Bank-Dependent Households and The Unequal Costs of Inflation

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Abstract

I study the welfare cost of anticipated inflation with an emphasis on distributional considerations. Two facts motivate my approach. First, around 60% of U.S. households are Bank-Dependent: they save all their liquid assets in bank deposits. Second, there is imperfect passthrough of market interest rates to bank deposit rates, i.e. deposit rates move less than one-to-one with market rates. As a result, high expected inflation lowers the real return on liquid savings for Bank-Dependent households, which impairs their precautionary saving capacity. I study a model of non-competitive banks along with households that vary in financial sophistication. In the model, the joint distribution of households' portfolio choices and wealth shapes demand elasticities for deposits thereby influencing banks' optimal interest rates. I use the model to explore the consequences of permanent and temporary changes in inflation. The model predicts the welfare costs of high inflation to be disproportionately borne by low- and medium-wealth households that rely on deposits to smooth consumption.

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1 Introduction

It is well understood that unanticipated inflation can have distributional consequences through changes in the real value of nominal assets and liabilities (Doepke and Schneider, 2006). It is also widely believed that anticipated inflation is costly, yet the precise mechanisms are less understood. Existing works have pointed to two main channels. The New-Keynesian business cycle literature argues that inflation distorts relative prices (Woodford, 2003). An earlier literature emphasizes how inflation acts as a tax on assets used for transactions (Friedman, 1969; Lucas, 2000). Building on this literature, this paper explores an alternative mechanism emphasizing its distributional consequences and the specific role played by banks.

I argue that anticipated inflation impairs households' ability to save for precautionary reasons, especially for lower-wealth households. My argument is based on two empirical facts. First, most U.S. households hold all their liquid assets in bank deposits, particularly those at the lower end of the wealth distribution. Second, deposit returns are low and unresponsive to market returns. Anticipated inflation, therefore, lowers the real return on households' savings since nominal rates on deposits do not adjust with inflation, as opposed to returns on other financial instruments. As a result, inflation both erodes households' assets value and reduces their incentives to save.

I formalize this argument using a parsimonious general equilibrium heterogeneous agent model that reproduces the motivating facts. I use the model to quantify the costs of inflation and how these costs are distributed across the wealth distribution. To capture the evidence that poorer households are more likely to save in deposits as well as the positive comovement between deposit spreads and market returns, the model incorporates a portfolio choice in the household problem and a non-competitive banking sector. I use the model to study a rise in trend inflation and a temporary shock that increases future inflation. The model predicts a sizable welfare cost of inflation, concentrated at the low end of the wealth distribution, due to the reduction in Bank-Dependent households' ability to smooth consumption under lower real rates.

This paper begins by providing empirical evidence on the importance of deposits in households' liquid assets portfolios and the dynamics of deposit returns. Using the Survey of

Consumer Finances, I document that approximately 60% of U.S. households accumulate all of their liquid assets in bank deposits. I label these households as *Bank-Dependent*. Surprisingly, this share has remained stable, even in periods of high inflation and high market returns, such as during the 1970s and the 1980s. Moreover, Bank-Dependent households are not necessarily poor: historically about half of all households with six months of total income in liquid assets fall into this category. Second, using data on Call Reports, and similarly to Drechsler, Savov, and Schnabl (2017), I document that banks keep their nominal returns on deposits low relative to similar market instruments. In other words, there exists a spread between market returns and deposit returns. On top of that, these spreads are larger in periods of higher nominal rates. This evidence motivates my mechanism: when inflation is high, the real return on assets for Bank-Dependent households falls.

In the second part of the paper, I develop a tractable heterogeneous agents model in the spirit of the recent HANK literature. Savings are crucial in the model for households to self-insure against idiosyncratic income shocks. To account for the evidence on asset market segmentation I incorporate into the households' problem a portfolio decision between three types of assets: checking deposits, savings deposits, and government bonds. All assets are equally liquid, mature in one period, and differ only in their rate of return. The portfolio decision is discrete: households choose a single asset to save each period.

Households are subject to periodic iid nonpecuniary fixed costs to save using high return assets. To keep the model tractable, I assume there are two types of households, Unsophisticated households and Investors, that differ only in the set of assets they can access. Unsophisticated households can only choose between a zero nominal return checking account and a higher return savings account. If their realized cost in a given period exceeds the benefits of saving in the savings account, the household chooses the checking account. Similarly, Investors can access the savings account for free and also have the option to pay their cost to save in government bonds at the market return. The assumption that the costs are fees payable each period implies that the portfolio choice is static and that agents save their entire portfolio in the account with the highest fee-adjusted returns. Once the portfolio decision is taken, households decide on their consumption-saving choice subject to a no-borrowing constraint.

A novel feature of this model is that the wealth distribution shapes the aggregate elasticity of checking and savings deposits to interest rates, a key determinant of non-competitive banks' optimal deposit spreads. Specifically, aggregate deposit elasticities can be decomposed as individual elasticities weighted by the relative importance of each household in the deposits market. In the model, deposits controlled by wealthier households are more elastic. The reason is that even a small reduction in interest rates results in a large dollar loss for wealthier households. Therefore, given the fixed nature of the cost, wealthier households are more likely to pay the cost and switch assets after a reduction in deposit rates. Consequently, shifts in the distribution of wealth and asset choices in counterfactual high-inflation scenarios will shape banks' optimal deposit spreads.

Recent work by Drechsler, Savov, and Schnabl (2017) argues that banks market power on deposits is the main determinant of the imperfect passthrough of market interest rates to bank deposit rates. Motivated by their work, I assume that the financial sector in the model is composed of small monopolistic banks. Banks are multi-product firms: they issue checking and savings deposits and post returns on both assets subject to a zero lower bound. For tractability, I assume that banks' demand for deposits is made up of a new random sample of households each period. This ensures that when banks set deposit rates, they only take into account their influence on current demand, which simplifies the analysis. Importantly, customers are locked-in for one period. Thus, the model captures in a parsimonious and tractable way the idea that there are costs of switching banks which confers some market power to banks in the short run.

In the calibrated steady state, banks face a very inelastic demand for checking deposits from Unsophisticated households and optimally choose to set the nominal return on checking accounts at the zero lower bound, as in the data. In other words, banks find it optimal to extract as much spread as possible from their inelastic checking account customers. On the other hand, the optimal interest spread between savings deposits and bonds depends on two elements. The first one is the elasticity of the funds in the savings account. The higher the elasticity of the funds in the savings deposit market, the higher the external competition banks face and, therefore, the smaller the optimal spread on savings. Additionally, banks internalize that a higher savings return attracts funds from their checking account into their savings. Thus, to prevent Unsophisticated households from parking their funds in savings deposits, banks would like to keep the return on savings low.

To validate the model, I show that the —untargeted— dynamics of the deposit rates to a shock that raises the nominal bond rate resembles the one observed in the data. In response to the shock, banks optimally keep the nominal return of checking at zero and only imperfectly pass through the changes in the bond return to savings deposit holders. The reason is that the higher bond return allows banks to increase the profits per dollar in the checking account, which provides extra incentives to keep the savings return low. However, if the bank does not lift its savings return, it triggers a migration of Investors' funds into the bond market. In equilibrium, banks balance those forces and choose to mimic only imperfectly the changes in the bond return with their savings rate.

To quantify the costs of higher trend inflation, I compare the model calibrated steady state with an alternative one with a higher inflation target. The high inflation steady state features a lower real return on checking accounts but a higher real return on savings deposits. The real bond rate, however, stays constant, meaning that the nominal return on bonds increases one-to-one with inflation. Somewhat surprisingly, the long-run movement in the savings interest rate is the opposite of the short-run: the nominal return on savings deposits increases more —and not less— than the bond rate in the new steady state. To understand this unexpected result and its consequences for welfare, we need to consider the effect of higher trend inflation on the wealth distribution and, hence, on banks' incentives.

In the new steady state with higher inflation, wealth shifts toward wealthy Investors inducing an increase in the savings deposits elasticity. Facing a more elastic market, banks optimally lower the savings spread. The reason for this wealth redistribution is that banks optimally continue to set their nominal return on checking at the zero lower bound which erodes Unsophisticated households' incentives to save. The long-run welfare costs are, therefore, concentrated in low-wealth Unsophisticated households that now find it harder to self-insure. The model delivers an average consumption equivalent loss of 0.11% for Unsophisticated households —61% of all potential losses— to an increase in the inflation target of 3pp.

I then use the model to explore the outcome of an unexpected temporary shock that increases future inflation. If the central bank follows a traditional Taylor rule, the real return on bonds rises to ameliorate the inflationary shock. However, this increase in real returns is not shared by all households since deposit rates only imperfectly reproduce bond movements. As a result, mid-wealth households end up exposed to negative real rates and optimally choose to reduce their asset holdings. The lower level of assets of these households expands the dispersion in their marginal utility after the shock, a sign of a decline in their self-insurance ability. I compare the calibrated economy with an alternative one in which all interest rates move uniformly. The counterfactual shows that the drop in precautionary saving capacity after the shock is driven by the heterogenous response in the interest rates.

Section 2 presents evidence on households' portfolios and deposit interest rates. Section 3 develops the model, explores the optimal rate setting by banks, and reveals the short-run dynamics of the model. Section 4 studies the cost and consequences of a rise in inflation in the long and short term. Section 5 presents additional results on monetary policy and inequality.

Related Literature

This paper contributes to several strands of the literature.

First, there is a long literature studying the welfare cost of inflation. The classical view studies inflation as a tax on a particular asset. This asset, generally assumed to be cash, provides non-pecuniary benefits to households. High inflation increases the cost of holding this asset. The work of Bailey (1956), Friedman (1969), Lucas (2000), and Lagos and Wright (2005) among many others lie within this group. Kurlat (2019) extends this literature using a model that includes a banking sector in order to quantify the cost of inflation by considering bank deposits as imperfect substitutes for cash. The business cycle literature, for example, Clarida, Gali, and Gertler (1999) or Woodford (2003), studies the cost of inflation arising from production misallocation. Finally, papers have argued that inflation surprises can be costly for lenders in presence of nominal contracts, like in the work of Doepke and Schneider (2006). Relative to this literature, in this paper I study an alternative channel for the cost of inflation. I focus on the role of inflation as a tax on precautionary saving through changes in real returns.

This paper, though, is not the first to claim that inflation impairs households' savings capacity. In a seminal work, İmrohoroğlu (1992) studies the welfare cost of inflation in an economy with imperfect insurance. A critical assumption in the paper is that cash is the only asset used for self-insurance and therefore inflation translates negatively one-to-one to the return on assets. This generates a welfare cost of inflation several times larger than the one studied previously in the transaction cost literature. Contrarily, Erosa and Ventura (2002) uses a model in which all agents have access to a second real asset —apart from cash— for precautionary saving and argues that the cost of inflation coming from distortions in the self-insurance capacity is minimum. My paper fills the gap between these two papers by arguing that a large share of households use only near cash assets (deposits) as their liquid savings device, and do not have access to more sophisticated instruments that preserve the real return in periods of high inflation.

Close to my evidence and modeling choices is Mulligan and Sala-i-Martin (2000) which documents similar household portfolio facts and uses the data to estimate the elasticity of the demand for money by exploiting a model with households' discrete choice decisions. The authors use the estimated elasticity to calculate the welfare cost of inflation. This paper complements their empirical work by extending the time horizon and including the returns that banks pay to deposit holders. Additionally, it embeds these channels in a general equilibrium environment with endogenous banking returns, which allows for conducting counterfactual exercises.

Additionally, a number of recent papers have studied the monetary policy implications of banks' market power on deposits. Beginning from the work of Drechsler, Savov, and Schnabl (2017) and followed by Polo (2021) and Wang (2020). These papers focus on how banks' market power on deposits shapes the transmission of monetary policy through bank lending. My contribution to this literature is to study the implications of a non-competitive banking sector on the household side, in particular, for inflation as a distortion to saving decisions.

More broadly, this paper is the first to combine the recent wave of heterogenous agents general equilibrium models in line with the work of Kaplan, Moll, and Violante (2018) and Auclert, Rognlie, and Straub (2018) with a model of non-competitive banking sector like Monti (1972) and Klein (1971). The presence of heterogeneous agents delivers a state-dependent elasticity that shapes the optimal deposit spreads to shocks. Additionally, I explore how monetary policy effectiveness is affected by the imperfect response of deposit rates. This last point provides a theoretical framework for the evidence documented in Drechsler, Savov, and Schnabl (2020).

Finally, this paper relates to the recent literature on the optimal design of monetary policy in models with heterogeneous agents (Bhandari, Evans, Golosov, and Sargent (2021), Dávila and Schaab (2022) and McKay and Wolf (2021)) by pointing to a channel through which inflation affects households' welfare —by reducing the ability to self-insure of deposit holders— generally not considered in these papers.

2 Data and Motivating Facts

In this section, I document facts that motivate my modeling choices and inform the quantitative analysis. The empirical section has two main parts. First, on the side of the households, I use the Survey of Consumer Finances (SCF) to document that historically most U.S. households have stored all their liquid assets in the form of bank deposits or cash. Then, using banks' Call Reports I show that banks have kept deposit rates historically low and insensitive to market returns.[1]

2.1 Bank-Dependent Households and Deposit Returns

I restrict my attention to documenting households' portfolios of liquid assets. I define *Liquid Assets* as the entire universe of financial assets in the SCF[2] excluding certificates of deposits, pension funds, life insurance, and other managed and miscellaneous assets. I focus on liquid assets because they have recently been recognized in the literature as the primary type of assets that households utilize to buffer consumption following income fluctuations.[3]

The data suggest that a major decision for households is whether to hold any liquid asset other than bank deposits. To illustrate this, I divide the data into two groups: those

[1]For details on the datasets, sample selection and computations see Appendix A.

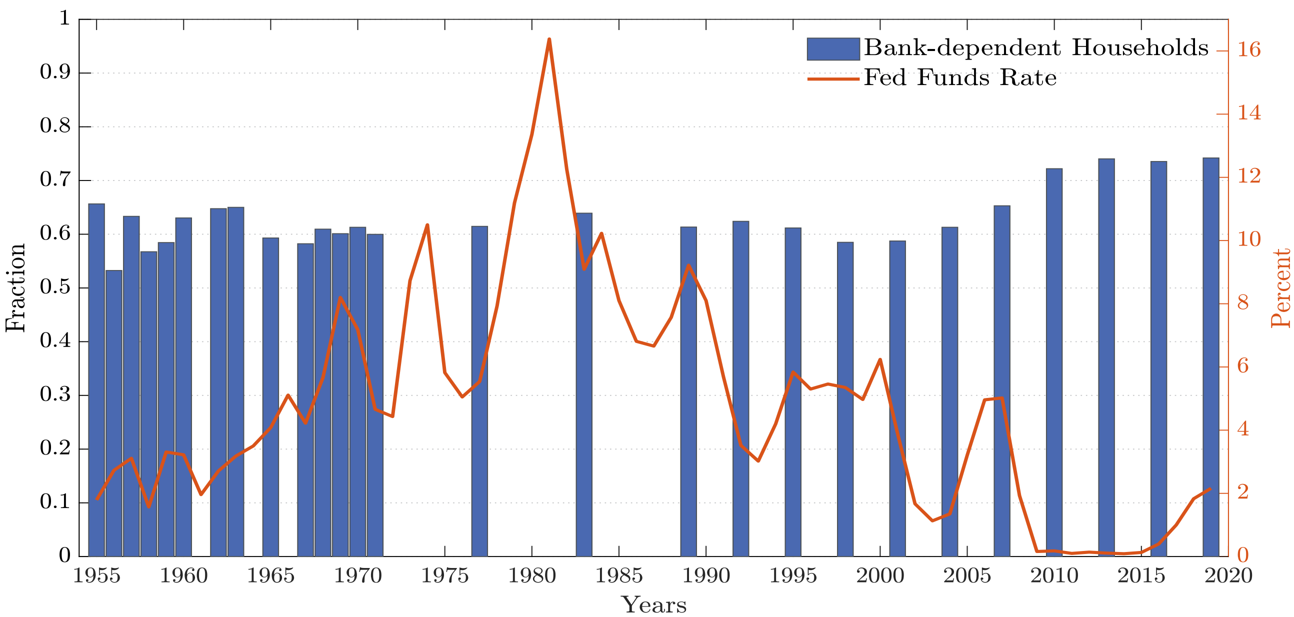
[2]Financial assets in the SCF includes all types of bank deposits and broker accounts, money market funds, prepaid credit cards, mutual funds, government and corporate bonds, and stocks.

[3]See for instance Kaplan and Violante (2014).

households with all of their liquid assets in the form of bank deposits and those with money invested in some market instrument. I refer to the first group of households as *Bank-Dependent*. In other words, a household is Bank-Dependent if all of its liquid assets are in the form of bank deposits.[4] The remainder of this section details the number of households in this category as well as their characteristics.

Figure 1 shows that historically around 60% of U.S. households hold all their liquid assets in the form of bank deposits. Surprisingly, despite significant fluctuations in market rates throughout U.S. history, this percentage has remained steady. That is, even when the interest rate on comparable assets is high, households do not appear to abandon the state of bank dependency.

Figure 1: Share of Bank-Dependent Households and Market Returns



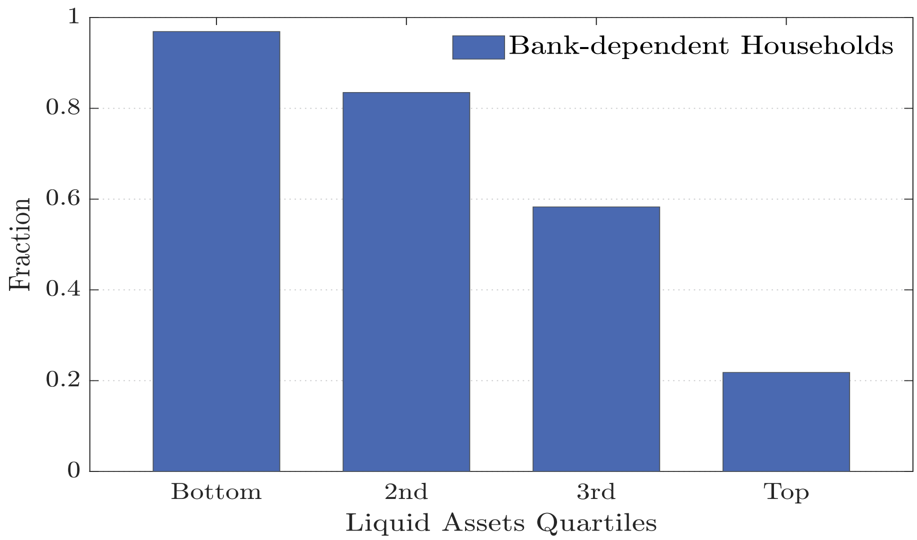
Note: Bank-Dependent households refers to households with all their liquid assets held in bank deposits or currency. The data comes from the Survey of Consumer Finances.

The opportunity cost of being Bank-Dependent depends on the level of household assets as well as the spread between deposits and market rates —i.e. the deposit spread. Figure 2 splits the 2007 population into liquid assets quartiles and calculates the share of Bank-Dependent

[4]Bank deposits include: checking, savings, and money market deposit accounts. Because they are cash holders and receive the same return as households with checking accounts, households that claim not to have a bank account are counted as Bank-Dependent.

households in each of them.[5] The figure shows that Bank-Dependent households are not poor households: 60% of households in the third quartile and 20% in the top quartile hold all their liquid assets in the form of bank deposits.

Figure 2: Distribution of Bank-Dependent Households in 2007



Note: Bank-Dependent households refers to households with all their liquid assets held in bank deposits. It also includes households that do not report having a bank account (cash holders). Data is from the SCF. Average liquid assets over income for households in the bottom quartile is less than one week, for those in the second approximately a month, in the third is four months, and in the top more than a year of household income.

