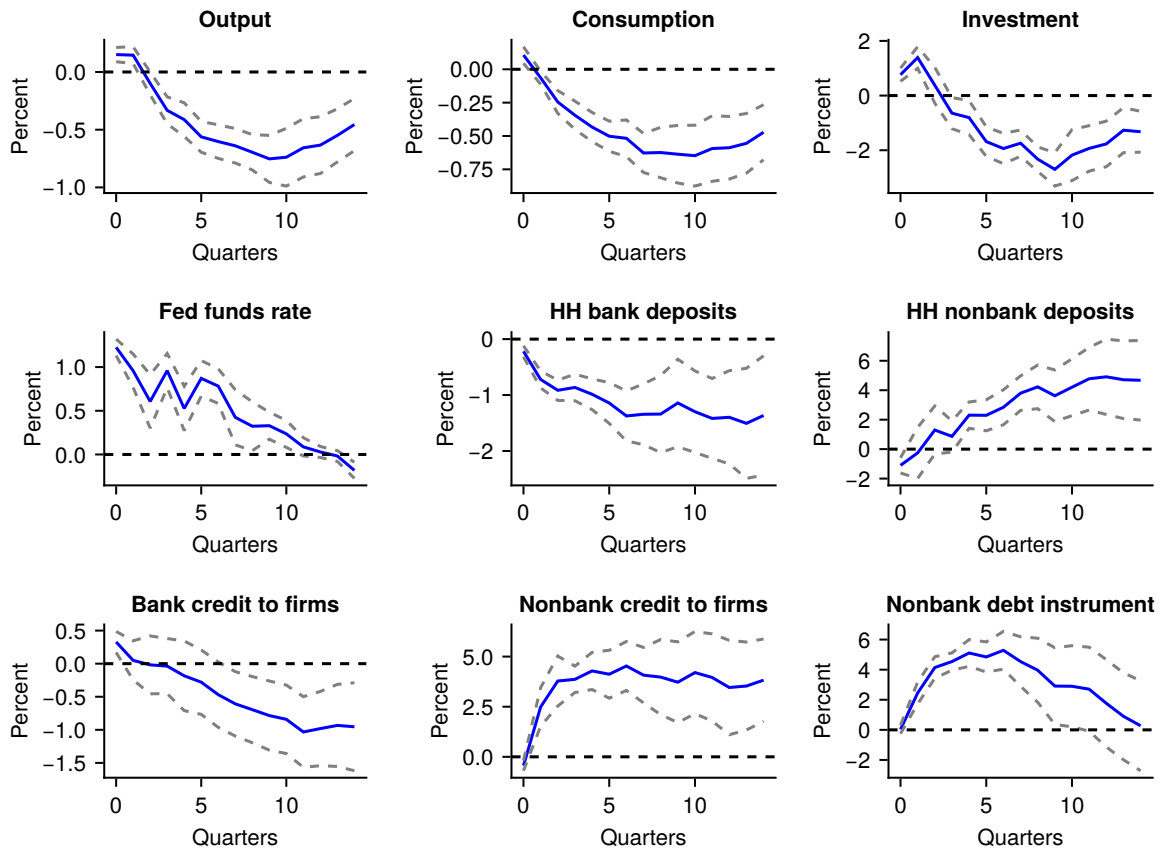
Note: This figure shows the banks' direct and indirect lending to U.S. nonfinancial firms in nominal billions USD from 1974 Q1 to 2022 Q4. Banks are defined as U.S.-chartered depository institutions and credit unions. The direct lending is measured by the amount of firm debt held by banks. The indirect lending through the NBFIs sector is identified using the methods of Gallin (2013) and Herman et al. (2017). The data is taken from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

FIGURE A7. Direct and indirect nonbank lending to nonfinancial firms



Note: This figure shows the investment funds' direct and indirect lending to U.S. nonfinancial firms in nominal billions USD from 1974 Q1 to 2022 Q4. Investment funds are defined as money market funds and mutual funds. The direct lending is measured by the amount of firm debt held by investment funds. The indirect lending through the NBFIs sector is identified using the methods of [Gallin \(2013\)](#) and [Herman et al. \(2017\)](#). The data is taken from the Financial Accounts of the United States. Gray shaded areas denote NBER recession dates.

