Precautionary Savings and Financial Frictions *

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Abstract

Banks provide households with liquid deposits – households' dominant liquid asset to buffer income fluctuations – and channel these into credit to firms. This paper shows both of these roles of the financial system are key to understanding how financial frictions amplify downturns. I first build a two-asset New Keynesian model with heterogeneous households and banks, and study the transmission of an income-risk shock that raises households' liquid asset demand. Constrained lending reduces investment and therefore household income. Lower income reduces consumption, while households also reduce savings in liquid bank deposits. Lower liquidity leaves households more exposed to the income fall, closer to their borrowing constraints, driving consumption further down. Monetary policy relaxes banks' leverage constraint, supports both lending and endogenous liquidity creation, and stabilizes the economy. Finally, I provide supporting evidence for the model predictions: in the data, tighter financial conditions deepen the recessionary impact of the shock, while contracting lending and dampening liquid deposit accumulation.

Keywords: liquidity transformation, precautionary savings, financial frictions, incomplete markets, nominal rigidities
JEL codes: E32, E21, E44

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1 Introduction

A long tradition in monetary macroeconomics, going back at least to Tobin (1969), views the liquidity characteristics of assets and the portfolio choices of agents as central to the business cycle.[1] In this view, the state of the banking system matters not only because banks provide *credit* to *firms*, but also because they issue *demand deposits* and engage in liquidity transformation. In doing so, banks provide a liquid store of value to *households*, which they use to self-insure against income fluctuations. The current paper seeks to probe into the importance of banking frictions in this household-centric view of intermediation, both in a model that explicitly accounts for households' need for a liquid store of value, and empirically by providing supporting evidence for the model's predictions.

I study the role of banks' liquidity transformation in shaping the aggregate effects of macroeconomic shocks in a quantitative New Keynesian model with heterogeneous households, a portfolio choice between liquid and illiquid assets, and banks (a "HANK" model, Kaplan et al. 2018). At its core, the model follows Bayer et al. (2019): households face idiosyncratic income risk; they can invest into illiquid capital, and they can purchase a liquid store of value. Into this setting, I introduce banks. The modeling follows Gertler and Karadi (2011), but with an emphasis on banks' ability to provide a liquid store of value: They issue demand deposits. Restrictions on bank leverage limit the ability of banks to channel liquid deposits into credit to firms, thereby impairing liquidity transformation. This renders aggregate liquidity in the economy endogenous to banking frictions, which is a distinctive feature of the current paper.[2]

In the model, I assess the transmission of a shock that induces households to rebalance their portfolios towards more liquid assets: a shock to households' uncertainty about their own labor income.[3] I find that the resilience of the economy to swings in the desired composition of household portfolios crucially depends on the state of the banking sector: a binding leverage constraint, indicating tight financial conditions, deepens the recessionary impact of the shock, dampens the accumulation of liquid bank deposits, and prevents the provision of bank credit.

The following mechanism is at work. Facing higher income uncertainty, households reduce consumption and rebalance their portfolios away from illiquid capital and towards liquid bank deposits. This drives down asset prices and returns, eroding banks' net worth. When banks are unconstrained, lower net worth matters little for lending and they channel deposits into credit. Liquidity transformation supports the economy through two related channels. First, bank lending sustains investment, stabilizing income and thus consumption. Second, on the liability side of banks' balance sheets (the household view), the endogenous expansion of liquid deposits is key for consumption, too: with more liquid portfolios, households move away from borrowing constraints. This tempers their precautionary saving motive and allows them to cushion the fall in income. Therefore, higher endogenous liquidity stabilizes consumption.

Under a constrained financial system, instead, falling bank net worth restricts credit, investment, and income. The deeper income fall prevents households from accumulating liquid

[1] Further classic references include Brunner and Meltzer (1972, 1976) and Friedman (1978).

[2] Recent papers incorporating financial intermediation in heterogeneous agent models, but with a different focus, include Fernández-Villaverde et al. (2023), Faccini et al. (2026), and Bigio and Sannikov (2021).

[3] Wide swings in household uncertainty have been documented by Storesletten et al. (2004) and Bayer et al. (2019). What makes a shock to household income risk particularly useful for the question at hand is that it affects the household level first and foremost while shifting the desired composition of households' portfolios.

deposits, which reinforces the consumption drop and feeds back into lower lending and investment. The model thus predicts that tight financial conditions dampen the accumulation of liquid bank deposits and constrain credit, unfolding into a deeper recession.

These dynamics reflect the dual role of banks through liquidity transformation: they supply a liquid store of value to households and channel these funds into firm credit and hence investment. Using the model, I analyze in more detail these distinct roles of banks to better understand the transmission of the shock.

On the asset side of banks' balance sheets, banking frictions constrain lending. In line with the literature on the macroeconomic consequences of frictional financial markets (Bernanke et al., 1999, Kiyotaki and Moore, 2019), constrained lending to firms amplifies the investment contraction. Through a general equilibrium counterfactual that fixes aggregate investment (while maintaining endogenous liquidity provision) I show that in the current framework the transmission from lending into investment matters for consumption too. Lower investment comes with a larger fall in income. Such income drop feeds into consumption, as the model features high marginal propensities to consume. As a result, when lending to firms is constrained, output falls more because both investment and consumption contract jointly. [4]

On the liability side of banks' balance sheets, the endogenous expansion of liquid deposits is key for consumption. Households at the bottom of the liquid wealth distribution hold few liquid assets, resulting in a high exposure to income fluctuations and high marginal propensities to consume. Under loose financial conditions (and in contrast to when the leverage constraint binds), these highly-exposed households increase their liquid bank deposits the most. Consequently, the liquid wealth distribution shifts: households move away from borrowing constraints, reducing their consumption sensitivity to income fluctuations. As such, when income falls, fewer households are borrowing-constrained and consumption falls less. I first show the partial-equilibrium effect of this shift in the liquid wealth distribution. When such a shift is not accounted for, more households with less liquid portfolios come with a larger consumption fall.

I then turn to the general equilibrium effects of banks' endogenous liquidity creation. I do so by means of counterfactuals that switch off the role of banks as liquidity providers while differencing out their role as lenders to firms. In general equilibrium, the larger consumption drop observed in the partial equilibrium exercise now feeds into lower economic activity, reinforcing the fall in income and leading to an amplification of the consumption drop. What is more, as households accumulate fewer liquid savings over time they are more likely to hit borrowing constraints. This strengthens their precautionary saving motive, reinforcing the consumption fall in the present. Both the heightened sensitivity to falling income and the stronger precautionary saving motive deepen the consumption response and exacerbate the recession.

Finally, I consider the role of monetary policy stabilization. By aggressively lowering nominal interest rates, a more accommodative central bank reduces banks' funding costs and improves their net worth. This, in turn, stimulates lending, investment, and income, enabling households

[4]This relevance of investment for consumption dynamics in heterogeneous-agent economies without financial frictions in the banking sector has been previously recognized in, for example, Auclert et al. (2020) and Bilbiie et al. (2022). Relative to these, the novelty of this paper lies in showing that such joint comovement of investment and consumption is crucially shaped by the state of the financial system and, through banks' liquidity transformation, by households' portfolio choices.

to restore their desired level of portfolio liquidity.

The feedback from investment into income and consumption and the effects of higher liquidity on households' portfolios render monetary stabilization more effective than in a representative-agent version of the model that also features constrained banks. The representative agent features a low marginal propensity to consume and liquidity does not serve as a store of value. Hence the channels presented in this paper are weak. To illustrate this further, I show that monetary policy is equally effective with heterogeneous households and with a representative agent when financial intermediation is absent. In that case, consumption responds more strongly under household heterogeneity, but investment responds less, leaving the output response similar in both frameworks (Luetticke, 2021). Therefore, the dual role of banks –as providers of liquid assets to households and of credit to firms – not only matters for the transmission of aggregate shocks, but also enhances the effectiveness of monetary policy stabilization.

In the last part of the paper, I provide empirical support for these model-based predictions. Relying on a series of shocks to household income risk that Bayer et al. (2019) identify following the methodology of Storesletten et al. (2004), I study the responses of GDP aggregates, bank credit, and deposits by means of local projections (Jordà, 2005). The projections are state-dependent in that I estimate the effect of the shock when financial conditions are tight and when they are loose. Following Adrian et al. (2019), I rely on the National Financial Conditions Index constructed by the Federal Reserve Bank of Chicago to determine the state of the financial sector.[5]

Consistent with the model's predictions, I find that the resilience of the economy to swings in the desired composition of household portfolios crucially depends on the state of the banking sector: tight financial conditions deepen the recessionary impact of the shock on output, consumption, and investment. What is more, tight financial conditions mute the accumulation of liquid bank deposits in spite of heightened income risk. On the asset side of the financial system, the contraction in bank credit is further amplified, in line with the sharper contraction in investment. The empirical results, thus, show that the state of the banking system is fundamental in shaping how shocks to household income risk (and the ensuing shift in the desired portfolio composition) transmit to economic activity.

Related literature

In studying the role of banks' liquidity provision to the household sector I contribute to several strands of the literature. First, my work relates to a strand of literature that views portfolio choice, and supply and demand of assets with different liquidity characteristics as key to studying business cycle fluctuations. That a shift in the desired liquidity of household portfolios can be recessionary has been documented in Den Haan et al. (2017) and Bayer et al. (2019). My contribution is twofold. I provide empirical evidence that the state of the financial system affects the transmission of such shocks. And I explicitly model the supply of liquid assets to the household sector as being provided by banks. This gives a novel perspective on the importance of the funding of banks.

[5] An advantage of the National Financial Conditions Index over other measures is that it offers a wide coverage of the financial sector. It includes commercial banks, the main suppliers of households' deposits.

The relevance of liquid assets in the presence of household heterogeneity and borrowing constraints has been an important topic of study in the literature. For example, Werning (2015) shows that the cyclicality of aggregate liquidity can shape the transmission of monetary policy. Guerrieri and Lorenzoni (2009) develop a one-asset search model of money in which low liquidity increases the sensitivity of consumption to aggregate shocks. Bayer et al. (2023) highlight the importance of viewing public debt as a liquid asset for understanding the transmission of fiscal policy. Cui and Sterk (2021) shows that quantitative easing policies also stimulate aggregate demand by affecting the liquidity of household portfolios. What sets this paper apart from these works is the endogeneity of aggregate liquid savings to financial frictions, within a framework that explicitly accounts for financial intermediation.

Second, my paper relates to the literature that studies the macroeconomic consequences of financial frictions. I share with Bernanke et al. (1999), Kiyotaki and Moore (1997), and, in particular, Gertler and Karadi (2011) the central idea that financial frictions can amplify aggregate shocks. My modeling builds on this literature. What I add is a shift of emphasis: from the asset side of banks (loans to firms) to the role of the funding side (creating liquid assets for households). The focus on liquidity transformation relates my paper to Brunnermeier and Sannikov (2016). Where I focus on households and labor-income uncertainty, they model idiosyncratic investment risk. The focus on liquidity provision and financial frictions relates my work to Kiyotaki and Moore (2019) and Del Negro et al. (2017). Liquid savings in my model are endogenously created, and affected by banking frictions. The relevance of liquid deposits in the financial system has been also emphasized, for example, in Drechsler et al. (2017) in the context of monetary policy transmission. My paper highlights, instead, the relevance of liquid bank deposits for households' consumption and hence aggregate demand.

Several other exciting papers have recently incorporated financial frictions into models with heterogeneous households. In all of these the focus differs from my work. Fernández-Villaverde et al. (2023), using a global solution method, study the non-linear interaction between the wealth distribution and leverage over the business cycle in a one-asset model with heterogeneous agents. Faccini et al. (2026) build a New Keynesian model with heterogeneous agents and financial intermediaries. They focus on the consequences of a countercyclical spread on consumer loans. Instead, I emphasize the role of the supply of a liquid vehicle for household saving. Bigio and Sannikov (2021) build a heterogeneous agents economy with financial frictions in the interbank market. I explore the link between deposit creation for households and shocks to idiosyncratic risk on the household side. Closely related, too, is Lee (2021) who studies the distributional effect of quantitative easing in a two-asset HANK model with banks and equilibrium unemployment. What I add to this work is a focus on banks as the main providers of liquidity to households, presenting empirical evidence that supports the importance of the channel that I study.

Third, my paper relates to a literature that looks at uncertainty as a driver of the business cycle. For the firm sector, the literature has discussed real options channels (Bloom, 2009) and financial frictions (Gilchrist and Zakrajšek, 2012, Gilchrist et al., 2014). Basu and Bundick (2017) also show that rigid prices can amplify shocks to aggregate risk even in complete-market settings. In my paper, aggregate uncertainty remains constant. The recession arises from an exogenous shift in idiosyncratic risk. I see this shift as a primitive, different from other work in the HANK literature, for example, Challe (2020), Den Haan et al. (2017), Gornemann et al. (2021), McKay and Reis (2021), Domínguez-Díaz (2025), and Ravn and Sterk (2017).

Finally, this paper also contributes to an active empirical literature that explores the state-dependent effects of aggregate shocks and policies. The literature has investigated the state-dependent effects of fiscal policy (e.g. Ramey and Zubairy 2018, Auerbach and Gorodnichenko 2012, Domínguez-Díaz and Zhang 2025, Born et al. 2024) and monetary policy (Tenreyro and Thwaites, 2016), for example. To the best of my knowledge, my paper is the first to document how changes in household income uncertainty depend on financial conditions.

The remainder of the paper is organized as follows. Section 2 lays out the model environment. Section 3 discusses the numerical implementation and calibration. Section 4 provides the model-based results, discussing the transmission of a shock to income risk and the role of banks' liquidity transformation and monetary policy stabilization. Section 5 provides supporting empirical evidence. A final section concludes. The appendix provides additional results and robustness checks.

2 Model

This section presents the theoretical framework used to study how banking frictions, by impairing liquidity transformation, affect the aggregate consequences of a shock that shifts households' demand for liquid assets. I build a two-asset New Keynesian model with heterogeneous households (Kaplan et al., 2018, Bayer et al., 2019) and financial intermediaries that engage in liquidity transformation, subject to a potentially binding leverage constraint (Gertler and Karadi, 2011).

More precisely, the model economy is composed of a household sector, a production sector, financial intermediaries, and a government. The production sector is comprised of a final good producer, capital goods producers, resellers that set prices subject to adjustment costs à la Rotemberg (1982), and intermediate good producers that use labor and capital as production inputs. Financial intermediaries use deposits issued to households and their own net worth to purchase financial claims on physical capital subject to a leverage constraint. Households consume, supply labor, and face time-varying idiosyncratic income risk, described in detail below. In order to self-insure, households can save in two assets: liquid bank deposits and financial claims on physical capital, which can only be traded infrequently.

Financial claims on physical capital are modeled following Gertler and Karadi (2011). In particular, non-financial firms in this economy will use labor and capital as production inputs. I assume that the entirety of firms' capital has to be financed through loans. These loans take the form of state-contingent claims on the earnings generated by capital. Therefore, they can be thought of as equity of the non-financial firm. Financial claims (or equity) can be purchased by both the household sector and financial intermediaries.

2.1 Households

The household sector builds on Bayer et al. (2019). I use small case letters to denote individual variables and capital letters to denote aggregate variables. There is a unit mass of ex-ante identical infinitely-lived households indexed by $i \in [0, 1]$. A household can be a worker or an entrepreneur. Both types of households consume and participate in asset markets, but only workers supply labor. Entrepreneurs, instead, receive a non-tradable share of aggregate profits.[6] Households randomly transition between being one of the two types.