The other component of the opportunity cost of being Bank-Dependent is the interest spreads on deposits. That is, holding deposits is costly only if the return on them is lower than the one on a market asset with similar characteristics. Figure 3 shows the time series for deposit interest rates for various forms of deposits —checking and savings accounts— together with a proxy for a safe return households can obtain on the market, the Fed funds rate.[6] The figure highlights two key points. First, there is a spread between the market return and deposit returns. Second, the spread is wider during times when the market nominal return is high.[7] In other words, holding deposits is costly, and is even more costly in periods of high

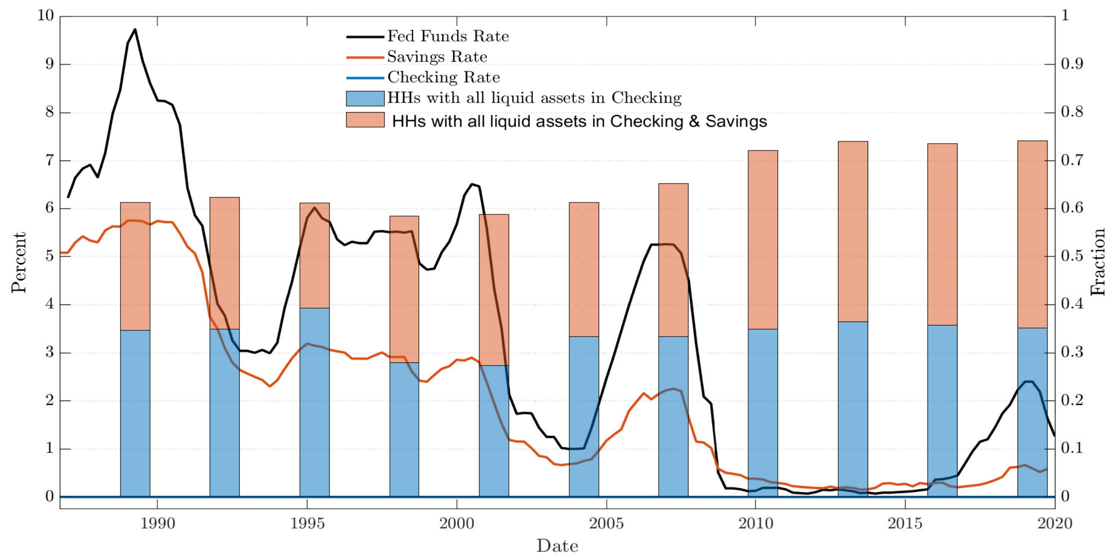
[5] This pattern is robust to the choice of the year.

[6] Some checking accounts do pay interest. However, the 2004 wave of the SIPP reveals that the share of Bank-Dependent households that hold interest-bearing checking accounts is small.

[7] This fact is not novel. Its implications for monetary policy have been studied in Drechsler, Savov, and

market returns. Figure 3 also divides Bank-Dependent households into those who hold all their assets in checking deposits —shown by blue bars— and those who have some savings deposits —in red bars. From the figure we see that around half of the Bank-Dependent households —30% of total households— hold all their assets in zero interest-bearing accounts.

Figure 3: Deposits and Market Returns, and Bank-Dependent Households Decomposition



Note: Savings return is computed as interest expenses over average holdings on savings deposits using Call Reports. The checking return is assumed to be zero for reasons explained in the text. Blue bars correspond to the share of Bank-Dependent households whose holdings are only in the form of checking deposits or currency. Red bars are those that also hold a positive ammount in savings deposits. Household data comes from the SCF.

To summarize, historically, deposits have been the sole source of liquid assets for approximately 60% of US households. Half of these households, or 30% of all households, maintain them in zero-interest accounts. These shares have remained stable even in periods when deposit spreads were very large. Finally, these households are not poor: one in every five households in the top liquid assets quartile is Bank-Dependent.

Additional Empirical Results

This section briefly mentions additional evidence on Bank-Dependent households and deposits. For details on calculations and figures refer to Appendix A.3 and Appendix A.4.

Schnabl (2017) among others

Figure 17 shows that Bank-Dependent households hold between 30% to 40% of total bank deposits, besides holding less than 10% of total liquid assets. Additionally, Figure 18 shows that they earn around 40-50% of total household income. Although the cross-sectional nature of the SCF does not allow computing the transition of households in and out of the Bank-Dependent state, using the SIPP survey I estimate a transition matrix between states. Table 8 shows that the Bank-Dependent state is indeed very persistent.

On the deposits side, Figure 21 shows that, besides the rigid extensive margin documented in Figure 1 and Table 8, deposits quantities are negatively correlated with market returns, and the magnitude of the correlation is large. Additionally, I show that the result on the imperfect passthrough from market to deposit rates in Figure 3 and on deposit fluctuations with market returns are not just a correlation but there is also suggestive evidence on causality from monetary policy to the variables studied. Figure 22 shows the result of an instrumented local projection on savings returns and Figure 23 on deposit quantities.

3 Model

Motivated by the empirical facts, in this section, I introduce a model of heterogeneous households that features segmented asset markets and an imperfect passthrough from market returns to multiple bank deposits. The model combines a tractable heterogeneous agent model with nominal rigidities[8] with models of non-competitive banking.[9] I show that the model can reproduce the empirical findings and use it to study the consequences of a temporal and permanent rise in inflation.

Time in the model is discrete and runs forever. Households in the model have perfect foresight about the future path of aggregate quantities and prices. I initiate the model in a calibrated steady state. Unexpected small deviations from the steady state will be interpreted as aggregate shocks. For the study of temporary shocks, I focus on linearized perfect-foresight transition sequences which, by certainty equivalence, deliver the same solutions as the

[8]For some references on this literature see for example Kaplan, Moll, and Violante (2018) and Auclert, Rognlie, and Straub (2018).

[9]For some references on this literature see Monti (1972), Klein (1971) and Drechsler, Savov, and Schnabl (2017)

analogous economy with aggregate risk, solved using conventional first-order perturbation techniques with respect to aggregate variables.

3.1 Households

The economy is populated by a unit mass of households. Each household periodically receives an idiosyncratic productivity shock that influences its labor income. Households have access to three different assets to smooth consumption: checking and savings deposits issued by banks, and bonds issued by the government. All assets are liquid, mature in one period, and are safe in real terms.[10] Assets differ only in their rate of return. In equilibrium, bonds have the highest rate of return, and checking deposits have the lowest. At the beginning of the period, households face a discrete choice decision in which they determine their asset choice to store their funds that period. That is, households will hold only one type of asset per period.[11]

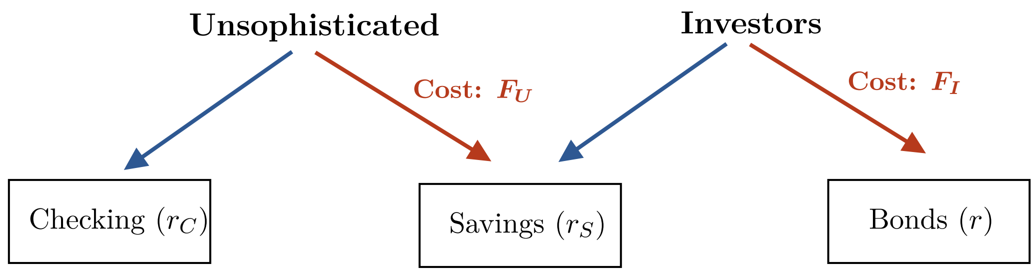
Households also periodically receive a random idiosyncratic fixed nonpecuniary trading cost that influences their ability to access high-return assets during that period. The economy is populated by two ex-ante heterogeneous groups of households: a share μ of *Unsophisticated* (U) households and $1 - \mu$ of *Investors* (I). Members of these groups differ in the distribution from which they draw their trading cost to access high-return assets.[12] In particular, I assume that Unsophisticated households can freely store funds in the checking account and need to exert a non-pecuniary cost F_U if they want to store their funds in the savings account. Unsophisticated households find it prohibitively costly to access the bond market. Conversely, Investors can store funds in savings accounts for free but can access the bond market only after exerting the cost F_I. Trading costs F_g for each group $g = \{\text{U,I}\}$ will be assumed to follow a logistic distribution with heterogeneous means but equal scale $F_g \sim \text{Logistic}\left(\mathcal{F}_g, \sigma_F\right)$. Figure 4 illustrates the households' discrete choice asset decision.

[10]Under perfect foresight, both the maturity length of the assets and the nominal vs real nature of the contracts are irrelevant in steady state and when studying long-run results. The reason is that absent aggregate uncertainty all returns are equalized. In the short run —when a shock hits— assuming one period real bonds helps the model to isolate from the effect of redistribution through inflation surprises on nominal contracts, and wealth redistribution through price changes of long-lived assets. Therefore, I can focus on exploring the short-term effects of inflation through changes in real deposit returns.

[11]This assumption, although extreme, isolates the role of assets solely as a saving instrument.

[12]Groups have identical income processes and preferences.

Figure 4: Households' Discrete Portfolio Choice



A household member of the group g starts the period with assets holdings a, a draw of the trading cost F_g, and idiosyncratic labor productivity s. Given that members of each group of households choose between two asset options —a low and a high return option— I describe the problem of a representative household of the group g. The households' problem can be divided into two subproblems. In the first stage, the household chooses between the high and the low return asset of its group. In the second, it decides how much to save and consume. Equation (1) describes the first stage.

$$V\left(s,a,F_g\right) = \max_{\left\{\mathbf{Low}_g,\mathbf{High}_g\right\}} \left\{\boldsymbol{v}_{\mathbf{Low}_g}\left(\boldsymbol{s},\boldsymbol{a}\right), \boldsymbol{v}_{\mathbf{High}_g}\left(\boldsymbol{s},\boldsymbol{a}\right) - \boldsymbol{F}_{\boldsymbol{g}}\right\} \tag{1}$$

In the second stage of the problem, conditional on their choice of asset, households determine their consumption and saving decisions. Equation (2) describes the second stage.

$$\nu_j\left(s,a\right) = \max_{\{c,a'\}} u\left(c\right) - v\left(n\right) + \beta\,\mathbb{E}_{F',s'}\left[V\left(s',a',F'\right)|s\right] \tag{2}$$

subject to,

$$c + \frac{a'}{(1+r_j)} = a + (1-\tau)\cdot w\cdot n\cdot s$$
$$a' \geq 0$$
$$\log s' = \rho_s \log s + \sigma_s u'$$

where c is household consumption that provides a flow utility $u(c)$, a' the savings decision, n the amount of hours worked that provide disutility $v\left(n\right)$. The household receives a wage w

per effective hour $s \cdot n$ that is taxed linearly by the government at the rate τ. Households face a no-borrowing constraint and the labor productivity follows a simple AR(1) process normalized such that $\mathbb{E}(s) = 1$. Households are not able to choose working hours due to frictions in the labor market I will explain later. Finally, notice that the only difference that choosing the low or high branches in equation (1) for the second stage (2) is on the saving return for that period r_j.

Optimal decisions of group g households are policy functions for consumption and saving $\{c_j^g(s,a), a_j'^g(s,a)\}$. These decisions depend on the level of labor productivity s, initial assets a, and the choice of the asset for that period j. The asset choice j can be either checking $\mathcal{C}$, savings $\mathcal{S}$, or directly held bonds B. Additionally, the households' problem delivers the share of households in the group g with states (s,a) choosing each type of asset j: $P_j^g(s,a)$. Appendix B.1 describes the households' optimal conditions in detail, its aggregation together with details on computation.

Given a distribution of households across the idiosyncratic states $\{\Psi^U(s,a), \Psi^I(s,a)\}$ the aggregate demand for checking and savings deposits are:

$$\mathcal{C} = \mu \cdot \int_{(s,a)} \left[P_{\mathcal{C}}^U(s,a) \frac{a_{\mathcal{C}}'^U(s,a)}{1+r_{\mathcal{C}}} \right] d\Psi^U(s,a) \tag{3}$$

$$\mathcal{S} = \mu \cdot \int_{(s,a)} \left[P_{\mathcal{S}}^U(s,a) \frac{a_{\mathcal{S}}'^U(s,a)}{1+r_{\mathcal{S}}} \right] d\Psi^U(s,a) + (1-\mu) \cdot \int_{(s,a)} \left[P_{\mathcal{S}}^I(s,a) \frac{a_{\mathcal{S}}'^I(s,a)}{1+r_{\mathcal{S}}} \right] d\Psi^I(s,a) \tag{4}$$

3.2 Commercial Banks

The financial sector in the model is composed of a measure one of small commercial banks. Each bank monopolizes the deposit issuance to a small random sample of the population independently drawn each period. It is assumed that households cannot switch the bank they were allocated to during that period.[13] Banks internalize their influence on the consumption-saving decision of their customers, but individual banks are too small to affect aggregates and prices. Banks issue two types of deposits to households that differ only on their rate of

[13]This is equivalent to assuming that banks operate in small islands —where consumption-saving decisions are taken— inhabited by a new random sample of the population each period.

return: checking accounts with a return r_C and savings accounts with a return r_S. Banks cannot raise equity and invest deposit funds in government bonds at a rate r.

Banks choose the return on their accounts subject to a zero lower bound on nominal rates.[14] They face a demand for checking $\mathcal{C}(r_C, r_S)$ and for savings $\mathcal{S}(r_C, r_S)$ from households that depend on the savings return only in the current period.[15] The problem of the bank is then to choose $\{r_C, r_S\}$ to maximize next period real profits π'_B:

$$\pi'_B = \max_{\{r_C, r_S\}} \ \mathcal{C}\left(r_C, r_S\right) \cdot \left(r - r_C\right) + \mathcal{S}\left(r_C, r_S\right) \cdot \left(r - r_S\right) \tag{5}$$

subject to,

$$r_C, r_S \geq -\frac{\pi'}{1 + \pi'}$$

Nominal returns are defined as usual $1 + i_j = (1 + \pi')(1 + r_j)$ where π' is next period price inflation $1 + \pi' \equiv \frac{P'}{P}$ with P the price level of the final good. Therefore, the real return on checking accounts is $r_C = -\frac{\pi'}{1+\pi'}$. Bank profits are taxed away by the government.

3.3 Supply Side

Production is done in two layers: intermediate monopolistic competitive unions demand task-specific labor from households and sell it to a competitive labor packer that aggregates them into final labor units. Then, the labor packer sells final labor hours to a competitive final good producer for the production of the consumption good. Given that this block is relatively standard, I only briefly discuss the key equations and relegate a detailed discussion to Appendix B.4.

[14] Cash is thought of as a latent competitor that is a perfect substitute with bank deposits. If nominal rates on deposits go below zero, households will switch all their funds to cash.

[15] Key here is the assumption that a new small random sample of households is drawn each period. If this were not the case, then banks' problem would become one of a dynamic monopoly and the demand for savings would depend not only on the current but also on future deposit returns.

Final Good Producer

A competitive final good producer hires final labor hours N from the labor packer and produces a final consumption good Y using a linear technology:

$$Y = N \tag{6}$$

Perfect competition ensures that nominal wage W equals the final good price P —and wage inflation equals price inflation $\pi = \pi_w$—, the real wage is constant and equal to one $w = 1$, and there are no profits on the production side.

Labor Unions

There is a continuum of monopolistic competitive unions $k \in [0, 1]$ that demand task-specific labor k from each household and aggregates it into effective hours $n_k = \int_i s_i n_{ik} \mathrm{di}$. Each union sells its task-specific labor to a competitive labor packer that packages these tasks into final labor hours using a constant elasticity of substitution function with elasticity ε_w. I will later interpret shocks to this elasticity, which influences the desired markup by the unions, more broadly as a supply shock. Unions satisfy labor demand by rationing labor equally across all households.

Unions need to pay a Rotemberg-type cost to adjust their task-specific nominal wages. I assume that there is perfect wage indexation to the inflation target so that the adjustment cost is paid only when wage changes deviate from trend inflation. Adjustment costs enter households' disutility of labor. It is assumed that when setting the wage unions evaluate the benefits of higher after-tax income using the marginal utility of average consumption. In the short run, this gives rise to a wage Phillips curve, which linearized around the inflation target is:

$$\widehat{\pi}_w = \kappa^w \left(\varphi \widehat{N} + \sigma \widehat{C}\right) + \beta \widehat{\pi}_w' + \frac{\kappa^w}{\varepsilon_w} \widehat{\varepsilon}_w \tag{7}$$

where $\widehat{\pi}_w$ is wage inflation deviations from trend, $\kappa^w \equiv \frac{\varepsilon_w n v'(n)}{\psi}$, $\varphi \equiv \frac{v''(n)n}{v'(n)}$, $\sigma \equiv \frac{u''(c)c}{u'(c)}$, $(\widehat{C}, \widehat{N})$ represent log deviations of aggregate consumption, and labor from the steady state and ψ

the Rotemberg adjustment parameter. In a steady state, labor supply is determined by

$$v'(N) = \frac{\varepsilon_w - 1}{\varepsilon_w} (1-\tau)\, w\, u'(C) \tag{8}$$

3.4 Government

The government issues bonds B_G, chooses their nominal return i, collects labor taxes T and bank profits π_B, and set the level of trend inflation $\overline{\pi}$. Government budget constraint is,

$$B_G = T + \frac{B'_G}{1+r} + \pi^B \tag{9}$$

where tax revenue comes from taxing labor income at rate τ over all households i:

$$T = \int_i \tau \cdot w \cdot s_i \cdot n \ \text{di} = \tau Y$$

where the last equality follows from the unions' assumption. Monetary policy will follow a Taylor rule in case inflation deviates from its trend:

$$(1+i) = (1+\bar{i}) \cdot \left(\frac{1+\pi}{1+\overline{\pi}}\right)^{\phi_\pi} \cdot \epsilon_i \tag{10}$$

where ϵ^i is a shock to the Taylor rule and $\bar{i}$ is the steady state value of the nominal bond rate. Fiscal policy is assumed to follow a smoothing rule in case of short-run deviations from the steady state:

$$T' = \phi_T \left(\frac{B'_G}{1+r} - \frac{\overline{B}_G}{1+\overline{r}}\right)$$

where $\overline{r}$ and $\overline{B}_G$ are steady state values. When I later compare different steady states, I will assume that in case tax revenues or bank profits change, the level of debt B_G will adjust to clear the budget (9).

Note that all the assets in the model, including government bonds, are assumed to be safe in real terms. This implies that even if inflation surprises expectations, the real return on the contracts is preserved.[16]

[16] This is only relevant in the period when an unexpected shock arrives. One way to understand the

3.5 Equilibrium

A perfect foresight equilibrium in this economy is a collection of paths for exogenous shocks $\{\widehat{\varepsilon}_{wt}, \varepsilon_{it}\}_{t=0}^{\infty}$, government policies $\{\tau_t, i_t, \overline{\pi}_t, B_t^G\}_{t=0}^{\infty}$, aggregate variables $\{C_t, Y_t, N_t, \mathcal{C}_t, \mathcal{S}_t, B_t, w_t, r_t, r_{St}, r_{Ct}, \pi_t, \pi_t^w, \pi_t^B\}_{t=0}^{\infty}$ and a distribution over individual states for each group of households $\{\Psi_t^U(s_t, a_{t-1}), \Psi_t^I(s_t, a_{t-1})\}_{t=0}^{\infty}$ such that:

1. The path of aggregate consumption $\{C_t\}_{t=0}^{\infty}$ and savings $\{\mathcal{C}_t, \mathcal{S}_t, B_t\}_{t=0}^{\infty}$ is consistent with the aggregated optimal households policy described in Section 3.1.

2. Real wage $\{w_t\}_{t=0}^{\infty}$ is consistent with final good firms problem in Section 3.3 and nominal wage is consistent with unions problem in Section 3.3. Aggregate production and labor $\{Y_t, N_t\}_{t=0}^{\infty}$ is consistent with the production function equation (6).