FIGURE A8. Impulse responses to monetary policy shock

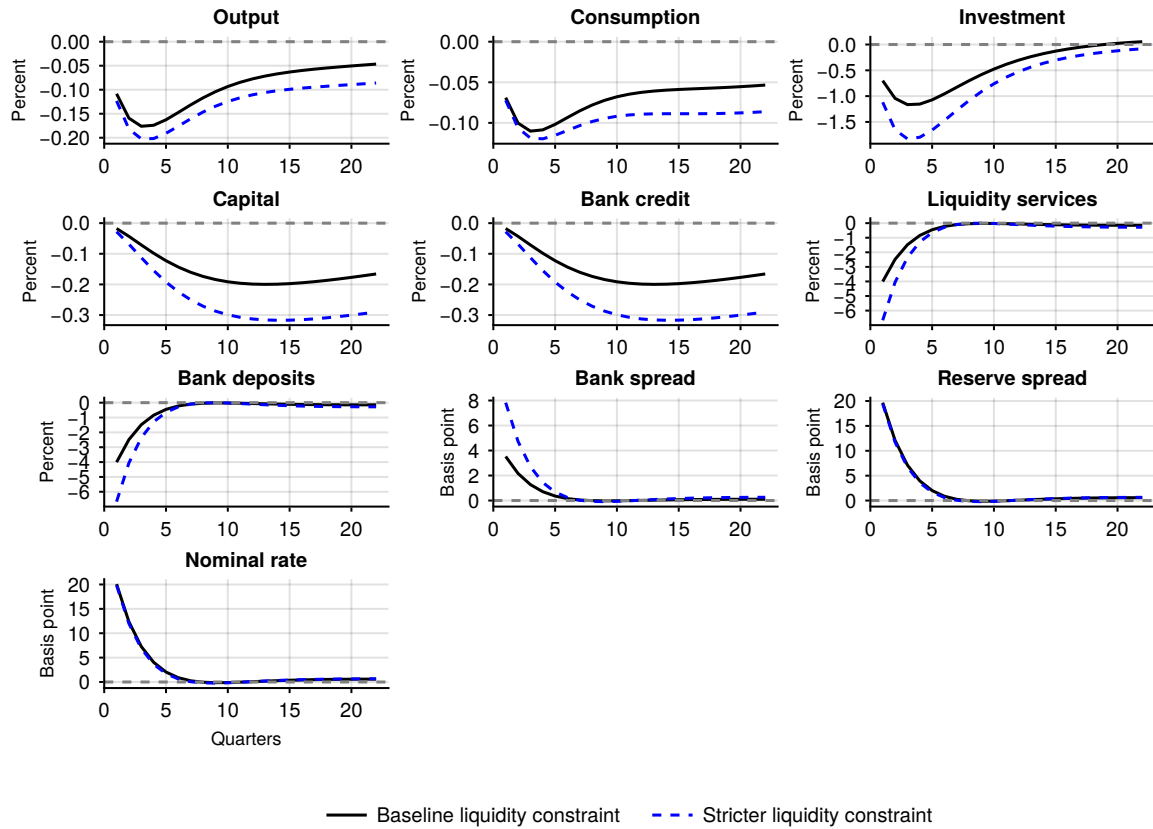


Note: This figure shows the estimated response to one standard deviation monetary policy shock, as identified in [Miranda-Agrippino and Rey \(2020\)](#). The gray dotted lines show the 66% confidence bounds, calculated using Eicker-Huber-White heteroskedasticity-robust variance-covariance estimator.

Appendix B. Model Appendix

B.1. Additional figures

FIGURE A9. Impulse responses to a monetary policy shock of 25 basis points: without nonbanks



Note: This figure shows the impulse responses, as deviations from steady state, to a monetary policy shock of 25 basis points. In both specifications, the household does not value nonbank deposits and nonbank financial intermediation is not active. The solid black lines show a specification in which $\zeta = 6.43$, which corresponds to a liquidity ratio of 0.1556. The dotted blue lines show a specification in which the banks face a stricter liquidity constraint, i.e. $\zeta = 2.8571$ which corresponds to a liquidity ratio of 0.35.