2.1.1 Idiosyncratic Productivity and Labor Supply

Workers face time-varying idiosyncratic labor productivity $h_{i,t}$. As in Bayer et al. (2019), labor productivity follows an $AR(1)$ process in logs with time-varying variance and a constant transition probability between the worker and the entrepreneur state:

$$\tilde{h}_{i,t} = \begin{cases} \exp\left(\rho_h \log \tilde{h}_{i,t-1} + \varepsilon^h_{i,t}\right), & \text{with probability } 1-\zeta \text{ if } h_{i,t-1} \neq 0, \\ 1, & \text{with probability } \iota \text{ if } h_{i,t-1} = 0, \\ 0, & \text{else,} \end{cases} \tag{1}$$

with individual productivity $h_{i,t} = \frac{\tilde{h}_{i,t}}{\int_0^1 \tilde{h}_{i,t} di}$, such that average worker productivity remains constant. The shocks $\varepsilon^h_{i,t}$ to labor productivity are normally distributed with time-varying variance given by

$$\sigma^2_{h,t} = \bar{\sigma}^2_h \exp\left(s_t\right), \quad \bar{\sigma}_h > 0, \tag{2}$$

$$s_{t+1} = \rho_s s_t + \varepsilon^s_t, \quad |\rho_s| < 1, \tag{3}$$

$$\varepsilon^s_t \sim \mathcal{N}\left(-\frac{\sigma^2_s}{2(1+\rho_s)}, \sigma^2_s\right), \quad \sigma_s > 0. \tag{4}$$

In words, a household that is a worker, $h \neq 0$, remains a worker next period with probability $1-\zeta$. With complementary probability, ζ, the household becomes an entrepreneur next period and has zero labor productivity, $h = 0$, but is compensated with a share of aggregate profits. A household that is currently an entrepreneur with zero productivity in the labor market returns to the workforce next period with median productivity with probability ι.

Households maximize the discounted sum of utility over consumption and leisure. In particular, they have time-separable Greenwood–Hercowitz–Huffman (GHH) preferences over consumption $c_{i,t}$ and leisure with time-discount factor β,

$$\mathbb{E}_0 \max_{\{c_{i,t}, n_{i,t}\}} \sum_{t=0}^{\infty} \beta^t u(c_{i,t} - G(n_{i,t}; h_{i,t})), \tag{5}$$

where $n_{i,t}$ denotes hours worked.[7] The felicity function u is of the constant-relative-risk-aversion (CRRA) type with risk aversion parameter $\xi > 0$,

$$u(x_{i,t}) = \frac{1}{1-\xi} x_{i,t}^{1-\xi}, \tag{6}$$

[6] The introduction of an entrepreneur state is useful for two reasons. First, it solves the problem of the allocation of profits without distorting factor returns and without the computational complexity of introducing a third tradable asset. Second, the entrepreneurial state, as a high-income state, is a useful modeling device to match the wealth distribution, following the idea of Castaneda et al. (1998).

[7] The assumption of GHH preferences together with the functional form assumed for $G(n_{i,t}; h_{i,t})$ simplifies the numerical analysis substantially, since it will imply that all households work the same number of hours.

where $x_{i,t} = c_{i,t} - G(n_{i,t}; h_{i,t})$ is a composite good of consumption and leisure, with $G(n_{i,t}; h_{i,t})$ measuring the disutility from working. In the following, I assume $G(n_{i,t}; h_{i,t}) = h_{i,t} n_{i,t}^{1+\gamma}/1+\gamma$, with $\gamma > 0$.

The labor income of a household $h_{i,t} n_{i,t} w_t$ is the product of the wage rate w_t, hours worked $n_{i,t}$, and idiosyncratic productivity $h_{i,t}$. Given a tax rate τ, the labor supply first order condition is,

$$h_{i,t} n_{i,t}^{\gamma} = (1-\tau) w_t h_{i,t}, \tag{7}$$

so that all households supply the same amount of hours, $n_{i,t} = N(w_t)$. Consequently, the total amount of effective hours worked $\int h_{i,t} n_{i,t} di$ is also equal to $N(w_t)$ since $\int h_{i,t} di = 1$.

2.1.2 Consumption and Saving Decisions

Financial markets are incomplete, and households can only use two assets to self-insure. They can hold liquid deposits, $d_{i,t}$, issued by financial intermediaries, with real gross return R_t. As described previously, households can also purchase financial claims on physical capital, $k_{i,t}^h$, at price q_t. The dividends generated by these claims will be, in equilibrium, equal to the net returns on physical capital, denoted by r_t^k. While households can access their savings in deposits every period, financial claims are illiquid. More specifically, following Luetticke (2021), I assume that in any given period only a random fraction $\nu \in (0,1)$ of households is allowed to trade these assets. Households that are allowed to participate in the market for claims on capital face the following budget and non-borrowing constraints:

$$\begin{gathered} c_{i,t} + q_t k_{i,t+1}^h + d_{i,t+1} = (q_t + r_t^k) k_{i,t}^h + R_t d_{i,t} + (1-\tau)(w_t n_{i,t} h_{i,t} + \mathbb{1}_{h_{i,t}=0} \Xi_t), \\ k_{i,t+1}^h \geq 0, \quad d_{i,t+1} \geq 0, \end{gathered} \tag{8}$$

where $\mathbb{1}_{h_{i,t}=0}$ is an indicator function that takes value one if the household is an entrepreneur and Ξ_t marks aggregate profits. Further note that households are not allowed to hold negative amounts of any of the two assets.[8] The real interest rate paid on deposits in period t is linked to the nominal interest rate $1+i_t$, set by the central bank in $t-1$, and inflation, $1+\pi_t$, through the Fisher equation:

$$R_t = \frac{1+i_t}{1+\pi_t}. \tag{9}$$

The fraction $1-\nu$ of households that cannot trade the illiquid asset at period t can access its liquid deposits and receive the dividends generated by their claims on physical capital. The budget constraint of these households simplifies to:

$$\begin{aligned} c_{i,t} + d_{i,t+1} &= r_t^k k_{i,t}^h + R_t d_{i,t} + (1-\tau)(w_t n_{i,t} h_{i,t} + \mathbb{1}_{h_{i,t}=0} \Xi_t), \\ d_{i,t+1} &\geq 0. \end{aligned} \tag{10}$$

The optimal consumption and saving choices of a household depend on its idiosyncratic states (d, k^h, h). As a consequence, aggregate prices will be a function of the joint distribution Θ_t over these idiosyncratic states at period t. This renders Θ_t a state variable of the household

[8]For a model that allows for consumer loans see Faccini et al. (2026).

problem that will fluctuate in response to aggregate shocks. The programming problem of a household is characterized by the following two Bellman equations, for the case of households who cannot and can adjust their holdings of capital claims:

$$\begin{aligned} V_t^n(d, k^h, h) = \max_{d'_n} u \left[x\left(d, d'_n, k^h, k^h, h\right)\right] + \beta \mathbb{E}_t \Big[\nu V_{t+1}^a \left(d'_n, k^h, h'\right) \\ + (1-\nu) V_{t+1}^n \left(d'_n, k^h, h'\right)\Big], \end{aligned} \tag{11}$$

$$\begin{aligned} V_t^a(d, k^h, h) = \max_{d'_a, k^{h'}} u \left[x\left(d, d'_a, k^h, k^{h'}, h\right)\right] + \beta \mathbb{E}_t \Big[\nu V_{t+1}^a \left(d'_a, k^{h'}, h'\right) \\ +(1-\nu) V_{t+1}^n \left(d'_a, k^{h'}, h'\right)\Big], \end{aligned} \tag{12}$$

where time subscripts summarize the dependence on aggregate states, including the joint distribution Θ_t. I denote by $d_{a,t}^*$ and $d_{n,t}^*$ the optimal savings policy in liquid deposits for adjusters and non-adjusters, respectively. Accordingly, $k_{a,t}^{h*}$ denotes the optimal savings policy for claims on capital for adjusters, and $k_{n,t}^{h*} = k^h$ for non-adjusters. These policies depend on the current idiosyncratic and aggregate states of the economy – including the joint distribution $\Theta_t(d, k^h, h)$ – as well as on current and future prices, summarized through expected continuation values $\{V_{t+1}^n, V_{t+1}^a\}$. Therefore, the aggregate amount of capital claims purchased by the household sector, K_{t+1}^h, is given by:

$$K_{t+1}^h = \mathbb{E}_t \left[\nu k_{a,t}^{h*} + (1-\nu) k_{n,t}^{h*} \right] \tag{13}$$

2.2 Financial Intermediaries

Financial intermediaries are the main providers of liquid savings to households. Thus, banks play a central role in this economy: they perform liquidity transformation, supplying the liquid deposits that households demand to self-insure against swings in labor income uncertainty. Through the balance sheet of banks, the supply of these assets will depend on the lending capacity of the financial sector. The financial system is modeled following Gertler and Karadi (2011), but with an emphasis on banks' ability to provide a liquid store of value.

There is a continuum of ex-ante identical financial intermediaries (or banks) of measure one. I use small-case letters to denote individual bank variables. Financial intermediaries use short-term deposits issued to households, d_t, and their own net worth, e_t, to finance their purchases of financial claims on capital, k_t^b. Due to financial market frictions described in detail below, banks may be constrained in the amount of assets that they can purchase.

Banks maximize the expected discounted profits from intermediating funds. At the beginning of the period a measure $(1-\sigma)/\sigma$ of banks enters the industry, where $\sigma \in (0, 1)$. All banks are then hit by an idiosyncratic random shock, indicating whether the bank should close down. With probability $1-\sigma$ the bank is forced to exit and pay back all its accumulated net worth, e_t, to its shareholders – the entrepreneurs – as dividends. With complementary probability the bank continues to operate. New entrants start with equity ω_t, that they receive from shareholders. By means of entry, the measure of operating banks always equals 1.[9]

[9]This device is commonly used in the literature to ensure that banks do not accumulate enough net worth to

Banks perform liquidity transformation. In particular, and contrary to households, financial intermediaries can trade financial claims on capital every period. I assume, however, that they face a linear utility cost ς for each financial claim that they trade. [10] Therefore, the franchise value of a surviving bank V_t^b is given by:

$$V_t^b = \mathbb{E}_t \Lambda_{t,t+1} \left[(1-\sigma) e_{t+1} + \sigma V_{t+1}^b \right] - \varsigma q_t k_{t+1}^b, \tag{14}$$

where $\Lambda_{t,t+1}$ is the discount factor of a bank, and e_{t+1} is the net worth that an exiting bank pays as dividends.

In the presence of incomplete markets with heterogeneous households and multiple assets there is no single candidate for the choice of the stochastic discount factor for banks and firms. For example, Faccini et al. (2026) assume that the discount factor of banks equals the time preference rate β; Kaplan et al. (2018) use the inverse of the illiquid return as a discount factor for firms; Auclert et al. (2024) opt to choose the inverse of the risk-free rate; and Gornemann et al. (2021) endow a mutual fund with the inverse of the return on households' savings. As a baseline, and in line with this literature, I assume that the discount factor of the bank equals the inverse of the return on liquid assets, $\Lambda_{t,t+1} = 1/R_{t+1}$. Under this assumption, this stochastic discount factor would reflect households' demand for liquid assets insofar as this results in a change in the real interest rate. For example, the discount factor would increase upon an income-risk shock that leads households to demand more liquid assets and therefore results in a fall in the real interest rate. In Appendix B, however, I also entertain a different assumption where the discount factor of banks is instead equal to the inverse of the return on the illiquid assets, and show that the main results of the paper remain unchanged.

At each period t the bank faces the following balance sheet constraint:

$$q_t k_{t+1}^b = e_t + d_{t+1}. \tag{15}$$

The left-hand side of (15) gives the volume of loans that the bank provides to firms, k_{t+1}^b being the claims on physical capital purchased by the bank at time t. The right-hand side shows that loans have to be financed through net worth or by issuing deposits to the household sector. The net worth of a bank born in period t is simply given by its start-up transfer $e_t = \omega_t$. Due to frictions left unmodeled, banks cannot issue new outside equity. They accumulate net worth through retained earnings. Hence, the net worth of a surviving bank in period $t+1$ is given by the market value of the assets intermediated in the previous period, $q_{t+1}k_{t+1}^b$, plus the dividends they receive on them, $r_{t+1}^k k_{t+1}^b$, net of the funding costs from deposits, $R_{t+1}d_{t+1}$:

$$e_{t+1} = (q_{t+1} + r_{t+1}^k) k_{t+1}^b - R_{t+1} d_{t+1}. \tag{16}$$

Banks further face a leverage constraint that constrains their franchise value, V_t^b, to not be

render the leverage constraint described below irrelevant.

[10] This utility cost can be motivated as a monitoring or origination cost for each loan that the bank provides. In my baseline calibration, this cost will be set to zero. However, it will be useful to make sure that all the experiments that I consider share the same steady state.

lower than a fraction θ of the market value of its holdings of capital claims, $q_t k^b_{t+1}$:

$$\theta q_t k^b_{t+1} \leq V^b_t. \tag{17}$$

The above constraint can be motivated by the following moral hazard problem. Suppose that each period a bank can decide to divert a fraction θ of its holdings of capital claims. If it decides to divert assets, depositors force the bank to declare bankruptcy, and hence the financial intermediary loses its franchise value V^b_t. Under this setup, households will only be willing to lend to banks when these do not have incentives to declare bankruptcy, effectively implying that the franchise value of the bank cannot be lower than the amount of assets that can be diverted.

To derive a solution for the bank problem it is useful to use equations (15) and (16) to derive the evolution of net worth of a continuing bank:

$$\begin{aligned} e_{t+1} &= [(R^k_{t+1} - R_{t+1})\psi_t + R_{t+1}]e_t, \\ \psi_t &= \frac{q_t k^b_{t+1}}{e_t}, \\ R^k_{t+1} &= \frac{q_{t+1} + r^k_{t+1}}{q_t}, \end{aligned} \tag{18}$$

where ψ_t denotes the leverage ratio and R^k_{t+1} the gross return on claims on capital holdings. Using (18) we can write the franchise value of the bank (14) as:

$$V^b_t = (\mu^b_t \psi_t + \eta^b_t)e_t, \tag{19}$$

where

$$\mu^b_t = \mathbb{E}_t[\Lambda^b_{t,t+1}(R^k_{t+1} - R_{t+1}) - \varsigma], \tag{20}$$

$$\eta^b_t = \mathbb{E}_t \Lambda^b_{t,t+1} R_{t+1}, \tag{21}$$

$$\Lambda^b_{t,t+1} = \Lambda_{t,t+1}(1 - \sigma + \sigma\varphi^b_{t+1}), \tag{22}$$

$$\varphi^b_t \equiv \frac{V^b_t}{e_t}. \tag{23}$$

The variable μ^b_t is the expected discounted excess return on banks' assets relative to deposits, net of intermediation utility costs ς, and η^b_t is the expected discounted cost of a unit of deposits. Intuitively, the marginal value of an extra unit of net worth to the bank, φ^b_t, will be higher when spreads or the return on deposits is high. In this situation, an additional unit of net worth would allow the bank to increase loans taking advantage of higher returns without relying on deposits.

Under the previous notation, the problem of a bank is to choose leverage, ψ_t, to solve:

$$\varphi^b_t = \max_{\psi_t}(\mu^b_t \psi_t + \eta^b_t), \tag{24}$$

subject to the leverage constraint

$$\theta\psi_t \leq \mu^b_t \psi_t + \eta^b_t. \tag{25}$$

The solution to the bank problem, (24) and (25), is characterized by the following first-order condition and the complementary slackness condition:

$$\mathbb{E}_t \Lambda^b_{t,t+1}(R^k_{t+1} - R_{t+1}) = \varsigma + \lambda_t \theta, \tag{26}$$

$$\lambda_t(\theta\psi_t - \mu^b_t \psi_t - \eta^b_t) = 0, \tag{27}$$

where λ_t denotes the Lagrange multiplier on the leverage constraint (25).

The leverage constraint (25) sets an upper bound on the amount of credit that banks can offer, impairing liquidity transformation. If banks are constrained (i.e. $\lambda_t > 0$), the leverage constraint is binding and banks' leverage ψ_t constrains lending. An erosion in banks' net worth, e_t, increases banks' leverage, restraining lending to firms. On the contrary, if banks are unconstrained (i.e. $\lambda_t = 0$), the leverage constraint is not binding and banks' leverage and hence net worth become irrelevant for banks as long as they are able to raise funding from households' deposits, channeling these into lending to firms and hence investment.