3. The paths for price and wage inflation, the output gap, and the markup shock $\{\pi_t, \pi_t^w, \widehat{\varepsilon}_{wt}\}_{t=0}^{\infty}$ are consistent with the Phillips curve in equation (7).

4. The paths for checkings and savings returns, and bank profits $\{r_{St}, r_{Ct}, \pi_t^B\}_{t=0}^{\infty}$ are consistent with banks' decisions of section Section 3.2.

5. Government debt and taxes $\{\tau_t, B_t^G\}_{t=0}^{\infty}$ are consistent with the budget equation (9). The nominal rate on bonds and the inflation target $\{i_t, \overline{\pi}_t\}_{t=0}^{\infty}$ follows the government choices.

6. The path for households' distributions over the idiosyncratic income state and wealth for each group $\{\Psi_t^U(s_t, a_{t-1}), \Psi_t^I(s_t, a_{t-1})\}_{t=0}^{\infty}$ is consistent with households' optimal policy.

7. Goods and assets markets clear:

$$C_t = Y_t$$
$$\mathcal{C}_t + \mathcal{S}_t + B_t = \frac{B_t^G}{1 + r_t}$$

dynamics in the period of the shock is to think that even if the government promised a nominal return of i when future expected inflation was π, it is anyway willing to compensate for any surprise in inflation.

3.6 Equilibrium Deposit Rates and Aggregate Elasticities

This section describes the optimal interest rate setting by banks. Banks' response to inflation will be key to understanding its impact on households' saving incentives. The section beings by describing how the aggregate deposit elasticities and the multi-product nature of the banks influence banks' choices. Then, the section illustrates the role of the wealth distribution in shaping aggregate elasticities.

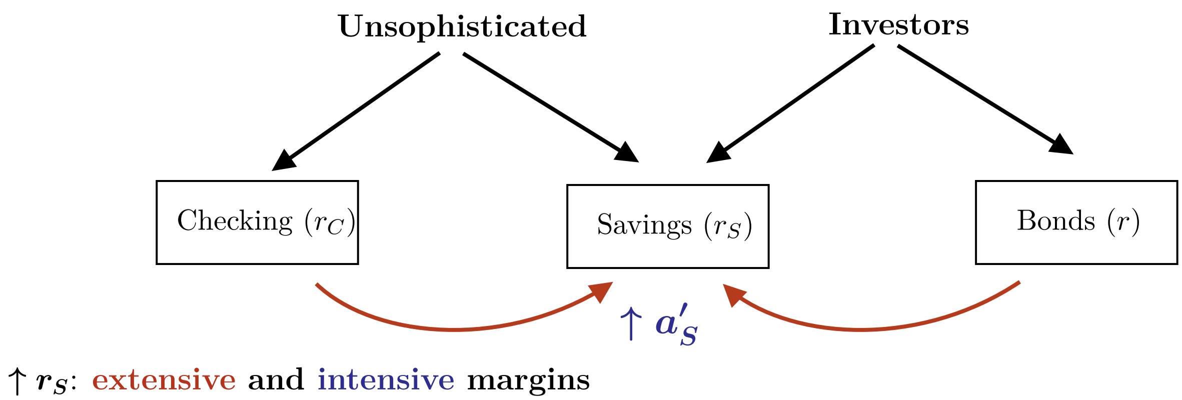
Optimal Deposit Rates

To understand the optimal rate setting by banks, we first need to recognize the channels through which changes in deposit interest rates affect aggregate deposit demands (equations (3) and (4)). As an illustrative example, consider the case of an increase in the savings return r_S, holding everything else constant. Figure 5 shows households' two margins of adjustment after the increase in r_S. In the first place, households that demand savings deposits now find it more attractive to postpone consumption and increase savings demand ($\uparrow a'_S$), an increase in the intensive margin. Secondly, the increase in the savings returns incentivizes households to switch their asset choice into savings deposits ($\uparrow P_S$).[17] The migration of households into the savings deposits occurs from both groups: marginal Unsophisticated households abandon checking and park their funds into savings deposits chasing the more attractive return, and also those Investors at the margin decide to stop exerting the cost and use savings deposits are their saving vehicle.

When setting the interest rates on deposits, monopolistic banks internalize households' responses to changes in returns. The first-order necessary conditions of the bank characterize the optimal rates setting:

[17] Both effects can revert if the household is very wealthy due to the income effect dominating the substitution. This happens, however, at the very top of the wealth distribution for households with a negligible measure in the calibrated economy.

Figure 5: Households' Response to an Increase in r_S



Note: The figure illustrates the two margins of adjustment after an increase in the return on savings r_S. The intensive margin refers to changes in a'_S and the extensive margins to changes in P_S in equation (4).

$$[r_C]: \quad \frac{\partial \mathcal{C}(r_C, r_S)}{\partial r_C} \cdot (r - r_C) \;\leq\; \mathcal{C}(r_C, r_S) - \frac{\partial \mathcal{S}(r_C, r_S)}{\partial r_C} \cdot (r - r_S) \tag{11}$$

$$[r_S]: \quad \underbrace{\frac{\partial \mathcal{S}(r_C, r_S)}{\partial r_S} \cdot (r - r_S)}_{\text{MB}} \;\leq\; \underbrace{\mathcal{S}(r_C, r_S) - \frac{\partial \mathcal{C}(r_C, r_S)}{\partial r_S} \cdot (r - r_C)}_{\text{MC}} \tag{12}$$

The left hand side of equations (11) and (12) represent the marginal benefit of increasing the rate on checking and savings deposits respectively, and the right hand side the marginal cost. Focus on the case of savings deposits in equation (12). For each extra marginal point in the savings rate, the bank is able to attract an additional $\frac{\partial \mathcal{S}(r_C, r_S)}{\partial r_S}$ funds to the savings account and profit $(r - r_S)$ from each of them. The marginal cost of increasing the rate on savings has two components. The first one is the standard component of a monopolistic firm: for each extra point increase in the savings return, the monopolistic bank has to pay it on all existing funds $\mathcal{S}(r_C, r_S)$. The second one comes from the fact that the bank is a multi-product firm that offers substitute products. When the bank increases the rate of savings it attracts funds from its own checking account into savings, cannibalizing its profits from the checking account. In other words, given that $\frac{\partial \mathcal{C}(r_C, r_S)}{\partial r_S} < 0$, for each point increase in the savings rate, the bank suffers an outflow from the checking deposits of $\frac{\partial \mathcal{C}(r_C, r_S)}{\partial r_S}$ causing a fall in profits of $\frac{\partial \mathcal{C}(r_C, r_S)}{\partial r_S} \cdot (r - r_C)$.

Optimal conditions of the bank —equations (11) and (12) — do not need to hold with equality due to the lower bound on nominal interest rates. Banks might want to reduce their returns to increase profits but the presence of cash as an outside option poses a hard lower bound. Throughout the paper, I focus on the equilibrium in which the bank chooses the return on checking at the lower bound $r_C = -\frac{\pi'}{(1+\pi')}$ and equation (11) holds with strict inequality. This result arises as an optimal decision for the banks if funds in the checking account are sufficiently inelastic, i.e. $\left|\frac{\partial \mathcal{C}}{\partial r_C} \frac{1}{\mathcal{C}}\right|$ is low, and banks would like to increase the spread $(r - r_C)$ but hit the lower bound first. Additionally, as long as the funds in the checking account remain sufficiently inelastic after a shock or in alternative steady states, banks will keep the return on checking at the lower bound.

As in the data, the model's optimal rate on savings deposits is not constrained by the zero lower bound. To understand the forces behind the savings spread, call $\varepsilon^{\mathcal{S}} \equiv \left|\frac{\partial \mathcal{S}(r_C, r_S)}{\partial r_S} \frac{1}{\mathcal{S}}\right|$ the semi-elasticity of savings deposits and $\varepsilon^{\mathcal{C}} \equiv \left|\frac{\partial \mathcal{C}(r_C, r_S)}{\partial r_S} \frac{1}{\mathcal{C}}\right|$ the cross semi-elasticity of checking deposits with respect to the return on savings. I can write the optimal rate on savings using equation (12) as:

$$r_S = \underbrace{r}_{\text{Competitive}} - \overbrace{\frac{1}{\varepsilon^{\mathcal{S}}}}^{\text{Monopoly}} - \underbrace{\frac{\varepsilon^{\mathcal{C}}}{\varepsilon^{\mathcal{S}}} \cdot \frac{\mathcal{C} \cdot (r - r_C)}{\mathcal{S}}}_{\text{Multi-product}} \tag{13}$$

Equation (13) decomposes the optimal interest rate on savings in three elements. The first one, r, is the interest rate that would be paid in savings deposits if the banking sector were competitive. The remaining two components, explain the sources of the markdown on r. The first one is the classical inverse elasticity of a monopoly $\frac{1}{\varepsilon^{\mathcal{S}}}$. The more inelastic the savings market is, i.e. $\varepsilon^{\mathcal{S}}$ close to zero, the higher markdown on r that the monopoly will want to charge. The second component comes from the multi-product nature of the bank. The bank internalizes that if the funds in the checking deposits are very elastic, i.e. $\varepsilon^{\mathcal{C}}$ is large, then even small movements in r_S will cause large fluctuations of funds from checking to savings. Therefore, if the bank is making large profits with the checking funds —$\mathcal{C} \cdot (r - r_C)$ is sizable— then it is in its best interest to keep r_S low and retain Unsophisticated households' funds in the checking account.

Overall there are three key components shaping the optimal rate on savings deposits: the semi-elasticity of savings funds and checking funds with respect to the savings return $(\varepsilon^{\mathcal{S}}, \varepsilon^{\mathcal{C}})$ and the importance of checking in bank profits $(\mathcal{C} \cdot (r - r_C))$. In order to understand the optimal banks' response to shocks, we first need to dive into what shapes aggregate elasticities.

Aggregate Elasticities

Elasticities of aggregate demand of deposits play a key role in shaping the response of deposit interest rates to shocks and in counterfactual steady states. In the model, these elasticities are the result of aggregating individual households' responses. Call $\varepsilon^{\mathcal{D}}$ to the semi-elasticity of checking or savings deposits funds $\mathcal{D} = \{\mathcal{C}, \mathcal{S}\}$ with respect to the savings return.[18] I can decompose these elasticities into the weighted average of individual elasticities

$$\varepsilon^{\mathcal{D}} \equiv \frac{\partial \mathcal{D}_j / \partial r_S}{\mathcal{D}} = \int_{(s,a)} \boldsymbol{\varepsilon^{\mathcal{D}}(s,a)} \cdot \boldsymbol{\omega_{\mathcal{D}}(s,a)} \tag{14}$$

where $\varepsilon^{\mathcal{D}}(s,a)$ represents the semi-elasticity of the funds in asset $\mathcal{D}$ controlled by households with states (s,a) and $\omega(s,a)$ the relative importance of those households demand in the aggregate demand of asset $\mathcal{D}$.[19] Individual elasticities, $\varepsilon^{\mathcal{D}}(s,a)$, depend on the household state variables. Figure 6 illustrates the relationship between the two components of equation (14) and households wealth for the case of savings deposits $\varepsilon^{\mathcal{S}}$.[20]

As shown in the blue line of Figure 6, funds controlled by wealthier households are more elastic to interest rate movements.[21] Figure 25 in the appendix shows that this pattern is driven by the extensive margin increasing sensitivity with wealth. That is, the share of households that switch in and out of the savings deposits market after movements in the interest rate r_S is increasing in wealth. Intuitively, the opportunity cost for households of

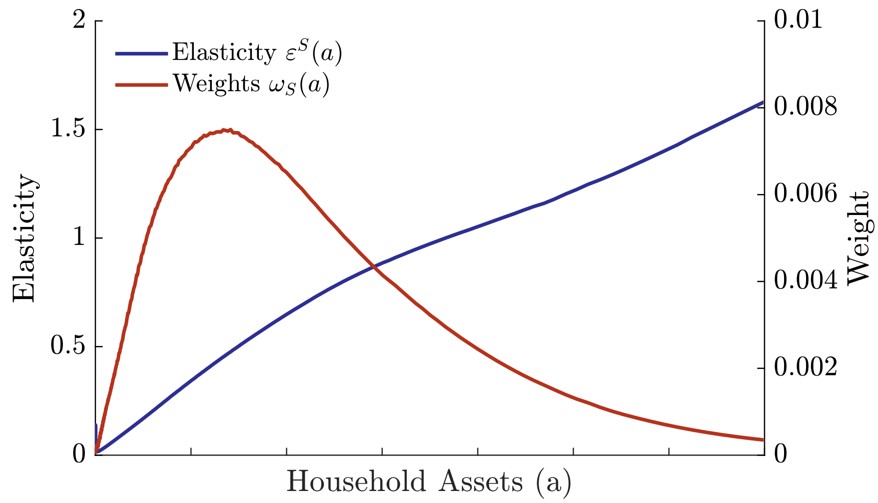
[18] The focus on the savings return only is because the return on checking will be optimally held fixed by banks.

[19] Appendix B.1.5 derives and defines the objects of equation (14).

[20] Similar qualitative results for checking are shown in Appendix B.1.5

[21] The relationship is monotonic for the most relevant part of the wealth distribution. See Appendix B.1.5 for details.

Figure 6: Decomposition of Aggregate Semi-Elasticity of Savings Deposits



Note: Figure shows the two components of aggregate savings deposits elasticity from equation (14). The semi-elasticity represents the log response of savings funds to a 1pp annualized change in the return on savings.

choosing the low return asset $(\nu_{\text{High}}(s,a) - \nu_{\text{Low}}(s,a))$ is increasing in wealth, and movements in interest rate generate larger movements in utility for richer households. Given that the trading cost F is fixed, a larger mass of wealthier relative to poorer households fluctuates as r_S moves.[22] The importance of the intensive margin in the elasticity, however, vanishes when funds are controlled by wealthier households.

What determines the aggregate elasticity is, however, the weighted average of individual elasticities. The red dashed line in Figure 6 reproduces this weight for the case of the savings deposits. Importantly, the distribution of deposit holdings will be a key object influencing the response of the aggregate elasticity after a shock or in alternative steady states, and consequently the equilibrium interest rates.

3.7 Calibration

The objective of the calibration is to accurately capture the wealth distribution and the opportunity cost of Bank-Dependent households. Achieving those objectives with precision

[22] Appendix B.1.5 shows conditions under which the elasticities are increasing for both groups of households and under different assumptions on the distribution of trading costs.

will be key for an accurate prediction of the cost of high inflation for deposit holders.

The model is quarterly. For all possible parameters that have a standard value in the literature or can be mapped directly to the data, I do so. The remaining parameters are chosen to match informative steady state moments. Table 1 shows the calibrated parameters.

Table 1: Parameter Selection

Assigned			**Calibrated**		
σ	1	CRRA coefficient	$\mathcal{F}_U$	Mean trading cost (Unsophisticated)	0.06
φ	2	Inverse Frisch elasticity	$\mathcal{F}_I$	Mean trading cost (Investors)	0.01
ρ_s	0.975	Persistence of log income	σ_F	Scale trading cost	0.04
σ_s	0.155	S.d. of log income innovations	μ	Share of Unsophisticated	0.4
B^G/Y	1.3	Assets/GDP	β	Discount factor	0.988
$\overline{\pi}$	0.03	Trend inflation			
κ	0.05	Slope of Philips curve			
ϕ_T	0.1	Tax smoothing			
ϕ_π	1.5	Taylor coefficient			

I assume log preferences for consumption $u(c) = \log(c)$ and a disutility of labor of $v(n) = n^{(1+\varphi)}/(1+\varphi)$ with a Frisch elasticity equals 0.5. For the income process, I use the persistence estimated in Floden and Lindé (2001) and convert it to quarterly values. For the standard deviation of the innovations, σ_s, the value targets the cross-sectional standard deviation of pre-tax log income of 0.7.[23] To capture the non-linear taxation system in the U.S. I scale down the variance of the innovation by $(1 - 0.181)^2$ where 0.181 is the value used in Heathcote, Storesletten, and Violante (2017).[24] For the level of liquid assets over output, B_G/Y, I match the sum of liquid assets in the SCF -as defined in Section 2- and divide it by total income in the same survey for the year 2007, which delivers a value of 1.3. The slope of the Phillips curve κ is chosen to be 0.05, a common value in the New Keynesian literature. The tax smoothing parameter ϕ_T is set to 0.1 following Auclert, Rognlie, and Straub (2020).

The rest of the calibration choices play a direct role in determining the opportunity cost

[23]The parametrization of the income process is in the neighborhood of one used in the earlier literature of heterogeneous agent models. See for example the parametrization in McKay, Nakamura, and Steinsson (2016) and Guerrieri and Lorenzoni (2017).

[24]This is also done in Auclert, Rognlie, and Straub (2020) among others.

of holdings deposits over market bonds. I pick the real rate on bonds to be $r = 3\%$ in annual terms and trend inflation to be $\overline{\pi} = 3\%$. These numbers approximate the values prior to the Great Recession. The optimal rate setting by banks under this calibration delivers a nominal checking return at the lower bound, which gives a real return on checking of $r_C = -3\%$. The parameters governing trading costs, the share of Unsophisticated households and the discount factor are chosen to match the moments shown in Table 2. The spread on savings deposits is chosen to be $r - r_S = 3\%$, which implies a null return on savings in real terms $r_S = 0\%$. Also, I target the fraction of households that keep all their funds in the bank in 2007, 65%, and the share that keeps all in checking accounts, 33%. Finally, the dispersion of the trading cost, σ_F, plays a key role in matching the joint distribution of wealth and asset choice.[25] In particular, I target the share of households in the top assets quartile that keep all their assets in bank deposits, 22%.

Table 2: Moments Used in Calibration

	Data	**Model**
Bank-Dependent households	65%	64%
Households with all assets in checking	32%	32%
Top quartile Bank-Dependent households	22%	24%
Spread on savings $(r - r_S)$	3%	3%
Interest rate on bonds	3%	3%

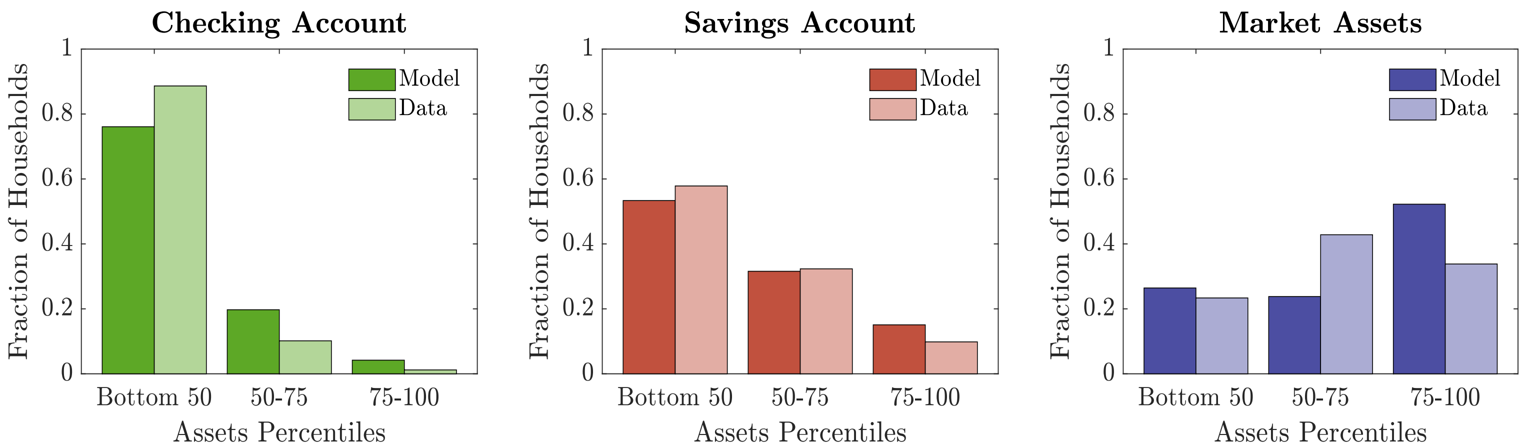
Note: Bank-Dependent households refers to the fraction of households with all their assets in deposits (checking and savings). Top quartile Bank-Dependent households is the share of the households in the top quartile that are Bank-Dependent.

The model does a good job at matching the targeted moments. Additionally, and besides its simplicity and few parameters, the model does a decent job at matching the wealth distribution conditional on asset choice. Figure 7 compares the model with the data. The figure splits households by their asset choice and shows for each of the assets the share of households in the bottom 50%, in percentile 50th to 75th, and the top 25% of the wealth

[25]The model mechanism to generate wealthy households choosing the low return account is by allowing for large trading costs via a disperse Logistic distribution.

distribution. The model reproduces the key data patterns well: low-wealth households keep their funds in checking accounts, mid-wealth in savings, and wealthy households are investors.

Figure 7: Wealth Distribution Conditional on Asset Choice



Note: In the model, Checking and Savings Accounts and Market Assets panels show the share of households that choose checking, savings, or government bonds respectively as their saving device. In the data, the Checking Account panel indicates the share of households that keep all their liquid assets in checking; the Savings Accounts panel points to the share of households that have a positive amount in savings but do not hold market assets; finally, the Market Assets panel accounts for the fraction of households that are not Bank-Dependent.

Appendix B.2 shows additional model results and compares them to the data. In particular, results on the wealth distribution, the persistence of the Bank-Dependent state, marginal propensity to consume, and the size of the banking sector are explored.

3.8 Model Dynamics

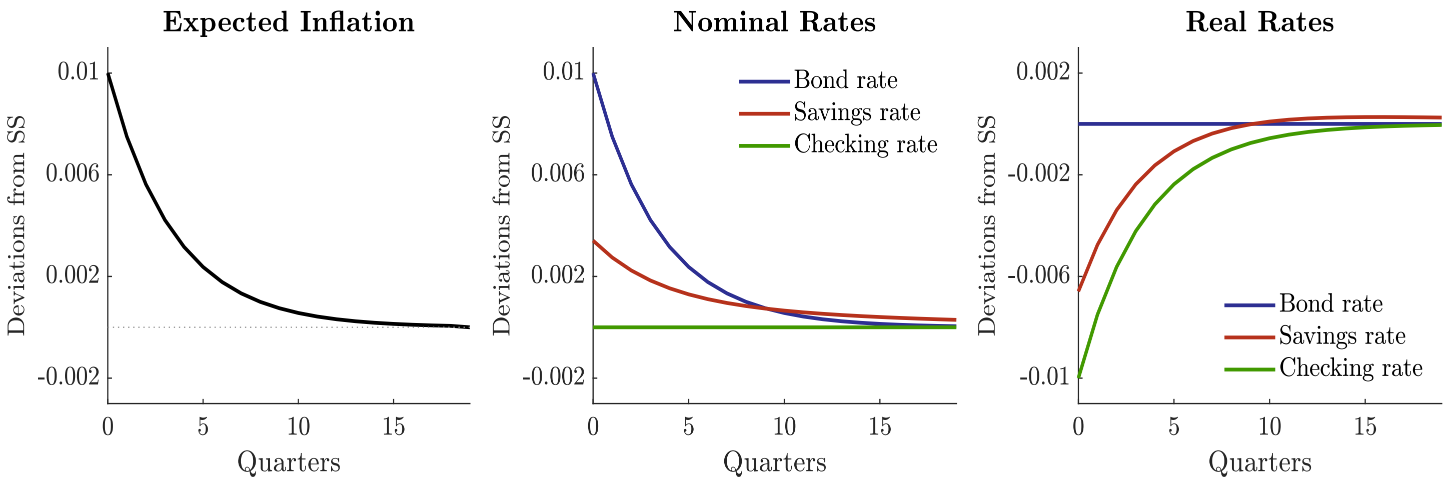
This section studies the response of the model to a temporal shock that raises future inflation. It begins by showing that the model dynamics of the interest rates and household portfolios resemble the ones documented in the data. Then, it explores the mechanism through which the model achieves its goal.

To keep the environment simple, I focus on a persistent positive markup shock[26], i.e. an increase in $\widehat{\varepsilon}_w$ in equation (7), under the assumption that the central bank keeps the real rate on bonds fixed. Figure 8 reproduces the dynamics of expected inflation, nominal and

[26]Similar results for a monetary shock can be found in Appendix B.1.6.

real interest rates after the shock.

Figure 8: Response to a Supply Shock



Note: The figure shows the response of expected inflation, nominal and real rates after a shock to the Phillips curve (7) with persistence assuming the central bank keeps the real return constant.

The left panel of Figure 8 reproduces the path of expected inflation, which is pushed up by the shock on desired markups by unions. In response to this shock, the central bank is assumed to lift the nominal rate on bonds —as shown in the blue line of the central panel— to keep their real return constant, as the right panel reproduces. Thus, the reaction of the central bank isolates bondholders' asset returns from future inflation.[27] The opposite is true for checking account holders, whose nominal return is held at zero by banks, and expected inflation translates negatively one-to-one into their real return on assets. Figure 8 also shows that banks' optimal decision is to only imperfectly pass through the movements in the bond rate to their savings account customers, a decision that also pushes the real return on savings to negative territory. To understand this last point, we need to recognize how the shock changes banks' optimal savings spread decisions in equation (13), which I rewrite here for convenience:

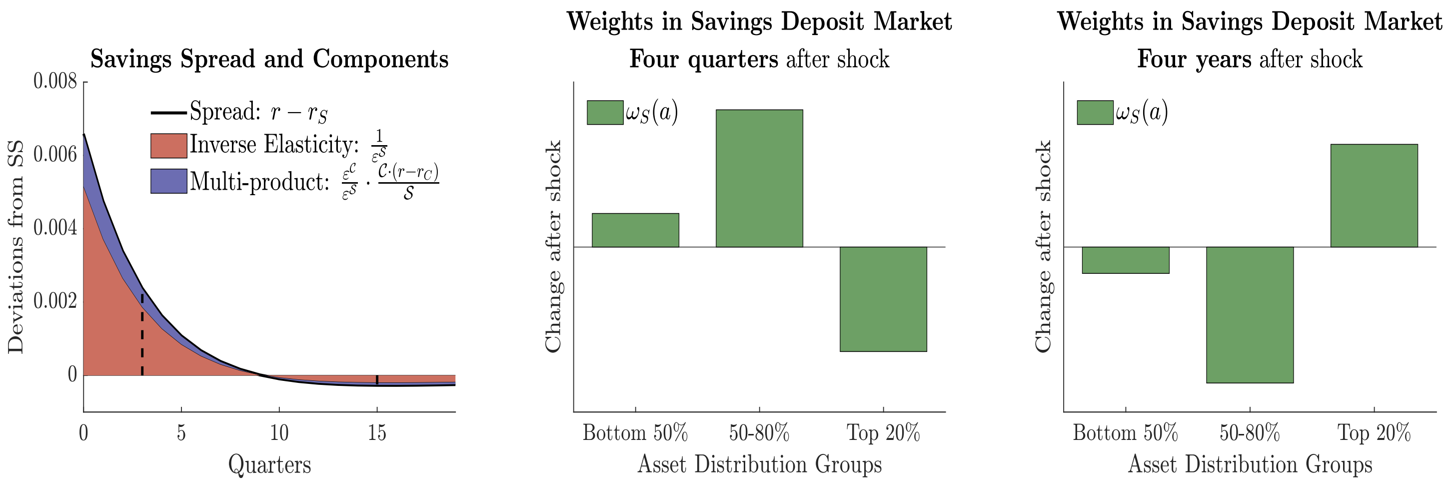
$$r - r_S = \frac{1}{\varepsilon^{\mathcal{S}}} + \frac{\varepsilon^{\mathcal{C}}}{\varepsilon^{\mathcal{S}}} \cdot \frac{\mathcal{C} \cdot (r - r_C)}{\mathcal{S}} \tag{15}$$

The shock increases the spread between bonds and checking account $(r - r_C)$. This gives banks additional incentives to keep Unsophisticated households' funds in the checking account

[27]Remember that asset contracts are real and mature in one period. Therefore, the surprise inflation at period zero does not affect realized returns.

and prevent their migration into savings deposits. To discourage such migration, the bank does not lift the nominal return on savings one-to-one with the bond return and optimally chooses to increase the spread between bonds and savings deposits $(r - r_{\mathcal{S}})$. But this increase in the spread triggers a migration of wealthy investors into the bond market lowering the aggregate elasticity of savings $\varepsilon^{\mathcal{S}}$. The new equilibrium spread is shaped by these two forces. Figure 9 decompose the contributions of the two terms on the right-hand side of equation (15).

Figure 9: Decomposing the Increase in Spreads



Note: Figure decompose the contributions of the interest elasticity of savings funds and the profits in the checking account in the increase in the spread after the shock.

The black line in the left panel of Figure 9 shows the evolution of the spread between the bond market and the savings market $(r - r_{\mathcal{S}})$ —i.e. the distance between the blue line and the red line in Figure 8. The shaded area below it decomposes the contributions between the two terms in the right-hand side of the equation (15). The red area illustrates that the equilibrium spread is mainly shaped by movements in the aggregate elasticity of savings deposits. This elasticity changes along the transition because the bank is optimally choosing to let wealthy elastic households migrate to the bond market in order to squeeze Unsophisticated households into the checking account.

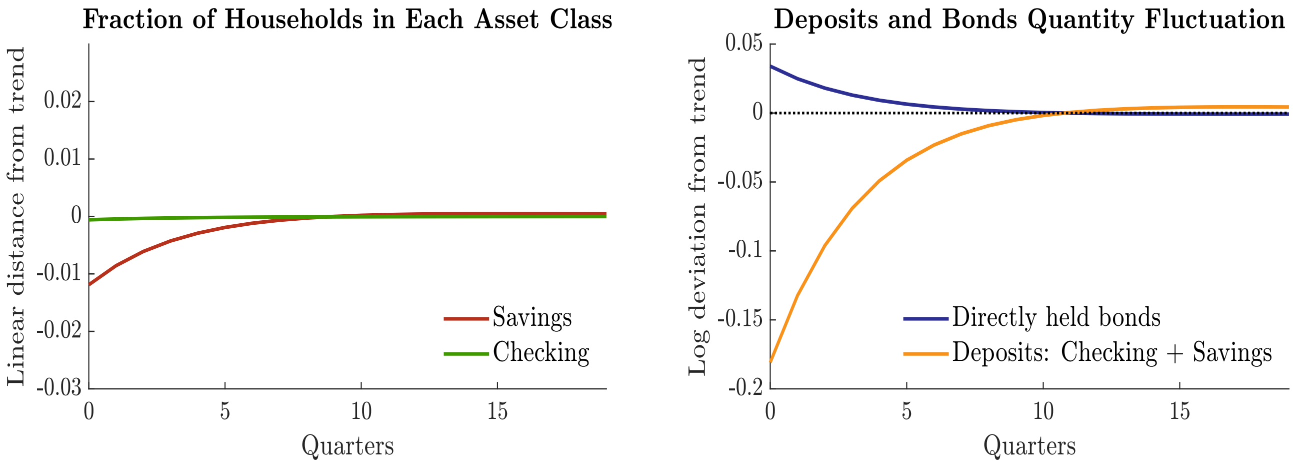
Recall from equation (14) that the relative weight $(\omega_{\mathcal{S}}(s, a))$ of wealthy households in the savings market shapes the aggregate elasticity. The central panel in Figure 9 plots the changes in these weights for different wealth groups in the savings deposit market four periods after the shock. Top wealthy households reduce their relative holdings of savings deposits, and the relative share of mid-wealth, more inelastic, households increases. The right panel shows that once the shock vanishes, however, these elastic investors return to the savings market, but now with relatively more wealth since they have been accumulating funds in the bond market. Therefore, their relative importance increases which pushes up the elasticity of savings and lowers the equilibrium spreads.[28]

The previous discussion illustrates that the model can account for the short-run imperfect passthrough of market to deposit rates documented in the data. Yet, for the model to deliver a sensible assessment of the cost of inflation, it also needs to capture households' portfolio substitution reasonably well. The evidence presented in Section 2.1 on portfolio adjustments shows that even after large fluctuations in deposit spreads, the share of Bank-Dependent households remained relatively stable. The left panel of Figure 10 shows that this is also true in the model after the shock. It illustrates that after the shock, the share of households using checking and savings deposits as their asset choice only slightly decrease —close to a 1pp drop in the savings share. Additionally, evidence shown in Appendix A.4 points to a large negative correlation between the quantity of deposits and market returns. This relationship is also present in the model. The right panel of Figure 10 shows that the drop in deposit quantities (checking plus savings) in the model is greater than 15% on impact. The model can account for the large quantity fluctuations because those few households that switch away from bank deposits are the very wealthy ones.

Overall this section shows that besides being calibrated using only steady state moments, the model dynamics after a shock resembles the evidence: deposit rates are insensitive to market returns and portfolio adjustments are limited. Additionally, this section showed that movements in the relative importance of households in the deposit market shape the elasticity that banks face influencing the equilibrium spreads. This idea will be key in the next section to understand interest rates in the new steady state.

[28]In Appendix B.1.7 I show that movements in the elasticity are driven by movements in the weights and not by changes in individual elasticities.

Figure 10: Response to a Supply Shock



Note: The figure shows the response of the changes in the fraction of households that chooses checking and savings deposits in the left panel, and the fluctuation in quantities of deposits and directly held bonds in the right panel after a shock to the Phillips curve (7) with persistence assuming the central bank keeps the real return constant

4 Consequences of Inflation

In this section, I explore the consequences of a rise in inflation with an emphasis on understanding the distribution of welfare costs. First, I compare the calibrated steady state with another one in which trend inflation is three percentage points higher. Then, I study the business cycle implications of a temporary shock that increases future inflation.

4.1 Long-run Consequences of Inflation

I consider a long-run rise in inflation of 3pp. That is, trend inflation goes from the benchmark calibration of three percent $\overline{\pi} = 3\%$ to a new trend of six percent $\overline{\pi} = 6\%$. I focus on comparing the new steady state with the benchmark calibration of Section 3.7. The welfare consequences of a higher trend inflation are shaped by the effect of inflation on assets' real rates. Thus, I begin this section by analyzing the response of real returns.

Table 3 compares assets' real returns in the benchmark calibrated economy with the ones in the high inflation steady state. High trend inflation translates negatively one to one into the real return on checking, which is -6% in the new steady state. Banks would still like to push the nominal return on checking into negative territory in the new steady state, but the zero lower bound constrains them.[29] This implies that in the new equilibrium, the bank continues to face a sufficiently inelastic demand for checking funds that would like to squeeze further by pushing the return lower. Also, bondholders enjoy the same real return in the new steady state which isolates them from inflation. In the new steady state, however, savings deposit returns increase by more than the bond interest rate —the opposite of the short-run result— going from the benchmark 0% real return to 0.5%. This means that the passthrough from market rates to savings deposits is greater than one in the long run.[30]

Table 3: Response of Real Rates to High Inflation

	Benchmark ($\bar{\pi} = 3\%$)	**High-inflation ($\bar{\pi} = 6\%$)**
Bonds (r)	3%	3%
Savings deposits ($r_{\mathcal{S}}$)	0%	0.5%
Checking deposits ($r_{\mathcal{C}}$)	-3%	-6%

The new equilibrium interest rates influence households' incentives to save. Table 4 shows the consequences of high inflation into wealth inequality. On one side, inflation increases asset holdings of wealthy households since they can now save at higher rates: the Gini index rises from 0.82 to 0.83, and the top 20% wealthy households now hold 89.3% of total assets, 1.3pp more than in the benchmark.[31] On the other side, poor households are now pushed against the borrowing constraint because high inflation reduces their incentives to save. As a consequence, in the high inflation equilibrium the share of households that are hand-to-mouth rises from 36% to 42%.[32]

We can combine the results derived in Section 3.6 with the implications of inflation for

[29]The multiplicity of equilibrium in the new steady state is not ruled out. In light of the evidence of zero nominal checking returns persisting even in periods of high inflation, I decided to focus on the steady state equilibrium with zero nominal checking returns.

[30]In nominal terms, the nominal bond return went from 6% in the benchmark economy to 9%, increasing 3pp, while the savings rate went from 0% to 3.5%, increasing more than 3pp.

[31]To understand the size of the results one can compare with the historical rise in concentration in the U.S. Using the SCF I computed the Gini for liquid assets as defined in Section 2.1. From 1989 to 2019 the Gini rise by 0.04. Moreover, holdings by the top 20% raised by 1.3pp.

[32]Table 12 in the appendix provides additional results.

Table 4: Distributional Consequences of High Inflation

	Benchmark ($\overline{\pi} = 3\%$)	**High-inflation ($\overline{\pi} = 13\%$)**
Gini Assets	0.82	0.83
Asset holdings by top 20%	88%	89.3%
Hand-to-mouth share	36%	42%

Note: Hand-to-mouth households refers to the share of households that consume all their income.

the wealth distribution to understand the resulting equilibrium rates under high inflation. Recall that the optimal savings deposit rate is determined by equation (13) in which the semi-elasticity of savings deposits ($\varepsilon^{\mathcal{S}}$) and the profits from checking ($\mathcal{C} \cdot (r - r_C)$) are the key components. In the first place, the redistribution of funds towards wealth investors pushes up the aggregate elasticity of savings deposits. On the other hand, the wealth share controlled by Unsophisticated households drops, which lowers banks' incentives to retain their funds in the checking account. Both forces combined result in a higher return on savings in the new steady state.

Finally, we can explore the welfare costs of a higher trend inflation. To do this, I calculate the change in lifetime consumption that let households indifferent between the benchmark economy and the new steady state with high inflation. In other words, for each household with state variables (s, a) I look for the percentage change in lifetime consumption that let it indifferent between the benchmark economy and the one with a higher trend inflation.[33]

Table 5 shows that inflation is not costly for the average household. That is, the average household's consumption equivalent loss of inflation is zero. However, this is masking a great amount of heterogeneity. On the one side, Investors benefit from the higher return on savings. On the other side, Unsophisticated households are left with no choice but to reduce their assets or find shelter from inflation in the costly savings deposits market. Both options are harmful: the first one reduces the ability to smooth consumption, while the second force them to exert extra non-pecuniary costs. As a result, their welfare is reduced.

To grasp the magnitude of the welfare implications, I compare the losses with those in

[33]See details on the calculation in Appendix B.1.8.

Table 5: Consumption Equivalent Loss of High Inflation

	Consumption Equivalent
Average	$\approx 0\%$
Average Investors	0.077%
Average Unsophisticated	-0.11%

Note: Consumption equivalent refers to the change in lifetime consumption that will let the household indifferent between the steady state benchmark economy and one under high inflation. Average consumption equivalent loss is computed under the benchmark steady-state distribution.

an economy under autarky in which households have no tools to smooth consumption, i.e. a scenario without a savings market.[34] The average loss for Unsophisticated households is 61% of autarky potential losses. This implies that for these households an increase in trend inflation of 3pp has non-negligible welfare consequences.

Alternatively, Figure 11 illustrates the costs of inflation along the wealth distribution by computing the average consumption equivalent change for different quintiles. Inflation hurts households at the lower end of the wealth distribution because it impairs their saving capacity, but benefits those at the top due to higher real returns.

In the long run, therefore, inflation has mainly redistributive consequences. The average household does not lose from inflation, but this is due to averaging those households who benefit from higher savings returns with those who lose due to negative checking interest rates.