Note that since the bank problem, (24) and (25), is linear in leverage, all banks, in equilibrium, will choose the same leverage ratio ψ_t. Consequently, financial intermediaries can be aggregated into a single representative bank. Summing across individual banks, we have that the aggregate value of capital claims held by the financial sector, $q_t K^b_{t+1}$, is related to aggregate net worth, E_t, according to,

$$q_t K^b_{t+1} = \psi_t E_t. \tag{28}$$

The evolution of aggregate net worth E_t is given by the sum of retained earnings from surviving banks plus the start-up funds of newborn banks, ω_t. I assume that start-up funds are given by a constant fraction of the current value of assets intermediated in the previous period $\omega_t = \frac{\bar{\omega}}{1-\sigma} q_t K^b_t$.[11] As a result, the evolution of aggregate net worth of banks is given by:

$$E_{t+1} = \sigma[(R^k_{t+1} - R_{t+1})\psi_t + R_{t+1}]E_t + \bar{\omega} q_{t+1} K^b_{t+1}. \tag{29}$$

2.3 Final Good Producer

Final good producers are perfectly competitive and use differentiated goods as inputs. The final good can be used for both consumption and investment. The problem of the representative final good producer is:

$$\max_{Y_t, y_{j,t} \in [0,1]} P_t Y_t - \int_0^1 p_{j,t} y_{j,t} dj \quad \text{s.t.} \quad Y_t = \left(\int_0^1 y_{j,t}^{\frac{\eta-1}{\eta}} dj \right)^{\frac{\eta}{\eta-1}}, \tag{30}$$

where $y_{j,t}$ is the quantity of the differentiated good j demanded. The first-order conditions of the final good producer deliver the following demand for differentiated goods:

$$y_{j,t} = \left(\frac{p_{j,t}}{P_t} \right)^{-\eta} Y_t. \tag{31}$$

The zero-profit condition implies that the price of the final good is given by $P_t = \left(\int_0^1 p_{j,t}^{1-\eta} dj \right)^{\frac{1}{1-\eta}}$.

[11] This formulation of the start-up transfer is common in the literature (Gertler and Karadi 2011, Bocola 2016).

2.4 Intermediate Goods Producers

Intermediate goods are produced with a constant returns to scale production function, using labor, hired in a competitive market, and capital as inputs:

$$Y_t = A_t N_t^{\alpha} K_t^{(1-\alpha)}, \tag{32}$$

where A_t is total factor productivity (TFP). It follows an AR(1) process in logs:

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_t^A, \quad \varepsilon_t^A \sim \mathcal{N}(0, \sigma_A^2). \tag{33}$$

Let MC_t be the relative price at which the intermediate good is sold to resellers. The first-order condition with respect to labor implies,

$$w_t = \alpha A_t MC_t \left(\frac{K_t}{N_t} \right)^{1-\alpha}. \tag{34}$$

As noted previously, intermediate good producers have to finance the purchases of capital through state-contingent claims on the earnings generated by this asset. These can be thought of as equity of these firms. In particular, the firm issues claims on capital (equity) to households and banks at price q_t. Then, it uses these funds to buy capital from the capital good producer. Using (34), we can express the profit per unit of capital, r_t^k, as,

$$r_t^k = \frac{MC_t Y_t - w_t N_t}{K_t} - \delta = (1-\alpha) A_t MC_t \left(\frac{N_t}{K_t} \right)^{\alpha} - \delta, \tag{35}$$

where δ is the depreciation rate of capital. As will be clear below, repairing depreciated capital stock is not subject to adjustment costs, and therefore its price is unity. Through perfect competition, the price of new capital goods will also be equal to q_t, and therefore the intermediate good producer makes zero profits state by state.

2.5 Resellers

Resellers differentiate intermediate goods and set prices, subject to quadratic adjustment costs à la Rotemberg (1982). Price setting is delegated to a measure zero of managers, who are compensated with a share of profits. As with financial intermediaries, I assume that the discount factor of managers, and therefore firms, is equal to the inverse of the real interest rate $\Lambda_{t,t+1} = 1/R_{t+1}$. Managers set prices taking as given the demand for good j (31), i.e., they maximize,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \left(\frac{1}{R_{t+1}} \right)^t Y_t \left\{ \left(\frac{p_{j,t}}{P_t} - MC_t \right) \left(\frac{p_{j,t}}{P_t} \right)^{-\eta} - \frac{\eta}{2\kappa} \left(\log \frac{p_{j,t}}{p_{j,t-1}} \right)^2 \right\}. \tag{36}$$

The first-order condition yields the Phillips curve:

$$\log(1+\pi_t) = \kappa \left(MC_t - \frac{\eta - 1}{\eta} \right) + \mathbb{E}_t \frac{1}{R_{t+1}} \left[\log(1+\pi_{t+1}) \frac{Y_{t+1}}{Y_t} \right]. \tag{37}$$

Additionally, managers obtain profits from adjusting the aggregate capital stock subject to adjustment costs:

$$K_{t+1} = K_t + I_t - \frac{\phi}{2}\left(\frac{K_{t+1} - K_t}{K_t}\right)^2 K_t, \tag{38}$$

where I_t denotes net aggregate investment.[12]

Since there is perfect competition in the capital market, managers will adjust the capital stock until the following first-order condition holds:

$$q_t = 1 + \phi\frac{K_{t+1} - K_t}{K_t}. \tag{39}$$

As managers have measure zero, all profits from non-financial firms go to entrepreneurs.

2.6 Government

The government is composed of a fiscal authority and a central bank. The central bank sets the nominal interest rate paid on deposits according to the following Taylor rule:

$$\frac{1 + i_{t+1}}{1 + \bar{i}} = \left(\frac{1 + i_t}{1 + \bar{i}}\right)^{\rho_i}\left(\frac{1 + \pi_t}{1 + \bar{\pi}}\right)^{\theta_\pi(1-\rho_i)} \exp(\epsilon_t^M), \quad \epsilon_t^M \sim \mathcal{N}(0, \sigma_M^2) \tag{40}$$

where ρ_i captures monetary policy inertia, θ_π determines the response of the central bank to inflationary pressures, $1 + \bar{i}$ is the steady-state gross nominal interest rate, and $1 + \bar{\pi}$ the gross inflation rate in steady state. The term ϵ_t^M is a monetary policy shock.

On the fiscal side, I abstract from government debt. This ensures that all liquid assets in the model are an endogenous result of the intermediation activity of banks. More in detail, the fiscal authority adjusts government expenditures G_t to balance the budget every period, where revenue comes from proportional taxes on income: [13]

$$G_t = \tau(w_t N_t + \Xi_t). \tag{41}$$

2.7 Market Clearing

The labor market clears if the condition (34) holds. The market for deposits clears if the following equation holds:

$$D_{t+1} = \mathbb{E}_t\left[\nu d_{a,t}^* + (1-\nu)d_{n,t}^*\right], \tag{42}$$

where D_{t+1} denotes the aggregate supply of deposits from the financial system, and $d_{a,t}^*$ and $d_{n,t}^*$ denote the optimal demand of deposits from adjusters and non-adjusters, respectively. These policies depend on the idiosyncratic and aggregate states of the economy, as well as on current and future prices. Expectations in the right-hand side of (42) are taken with respect to the joint distribution $\Theta_t(d, k^h, h)$.

The market for capital claims clears if the aggregate claims on capital held by the household sector, K_t^h, and the financial sector, K_t^b, equal the aggregate stock of capital, K_t:

$$K_t = K_t^b + K_t^h. \tag{43}$$

[12] Note that adjustment costs only apply to new capital created. Therefore, gross investment equals $I_t + \delta K_t$.

[13] In Appendix B I show that results remain robust to the government adjusting taxes instead.

The goods market clears due to Walras' law if the markets for labor services, capital claims and deposits clear.

2.8 Equilibrium

A *sequential equilibrium with recursive planning* is a set of policy functions for households $\{d^*_{a,t}, d^*_{n,t}, k^{h*}_{a,t}, k^{h*}_{n,t}, x^*_{a,t}, x^*_{n,t}\}$ and banks $\{k^b_t, d_t\}$, a set of value functions for households $\{V^a_t, V^n_t\}$ and banks $\{V^b_t\}$, pricing functions $\{r^k_t, w_t, 1+i_t, \pi_t, \Xi_t\}$, aggregate capital and labor supply functions $\{K_t, N_t\}$, distributions Θ_t over individual asset holdings and productivity, and a perceived law of motion Γ, such that given prices, (i) households' and banks' policy and value functions solve their decision problems, (ii) the labor, the final goods, the deposit, the capital claims and the intermediate good markets clear, i.e., (34), (37), (42), and (43) hold, and (iii) the actual law of motion and the perceived law of motion Γ coincide, i.e. $\Theta_{t+1} = \Gamma(\Theta_t)$.

3 Numerical Implementation and Calibration

The dynamic problem of households, characterized by (11) and (12), and therefore the recursive equilibrium, are not computable because it involves the infinite-dimensional object Θ_t. Instead, I discretize the distribution Θ_t and represent it by its histogram, that is a finite-dimensional object. The household problem is solved using the endogenous grid method developed by Carroll (2006) and extended by Hintermaier and Koeniger (2010). The idiosyncratic productivity process is approximated by a Markov chain with 11 states. The time-varying probabilities of this Markov chain are obtained using the Tauchen (1986) method. I use 80 grid points for capital claims and deposits to solve the household problem.

The model is written such that the leverage constraint may be binding only occasionally. However, solving the model with heterogeneous agents, two assets, and an occasionally binding constraint is beyond the scope of the current paper. Instead, I entertain two distinct scenarios: one where the leverage constraint always binds and one where the leverage constraint never binds. Specifically, I solve the model by perturbation methods. I use first-order perturbation around the non-stochastic steady state of the model.[14] I rely on the method proposed in Bayer and Luetticke (2020) to reduce the dimensionality of the problem. This method approximates the joint distribution Θ_t over idiosyncratic states with a distribution with time-varying marginals and a fixed copula. Moreover, the value functions of the household problem are approximated by sparse polynomials around their steady-state solutions.

3.1 Calibration

I calibrate the model to the US economy. All targets correspond to a data sample covering the period between 1983 and 2015. One period in the model is a quarter. As a baseline, the

[14]Note that while a first-order perturbation of course prevents one from exploring the effects of aggregate risk, idiosyncratic risk still persists and therefore the macroeconomic impact of idiosyncratic income-risk shock can be studied. Papers studying the effects of idiosyncratic risk within linearized frameworks include, for example, Bayer et al. (2019) for the case of idiosyncratic income-risk shocks and Ravn and Sterk (2017) or Challe (2020) for the case of endogenous idiosyncratic unemployment risk.

calibrated parameters imply that the leverage constraint is always binding in equilibrium. Table 1 contains the parameter values, with letters with bars denoting steady-state variables.

Households. The relative risk aversion of households is set to $\xi = 4$ as in Kaplan and Violante (2014). The inverse Frisch elasticity γ is set to 1, in line with the estimates of Chetty et al. (2011). The time discount factor $\beta = 0.97$ and the participation frequency $\nu = 0.13$ are jointly calibrated to match the ratio of aggregate capital to output and the ratio of liquid assets to aggregate output. I target a quarterly capital-to-output ratio of 11.4 following Bayer et al. (2019). Following Kaplan et al. (2018) and Bayer et al. (2019) I target a ratio of aggregate liquidity to aggregate quarterly output of 1.04. [15]

I set the quarterly long-run standard deviation of persistent shocks to idiosyncratic income, σ_h, to 0.06 and its persistence, ρ_h, to 0.98, as estimated in Bayer et al. (2019). The persistence (ρ_s) and the standard deviation (σ_s) of innovations to the variance of shocks are set to the estimated values from Bayer et al. (2019). These values are consistent with the estimated shocks to income uncertainty used in the empirical specification discussed in Section 5. The probability of dropping out of the entrepreneurial state, ι, is set to match the probability that a household falls out of the top 1% of the income distribution reported in Guvenen et al. (2014). The probability of entering the entrepreneurial state ζ is calibrated to match a Gini coefficient of wealth of 0.78, the average Gini coefficient in the Survey of Consumer Finances over the calibration period.

Financial Intermediaries. The bank survival probability σ is set to 0.97, as in Gertler and Karadi (2011). The proportional transfer to newborn banks $\bar{\omega}$ is set to match a steady-state leverage ratio of 4, as in Gertler and Karadi (2011). The fraction of divertible assets θ is set to 0.4, implying that the leverage constraint binds. The utility cost of intermediating assets ς is set to zero in my baseline.

Production. I set the labor share α to match a labor income share of 2/3. The slope of the Phillips curve κ implies a price duration of 5 quarters in a Calvo setting. The elasticity of substitution η is calibrated to match a steady-state markup of 5%, a common value in the literature. The adjustment cost of capital ϕ is calibrated to match a relative volatility of investment of 3 conditional on a TFP shock. The autocorrelation of TFP and the standard deviation of TFP shocks are set to standard values in the literature.

Government. I set the steady-state tax rate on income τ to match a government-spending-to-output ratio of 20%. The steady-state inflation rate is set to zero, and the real return on deposits is set to 3.6% per year to target an excess return of capital over liquid assets of 100 basis points, as in Gertler and Karadi (2011). The monetary policy inertia parameter ρ_i and the

[15] Liquid assets are measured using the Survey of Consumer Finances and are composed of deposits in financial institutions (checking, saving, call, and money market accounts), government bonds, and corporate bonds net of revolving consumer credit. Deposits account for almost 89% of liquid assets (see Kaplan et al. 2018). As a robustness check, I have entertained an alternative calibration where liquid assets in the model were only matched to deposits. Results remain unaffected. Illiquid assets are equated to all capital goods in the NIPA tables, net of non-housing durable consumption goods (Bayer et al., 2019).

Table 1: Calibrated parameters.

Parameter	Description	Value	Target / Source
Households			
ξ	Risk aversion	4	Kaplan and Violante (2014)
ν	Adj. probability	0.13	$\bar{D}/\bar{Y} = 1.04$
β	Discount factor	0.97	$\bar{K}/\bar{Y} = 11.4$
γ	Inverse Frisch elasticity	1	Chetty et al. (2011)
ρ_h	Persistence productivity	0.98	Bayer et al. (2019)
σ_h	Std. shocks	0.06	Bayer et al. (2019)
ρ_s	Persistence innovations	0.84	Bayer et al. (2019)
σ_s	Std. shocks to variance	0.54	Bayer et al. (2019)
ι	Trans. prob. from E. to W.	1/16	Guvenen et al. (2014)
ζ	Trans. prob. from W. to E.	0.0005	Gini = 0.78
Non-Financial Firms			
δ	Depreciation	1.35 %	NIPA
α	Labor share	0.7	Labor Income Share 66%
η	Elasticity substitution	20	Markup 5%
κ	Slope Phillips curve	0.05	Calvo price duration 5 quarters
ϕ	Capital adj. costs	10	std(I)/std(Y) = 3
ρ_A	Persistence TFP	0.90	Standard value
σ_A	Std. TFP shocks	0.01	Standard value
Financial Intermediaries			
θ	Divertible assets	0.4	Binding Leverage Constraint
σ	Life bank	0.97	Gertler and Karadi (2011)
$\bar{\omega}$	Proportional startup transfer	0.002	Leverage of 4
ς	Utility cost intermediation	0	
Government			
ρ_i	Inertia Taylor Rule	0.8	Standard value
θ_π	Response to Inflation	1.25	Standard value
$1+\bar{i}$	Nominal Rate	1.0091	$\bar{R}^k - \bar{R} = 100$ bps p.a.
$1+\bar{\pi}$	Inflation	1	0% p.a.
σ_M	Std. monetary policy shocks	9e-4	Wieland and Yang (2020)
τ	Tax Rate	0.27	$\bar{G}/\bar{Y} = 0.20$

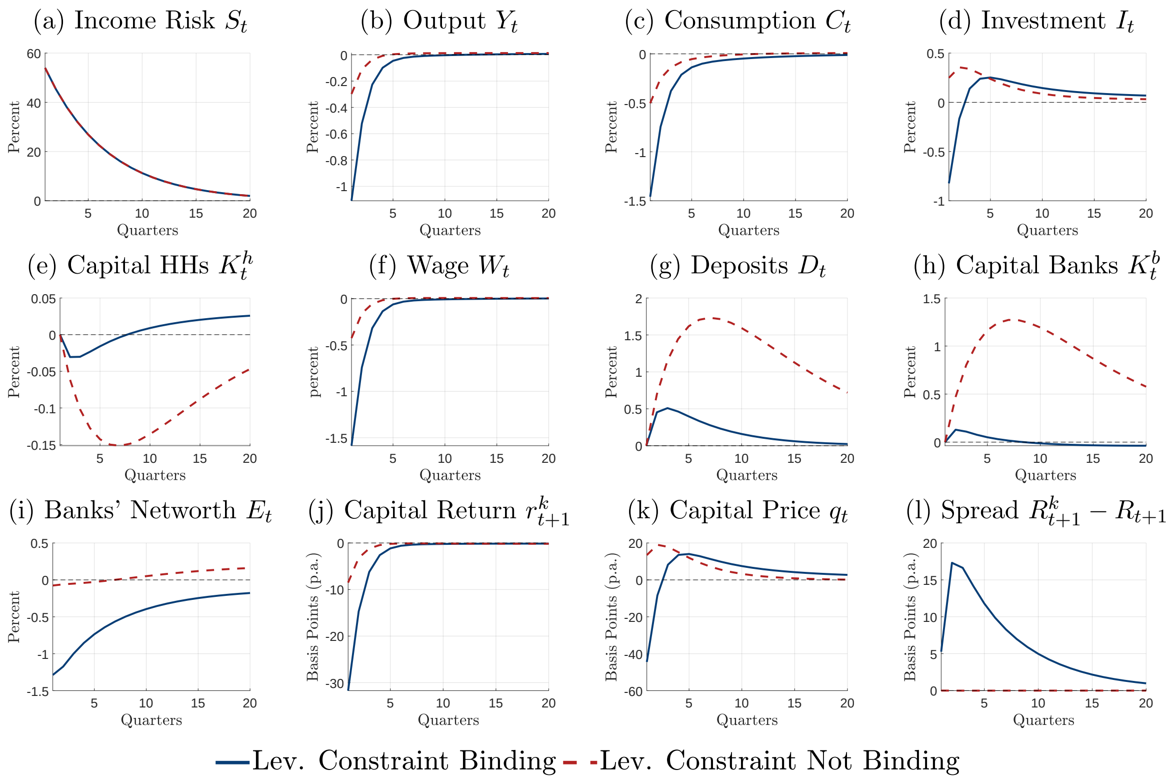
Notes: Letters with bars capture steady-state variables. The main text provides further details.

response to inflation θ_π are set to conventional values in the literature. The standard deviation of monetary policy shocks σ_M follows Wieland and Yang (2020).

4 Results

This section explores the role of banks' liquidity transformation, and how it is impaired by financial frictions, in shaping the aggregate consequences of an income risk shock. Towards this end, I assess the effects of an increase in labor income risk. This increase raises households' demand for liquid savings, shifting the desired liquidity of their portfolios. I first consider the economy with banks and a binding leverage constraint. Then I contrast it with the same

Figure 1: Impulse Response Functions to an Income Risk Shock



Notes: Impulse response functions to one standard-deviation increase in the variance of income shocks. Blue solid lines show the response in the model where the leverage constraint of financial intermediaries is binding. Red dashed lines show the response in the economy where the leverage constraint is not binding.

economy with financial intermediaries but where the leverage constraint is not binding.[16] This allows me to isolate how banking frictions impair liquidity transformation, and how this affects aggregate activity. I then explore the transmission mechanism in more detail through a series of counterfactuals. Finally, I analyze monetary policy stabilization in the current model where banks' liquidity transformation is accounted for.

4.1 The Aggregate Consequences of Liquidity Transformation

Figure 1 shows the responses to a one standard deviation increase in household income risk. The shock itself is depicted in panel (a). Blue solid lines show the aggregate effects of this shock in the economy where the leverage constraint of financial intermediaries is binding. Red dashed lines display the response to the same shock in the economy where the leverage constraint does not bind.[17]

Focus first on the economy where the leverage constraint does not bind– the dashed red lines. The increase in idiosyncratic income risk induces households to build a buffer of precautionary savings. Next to this, households seek to rebalance their portfolios away from illiquid claims on

[16] I adjust the utility costs of bank asset intermediation, ς, to match the same steady-state excess return between capital and deposits as in my baseline. This ensures that the steady state of both economies is exactly the same, so that all results only arise from the fact that the leverage constraint is binding or not.

[17] Figure A.1 in Appendix A provides impulse responses of additional variables. In addition, Appendix B shows that the results are robust to alternative calibrations of the model.

capital toward liquid bank deposits. Banks are able to meet the increase in demand for liquid savings, leading to a peak increase in deposits of almost 2% (panel g) which households partially finance by selling their illiquid capital (panel e), tilting households' portfolios toward the liquid asset. Banks use deposits to increase loans to non-financial firms (panel h). That is, while the household sector pulls back on investment, banks take over instead. With the economy-wide savings increasing, overall investment rises by almost 0.5% (panel d). As a consequence, capital returns and prices (panels j and k) are stable and there is no increase in excess returns (panel l). This, in turn, results in stable bank net worth (panel i).

Despite heightened income risk, the fall in household consumption is mild (panel c). This resilience stems from two key channels that interact through banks' balance sheets, as I will analyze in detail in the following sections.

First, on the asset side of banks' balance sheets, bank lending supports investment demand, helping to sustain output and hence households' labor income (panel f). This moderates the drop in consumption while enabling households to maintain their increased liquid savings. These savings, in turn, provide banks with additional deposits to lend, further supporting lending.

Second, on the liability side of banks' balance sheets, the endogenous increase in liquid bank deposits supports consumption. More liquid portfolios mean that households move away from their borrowing constraints. Higher liquid savings, therefore, allow households to smooth the given fall in income, muting the consumption drop. Next to this, as households are less likely to hit their borrowing constraints, higher liquidity going forward also reduces the precautionary saving motive in the present. This further raises consumption. Taken together, these channels imply that an unconstrained financial system makes the economy more resilient to shocks that shift households' desired portfolio liquidity, resulting in only a mild decline in output (panel b).

By contrast, the solid blue lines in Figure 1 show the case in which the leverage constraint binds. Overall, we observe a marked amplification in the declines of investment (panel d), aggregate consumption (panel c), and output (panel b), as well as a muted increase in liquid bank deposits (panel g) and bank lending (panel h).

When financial conditions are tight, a feedback loop emerges that amplifies the shock. The initial household response - reducing consumption and shifting portfolios toward liquid assets - puts downward pressure on capital returns (panels j and k). This harms banks' net worth (panel i) and weakens banks' balance sheets, tightening their leverage constraint and limiting their ability to extend credit (panel h). The resulting decline in bank lending, combined with households' portfolio rebalancing, causes investment to contract. As investment falls, household labor income further drops. This income loss both deepens the consumption drop and constrains households' ability to build liquid savings. The muted accumulation of liquid assets further restricts bank lending capacity while leaving households with less buffer to smooth income fluctuations, thereby amplifying the overall contraction in consumption and investment.

Overall, we observe that the aggregate consequences of an increase in households' demand for liquid savings, resulting from higher income risk, crucially depend on the state of the financial system. When the banking sector is unconstrained, the creation of liquid savings in equilibrium is ample. Furthermore, the intermediation of deposits into lending helps to stabilize investment. Both higher investment and more liquid households' portfolios constrain the fall in household consumption and hence output. A binding leverage constraint, instead, impairs banks' liquidity transformation: the responses of liquid deposits and credit are muted and much lower than if banks are unconstrained. This leads to marked falls in aggregate consumption and investment, amplifying the recessionary impact of the shock.

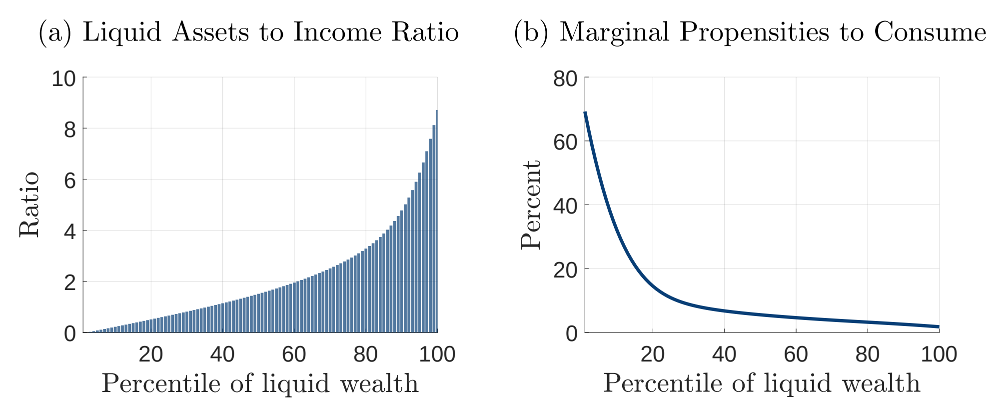
4.2 Inspecting the Transmission Mechanism

Banking frictions, by impairing the dual role of banks as providers of credit to firms and of liquid savings to the household sector, crucially shape the aggregate consequences of the household income risk shock. I now seek to understand and quantify the contribution of each of these roles to the amplification of such a shock. Towards this end, I first discuss the role of liquid savings for consumption dynamics and then consider a series of counterfactuals that illustrate the role of both lending and endogenous aggregate liquidity in general equilibrium.

4.2.1 Consumption and Liquid Savings

I begin by characterizing households' steady-state behavior, which provides important context for understanding their responses to shocks. Figure 2 presents two key steady-state relationships across the liquid wealth distribution: the ratio of liquid wealth to quarterly income (left panel), and households' marginal propensities to consume (MPCs) out of liquid wealth (right panel).

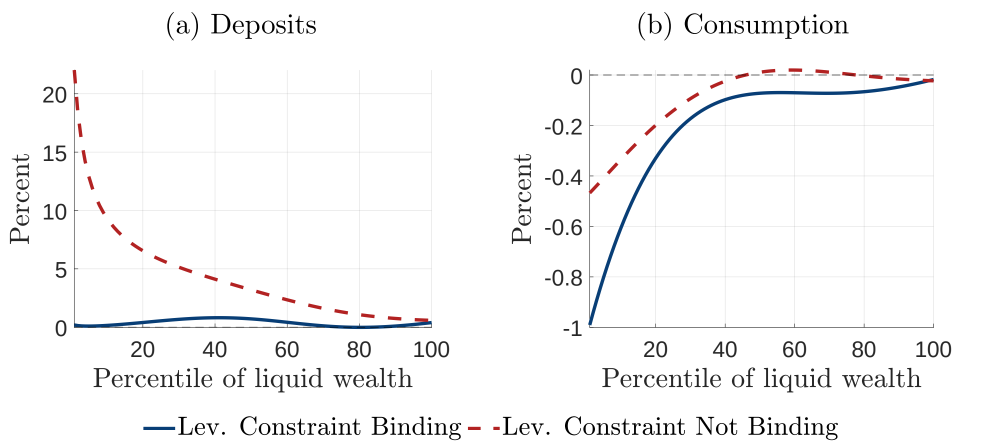
Figure 2: Liquidity and Marginal Propensity to Consume by Percentile of Liquid Wealth



Notes: Left panel displays the steady-state ratio of liquid wealth to quarterly income over the liquid wealth distribution. The right panel shows the steady-state marginal propensities to consume out of liquid wealth over the liquid wealth distribution.

The left panel reveals the limited liquid wealth holdings across the majority of the population. Specifically, households in the bottom 60% of the liquid wealth distribution maintain less than two quarters' worth of income in liquid assets, with 40% holding less than a single quarter's income. This widespread lack of liquid buffers leaves these households particularly vulnerable to income fluctuations, both aggregate and idiosyncratic. The right panel reinforces this vulnerability through the quarterly marginal propensities to consume (MPCs), which exhibit a clear negative relationship with liquid wealth. MPCs are especially elevated at the bottom of the distribution - households in the bottom half have an average MPC of 19%, rising to 35% for

Figure 3: Change in Deposits and Consumption by Percentile of Liquid Wealth



Notes: Equilibrium change of deposits (left panel) and of consumption (right panel) over the liquid wealth distribution six quarters after the household income risk shock. Red dashed lines show the case of non-binding leverage constraint. Blue solid lines show the scenario with a binding leverage constraint. Changes computed using a local linear regression technique with a Gaussian kernel and a bandwidth of 0.1.

those in the bottom quintile.

These steady-state patterns help us to interpret the heterogeneous household responses to the aggregate shock shown in Figure 3. The figure presents the distributional responses of liquid deposits (left panel) and consumption (right panel), measured at the peak response of aggregate deposits six quarters after the shock (recall Figure 1). The dashed red lines show the case of a non-binding leverage constraint, the solid blue lines the case of a binding leverage constraint.

When the financial system is unconstrained, the red dashed line in panel (a) shows that all households increase their liquid deposit holdings in response to heightened income risk. This increase is particularly pronounced among households in the bottom half of the distribution, who initially hold little liquid wealth and are thus poorly insured against income fluctuations. By building stronger liquid buffers, these high-MPC households become better equipped to smooth consumption amid falling labor income and increased uncertainty. Nevertheless, as the right panel illustrates, households at the bottom of the distribution still exhibit the largest consumption declines. In contrast, households at the top of the distribution make smaller increases to their already substantial liquid savings, while their consumption remains nearly unchanged due to their low MPCs and ample existing liquidity buffers.

The dynamics shift markedly when financial conditions are tight, as shown by the solid blue lines. Households face conflicting pressures: while heightened income risk creates incentives to increase portfolio liquidity, the amplified economic contraction and resulting income decline constrain their ability to save. The net result is that households maintain roughly unchanged liquid savings positions. This deviation from the unconstrained case is most striking for high-MPC households at the bottom of the distribution, as evidenced by comparing the solid and dashed lines in the left panel. These households, facing a larger income decline and holding less liquid portfolios, ultimately experience the most severe amplification in their consumption response, as depicted in the right panel.

The results presented in Figure 3 show that the endogenous increase in liquid bank deposits witnessed in the aggregate come with a significant distributional change in the liquid wealth distribution, with households moving away from their borrowing constraints and reducing their consumption sensitivity to income fluctuations. As such, when income falls, fewer households are borrowing constrained and consumption falls less. To appreciate this point more clearly, I construct a partial equilibrium counterfactual that isolates the impact of the shift in the liquid wealth distribution on aggregate consumption. Let $\{\Omega_t\}_{t\geq 0}$ denote the equilibrium paths of prices and shocks, where $\Omega_t = \{R_t, q_t, r_t^k, w_t, \Xi_t, \varepsilon_t^s\}$. Using the sequence of household policy functions (cf. Kaplan et al. 2018, Luetticke 2021) we can express aggregate consumption as:

$$C_t(\{\Omega_t\}_{t\geq 0}) = \int [\nu c_t^a(d, k^h, h; \{\Omega_t\}_{t\geq 0}) + (1-\nu) c_t^n(d, k^h, h; \{\Omega_t\}_{t\geq 0})] d\Theta_t,$$

where Θ_t is the equilibrium joint distribution over deposits d, capital k^h, and human capital h induced by households' policy functions.

To isolate the effect of deposit accumulation, I construct a counterfactual distribution that fixes the marginal distribution over liquid wealth at its steady-state level, while other variables are allowed to respond. The corresponding aggregate consumption path is given by:

$$\widetilde{C}_t(\{\Omega_t\}_{t\geq 0}) = \int [\nu c_t^a(d, k^h, h; \{\Omega_t\}_{t\geq 0}) + (1-\nu) c_t^n(d, k^h, h; \{\Omega_t\}_{t\geq 0})] d\widetilde{\Theta}_t,$$

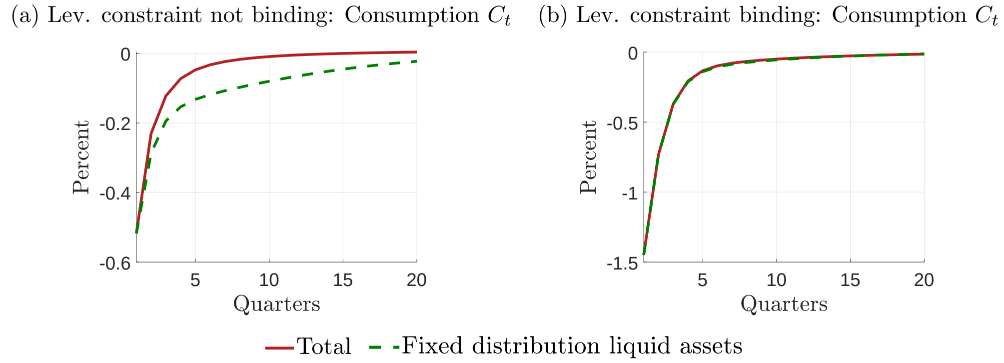
where $\widetilde{\Theta}_t$ is the counterfactual distribution with a fixed marginal distribution over deposits. Note, in particular, that both in $\widetilde{C}_t$ and in C_t the individual consumption policy functions c_t^a and c_t^n are exactly the same. The only difference comes from the distribution used for aggregating them.