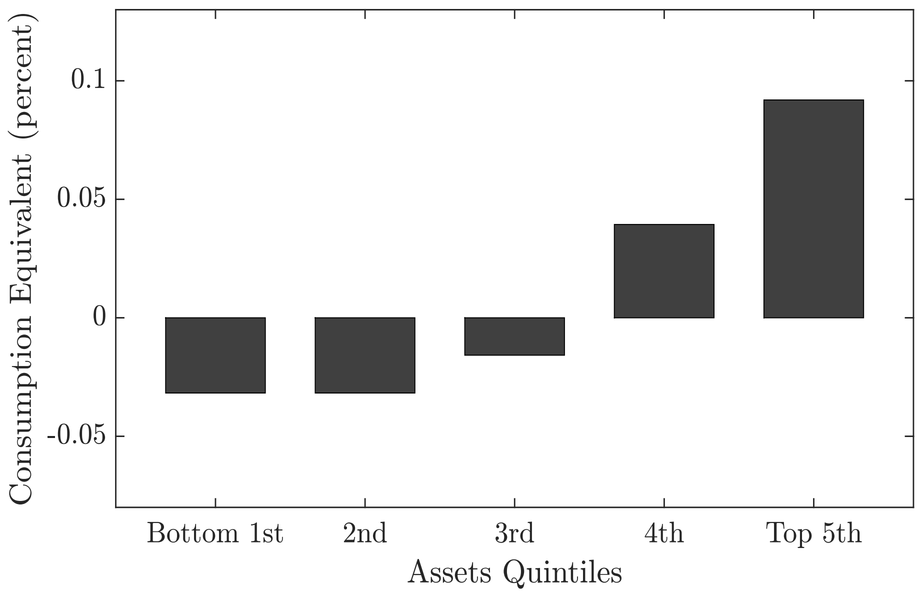
4.2 Short-run Consequences of Inflation

In this section, I discuss the implications of a temporary shock that raises future inflation. In particular, I focus on a shock that increases the desired markup of the unions — $\widehat{\varepsilon}_w$ on the Phillips curve (7)— which I will interpret more broadly as a supply shock.[35] I choose the size of the shock to generate an increase in the following quarter's annualized inflation

[34]In this scenario a household with states (s, a) consumes all their assets and income in the first period, followed by consuming just the idiosyncratic income forever.

[35]The shock process follows an AR(1) with a persistence of 0.85.

Figure 11: Consumption Equivalent Change from High Inflation by Assets Quintiles



Note: Figure reproduces the average consumption equivalent change for households in each quintile of assets in the benchmark steady state.

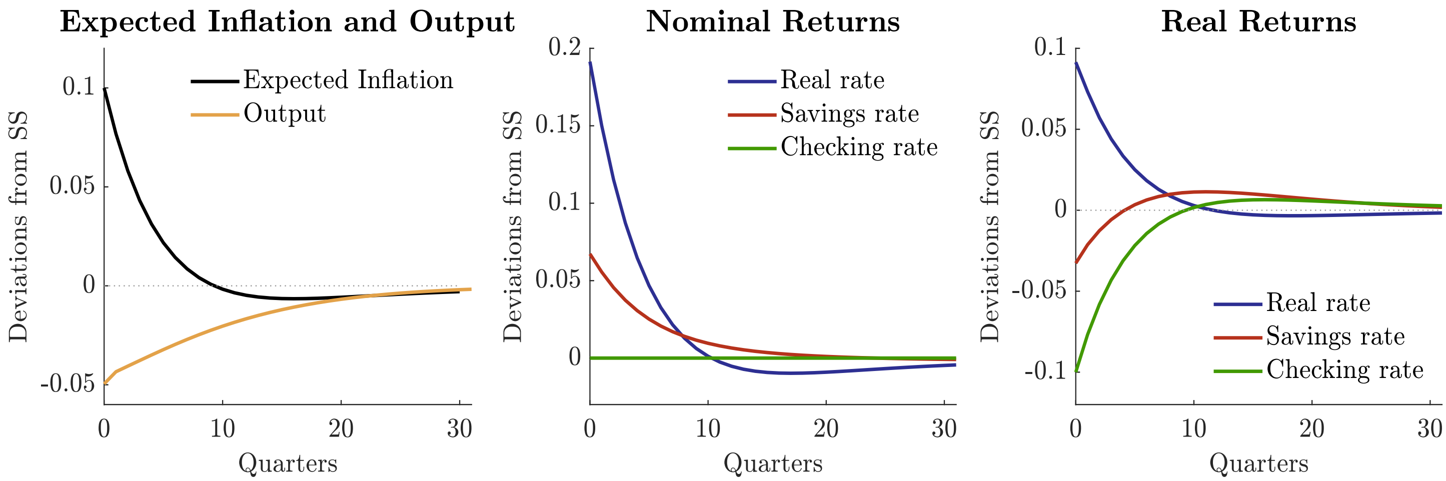
of 10%, resembling the recent experience of high inflation during the Covid-19 recession. I conclude the section by comparing the response in the benchmark calibrated economy with a counterfactual economy that features full passthrough of deposit rates.[36]

Figure 12 illustrates the response of expected inflation, interest rates, and output to the shock. The left panel shows that the shock pushes up expected inflation for several quarters. In response to the shock, and following its rule from equation (10), the government lifts the nominal rate on bonds to prevent higher inflation, which increases the real bond return, as the blue line in the central and right panel show. Banks, facing similar incentives to the ones described in Section 3.8, optimally keep the nominal return on checking at zero and pass only imperfectly the rise in the bond rate to its savings deposits customers, as the green and red lines show. Consistently with models that incorporate nominal rigidities, the rise in the real bond rate pushes output below its trend, as seen in the yellow line in the left panel.

Interestingly, even though the government is tightening to fight inflation, the increase in the real return on bonds does not imply higher real returns on assets for deposit holders

[36]For additional results not shown in this section see Appendix D.

Figure 12: Response to a Supply Shock

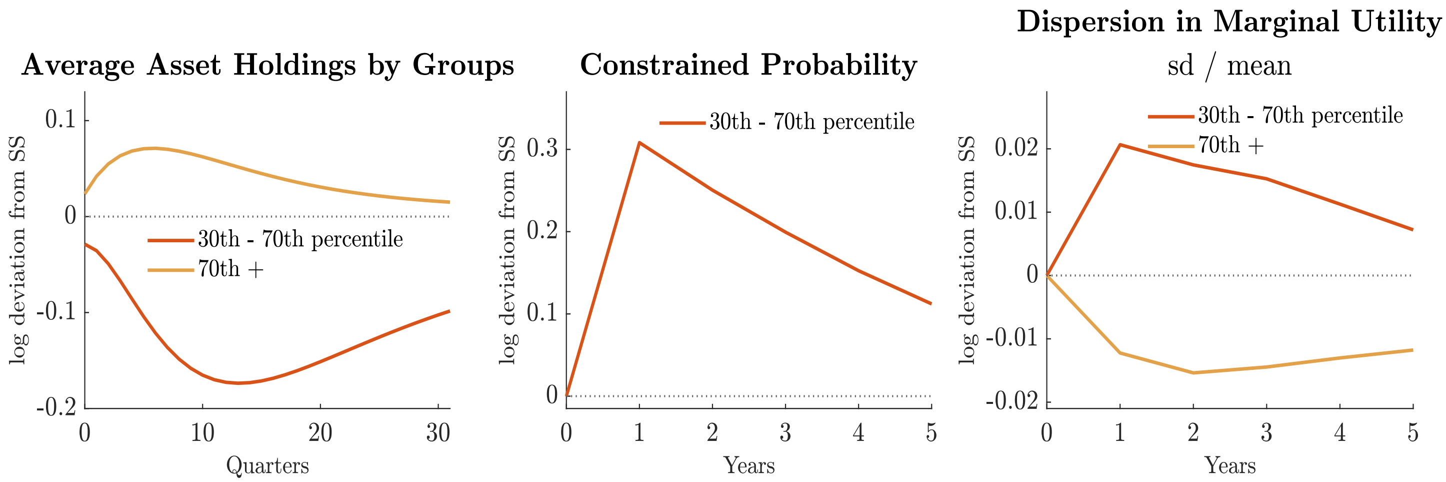


Note: The figure shows the response of inflation, output, and returns after a shock to the Phillips curve (7) with persistence.

because banks optimally keep returns on deposits low. This imperfect passthrough of bond to deposit rates generates an unequal response of saving decisions across the wealth distribution, as Figure 13 shows in the left panel. Households that belong to the top thirty percent of the wealth distribution at the moment of the shock —whose average is represented in the yellow line of the left panel— exploit the higher return on bonds to increase their asset holdings. Note that this occurs even though their income is falling because the economy is going into a recession. On the contrary, the red line reveals that mid-wealth households —those between the 30th and 70th wealth percentile— who are mainly deposits holders, decide to drain their assets from their deposit accounts in response to the negative returns.

Mid-wealth households' lower assets level reduces their ability to self-insure and leaves them more exposed to future idiosyncratic income fluctuations. The central panel of Figure 13 shows that the probability of being constrained in the future for the average household that belongs to the 30th to 70th wealth percentile at the moment of the shock increases relative to their expected value in steady state. In other words, due to the reduction in assets and income, mid-wealth households find it more likely to hit the borrowing constraint in the future. The right panel shows that the future marginal utility becomes more dispersed for the average mid-wealth household, in contrast to what happened to the average top-wealth household, who can use their additional assets as a buffer for future income shocks.

Figure 13: Assets Groups Response to a Supply Shock



Note: The figure shows the response of average asset holdings, probability of hitting the borrowing constraint, and the dispersion in the marginal utility after a shock to the Phillips curve (7) with persistence. Wealth groups are computed before the shock hits and the response of these same households is tracked.

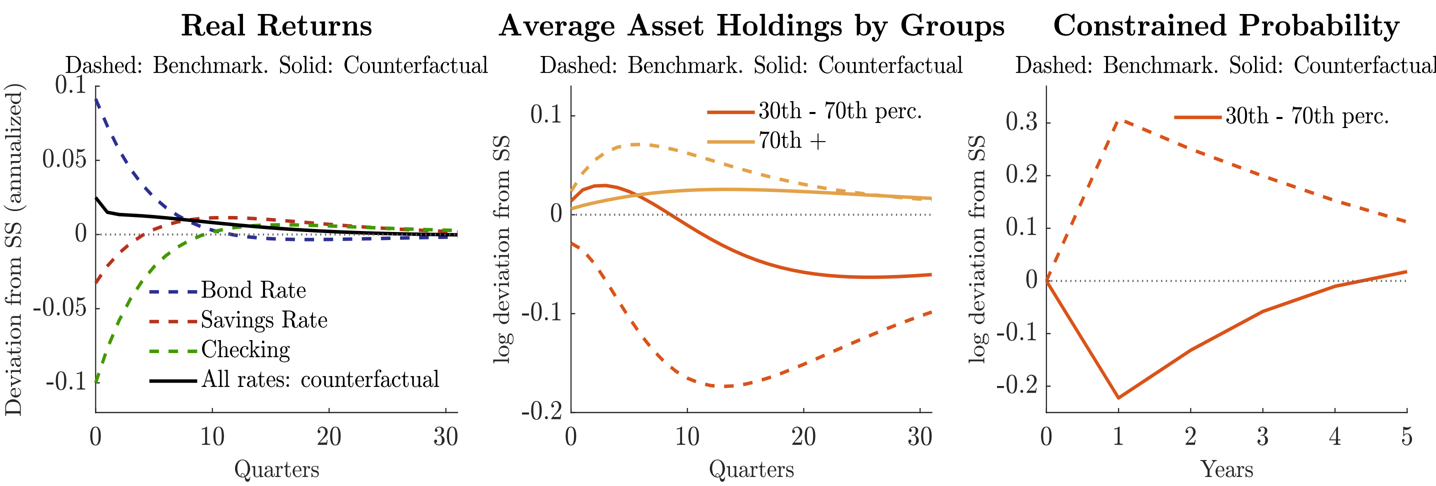
I use this model to examine the role of the imperfect passthrough from bond rates to deposit rates on the saving behavior of households. I look to understand if the drop in assets of mid-wealth households documented on Figure 13 is a standard feature of a recession or is due to the imperfect passthrough of deposit rates. To do that, I compare the dynamics in the benchmark calibrated economy with an alternative scenario in which there is no imperfect passthrough from the market rate to deposit rates, i.e. movements in interest rates are equalized: $\Delta r = \Delta r_S = \Delta r_C$. I will call this scenario a competitive banking counterfactual.[37] Under competition, spreads will be held constant at the steady state level even after the shock hits. To make the counterfactual cleaner, I assume that the government engineers the movements in the bond rate (r) to achieve the same path of output —and therefore of inflation— as in Figure 12. Figure 14 shows the result and compares the competitive with the benchmark economy.

The left panel of Figure 14 compares the response of the real rates in the benchmark calibration in dashed lines with the counterfactual competitive banking economy in the black solid line. Note that in the counterfactual competitive economy, the lift on interest rates

[37]Fully accounting for bank competition in this model will imply also changes in the spreads in the steady state. The objective of this exercise is to understand how changing the dynamics of the interest rates can alter the responses of the economy even without altering the steady state.

required to achieve the same path of inflation and output is much smaller. That is, when the economy features complete passthrough from bond rates to deposit rates, changes in interest rates reach all households and make monetary policy more effective.[38]

Figure 14: Competitive Banking Counterfactual



Note: The figure shows the response of real returns on assets, the movements in average asset holdings, and changes in the probability of hitting the borrowing constraint after a shock to the Phillips curve (7) with persistence. The benchmark economy refers to the calibrated version. The counterfactual assumes that movements in interest rates are equalized (full passthrough). Wealth groups are computed before the shock hits and the response of these same households is tracked.

The central panel of Figure 14 compares the response of asset holdings for the average mid-wealth in red and top-wealth household in yellow. Note that, even though the economy is going through the same recession in both scenarios, mid-wealth households take advantage of the higher interest rates in the competitive counterfactual and accumulate assets, in sharp contrast with the benchmark case in which these same households reduce their holdings.[39] This difference in the response of asset accumulation generates a reduction in the probability of mid-wealth households hitting the borrowing constraint in the future —as the right panel shows—, a signal of a better self-insurance capacity in the competitive versus the benchmark economy.

The counterfactual exercise shows that the unequal response of interest rates to inflationary

[38]I explore this point further in Section 5.1.

[39]The path of inflation and output in both scenarios is identical. After-tax income, however, differs between economies. In Appendix D I argue that the difference in the paths of asset accumulation is mainly driven by the different interest rates, and not by taxes.

shocks exposes mid-wealth households to an additional cost from inflation typically unexplored in previous literature. This cost arises from the fact that inflation lowers the real returns on deposits which incentivizes deposit holders to reduce their assets leaving them more exposed to future idiosyncratic shocks. Notoriously, this cost arises even if the central bank increases the policy rate to fight inflation.

5 Additional Results

This section presents two additional results with the objective of understanding the role of spreads in the banking sector beyond their implications for the cost of inflation. First, I explore the consequences of imperfect banking competition and segmented assets market in affecting the ability of the central bank to control inflationary pressures. Then, I study the importance of banking spreads for wealth inequality.

5.1 Controlling Inflation Under Imperfect Banking Competition

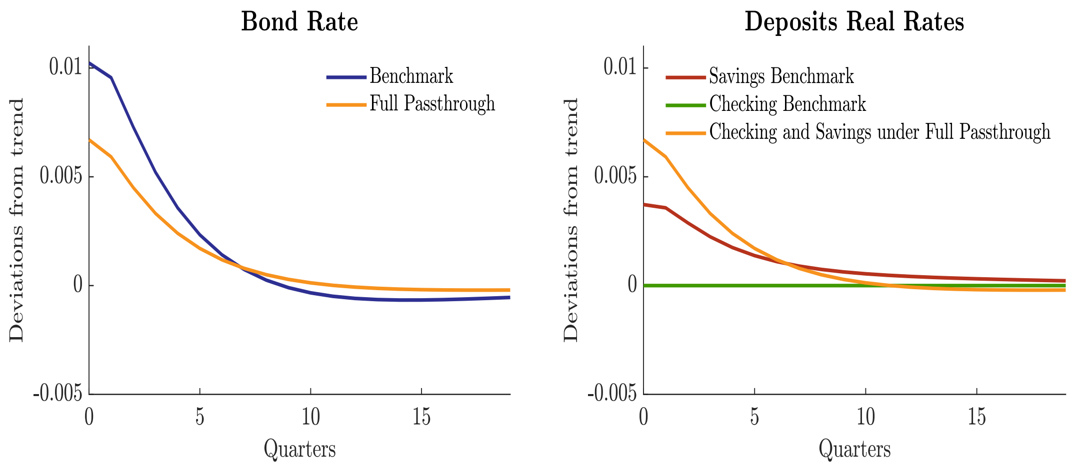
In this section, I argue that market power in the banking sector impairs central banks' ability to control inflationary shocks. This implies that if the passthrough of the central bank rate to deposit rates improves, smaller increases in the central bank's policy rate would be needed to control inflation. To show this, I consider again a shock to the Phillips curve (7) with persistence but consider now the case of a central bank that targets full price stability $\widehat{\pi} = 0$. I study the movements of interest rates needed in the benchmark calibrated economy and compare it to a counterfactual scenario with a full passthrough, that is, a scenario in which all movements in deposits are coordinated $\Delta r = \Delta r_S = \Delta r_C$.

The left panel of Figure 15 shows the changes in the central bank policy rate needed to control inflation after the shock. The blue line shows the movements in the benchmark calibrated economy and the yellow line in the full passthrough counterfactual. From the figure, we observe that much smaller deviations in the return on bonds would be needed if the passthrough from the bond to deposit rates were perfect.[40] The reason is that the changes in the bond rate in the benchmark economy do not reach all households. As the

[40]The average deviation from trend is 50% larger in the first two years.

right panel shows, savings and checking real rates only imperfectly reproduce the movements in the bond rate, whereas in the full passthrough counterfactual, all agents in the economy are exposed to the same changes in interest rates, which spread further the incentives to lower consumption, benefiting the control of inflation.

Figure 15: Response to a Supply Shock



Note: The figure shows the response of the real return on assets after a shock to the Phillips curve (7) with persistence in an economy in which the central bank achieves full price stability. It compares the necessary change needed in the benchmark calibrated economy with a counterfactual scenario of full passthrough.

5.2 Deposit Spreads and Wealth Inequality

This section studies the implications of deposit spreads on the wealth distribution. To do this, I compare the calibrated benchmark with an alternative steady state in which all bank spreads are removed: $r = r_S = r_C$. Table 6 shows that the implications for wealth inequality from deposit spreads are substantial. The equalization of the return on assets provides extra incentives to poor households to save, which reduces wealth inequality and concentration of holdings at the top.

Table 6: Deposit Spreads and Wealth Inequality

	Benchmark	**No Deposit Spreads ($r = r_S = r_C$)**
Bond return (r)	3%	2%
Savings return (r_S)	0%	2%
Checking return (r_C)	-3%	2%
Gini Assets	0.82	0.71
Asset holdings by top 20%	88%	73%
Hand-to-mouth share	36%	19%

Note: The table compares the benchmark calibrated economy with an alternative in which the spreads on deposits are removed. Hand-to-mouth households refers to the share of households that consume all their income.

6 Conclusion

In this paper, I explored the cost of inflation as a tax on household savings. I motivated the mechanism by documenting that most U.S. households use bank deposits as their only source of liquid assets and that deposit nominal returns are low and do not adjust with inflation. I studied the magnitude of this channel using a general equilibrium heterogeneous agents model calibrated to match sensible moments of the households' portfolio choice, wealth distribution, and banking spreads.