Comparing the paths for C_t and $\widetilde{C}_t$ allows me to illustrate how shifts in the distribution induced by the differential liquid savings responses documented above translate into aggregate consumption dynamics. Under the counterfactual path $\widetilde{C}_t$ we do not account, for example, for the fact that with loose financial conditions households at the bottom of the distribution are accumulating liquid wealth and moving away from their borrowing constraints (recall Figure 3). Hence, aggregate consumption is counterfactually computed assuming that a larger mass of households are still sitting near the borrowing constraints, unable to smooth income fluctuations.

Figure 4 plots, for reference, with solid red lines the baseline aggregate consumption to the shock. Dashed green lines display the counterfactual consumption path arising by aggregating consumption responses under $\widetilde{\Theta}_t$, which does not account for the shift in the liquid savings distribution. The left panel shows the case of loose financial conditions, where the leverage constraint is not binding. The right panel shows the case with a binding leverage constraint.

Focus first on the case of loose financial conditions (left panel). We observe that the shift in the liquid wealth distribution plays a significant stabilization role. With less liquid wealth in the portfolios of households the consumption drop is larger over time. In contrast, under tight financial conditions (right panel), the gap between the two paths is negligible. In this case, the equilibrium deposit response is already limited due to banking frictions, and fixing deposit holdings produces only modest differences. Figure A.2 in Appendix A further illustrates the

Figure 4: Transmission Channels: Partial Equilibrium



Notes: Solid red lines show the baseline aggregate consumption response to the household income risk shock. Dashed green lines show the counterfactual consumption path computed by aggregating individual consumption responses under a distribution that keeps liquid savings fixed at steady state levels. Left panel shows case with non-binding leverage constraint, right panel shows case with binding leverage constraint.

quantitative relevance of these differences by plotting the cumulative consumption responses. There, it is shown that under loose financial conditions the cumulative consumption drop more than doubles at the end of the horizon when the shift in the liquid wealth distribution is not accounted for.

These results show that banking frictions also matter for aggregate outcomes because they mute the endogenous accumulation of liquid wealth in the portfolios of households. This prevents households from moving away from their borrowing constraints, hindering the underlying shift in the liquid wealth distribution, and amplifying the drop in consumption as the sensitivity of consumption to income fluctuations increases. The counterfactual exercise presented in Figure 4, however, does not account for general equilibrium effects. Namely, it does not take into account that lower consumption feeds back into economic activity, further reducing income and consumption. What is more, by keeping individual consumption choices fixed, it ignores how the endogenous changes in aggregate liquid savings coming with lower economic activity shape precautionary savings motives. I address these dimensions next by means of general equilibrium counterfactuals.

4.2.2 General Equilibrium Counterfactuals

In order to understand the general equilibrium effects of the dual role of banks as liquidity providers to households and lenders to firms I now consider two additional counterfactuals. These build on the economy without a binding leverage constraint. I discuss here the main characteristics of these counterfactuals. Appendix C provides a more detailed discussion.

Lending and Investment. The first counterfactual that I consider aims to quantify the relevance of the channeling of lending funds into investment. To do so, I consider an economy identical to the baseline, except that aggregate investment is fixed at its steady-state level. This corresponds to taking the limit of infinite adjustment costs in equation (38), i.e., $\phi \to \infty$.

The dotted green lines in Figure 5 show the resulting general equilibrium dynamics. For reference, the solid red lines reproduce the baseline responses under loose financial conditions, where the leverage constraint does not bind.

Under loose financial conditions, the shift in household portfolios and the increase in liquid precautionary savings materialized into lending and investment (panel c). Now, with aggregate investment fixed in this counterfactual, the missing increase in demand for investment goods means lower demand for labor and hence lower wages and household income. Given the high MPCs of households, lower income translates into a larger fall of consumption, which nearly doubles relative to the baseline (panel b). Consequently, output contracts not only due to stagnant investment but also because of the amplified decline in consumption (panel a).

The literature studying the macroeconomic consequences of banking frictions has long recognized the importance of these for lending and therefore investment (e.g. Bernanke et al. 1999, Kiyotaki and Moore 2019). This first counterfactual emphasizes that, in addition, banking frictions impairing lending matter for consumption too: the lower income that comes with the investment slump feeds into consumption owing to the high MPCs of households. This relevance of investment for consumption dynamics in heterogeneous-agent economies without financial frictions in the banking sector has been previously recognized in, for example, Auclert et al. (2020) and Bilbiie et al. (2022). Relative to these, the novelty of this paper lies in showing that such comovement of investment and consumption is crucially shaped by the state of the financial system and, through banks' liquidity transformation, by the portfolio choice of households.

Importantly, under this first counterfactual, banks no longer serve as lenders to firms, but they still perform liquidity provision for households. Although the aggregate capital stock is fixed, capital is reallocated from household portfolios to bank balance sheets.[18] Banks finance this shift by issuing deposits, so aggregate deposits still increase as in the baseline (panel d). This mechanism supports household self-insurance and partially stabilizes consumption.

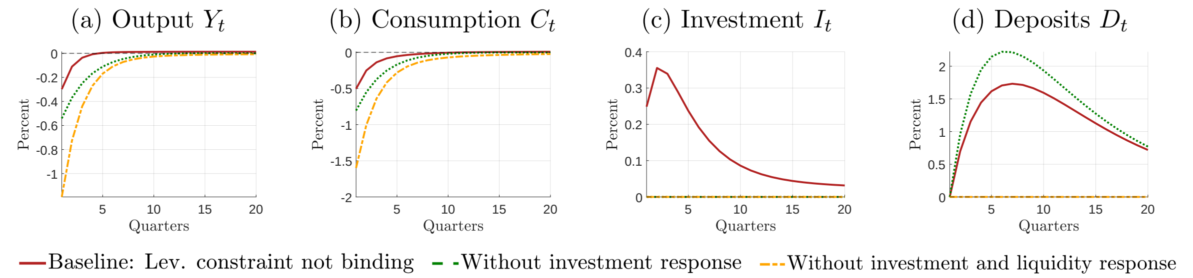
Banks' Deposits and Aggregate Liquidity. The second counterfactual additionally turns off the role played by financial intermediaries as providers of liquid savings, effectively removing active financial intermediation. More precisely, I start from the same economy with fixed aggregate investment. In addition, I assume that both the supply of bank deposits and lending remain fixed at their steady-state levels. This setting resembles a standard heterogeneous-agent model with an exogenous supply of liquid assets and no financial intermediation (cf. Kaplan et al. 2018, Bayer et al. 2019, Auclert et al. 2024).

The general equilibrium effects of banks as liquidity providers can be observed in Figure 5 by comparing the dotted green line (with only aggregate investment fixed, the first counterfactual economy) with the dashed yellow line (which adds a fixed supply of liquid bank deposits, the second counterfactual). As can be observed in panels (c) and (d), neither aggregate investment nor aggregate liquid bank deposits expand under this second counterfactual.

Recall from Figure 3 that in the baseline economy, households – especially those at the bottom of the distribution – accumulated liquid savings. This allowed households to move away from their borrowing constraints, self-insure, and buffer the equilibrium drop in income,

[18]In Figure C.1 in Appendix C I report the dynamics of capital held by households and banks separately.

Figure 5: Transmission Channels: General Equilibrium



Notes: Solid red lines show the baseline aggregate response to the household income risk shock under non-binding leverage constraint. Dotted green lines show the counterfactual response to the shock when the stock of capital is fixed at its steady-state level. Dashed yellow lines show the counterfactual response when the stock of capital is fixed at its steady-state level and the supply of liquid bank deposits is fixed at its steady-state level too.

thereby sustaining consumption over time (recall Figure 4). These dynamics are no longer possible once the role of banks as endogenous liquidity providers is absent. The amplified drop in consumption observed in partial equilibrium now feeds into economic activity. Lower economic activity further drives income down, which feeds back into households' consumption leading to a more pronounced and prolonged contraction in aggregate consumption. What is more, as households accumulate lower liquid savings over time they are more likely to hit their borrowing constraints. As a result, the precautionary saving motive strengthens, further reducing consumption already in the present.

As a result, with the liquidity provision of banks no longer expanding, the overall response of consumption is severely amplified (observe dashed yellow lines in panel b). With the investment response being absent and the fall in consumption being amplified, the contraction in output is now significantly larger (panel a).

In sum, these counterfactuals illustrate that the dual role of banks as liquidity providers and lenders to firms is crucial in shaping general equilibrium dynamics. Households accumulate liquid wealth savings in form of bank deposits. This moves households away from their borrowing constraints, reducing the sensitivity of consumption to income fluctuations and softening their precautionary saving motive. Banks use these deposits to lend to firms, sustaining aggregate investment, which in turn raises wages and income. Higher income, in turn, allows households to further sustain consumption and increase their liquid savings, further reinforcing lending and investment. Tight financial conditions disrupt this liquidity transformation of banks, impairing lending and liquid wealth accumulation, leading to a more severe contraction in economic activity.

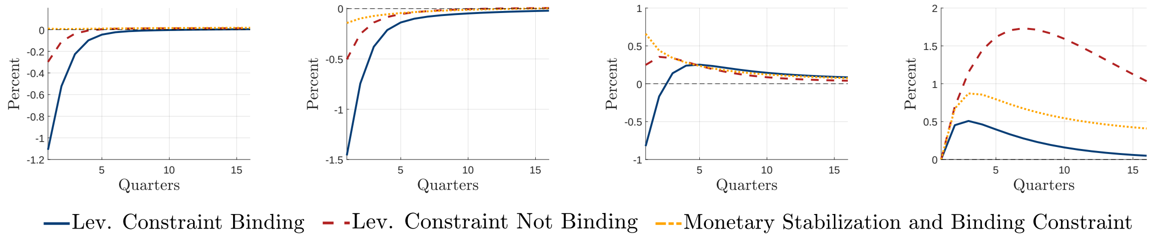
4.3 Monetary Stabilization Policy

The central bank, by cutting interest rates aggressively, can stabilize the economy when financial conditions are tight. I next discuss the transmission of such monetary stabilization in the presence of the dual role of banks highlighted in the current paper.

Figure 6 repeats, for reference, the responses of output, consumption, investment and liquid bank deposits when financial conditions are tight (solid blue lines) and when financial conditions

Figure 6: Monetary Policy Stabilization

(a) Output Y_t (b) Consumption C_t (c) Investment I_t (d) Deposits D_t



Notes: Solid blue and dashed red lines show, respectively, the baseline responses to the household income-risk shock when the leverage constraint is binding and non-binding. The dotted yellow lines show responses when the central bank fully stabilizes inflation by setting $\theta_\pi = 100$ under a binding leverage constraint.

are loose (dashed red lines) under the Taylor rule (40) with the baseline calibration. I consider a central bank that fully stabilizes inflation, and hence output, under tight financial conditions by setting the response of the nominal interest rate to inflation in the Taylor rule (40) to $\theta_\pi = 100$. The resulting dynamics are shown with dotted yellow lines in Figure 6.

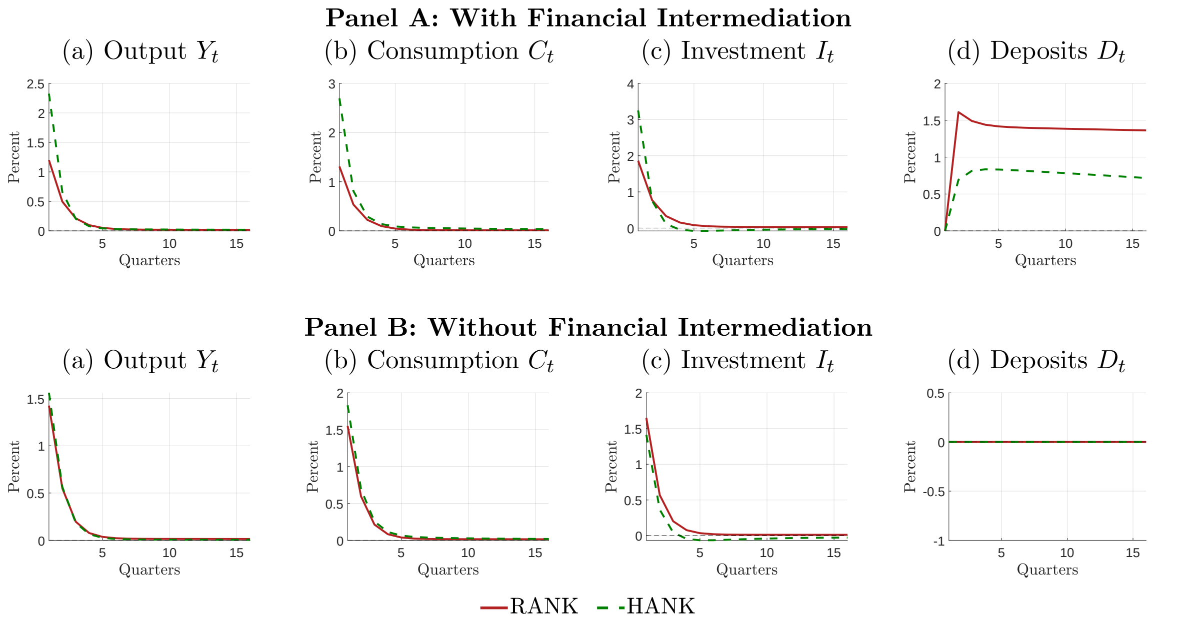
A more accommodative central bank reduces the nominal rate aggressively, lowering banks' funding costs. Lower funding costs raise banks' net worth, relaxing leverage constraints. As a result, bank lending and investment increase, see panel (c). Higher investment, in turn, raises income, allowing households to reduce their consumption contraction and increase their liquid savings in bank deposits, see panel (d). As explained in previous sections, higher liquid savings further feed back into investment through banks' balance sheets and into consumption, as it tempers their precautionary saving motive and allows them to better cushion income fluctuations. Overall, the recession is avoided and aggregate output barely falls (panel a).

In order to appreciate how the dual role of banks and financial frictions shape the monetary policy transmission in the current paper's framework I study the transmission of an expansionary monetary policy shock. The top panel of Figure 7 plots the impulse responses to a monetary policy shock in the two-asset heterogeneous agents model with a binding leverage constraint (dashed green lines) against a representative-agent version of the model (solid red lines) that also includes financial intermediaries and a binding leverage constraint (Gertler and Kiyotaki, 2015). [19]

In both models, in line with the previous logic, lower nominal interest rates relax banks' leverage constraint, expand lending and investment, as well as deposits. We see however, that the effects of monetary policy are amplified in the heterogeneous agent version of the model, with both consumption and investment expanding more (see panels b and c), and hence output (panel a). The reason for this is that the channels highlighted in this paper are weak with a representative agent. The representative agent has a low marginal propensity to consume, and hence the income increase brought about by higher investment matters less for consumption. Simultaneously, owing to Ricardian equivalence and in the absence of borrowing constraints, liquid bank deposits have no implications for consumption smoothing. As a result, the con-

[19] The structure of the representative-agent model is discussed in more detail in Appendix C.

Figure 7: Monetary Policy Transmission: HANK vs. RANK Models



Notes: The figure compares impulse responses to an expansionary monetary policy shock between two-asset heterogeneous agents models (dashed green lines) and representative agent models (solid red lines). Panel A shows the responses when both models include financial intermediaries with a binding leverage constraint. Panel B shows the responses when both models exclude financial intermediaries.

sumption response is muted. This leads to a smaller expansion in economic activity.

The bottom panel of Figure 7 illustrates the interaction between household heterogeneity and monetary policy transmission most clearly. It compares the transmission of the same monetary policy shock as before when financial intermediation is absent in both models. With endogenous liquidity creation and lending absent, the response of output is similar in both models. The reasons are well understood. First, consumption increases more with heterogeneous households, see panel (b). This is a direct consequence of the higher marginal propensities to consume relative to the representative agent (e.g. Kaplan et al. 2018). Second, in a counterbalancing effect, investment increases less in the heterogeneous-agent model than with a representative agent. This result has been explained in Luetticke (2021). The logic stems from the redistribution of income between low wealth households with high marginal propensity to consume and high wealth households, that have low marginal propensities to consume but high marginal propensities to invest.

Overall, inspecting the transmission of monetary policy stabilization reveals that banks' liquidity transformation and their dual role as liquidity providers to households and lenders to firms is crucial for both the consequences of aggregate shocks as well as for policy in the presence of household heterogeneity.

5 Supporting Empirical Evidence

The model predicts that the state of the financial system is fundamental for the aggregate consequences of a shock to household income risk that raises households' demand for liquid savings: tight financial conditions dampen the accumulation of liquid bank deposits and constrain credit, unfolding into a deeper recession. This section provides supporting empirical evidence for these predictions. I document how an increase in idiosyncratic labor income risk affects banks' deposit creation and aggregate activity, and how that effect in turn depends on the state of the financial sector. I first describe the data, then the baseline empirical specification, and finally the main empirical results.

5.1 Data

I rely on the measure of household income risk shocks at quarterly frequency identified in Bayer et al. (2019), available from 1983 until 2013. These authors extend the procedure of Storesletten et al. (2004) to estimate a time series of shocks to the variance of the persistent component of after-tax household labor income. In particular, they first specify an income process consisting of a transitory component, a household-fixed, a deterministic and a persistent component with time-varying variance. Then, they estimate this income process using panel data from the U.S. Survey of Income and Program Participation (SIPP). Changes in the dispersion of residual income across cohorts over time allow them to estimate a time series for the variance of the persistent component of income (income risk) and a time series of the shocks to this variance (income risk shocks). Figure D.1 in Appendix D.1 displays the estimated time series of household income uncertainty and the shocks to household income uncertainty.

Therefore, my measure of shocks to household income risk consists of the innovations to the variance of the persistent component of household income. Thus, I focus on swings in uncertainty about long-term household income, rather than on uncertainty about short-term household income fluctuations. This means that these shocks are less likely to be contaminated by aggregate fluctuations that only induce changes in household income at business cycle frequency. This point receives further empirical support by the results of Bayer et al. (2024). These authors, extending the procedure of Bayer et al. (2019), allow idiosyncratic household income uncertainty to respond endogenously to fluctuations in aggregate output in an estimated quantitative heterogeneous agents model. They find the estimated feedback of aggregate activity to idiosyncratic household income risk to be negligible. Still, in the next subsection, I present further robustness checks addressing potential concerns regarding the exogeneity of shocks.

Following Adrian et al. (2019), I use the National Financial Conditions Index (NFCI) constructed by the Federal Reserve Bank of Chicago to measure the state of the financial system.[20] The NFCI provides a weekly estimate of financial conditions of the U.S. in money markets, debt and equity markets, and the traditional and shadow banking systems. Although the NFCI starts in 1971, I only use the sample period between 1983 and 2015, the period for which the household income risk shocks are available. The weekly estimates are aggregated to quarterly

[20] An advantage of the NFCI over other measures is that it offers a wide coverage of the financial sector, including commercial banks that are the main suppliers of households' deposits.

frequency by averaging over the quarter. Figure D.1 in Appendix D.1 provides the resulting time series for the quarterly NFCI.

The rest of the aggregate data used in the analysis consist of quarterly U.S. time series from 1983 to 2015, retrieved from FRED, Federal Reserve Bank of St. Louis, and are described in detail in Appendix D.1.[21]

5.2 Empirical Response to Household Income Risk Shocks

I compute the responses of macroeconomic aggregates to household income risk shocks by means of state-dependent local projections (Jordà, 2005). Local projections provide a flexible alternative to structural vector autoregressions, allowing for a direct estimation of impulse response functions without imposing dynamic restrictions. Furthermore, local projections can be easily extended to study state-dependent responses, rendering them well-suited for my analysis. More precisely, I entertain the following state-dependent specification that allows me to estimate how financial conditions shape the response of macroeconomic aggregates to household income risk shocks:

$$y_{t+l} = \gamma_l \text{trend}_t + (1 - F_{t-1}) \left(\alpha_l + \phi_l(L)\mathbf{x}_t + \beta_l \frac{\varepsilon_t^s}{\sigma_s} \right) + F_{t-1} \left(\alpha_l^F + \phi_l^F(L)\mathbf{x}_t + \beta_l^F \frac{\varepsilon_t^s}{\sigma_s} \right) + \nu_{t+l} \,, l \geq 0, \tag{44}$$

where y_{t+l} is the variable of interest, ε_t^s is the household income-risk shock normalized by its standard deviation σ_s, trend_t is a linear trend, and α_l is a constant. The vector $\mathbf{x}_t$ is a set of controls and $\phi_l(L)$, $\phi_l^F(L)$ are lag polynomials. The controls include a lag of the dependent variable y, the log of household income uncertainty, and—to control for the state of the economy and the monetary policy stance—the log of real GDP, the unemployment rate, and the 3-month Treasury bill rate.

The variable F_{t-1} is a dummy that equals one if the NFCI index—my measure of financial conditions—is above its sample average, indicating tight financial conditions. The coefficient β_l measures the response of y_{t+l} to a household income-risk shock under loose financial conditions, while β_l^F measures the response under tight financial conditions.

Figure 8 shows the estimated responses of output, bank credit, and bank deposits to a one standard-deviation shock to household income risk under loose financial conditions (β_l, Panel A), tight financial conditions (β_l^F, Panel B), and their difference ($\beta_l^F - \beta_l$, Panel C). Shaded areas denote block bootstrapped 66% and 90% confidence bands.

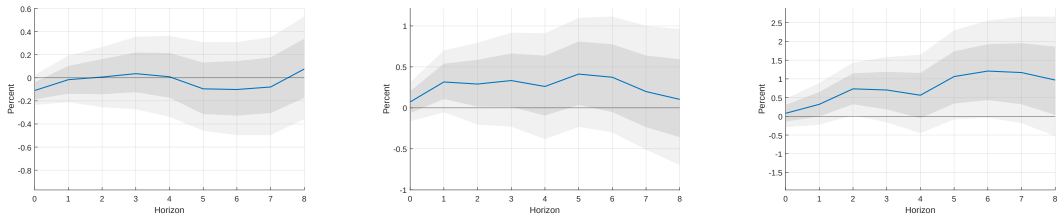
In line with the model predictions, Figure 8 shows that the effects on aggregate activity of such a shock markedly depend on the state of the financial system. During times of tight financial conditions, the shock leads to a recession. Output persistently falls by around 0.5%. In contrast, the contractionary effects of the shock are muted if financial conditions are loose. In this case, output falls on impact and then recovers quickly. Figure D.2 in the appendix further shows that aggregate consumption and investment display a similar state-dependent response.

[21] Note that shocks are available until 2013. However, the local projections described in more detail below provide an estimate of the dynamic effects of an income-risk shock occurring at time t on macroeconomic variables from time t and up to time $t + H$. Since below I consider responses over 8 quarters ($H = 8$), the time series of macroeconomic variables ends in 2015.

Figure 8: Response to an Increase in Income Risk under Different Financial Conditions

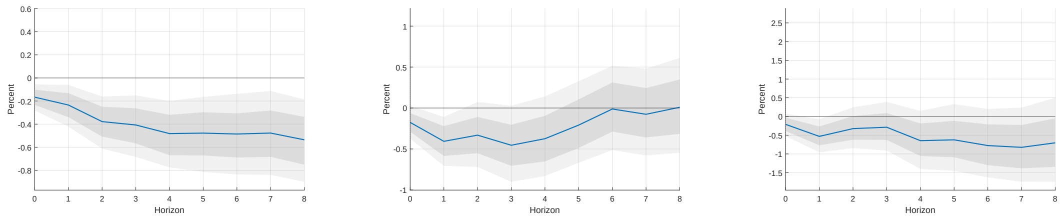
Panel A: Loose Financial Conditions

(a) Output (b) Credit (c) Deposits



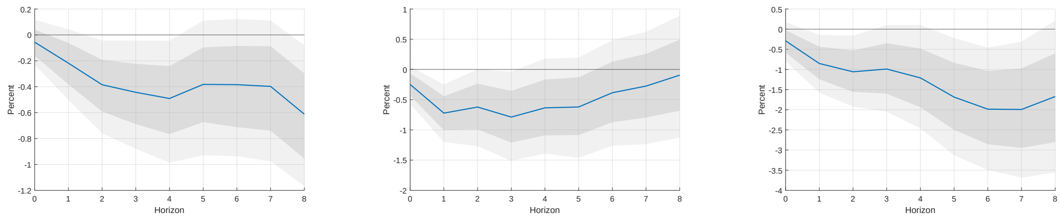
Panel B: Tight Financial Conditions

(d) Output (e) Credit (f) Deposits



Panel C: Difference (Tight − Loose)

(g) Output (h) Credit (i) Deposits



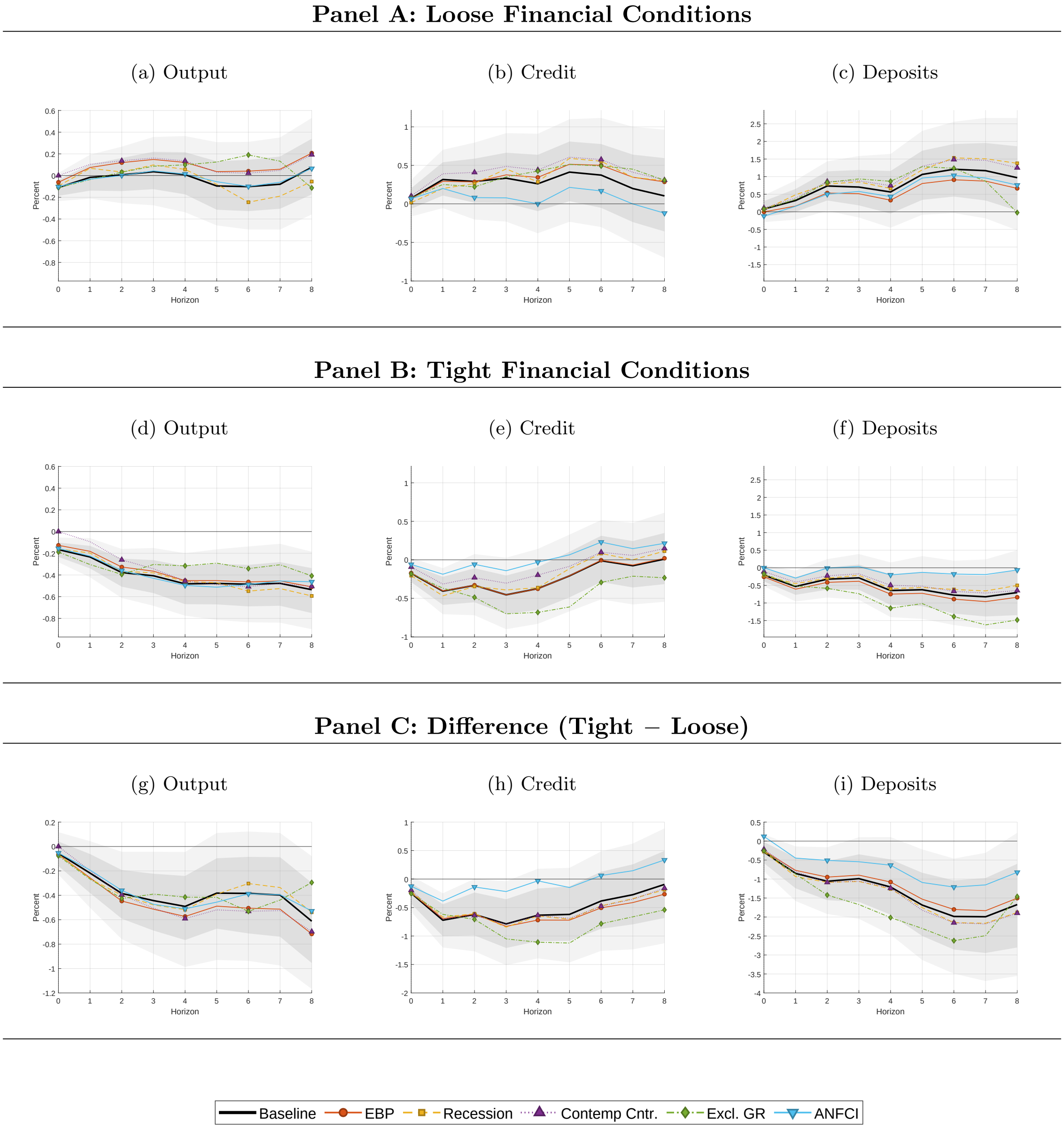
Notes: Estimated responses to a one standard-deviation shock to household income risk, as identified in Bayer et al. (2019). Panel A shows responses under loose financial conditions (β_l). Panel B shows responses under tight financial conditions (β_l^F). Panel C shows the difference ($\beta_l^F - \beta_l$). Shaded areas denote block bootstrapped 90% and 66% confidence bands.

They, too, fall sharply under tight financial conditions but respond mildly when conditions are loose.

What is more, the aggregate response of liquid deposits to an increase in income uncertainty is notably shaped by the health of the financial sector, too. Loose financial conditions come with an ample expansion of liquid savings. In marked contrast, and despite the increase in income risk, this expansion of liquid savings is absent during periods of tight financial conditions. On the asset side of the financial system, credit falls during periods of tight financial conditions, while the response is muted if financial conditions are benign.

In sum, Figure 8 shows that the effects of a shock that induces households to increase their demand for liquid savings, an increase in income risk, crucially depend on the state of the financial sector. During times of tight financial conditions, the shock triggers a pronounced

Figure 9: Baseline and Robustness: Response to an Increase in Income Risk



Notes: Baseline impulse responses (black solid line) with 90% and 66% block bootstrapped confidence bands (shaded areas), overlaid with point estimates from robustness specifications. *ANFCI*: Adjusted NFCI as state indicator. *Recession*: horse race against a recession dummy (unemployment above HP trend) interacted with the shock. *EBP*: excess bond premium of Gilchrist and Zakrajšek (2012) added as control. *Excl. GR*: Great Recession excluded from sample. *Contemp Cntr.*: contemporaneous macroeconomic controls (income risk ordered last).

recession, and the creation of liquid deposits and bank credit is markedly muted. These empirical results, thus, support the model's prediction that the state of the banking system is fundamental in shaping how shocks to household income risk transmit to economic activity.

Robustness I next consider a series of robustness checks to assess the sensitivity of the results to alternative specifications and to address competing explanations for the baseline empirical findings presented in Figure 8.

A first concern is that tight financial conditions often coincide with economic downturns—

the Global Financial Crisis being a prominent example—as can be observed in Figure D.1. This raises the question of whether the state-dependent responses in Figure 8 reflect the role of financial conditions or simply differences between expansions and recessions. I address this concern in two ways. First, I replace the NFCI with the Adjusted NFCI, which provides a measure of financial conditions that is orthogonal to the state of the economy (Brave and Kelley, 2017). Second, following Ramey and Zubairy (2018), I augment specification (44) to consider a "horse-race" type of regression against a measure of recessions. More specifically, I include an interaction between the income-risk shock and a recession indicator—a dummy equal to one when the unemployment rate exceeds its HP-filtered trend. This directly absorbs any differential propagation of the shock during economic downturns, ensuring that the estimated role of financial conditions is not confounded by the business cycle.

A second concern is that the baseline results might be driven by the coincidence of income-risk shocks with financial shocks, rather than by the interaction of income-risk shocks with the prevailing state of the financial system. I address this in two ways. First, I exclude the Great Recession from the estimation sample, so as to ensure results are not driven by this particular period of financial disruption. Second, I augment specification (44) with the excess bond premium of Gilchrist and Zakrajšek (2012)—a widely used measure of financial shocks—as an additional control variable, ensuring that the estimated income-risk shock coefficients are not confounded by coincident financial disturbances.

Finally, I consider an alternative identification assumption. The baseline specification (44) allows the income-risk shock to affect all variables contemporaneously, which is equivalent to ordering income risk first in a Cholesky-identified SVAR. As a robustness check, I take the opposite ordering and include contemporaneous values of the macroeconomic controls, so that only income uncertainty itself responds on impact to the income-risk shock.

Figure 9 summarizes the results. It overlays point estimates from all robustness specifications on the baseline confidence bands. Across all panels and variables, the robustness estimates closely track the baseline. Overall, these results support the view conveyed by the baseline estimates that the state of the financial system is fundamental in shaping how household income-risk shocks—and the ensuing shift in the liquidity composition of households' portfolios—transmit to economic activity.