The model predicts that a rise in inflation impairs the precautionary saving capacity of households at the low end of the wealth distribution, generating sizable welfare costs. The reason is that banks do not pass through the increase in the nominal bond rate and expose a large share of households to negative real saving rates when inflation rises.

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Appendix

A Data Appendix

This section complements the evidence presented in Section 2.1 and show details on data computations.

A.1 Data Sources

Data on households' portfolios comes from the Survey of Consumer Finances (SCF), a U.S. households survey sponsored by the Federal Reserve Board. The survey is a repeated cross-sectional survey of U.S. families that collects information on household balance sheets, income, and demographic characteristics. Post-1983 data of the SCF is available on the website of the Board of Governors of the Federal Reserve System, and pre-1983 waves have been linked to the new waves by Kuhn, Schularick, and Steins (2020).[41] In the modern version of the survey around 6500 families are interviewed every three years with particular attention to capturing top wealthy families. I keep the entire sample of households in the SCF without any demographic or income restrictions. Some additional results on households' portfolios are computed using the Survey of Income and Program Participation (SIPP).

For bank interest rates I use the banks' Consolidated Report of Condition and Income —generally referred to as Call Reports—. Specifically, banks need to file a Call Report every quarter reporting their balance sheet and cash flow to the regulatory entity. I use data on banks' average holdings of deposits and expenses to implicitly compute the interest rate on deposits.

A.2 Call reports sample selection and definitions

Data from Call Reports is obtained from WRDS for years between 1987 and 2021. Data is quarterly and account for the entire universe of depository institutions in the US. My main reference paper for sample selection and definitions is Acharya and Mora (2015). In

[41] I would like to thank Alina Kristin Bartscher for providing me with additional requested computations on the data.

particular, banks are aggregated to top holder level (RSSD9348). Bank organizations with assets less than \$100 million are excluded. As a merger control, bank organizations with asset growth greater than 10% during a quarter are excluded in that quarter. Rates are trimmed at the 1% and 99% level. Interest rates on savings deposits are computed as:

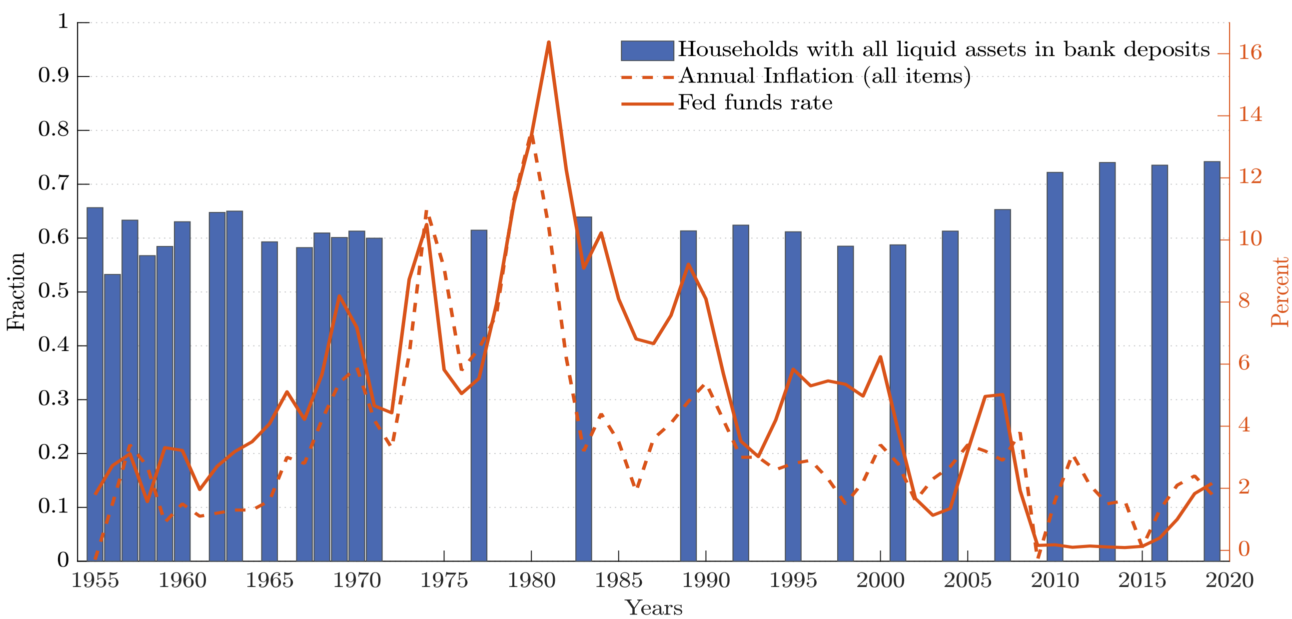
- Savings Account interest rate: is computed as interest expenses on saving accounts (RIAD0093 and RIAD4509 + RIAD4511 before 2001) divided by quarterly average savings (RCONB563 and RCON3486+RCON3487 before 2001). This includes MMDA and other savings accounts.

A.3 Additional Results on Households Portfolio

Bank-Dependent Households Share and Inflation

We can add inflation to Figure 1. From the figure, we see that inflation and the Federal Funds rate comove closely before 1980. Also, that inflation has been relatively stable since then.

Figure 16: Share of Bank-Dependent Households, Market Returns, and Inflation

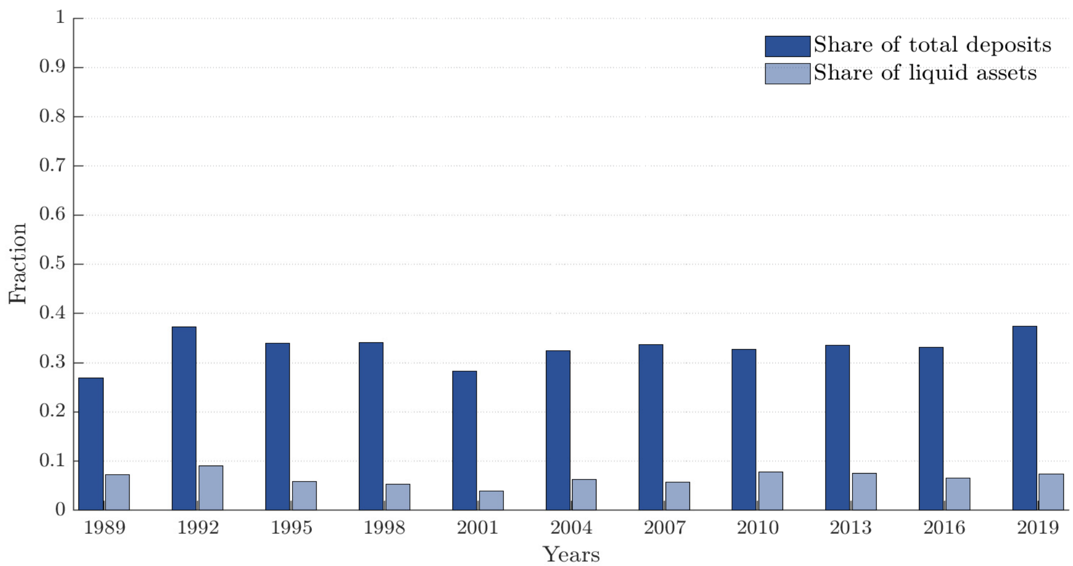


Note: Bank-Dependent households refers to households with all their liquid assets held in bank deposits. It also includes households that do not report having a bank account (cash holders). Data is from the SCF.

Income and Assets share of Bank-Dependent Households

We saw in Section 2.1 that around 60% of U.S. households can be classified as Bank-Dependent. Figure 17 shows that they account for around one third of the total market of deposits, but less than ten percent of total liquid assets. Additionally, Figure 18 shows that they account for between forty and fifty percent of income.

Figure 17: Share of deposits and liquid assets held by Bank-Dependent households



Portfolio of Investors

Figure 19 shows that once households broke the barrier of bank dependency, they choose to hold a small share of deposits in their portfolio, especially of low interest rate deposits like checking and normal savings accounts. In particular, it shows that around one third of investor households hold near zero low return deposits in the portfolio and the median investor holds only close to 25%.

What do investors hold in their financial portfolio? Table 7 reproduces the average holdings of each class of assets for 2007

Figure 18: Share of labor and total income by Bank-Dependent households

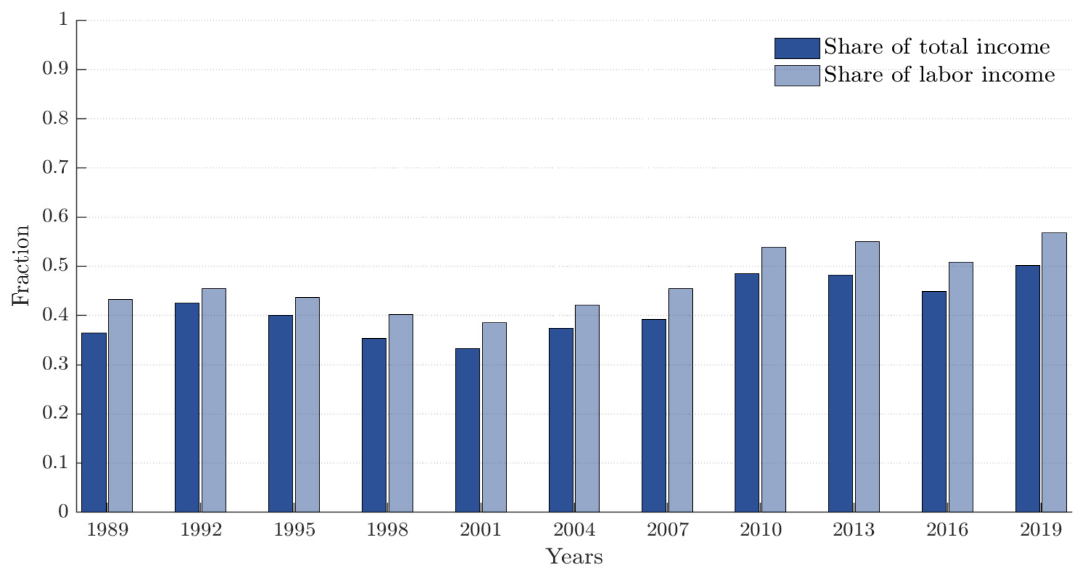
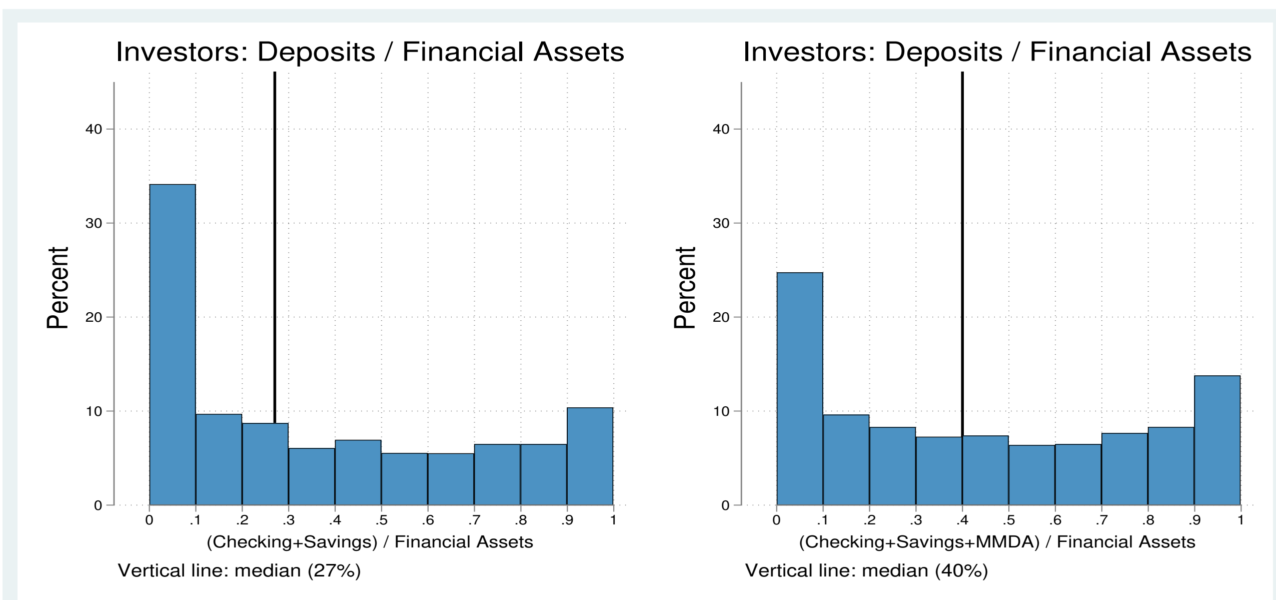


Figure 19: Distribution of deposits over liquid assets for investors



Transition Matrix

The data used in Section 2.1 to calculate the share of Bank-Dependent households is a collection of cross-sectional surveys whose nature does not allow to compute the persistence

Table 7: Average Portfolio of Investors

	Share of total portfolio	**Share in market portfolio**	**Fraction with zero holdings**
Money market funds	4%	6%	$\approx$ 75%
Call accounts	1%	1%	$\approx$ 90%
Directly held investment funds (exc. money mkt funds)	18%	24%	$\approx$ 50%
Savings bonds	8%	28%	$\approx$ 50%
Directly held stocks	22%	40%	$\approx$ 38%
Other directly held bonds	1%	2%	$\approx$ 95%
Bank deposits	45%	-	$\approx$ 1%

of being Bank-Dependent. However, the Survey of Income and Program Participation (SIPP) has data that allows making an idea of the likelihood of transitioning in and out of the Bank-Dependent state. For this purpose, I use the 2004 wave of the SIPP and bundle individual records at the household-quarter level. Participants of the survey are asked to indicate if they hold or not different types of assets. For those households that report only having bank deposit accounts, I classify them as Bank-Dependent. If they report holding liquid assets apart from bank deposits, I label them as investors[42]. Table 8 indicates the quarterly likelihood of transitioning between the Bank-Dependent state and the Investor state computed as the number of households that switch divided by the number of households in the departing state in the previous quarter.

Table 8: Quarterly Transition Matrix

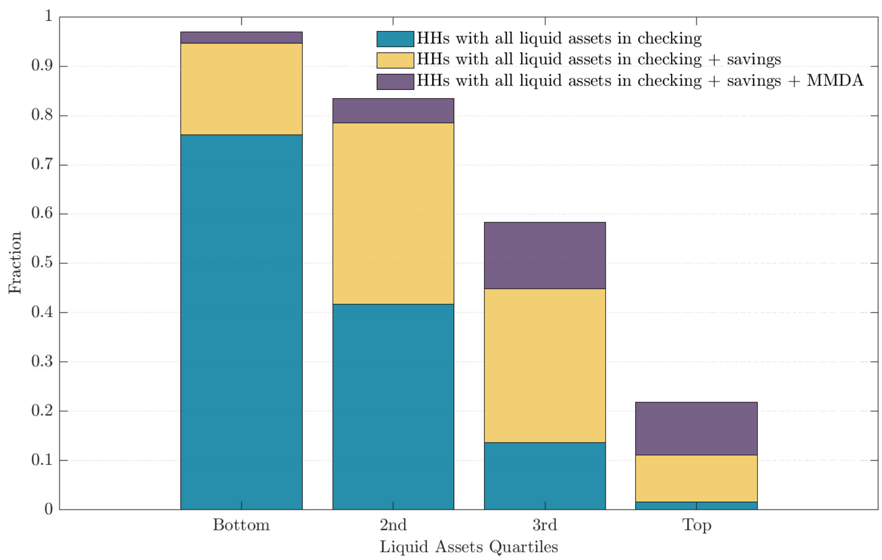
	Deposits	**Investor**
Deposits	0.94	0.06
Investor	0.02	0.98

[42]There is a difference between this definition and the one used in Section 2. SIPP does not report if you hold a positive amount of the assets you declare. Suppose then that a household opened a money market account in the past but now it is empty, and also that they have no other liquid asset outside bank deposits. In the SCF I will label this household as Bank-Dependent. In the SIPP, however, it will appear as investor

Wealth and Deposits Classes

Here I reproduce Figure 2 but now decomposing it by type of deposits. That is, I split Bank-Dependent households into those that hold all their assets in checking deposits, those that hold some funds in savings, and those that hold some positive value in high-return money market accounts (and potentially some in checking and/or savings). Figure 20 shows the results. From the figure, we can observe that most of the households with very few assets hols all their money in checking accounts, mid-wealth households use mainly savings deposits, and rich households use high-return money market deposit accounts.

Figure 20: Distribution of Bank-Dependent Households in 2007 by Type of Assets



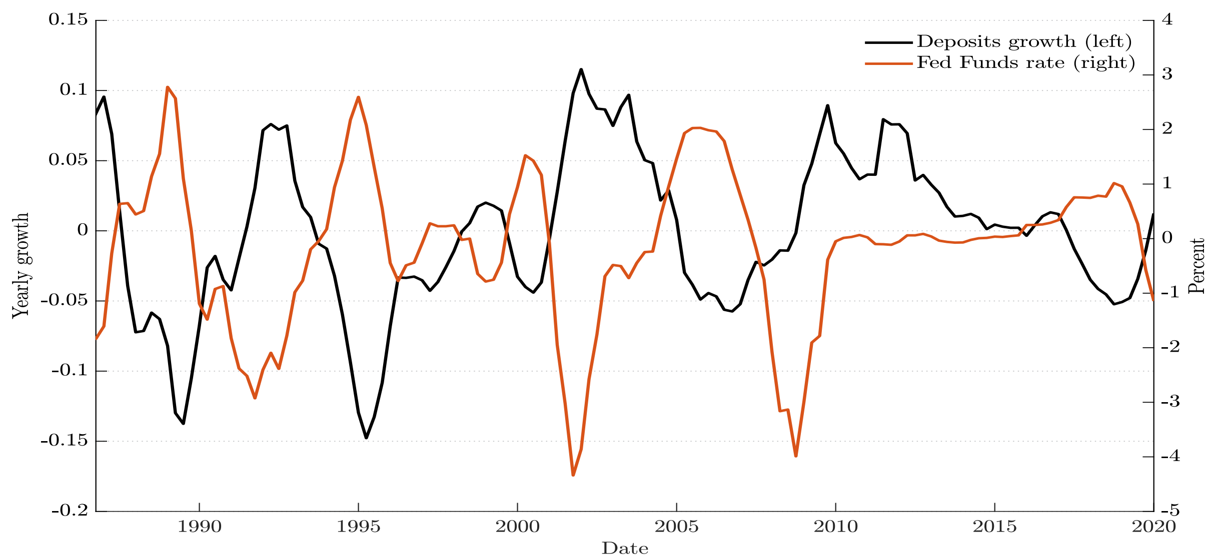
Note: Bank-Dependent households refers to households with all their liquid assets held in bank deposits. It also includes households that do not report having a bank account (cash holders). Data is from the SCF. MMDA refers to money market deposit accounts at banks.

A.4 Additional Results on Deposits and Rates

Deposits Fluctuation

We have seen in Figure 1 that the share of households in the Bank-Dependent state is very rigid and does not fluctuate. Nevertheless, deposit quantities do fluctuate, and its growth correlates negatively with market returns.[43] The black line in Figure 21 shows the log annual change in deposits around a linear trend. The measure for deposits used in the figure is the sum of checkable and savings deposits from the Fed's H.6 Money Stock Measures report. Additionally, the figure shows the yearly change in the Fed funds rate in the red line. We can see from the plot that the magnitude of deposits inflows and outflows is large and that they follow a clear negative correlation with changes in the Fed rate.

Figure 21: Deposits Fluctuations and Fed Funds Rate



Note: Deposits growth is the log annual difference around a linear trend. The measure of deposits used is the sum of checkable and savings deposits from the Fed's H.6 Money Stock Measures report.