6 Conclusion

This paper investigates how financial frictions, by impairing banks' liquidity transformation, affect the propagation of shocks that shift the desired liquidity of households' portfolios. At the theoretical level, I study how financial frictions and liquidity transformation affect the propagation of swings in the demand for liquid savings in a two-asset heterogeneous agent model with a banking system. A binding leverage constraint restrains lending, and hence investment and income, amplifying the drop in consumption. Crucially, I show that endogenous liquidity in the form of bank deposits is key too for consumption dynamics. A muted accumulation of liquid savings in households' portfolios prevents them from moving away from borrowing constraints, leaving them more exposed to the ensuing fall in income and amplifying the consumption drop.

At the empirical level, I provide supporting evidence that the state of the financial system is fundamental for the aggregate consequences of a shock to household income risk. Tight financial conditions induce a sharper contraction in output, while muting the accumulation of liquid bank deposits and amplifying the response of bank credit.

There are fruitful areas for future research. For example, financial frictions usually come with highly non-linear dynamics (Brunnermeier and Sannikov, 2014, Bocola, 2016). Future work could extend the model to examine non-linear interactions with an occasionally binding leverage constraint using recent global solution methods for economies with heterogeneous agents (Fernández-Villaverde et al., 2023).

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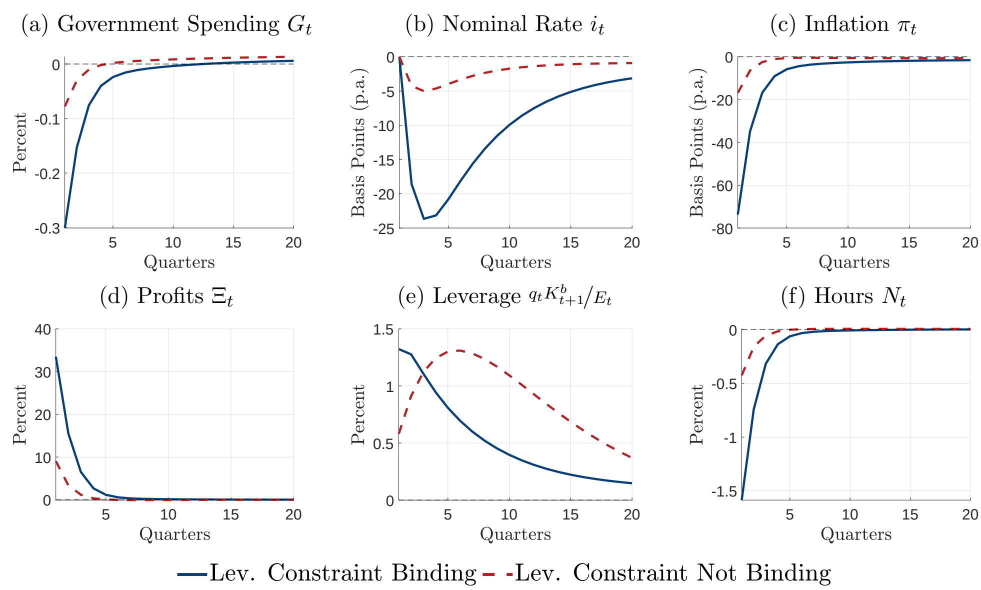
Online Appendix to "Precautionary Savings and Financial Frictions"

Rubén Domínguez-Díaz

A Additional Impulse Responses

Figure A.1 shows the response of additional variables to the household income risk shock considered in section 4.1. Blue solid lines show the impulse response functions when the leverage constraint is binding. The larger contraction in output with an impaired financial system (see Figure 1) has a larger impact on tax revenues, and hence the government cuts government spending more strongly to balance the budget (panel a). Similarly, the larger recession means a more pronounced drop in inflation (panel c), which entails a larger cut in the nominal interest rate from the central bank (panel b). A common feature of New Keynesian models with sticky prices is that profits are countercyclical to inflation (panel d), and they increase more when the leverage constraint binds, as a consequence of the larger fall in output and, hence, inflation. Bank leverage increases in both situations, but substantially more when the financial system is unconstrained (panel e).[22] Finally, the larger drop in the wage rate discussed in the main text implies a larger drop in hours worked when financial conditions are tight (panel f).

Figure A.1: Impulse Response Functions to an Income Risk Shock



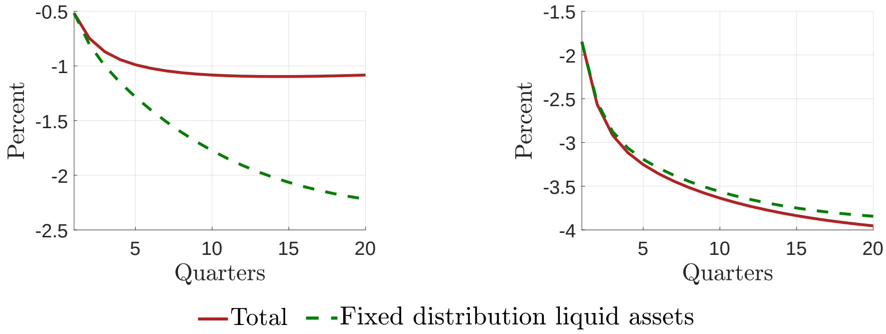
Notes: Impulse response functions to one standard-deviation increase in the variance of income shocks. Blue solid lines show the response in the baseline model, where the leverage constraint of financial intermediaries is binding. Red dashed lines show the response in a counterfactual economy where the leverage constraint is not binding.

Figure A.2 complements Figure 4 in the main text by showing cumulative consumption re-

[22] Leverage increases more on impact when the leverage constraint is binding because asset prices fall (see panel (k) in Figure 1). Leverage quickly takes over with an unconstrained financial system, since the expansion in credit is larger in this case (see Figure 1).

Figure A.2: Transmission Channels: Partial Equilibrium (Cumulative)

(a) Lev. constraint not binding: Cumulative C_t (b) Lev. constraint binding: Cumulative C_t



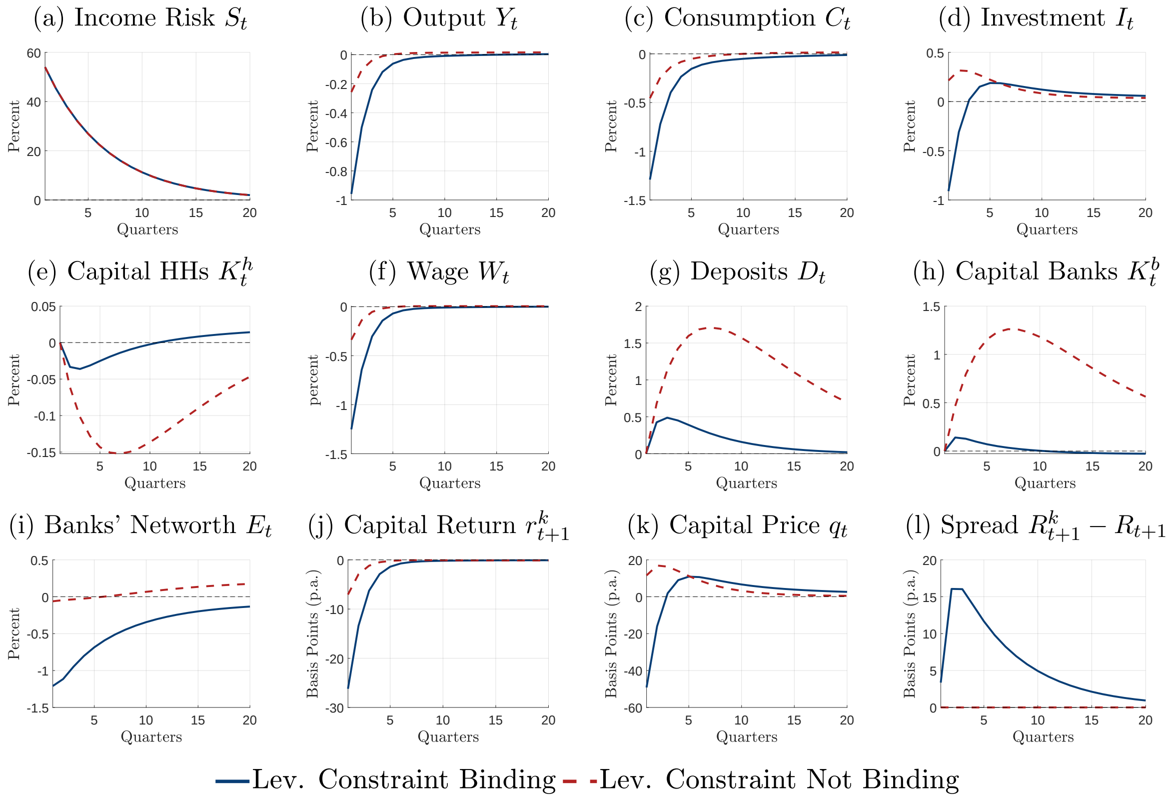
Notes: Solid red lines show the baseline cumulative consumption response to the household income risk shock. Dashed green lines show the counterfactual cumulative consumption path computed by aggregating individual consumption responses under a distribution that keeps liquid savings fixed at steady state levels. Left panel shows case with non-binding leverage constraint, right panel shows case with binding leverage constraint.

sponses. Under loose financial conditions (left panel), the shift in the liquid wealth distribution plays a significant stabilization role: when this shift is not accounted for, the cumulative consumption drop more than doubles at the end of the horizon. In contrast, under tight financial conditions (right panel), the gap between the two paths remains negligible, as banking frictions already limit the equilibrium deposit response.

B Robustness Model Results

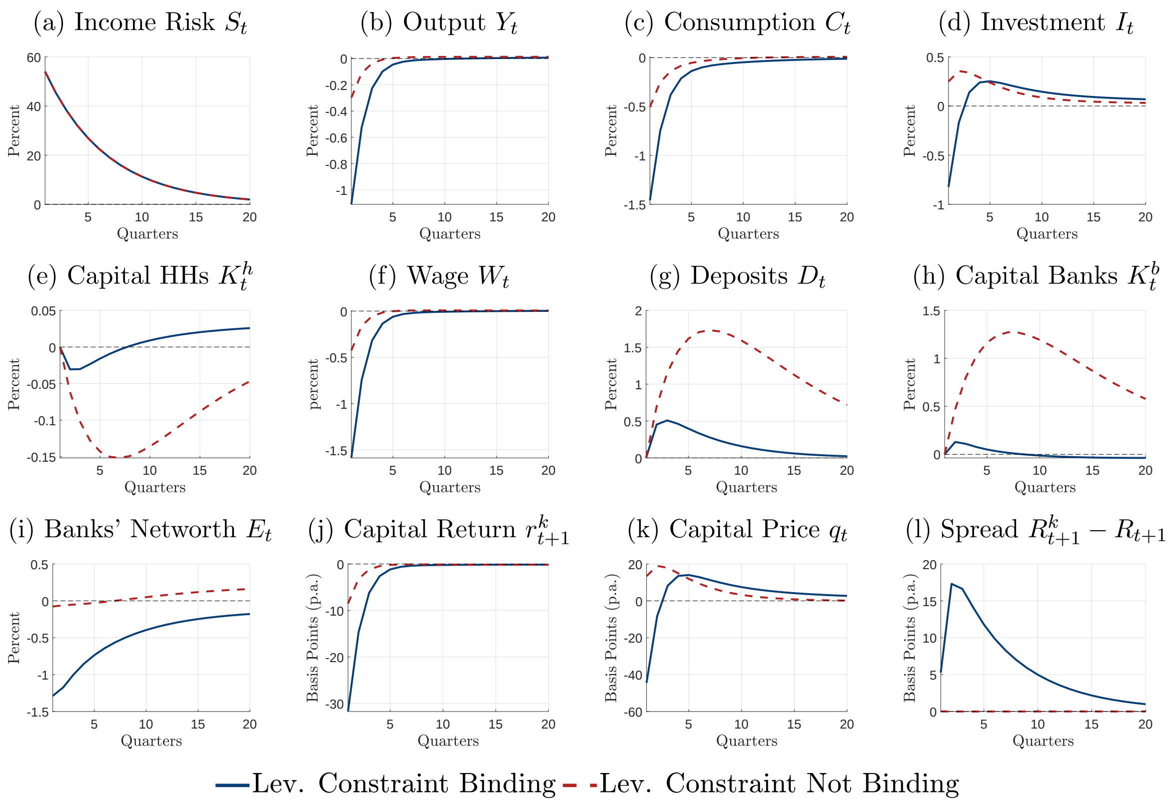
This section provides robustness checks regarding the main quantitative results of the paper. Figure B.1 shows dynamics of aggregate variables following an increase in income risk when the government adjusts the tax rate on income τ_t instead of government spending to balance the budget. In Figure B.2 I consider a scenario with more flexible prices $\kappa = 0.09$, implying an average price duration of four quarters. Figure B.3 entertains a scenario with a stronger response on the nominal interest rate to inflation $\theta_\pi = 1.5$. Finally, Figure B.4 considers an alternative calibration where the bank's discount factor is set equal to the inverse of the return on illiquid capital rather than the inverse of the return on the liquid asset. The amplification of idiosyncratic income risk shocks when financial frictions bind remains robust in all these scenarios.

Figure B.1: Impulse Response Functions to an Income Risk Shock - τ_t adjusts



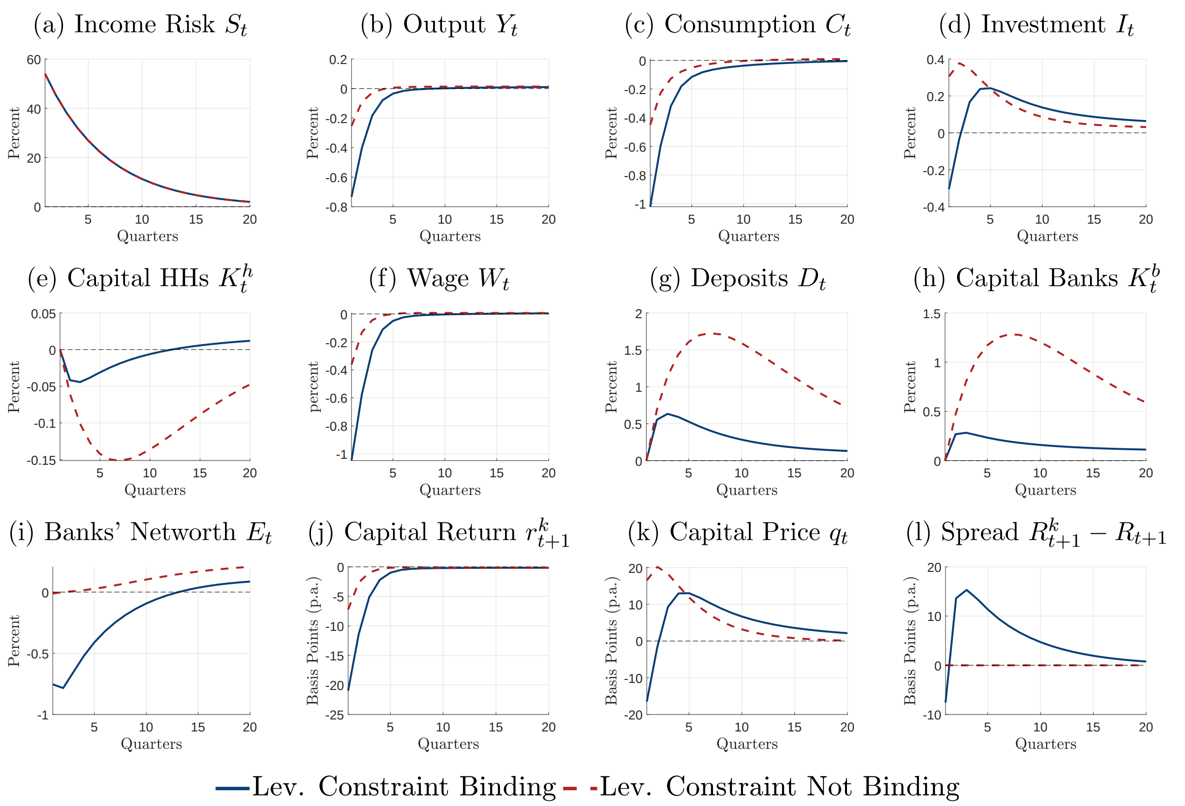
Notes: Impulse response functions to 1 standard-deviation increase in the variance of income shocks, when the income tax τ_t adjusts. Blue solid lines show the response in the baseline model. Red dashed lines show the response in a counterfactual economy where the leverage constraint is not binding.

Figure B.2: Impulse Response Functions to an Income Risk Shock - More Flexible Prices



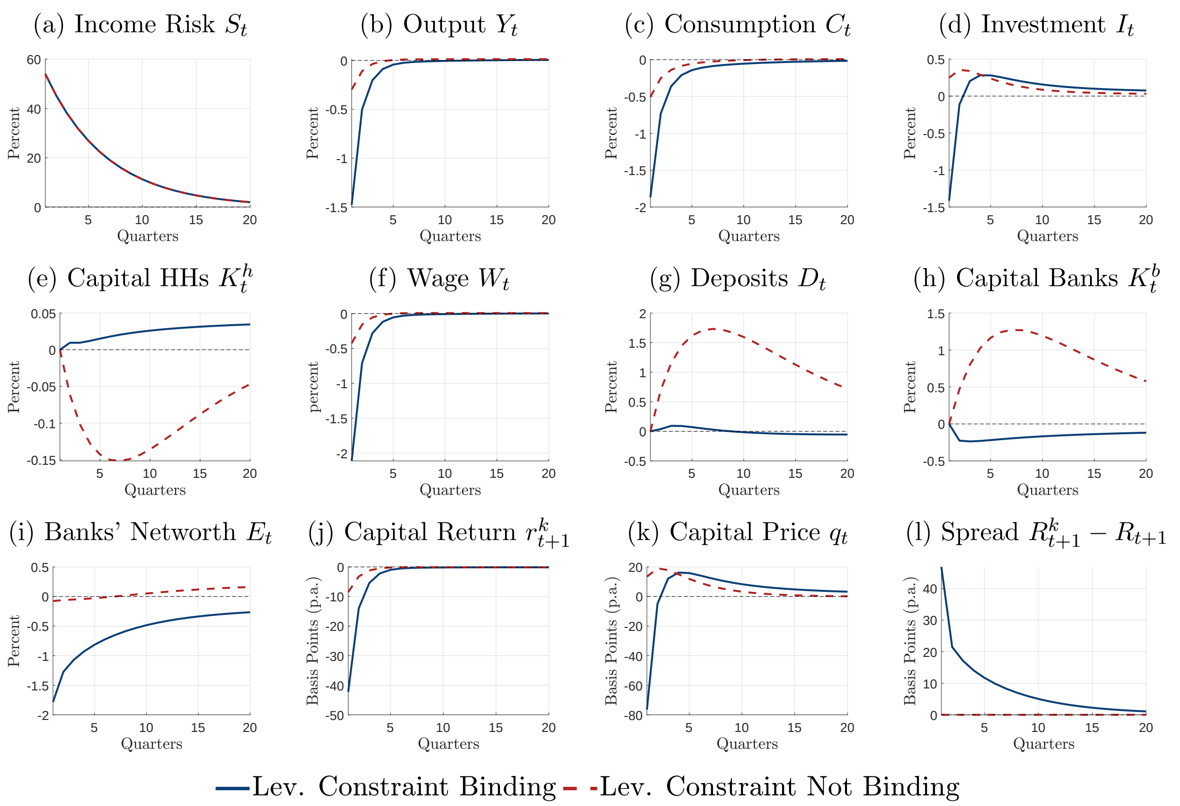
Notes: Impulse response functions to 1 standard-deviation increase in the variance of income shocks, with $\kappa = 0.09$ implying an average Calvo duration of prices of 4 quarters. Blue solid lines show the response in the baseline model. Red dashed lines show the response in a counterfactual economy where the leverage constraint is not binding.

Figure B.3: Impulse Response Functions to an Income Risk Shock - Stronger Response of Monetary Policy



Notes: Impulse response functions to 1 standard-deviation increase in the variance of income shocks, with a stronger response of the central bank to inflation $\theta_\pi = 1.5$. Blue solid lines show the response in the baseline model. Red dashed lines show the response in a counterfactual economy where the leverage constraint is not binding.

Figure B.4: Impulse Response Functions to an Income Risk Shock - Alternative Bank Discount Factor



Notes: Impulse response functions to 1 standard-deviation increase in the variance of income shocks, with the bank's discount factor calibrated to the return on illiquid capital. Blue solid lines show the response in the baseline model. Red dashed lines show the response in a counterfactual economy where the leverage constraint is not binding.

C Counterfactual Economies

This appendix contains the details regarding the counterfactual economies discussed in section 4.2.2 and the representative agent model discussed in section 4.3.

Fixed Aggregate Investment In this economy, the only modification relative to the baseline economy without a binding leverage constraint is that the aggregate capital stock is fixed at its steady-state level. This corresponds to taking the limit of infinite adjustment costs in equation (38), i.e., $\phi \to \infty$, such that we have that:

$$K_t = \bar{K}, \tag{45}$$

where $\bar{K}$ is the steady-state level of aggregate capital. In turn, the market clearing condition for capital (43) now reads:

$$\bar{K} = K_t^b + K_t^h. \tag{46}$$

Note in particular that in this economy, although the aggregate capital stock is fixed, equation (46) makes clear that the share of capital held by households or by banks is not restricted. As discussed in the main text, this allows capital to shift from the portfolio of households towards the balance sheet of banks, leaving the overall stock of capital unchanged. Importantly, banks finance the new claim on capital purchased from households by issuing liquid bank deposits. Hence, liquid bank deposits still increase under this counterfactual as in the baseline (recall Figure 5). The resulting dynamics of claims on capital held by households and banks in this counterfactual are shown with dotted green lines in Figure C.1.

Fixed Aggregate Investment and Aggregate Liquid Assets This economy builds on the first counterfactual with a fixed aggregate capital stock, and in addition removes financial intermediation altogether by fixing the supply of bank deposits and lending at their steady-state levels. More precisely, I assume that financial intermediaries always keep their supply of deposits, D_t, fixed at the steady-state level $\bar{D}$. Similarly, financial intermediaries are also assumed to keep their capital holdings fixed at the steady-state level $K_t^b = \bar{K}^b$. This assumption effectively renders banks irrelevant for aggregate dynamics. I further assume that any capital gains or losses incurred by financial intermediaries are rebated to shareholders, the entrepreneurs. This ensures that the steady state of this economy without an active financial sector is the same as in my baseline, presented in section 2. The market clearing conditions for capital, (43), and deposits, (42), now read:

$$\bar{K} = K_t^h + \bar{K}^b, \tag{47}$$

$$\bar{D} = \mathbb{E}_t \left[\nu d_{a,t}^* + (1-\nu) d_{n,t}^* \right]. \tag{48}$$

Contrary to the previous case, now (48) and (47) also imply that the aggregate holdings of claims on capital in the hands of households are also fixed at their steady-state levels, observe dotted yellow lines in Figure C.1.

Representative Agent Model In section 4.3 I consider a representative agent version of the model to illustrate how the mechanisms highlighted in this paper through liquidity transformation shape monetary policy stabilization.

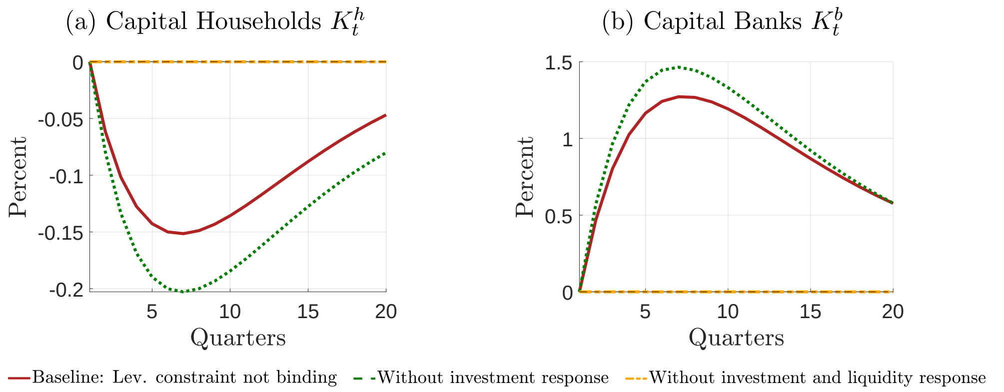
This representative agent model builds on Gertler and Kiyotaki (2015) and parallels the structure of the two-asset heterogeneous-agent model with a binding leverage constraint. The bank block and the non-financial firms remain exactly the same as in the heterogeneous-agent model, with the only difference arising from the household block. More precisely, the household problem is now summarized by the following conditions. First, a standard Euler equation for bank deposits:

$$u'(x_t) = \beta \mathbb{E}_t R_{t+1} u'(x_{t+1}), \tag{49}$$

where recall that under GHH preferences we have that $x_t = c_t - G(n_t)$.

Second, as in Gertler and Kiyotaki (2015), the representative agent can also hold claims on

Figure C.1: Transmission Channels: General Equilibrium



Notes: Solid red lines show baseline aggregate response to the household income risk shock under loose financial conditions. Dotted green lines show counterfactual aggregate response to the shock when the stock of capital is fixed at steady state. Dashed yellow lines show counterfactual aggregate response to the shock when the stock of capital is fixed at steady state and the supply of liquid bank deposits is fixed at steady state.

capital facing a portfolio adjustment cost $f(K^H_{t+1}) = \frac{\kappa_H}{2}(K^H_{t+1})^2$. This delivers the following Euler equation for capital:

$$u'(x_t) = \beta \mathbb{E}_t \frac{r^k_{t+1} + q_{t+1}}{q_t + \kappa_H K^H_{t+1}} u'(x_{t+1}), \tag{50}$$

where I calibrate κ_H to ensure that the representative agent model features the same capital in the hands of households as in the heterogeneous-agent model, ensuring that both models share exactly the same steady state allocation and prices.

Finally, the average productivity of the representative agent is equal to one, implying that labor supply condition (7) now reads:

$$n_t^{\gamma} = (1 - \tau) w_t. \tag{51}$$

D Empirical Appendix

This appendix regards the empirical analysis discussed in section 5. Section D.1 describes the data used in the empirical analysis. Section D.2 provides additional empirical responses to a household income risk shock, complementary to those discussed in section 5.2.

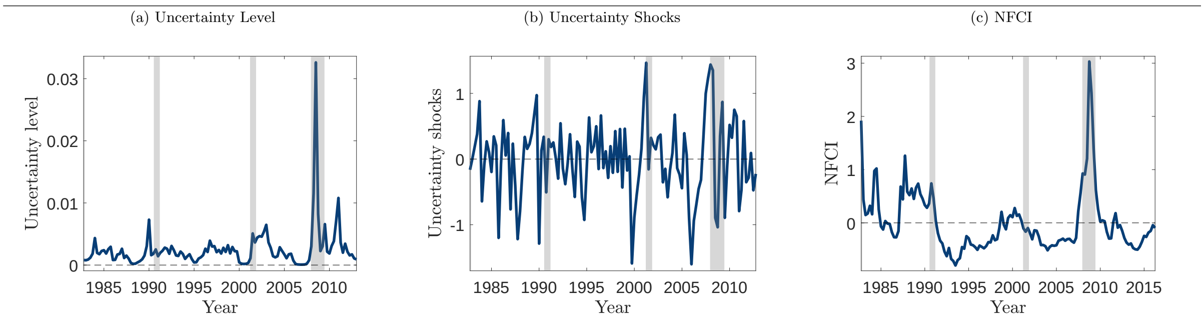
D.1 Data

Unless otherwise noted, data are taken from the FRED, Federal Reserve Bank of St. Louis. Nominal variables are deflated using the Consumer Price Index for All Urban Consumers: All Items.

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

- Consumption: Real Personal Consumption Expenditures, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate
- Investment: Real Gross Private Domestic Investment, Billions of Chained 2012 Dollars, Quarterly, Seasonally Adjusted Annual Rate
- Credit: Total Credit to Private Non-Financial Sector, Adjusted for Breaks, for United States, Billions of US Dollars, Quarterly, Not Seasonally Adjusted
- Deposits: Households and Nonprofit Organizations; Total Currency and Deposits Including Money Market Fund Shares; Asset, Level, Billions of Dollars, Quarterly, Not Seasonally Adjusted minus Households and Nonprofit Organizations; Money Market Fund Shares; Asset, Level, Billions of Dollars, Quarterly, Not Seasonally Adjusted
- Unemployment: Unemployment Rate, Percent, Quarterly, Seasonally Adjusted
- Nominal interest rate: 3-Month Treasury Bill: Secondary Market Rate, Percent, Quarterly, Not Seasonally Adjusted
- NFCI: Chicago Fed National Financial Conditions Index, Index, Monthly, Not Seasonally Adjusted. Aggregated to quarterly frequency by averaging over the quarter.
- Income risk shocks: Bayer et al. (2019)

Figure D.1: Estimated level of household uncertainty and income risk shocks, and National Financial Conditions Index



Notes: Panel (a): Estimated standard-deviation of persistent income shocks. Panel (b): Shocks to income risk. Both series have been estimated in Bayer et al. (2019). Panel (c): Time series of the National Financial Conditions Index (NFCI). NBER recession dates are displayed with gray areas.

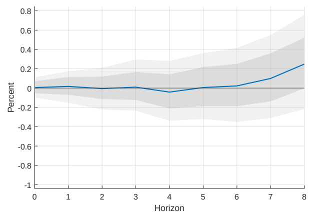
D.2 Additional Empirical Responses

This appendix provides additional empirical responses to a household income risk shock, complementary to those discussed in section 5.2. Figure D.2 reports the estimated responses of consumption, investment, and the unemployment rate under the baseline specification (44). Consistent with the model of section 2, the estimated responses show that the deeper contraction in output under tight financial conditions (recall Figure 8) is driven by a sharper decline in both consumption and investment, and accompanied by a larger increase in the unemployment rate.

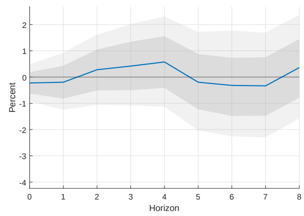
Figure D.2: Response to an Increase in Income Risk: Additional Variables

Panel A: Loose Financial Conditions

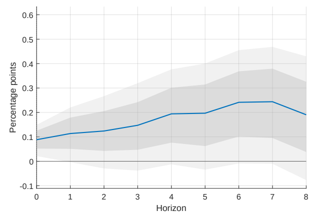
(a) Consumption



(b) Investment

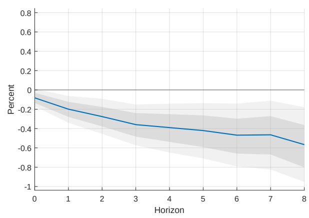


(c) Unemployment

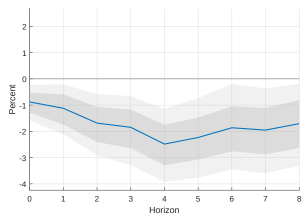


Panel B: Tight Financial Conditions

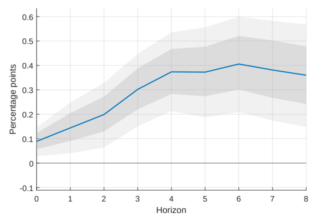
(d) Consumption



(e) Investment

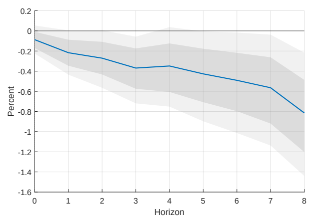


(f) Unemployment

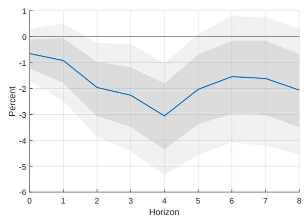


Panel C: Difference (Tight − Loose)

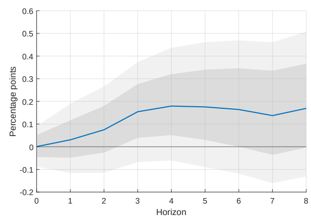
(g) Consumption



(h) Investment



(i) Unemployment



Notes: Estimated responses to a one standard-deviation shock to household income risk, as identified in Bayer et al. (2019). Panel A shows responses under loose financial conditions (β_l). Panel B shows responses under tight financial conditions (β_l^F). Panel C shows the difference ($\beta_l^F - \beta_l$). Shaded areas denote block bootstrapped 90% and 66% confidence bands.