Instrumented Local Projections

Instead of showing the simple correlations between rates and the Fed's rate in Figure 3 and on quantities in Figure 21 we can show some evidence of the causal mechanism. In order to do it, I run Jordà (2005) type local projection using an instrument for changes in the Fed Funds rate. Specifically, I run

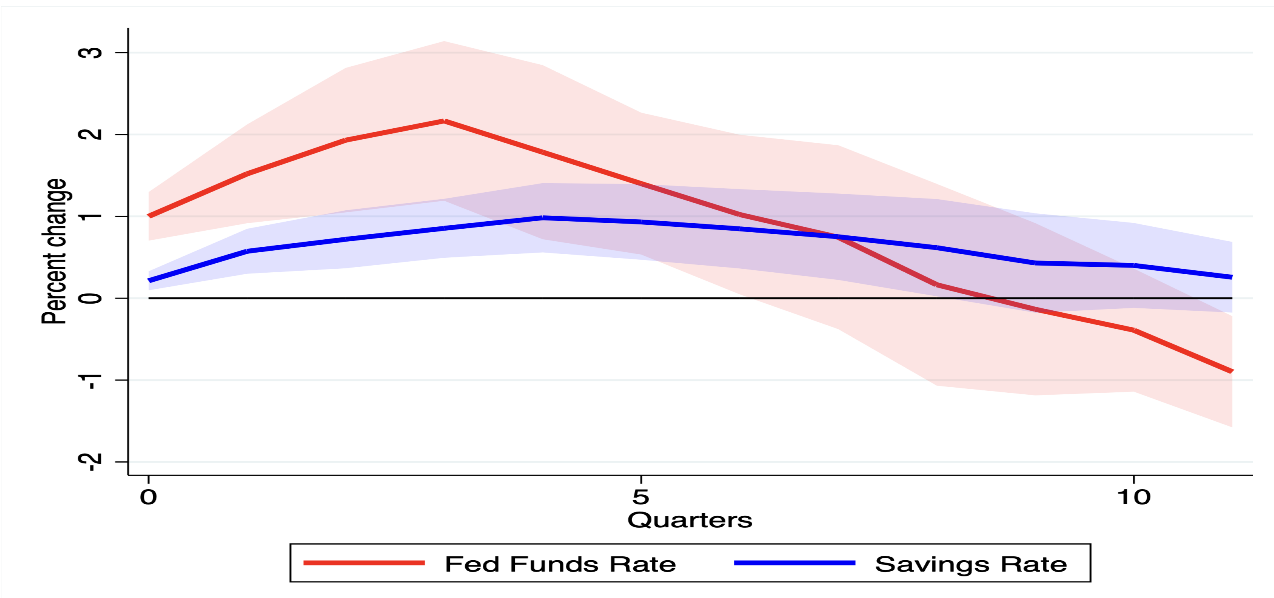
$$y_{t+h} = \alpha_h + \beta_h \, \epsilon_t + \gamma_h \, \text{controls}_{t-1} + u_{t+h} \tag{16}$$

[43]This point is also present in Drechsler, Savov, and Schnabl (2017).

where y_{t+h} is the outcome of interest -deposits or interest rates- and ϵ_t is a measure of monetary shocks for which I use Bauer and Swanson (2022) measure of surprises normalize to have an impact of 1pp in the Fed Funds rate. In the controls, I include four quarter[44] lags on the outcome variable y_t, together with industrial production, CPI, and the Fed Funds rate. Figure 22 and Figure 23 show the time series of the β_h for savings deposit rates and for deposits respectively.

We see from the figures that the same patterns observed in Figure 3 and Figure 21 are present in the instrumented local projections. This suggests that the causal effect goes from the Fed return changes to changes in savings rates and deposits. Moreover, we see that the passthrough to savings rate is imperfect and that the magnitude of the fluctuations in deposits is large.

Figure 22: Savings Rate and Fed Funds Rate



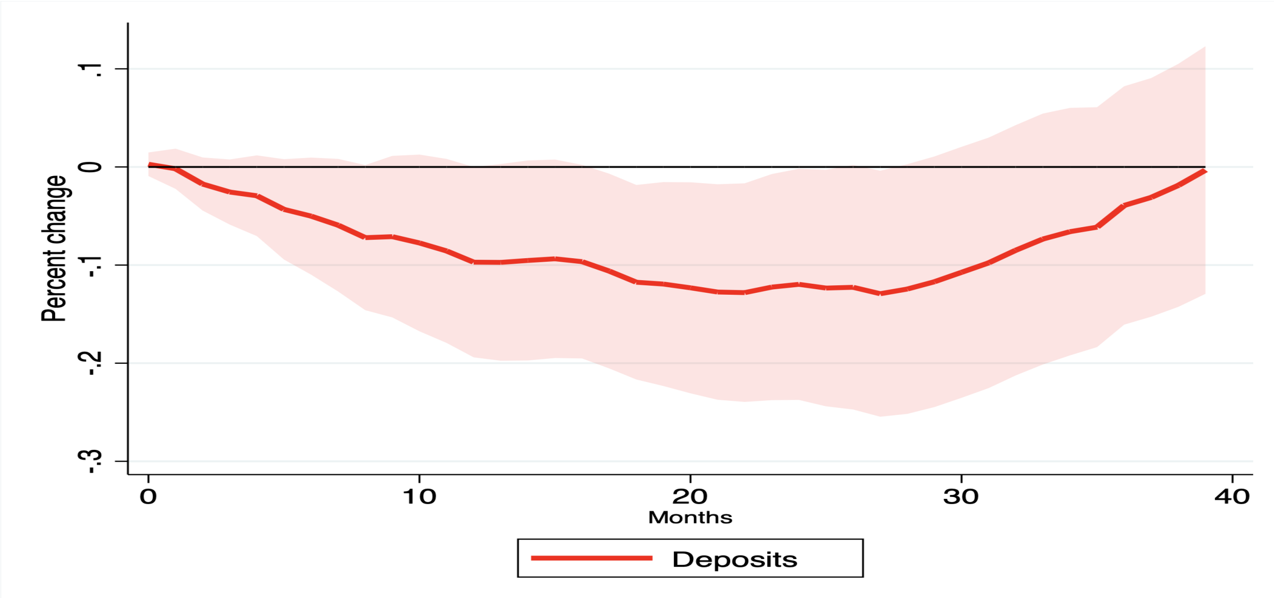
Note: Figure shows the collection of the β_h coefficients in equation (16) for savings rates. Savings returns are expenses over average holdings on savings deposits using Call reports.

B Model

This section contains details and derivations of the model part.

[44]The deposits data is monthly, so I use 12 months instead.

Figure 23: Deposits Fluctuations and Fed Funds Rate



Note: Figure shows the collection of the β_h coefficients in equation (16) for deposits. The measure of deposits used is the sum of checkable and savings deposits from the Fed's H.6 Money Stock Measures report.

B.1 Households

B.1.1 Optimal Decisions

After observing its productivity level for the period a household of group g chooses between the low (L) and high (H) return assets of its group g. This optimal choice delivers a probability $P_H^g(s,a)$ that the high return asset is chosen by households with these state variables. Given the assumption on the distribution of trading cost F_g being Logistic($\mathcal{F}_g, \sigma_F$), the probability for household of group g with states (s,a) of choosing the high return asset is given by,

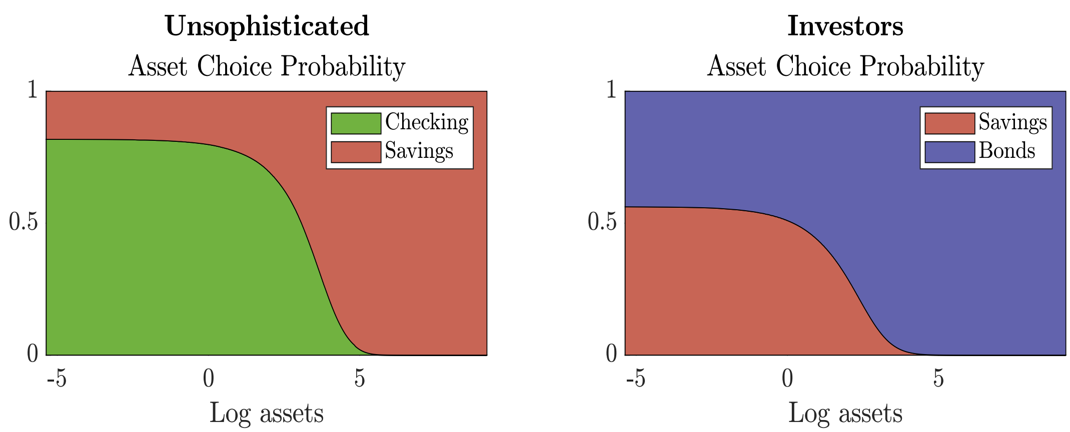
$$P_H^g(s,a) = \frac{\exp\left[\frac{\nu_H(s,a)-\mathcal{F}_g}{\sigma_F}\right]}{\exp\left[\frac{\nu_H(s,a)-\mathcal{F}_g}{\sigma_F}\right] + \exp\left[\frac{\nu_L(s,a)}{\sigma_F}\right]} \tag{17}$$

and $P_L(s,a) = 1 - P_H(s,a)$ is the probability of choosing the low return asset on the group. Note that this delivers four probabilities:

$$P_B^I(s,a) \text{ :the probability of Investors of choosing the bond}$$
$$P_{\mathcal{S}}^I(s,a) \text{ : the probability of Investors of choosing savings deposits}$$
$$P_{\mathcal{S}}^U(s,a) \text{ : the probability of Unsophisticated of choosing savings deposits}$$
$$P_{\mathcal{C}}^U(s,a) \text{ : the probability of Unsophisticated of choosing checking deposits}$$

For the calibrated economy these probabilities are shown in Figure 24. Remember from the calibration that the distribution of the trading shock F is in part chosen to get the right share of households as Bank-Dependent along the wealth distribution.

Figure 24: Asset choice conditional on assets



Once the asset choice $j = \{\mathcal{C}, \mathcal{S}, B\}$ is done by the household, it has to choose its optimal level of consumption and saving. This decision is dictated by the Euler equation,

$$u'(c_j(s,a)) \geq \beta(1 + r_j)\mathbb{E}\left[\partial_a V(s', a')\right] \tag{18}$$

where equality holds if $a' > 0$. This delivers a set of policy functions for consumption and saving:

$$c_B^I(s,a) : \text{consumption of Investors choosing the bond}$$
$$c_{\mathcal{S}}^I(s,a) : \text{consumption of Investors choosing savings deposits}$$
$$c_{\mathcal{S}}^U(s,a) : \text{consumption of Unsophisticated choosing savings deposits}$$
$$c_{\mathcal{C}}^U(s,a) : \text{consumption of Unsophisticated choosing checking deposits}$$
$$a_B'^I(s,a) : \text{saving of Investors choosing the bond}$$
$$a_{\mathcal{S}}'^I(s,a) : \text{saving of Investors choosing savings deposits}$$
$$a_{\mathcal{S}}'^U(s,a) : \text{saving of Unsophisticated choosing savings deposits}$$
$$a_{\mathcal{C}}'^U(s,a) : \text{saving of Unsophisticated choosing checking deposits}$$

The issue with solving this problem is that the first-order conditions are necessary but not sufficient. Random fixed costs make the problem continuous and differentiable but do not necessarily convexify the problem. The following section describes how to efficiently compute the solution to this type of problem.

B.1.2 Computation of Household's Problem

This section briefly describes how to compute the optimal policy functions for the household problem. The method used is an extension of the original Endogenous Grid Method (EGM) (Carroll (2006)) to non-convex problems. In doing so, I rely on advances done in Fella (2014), Iskhakov, Jørgensen, Rust, and Schjerning (2017) and Bardóczy (2020).[45] For details on solution methods for non-convex optimization, please refer to the cited papers.

For the computation of the household problem, initiate the algorithm by discretizing the state space (s,a) and a guess for the value functions $\{\nu_L(s,a), \nu_H(s,a)\}$ for each group. I will label this original grid on assets A^{exo} in order to distinguish it from the endogenous one. Use the guess of the value functions to calculate the implied probability of choosing the high return asset using equation (17) and numerically obtain the partial derivative of the value function with respect to assets $\partial_a \nu_j$. The right-hand side of the Euler equation (18) can be

[45] I would also like to thank Bence Bardóczy for generous conversations that helped me to improve the model computation.

computed using these two objects,

$$\mathbb{E}_{s',F'}\left[\partial_a V(s',a')\right] = \mathbb{E}_{s'}\left[(1-P_H(s',a'))\cdot\partial_a\nu_L(s',a') + P_H(s',a')\cdot\partial_a\nu_H(s',a')\right]$$

Next, invert the Euler equation -as done in the typical step in the EGM- to obtain an implied consumption function $c_j(s,a)$ for each asset choice and replace into the budget constraint to obtain an endogenous grid A_j^{endo}. In the classic EGM the next step is to interpolate the implied cash-on-hand generated by the endogenous grid into the exogenous one generated by the grids. The problem here is that A^{endo} might not be increasing and the obtained $c_j(s,a)$ not be optimal.

The final step is a quick implementation of an upper envelope method to discard sub-optimal points. The key is to partition the endogenous grid into increasing and decreasing regions. For the increasing regions, EGM works well to identify optimal consumption levels. For the non-increasing regions, if multiple segments contain an exogenous grid point, discard the one that provides less utility. For this last step use that the expected value under Logistic cost distribution as follows:

$$\mathbb{E}_{s',F'}\left[V\left(s',a'\right)\right] = \mathbb{E}_{s'}\left\{\sigma_F \ln\left[\exp\left(\frac{\nu_L\left(s',a'\right)}{\sigma_F}\right) + \left(\frac{\nu_H\left(s',a'\right)-\mathcal{F}_g}{\sigma_F}\right)\right]\right\}$$

Finally update the marginal value of assets using the envelope theorem valued on the obtained consumption $\partial_a\nu_j(s',a') = u'(c_j(s,a))$ and repeat until convergence.

B.1.3 Aggregation and other statistics

Given a distribution over idiosyncratic states for Unsophisticated and Investors households $\left\{\Psi^U(s,a),\Psi^I(s,a)\right\}$ aggregate consumption is,

$$\begin{aligned}C = \mu\cdot\int_{(s,a)}&\left[P_{\mathcal{C}}^U(s,a)c_{\mathcal{C}}^U(s,a) + P_{\mathcal{S}}^U(s,a)c_{\mathcal{S}}^U(s,a)\right]d\Psi^U(s,a)+\\&+(1-\mu)\cdot\left[P_{\mathcal{S}}^I(s,a)c_{\mathcal{S}}^I(s,a) + P_B^I(s,a)c_B^I(s,a)\right]d\Psi^I(s,a)\end{aligned}$$

Aggregate demand for checking deposits is,

$$\mathcal{C} = \mu \cdot \int_{(s,a)} \left[P^U_{\mathcal{C}}(s,a) \frac{a'^U_{\mathcal{C}}(s,a)}{1+r_{\mathcal{C}}} \right] d\Psi^U(s,a)$$

Demand for savings is,

$$\mathcal{S} = \mu \cdot \int_{(s,a)} \left[P^U_{\mathcal{S}}(s,a) \frac{a'^U_{\mathcal{S}}(s,a)}{1+r_{\mathcal{S}}} \right] d\Psi^U(s,a) + (1-\mu) \cdot \int_{(s,a)} \left[P^I_{\mathcal{S}}(s,a) \frac{a'^I_{\mathcal{S}}(s,a)}{1+r_{\mathcal{S}}} \right] d\Psi^I(s,a)$$

Demand for directly held government bonds is,

$$B = (1-\mu) \cdot \int_{(s,a)} \left[P^I_B(s,a) \frac{a'^I_B(s,a)}{1+r} \right] d\Psi^I(s,a)$$

The share of Bank-Dependent households is the share of households that choose deposits as their savings vehicle:

$$BD = \mu + (1-\mu) \cdot \int_{(s,a)} P^I_{\mathcal{S}}(s,a) d\Psi^I(s,a)$$

B.1.4 Numerical Computation of Elasticities

Calculating the elasticity of the demand for checking and savings is a key step for getting optimal deposit returns. Given that no close form exists for aggregate demands, these elasticities have to be computed numerically.

Due to the perfect foresight assumption, the household problem depends on the entire path for aggregates and prices. When calculating the current period elasticities, but since banks are small they take the path of aggregates (including its rates $\{r_C, r_S\}$) as given. Then, given a path for aggregates, the current period elasticity of checking and savings deposits with respect to the current r_S is computed numerically using simple differences. Take $h = 10^{-5}$, then:

$$\mathcal{S}'(r_S) = \frac{\mathcal{S}(r_S + h) - \mathcal{S}(r_S)}{h}$$

and therefore $\varepsilon_{\mathcal{S}} = \frac{\mathcal{S}'(r_S)}{\mathcal{S}(r_S)}$. Identically for checkings,

$$\mathcal{C}'(r_S) = \frac{\mathcal{C}(r_S + h) - \mathcal{C}(r_S)}{h}$$

and therefore $\varepsilon_{\mathcal{C}} = -\frac{\mathcal{C}'(r_S)}{\mathcal{C}(r_S)}$. Note that this cross elasticity is defined with the negative sign. To compute the elasticity with respect to the checking return repeat these steps.

B.1.5 Additional Results on Households Elasticities

This section explores additional results on households' elasticities in Section 3.6. I begin by decomposing individual elasticities into an extensive and intensive margin and show that numerically the extensive margin is responsible for the increasing pattern of Figure 6. Later, I show that this result depends on the distribution of the fixed cost, but that the result is valid for the classical distribution functions used in the literature. I will show the results for the savings market but the steps are equivalent for the checking market.

The aggregate semi-elasticity of savings funds is

$$\varepsilon^S \equiv \frac{\partial \mathcal{S}/\partial r^S}{\mathcal{S}}$$

and can be decomposed into

$$\varepsilon^S = \int_{(s,a)} \varepsilon^S(s,a) \cdot \omega_S(s,a)$$

In which I have used that,

$$\varepsilon^S(s,a) \equiv \frac{\partial d_S(s,a)}{\partial\, r_S} \cdot \frac{1}{d_S(s,a)} \tag{19}$$

$$\omega_S(s,a) \equiv \frac{d_S(s,a) \cdot \mathrm{d}\Psi(s,a)}{\int_{(s,a)} d_S(s,a) \cdot \mathrm{d}\Psi(s,a)} \tag{20}$$

Where $d_S(s,a)$ stands for average savings deposits held by households with states (s,a):

$$d_S(s,a) = \frac{P_S^U \frac{a_S'^U}{1+r_S}\, \mu\, \mathrm{d}\Psi^U(s,a) + P_S^I \frac{a_S'^I}{1+r_S}\, (1-\mu)\, \mathrm{d}\Psi^I(s,a)}{\mu\, \mathrm{d}\Psi^U(s,a) + (1-\mu)\, \mathrm{d}\Psi^I(s,a)}$$

and the measure Ψ is,

$$\Psi(s,a) = \mu \, \Psi^U(s,a) + (1-\mu) \, \Psi^I(s,a)$$

The following analysis will be clearer if I work with elasticities for one group at a time. First note that the elasticity of equation (19) for households with state (s,a) is a weighted average between groups:

$$\varepsilon^S(s,a) = \frac{\varepsilon^{U,S}(s,a) \cdot P_S^U \frac{a_S'^U}{1+r_S} \, \mu \, \mathrm{d}\Psi^U(s,a) + \varepsilon^{I,S}(s,a) \cdot P_S^I \frac{a_S'^I}{1+r_S} \, (1-\mu) \, \mathrm{d}\Psi^I(s,a)}{d(s,a) \left[\mu \, \mathrm{d}\Psi^U(s,a) + (1-\mu) \, \mathrm{d}\Psi^I(s,a)\right]}$$

where each individual elasticity is the object I will study in detail:

$$\varepsilon^{g,S}(s,a) = \frac{\partial \left[\frac{a_S'(s,a)}{1+r_S} P_S(s,a)\right]}{\partial r_S} \cdot \frac{1}{\left[\frac{a_S'(s,a)}{1+r_S} P_S(s,a)\right]}$$

I can now decompose $\varepsilon^{g,S}(s,a)$ into an extensive and an intensive margin. Call $\widehat{a}_S(s,a) \equiv \frac{a_S'(s,a)}{1+r_S}$ to the savings of a household that choose the savings market for simplicity. Expand the product to get

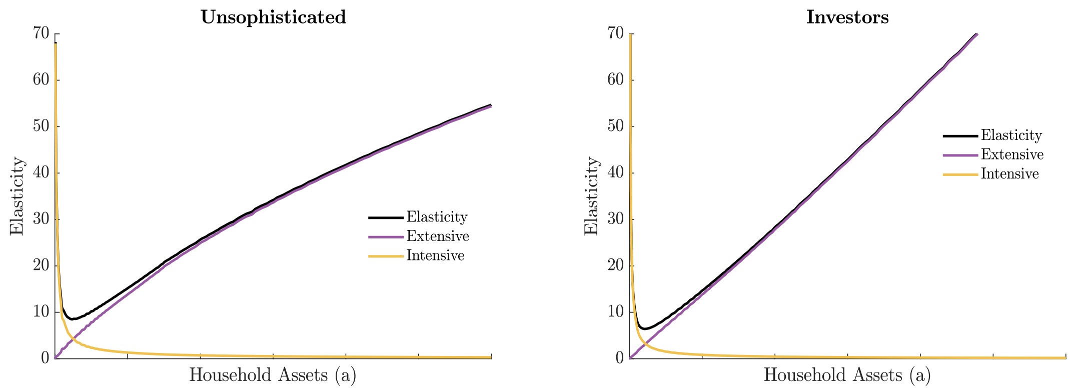
$$\varepsilon^{g,S}(s,a) = \underbrace{\frac{\partial \widehat{a}_S(s,a)}{\partial r_S} \frac{1}{\widehat{a}_S(s,a)}}_{\text{Intensive Margin}} + \underbrace{\frac{\partial P_S(s,a)}{\partial r_S} \frac{1}{P_S(s,a)}}_{\text{Extensive Margin}}$$

Note what these two terms represent: the intensive margin describes the semi-elasticity of the funds of those households that have chosen the savings market, and the extensive margin represents the semi-elasticity of households switching to/from the savings market. Figure 25 next show how these two margins shape household elasticity.

The figure shows that for low values of wealth, this elasticity is decreasing, driven by the intensive margin, which converges to zero as wealth increases. It is later increasing in wealth driven exclusively by the extensive margin. I can explore further the reasons behind these shapes.

Using the budget equation of the households we can get an intuition on why the intensive

Figure 25: Decomposition of Elasticities



margin falls

$$\frac{\partial \widehat{a}_S(s,a)}{\partial r_S}\frac{1}{\widehat{a}_S(s,a)} = -\frac{\partial c_S(s,a)}{\partial r_S}\frac{1}{\widehat{a}_S(s,a)}$$

In incomplete market models, as households get wealthier, policy functions approach full insurance. We know that in full insurance models, the sensitivity of consumption to interest rate is small, then $\frac{\partial \widehat{a}_S(s,a)}{\partial r_S}\frac{1}{\widehat{a}_S(s,a)}$ is close to zero. Moreover, as the household gets wealthy, this number is divided by a large denominator, which pushes the intensive margin to zero. In other words, as the household gets wealthier, consumption is not sensitive to interest rates, especially relative to savings.

For the extensive margin, remember that a household will choose savings deposits that period if the draw in the cost F is such that,

$$\text{Unsphisticated: } \nu_{\mathcal{C}}^{U}(s,a) \leq \nu_{\mathcal{S}}^{U}(s,a) - F$$

$$\text{Investors: } \nu_{\mathcal{S}}^{I}(s,a) \geq \nu_{B}^{I}(s,a) - F$$

I assume that F was Logistically distributed, but let's keep it general for now and call G_g the distribution of F for each group $g = \{U, I\}$. Then, the share of households that choose the savings market of each group is,

$$\text{Unsphisticated:}\quad P_S^U(s,a) = G_U\left(\nu_S^U(s,a) - \nu_C^U(s,a)\right)$$
$$\text{Investors:}\quad P_S^I(s,a) = 1 - G_I\left(\nu_B^I(s,a) - \nu_S^I(s,a)\right)$$

Two objects are key to generating an increasing extensive margin: the response of $\nu(s,a)$ to interest rates and the shape of $G(\cdot)$. The extensive margin therefore is,

$$\frac{\partial P_S^U(s,a)}{\partial r_S}\frac{1}{P_S^U(s,a)} = \frac{G_U'\left(\nu_S^U(s,a) - \nu_C^U(s,a)\right)}{G_U\left(\nu_S^U(s,a) - \nu_C^U(s,a)\right)} \cdot \frac{\partial \nu_S^U(s,a)}{\partial r_S} \tag{21}$$
$$\frac{\partial P_S^I(s,a)}{\partial r_S}\frac{1}{P_S^I(s,a)} = \frac{G_I'\left(\nu_B^I(s,a) - \nu_S^I(s,a)\right)}{1 - G_I\left(\nu_B^I(s,a) - \nu_S^I(s,a)\right)} \cdot \frac{\partial \nu_S^I(s,a)}{\partial r_S} \tag{22}$$

Using the Envelope theorem on the household's problem we get,

$$\frac{\partial \nu_S^g(s,a)}{\partial r_S} = u'(c_S^g)\widehat{a}_S^g\frac{1}{1+r_S}$$

For the log utility case used in the calibration the right hand side simplifies to assets holdings over consumption $u'(c_S^g)\widehat{a}_S^g\frac{1}{1+r_S} = \frac{\widehat{a}_S^g}{c_S^g}\frac{1}{1+r_S}$ which in these class of incomplete markets models is increasing in wealth. Then, we have the second component of the product in the right of equations (21) increasing in wealth. Next, I look at the first component that depends on $G(\cdot)$.

Let's focus first on the case of the investors. The denominator $\left[1 - G_I\left(\nu_B^I(s,a) - \nu_S^I(s,a)\right)\right]$ is decreasing in wealth since the value of bonds vs savings deposits increases with wealth.[46] Then, what we need for the investors' extensive margin to be increasing is that the slope of $G(\cdot)$ does not fall too quickly.[47] For the Logistic case, as well as Exponential or Uniform distribution, this is true.

Conditions for Unsophisticated households having an increasing elasticity are more strict. The reason is that once this households become very wealthy, savings deposits is their best

[46]This is true for the relevant part of the wealth distribution. For the very top wealth holders, the relationship reverts. The reason is that in this model top wealthy households will not pay the cost and invest since the marginal value of consumption converges to zero.

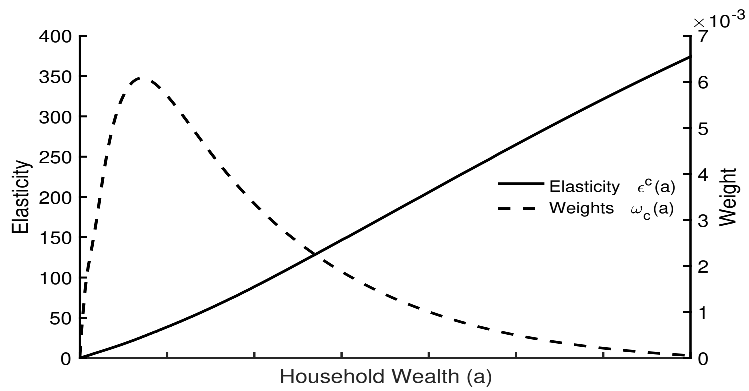
[47]A sufficient condition is that the second derivative of G satisfies: $G'' \geq -\frac{(G')^2}{1-G}$.

option for consumption smoothing. Therefore, the extensive margin -the percent increase in the number of households- elasticity drops for high levels of wealth because the denominator $G_U(\cdot)$ becomes very large. At this point, however, the slope of the elasticity is controlled by Investors, given that they are a large presence in the savings market.

Decomposition of Checking funds semi-elasticity

In the same way that in Figure 6 is shown the decomposition of the semi-elasticity of savings funds into individual elasticities and weights, Figure 26 does for the checking funds.

Figure 26: Decomposition of aggregate semi-elasticity for checking funds



Note: Figure shows the two components of aggregate elasticity from equation (14).

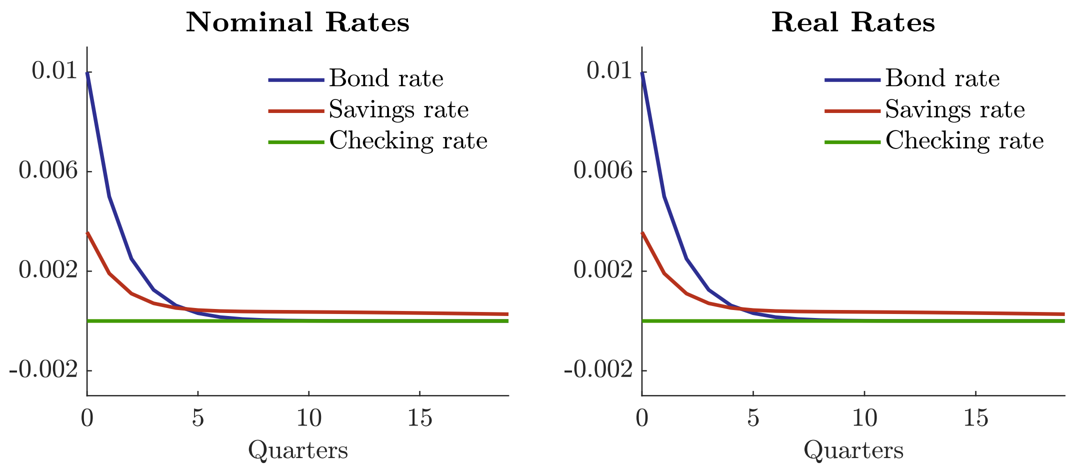
B.1.6 Additional Results on Dynamics

This section shows additional results on the response of the model to shocks. Figure **??** shows the dynamics of the interest rates after a shock that rises the level of the real return on bonds holding prices fixed. Figure 28 shows the response to a shock to the Taylor rule. In both figures, we can see that there is an imperfect passthrough from bond rates to deposit rates.

B.1.7 Additional Results on Households Elasticities: Dynamics

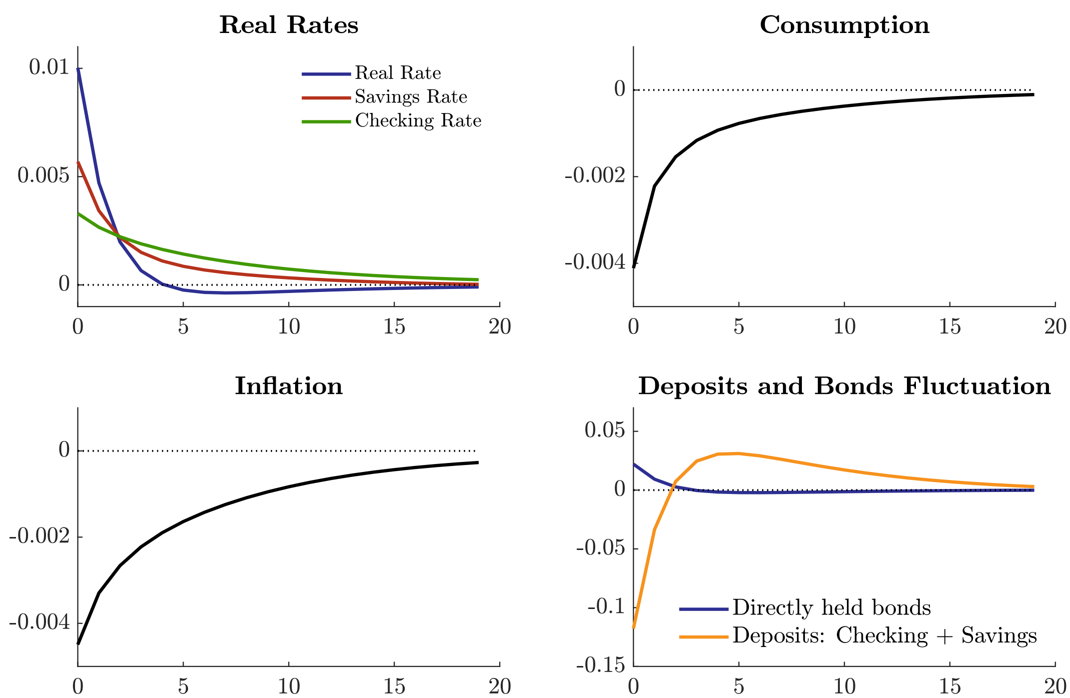
After a shock, movements in the aggregate elasticity of savings deposits can arise from changes in individual elasticities $\varepsilon^S(s,a)$ as well as movements in weights $\omega^S(s,a)$, as equation (14) shows. This section numerically shows that the moving piece of equation (14) after the shock

Figure 27: Dynamics After a Monetary Policy Shock with Fixed Prices



Note: The figure shows the response of the nominal and real rates after a shock that rises the real rate with persistence under the assumption that prices are fixed.

Figure 28: Dynamics After a Monetary Policy Shock



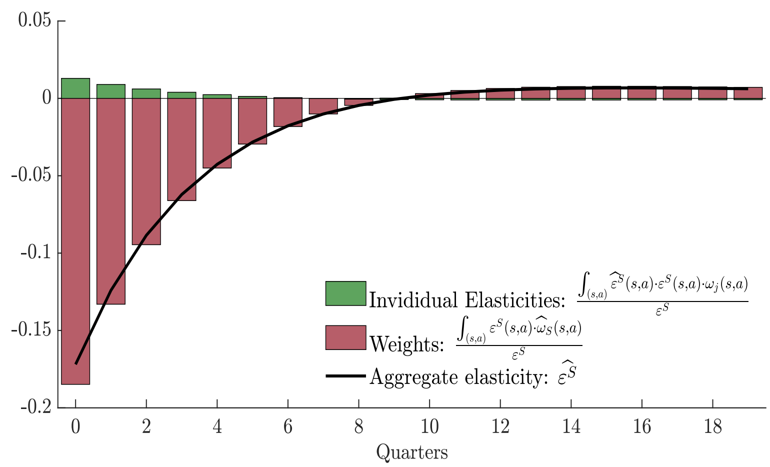
Note: The figure shows the response of the nominal and real rates after a shock to the Taylor rule.

are the weights and not the elasticities. To do this, differentiate equation (14) in logs around the steady state:

$$\widehat{\varepsilon}^S = \frac{\int_{(s,a)} \widehat{\varepsilon}^S(s,a) \cdot \varepsilon^S(s,a) \cdot \omega_j(s,a)}{\varepsilon^S} + \frac{\int_{(s,a)} \varepsilon^S(s,a) \cdot \widehat{\omega}_S(s,a)}{\varepsilon^S} \tag{23}$$

Where variables with a hat "^" refer to deviations from steady state. Figure 29 shows the contribution of each component to the movement in aggregate elasticity after the same shock studied in Section 3.8. As shown in the figure, the redistribution of weights between households with different elasticities is responsible for the movements in the aggregate.

Figure 29: Decomposing the Movements in Elasticity



Note: The figure shows movements in the components of equation (23) after the the Phillips curve (7) with persistence studied in Section 3.8.

B.1.8 Computing Consumption Equivalent Changes

In this section, I show how to compute the required change in lifetime consumption to compensate between two economies with different aggregates paths. I focus on steady state environments which exclude deviations of inflation from trend.[48]

The welfare in the calibrated benchmark economy for an agent with state variables (s, a)

[48]Inflation deviations from trend is relevant only in the short run. Since I only calculate welfare changes between steady states in the paper or under flexible prices, I exclude them from the equations. Adding this cost is straightforward.

-before the trading cost is realized- is given by the discounted value of optimal consumption c_t^* and trading decisions I_t^*:

$$V(s,a) = \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left(u(c_t^*) - I_t^* \cdot F_t\right)\right]$$

(note that labor cost is not present because will be the same if both economies). If consumption in the benchmark economy increases by $\gamma\%$ -keeping the trading and savings decisions constant- the welfare of the agent is,

$$V_{\text{Bench}}(s,a;\gamma) = \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left(u(c_t^*(1+\gamma)) - I_t^* \cdot F_t\right)\right]$$

Take an economy with high inflation, I will search for the value of γ such that

$$V_{\text{Bench}}(s,a;\gamma) = V_{\text{Inf}}(s,a)$$

for each pair (s,a). The computation of γ is not straightforward because $V(\cdot)$ is not homogenous in γ. However, the consumption part of the welfare is homogenous:

$$V_{\text{Bench}}(s,a;\gamma) = \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t\left((1+\gamma)^{1-\sigma}u(c_t^*) - I_t^* \cdot F_t\right)\right]$$

Define,

$$U(\gamma) \equiv \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t(1+\gamma)^{1-\sigma}u(c_t^*)\right]$$
$$\mathcal{F} \equiv \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t I_t^* \cdot F_t\right]$$

Then, the consumption equivalent needed is obtained by,

$$\gamma(s,a) = \left[\frac{V_{\text{Inf}}(s,a) + \mathcal{F}_{\text{Bench}}(s,a)}{U_{\text{Bench}}(0)(s,a)}\right]^{\frac{1}{1-\sigma}}$$

The average γ is then computed as,

$$\overline{\gamma} = \int \gamma(s,a)\mathrm{d}\Psi(s,a)$$

where $\Psi(s,a)$ is the steady state distribution.

B.2 Additional Results on Calibration

This section shows additional results from the model and compares them with the data. All these moments have not been targeted.

Table 9 shows the model performance on measures of asset distribution. Getting this distribution right on simple heterogeneous agent models has been shown to be a challenge. The table shows that the model does a reasonable job in getting the asset distribution, especially if compared to the trimmed data, even without assuming a very unequal income process. The counterfactual scenario performed in Section 5.2 points to the heterogenous returns being the source of this success.

Table 9: Model performance on assets holdings distribution

	Model	**Data**	**Data trimmed top 1%**
Gini Assets	0.82	0.925	0.86
Gini Income	0.37	0.64	
Asset holdings share			
Top 10%	0.68	0.896	0.79
Top 20%	0.88	.955	0.9
50-80%	0.11	0.04	.08
0-50%	0.01	0.005	0.02

Note: Data calculations are for the year 2007 and are calculated using the SCF for the definition of liquid assets in Section 2. Income refers to total income. Data Trimmed re-do the calculation excluding the top 1% of asset holders from the sample.

The size of the deposits market is 20% of GDP in the model which is very close to the 22% calculated using the definition of deposits in Section 2 and total income from the SCF in 2007. Also, bank profits are 0.76% of output in the model, which is very close to the 0.8% of the profits in the financial U.S. sector relative to private industry GDP.

The model generates an average marginal propensity to consume of 39%, a number on the upper bound of the range generally targetted in this class of models. It does so because the share of hand-to-mouth agents -those that are borrowing constrained- is 36%, which can be viewed as a large share.[49]

Finally, I compute the model counterpart of the transition matrix in Appendix A.3 (reproduced again here for clarity). As Table 10 shows, the model is able to generate some persistence between Bank-dependency and the market investor-state, generated by the fact that wealth is persistent in these models. The assumption of idiosyncratic trading cost shocks needs to be relaxed for one that depends on the departing state if one wants to target this transition matrix.

Table 10: **Model**

	Deposits	**Investor**
Deposits	0.81	0.19
Investor	0.33	0.67

Table 11: **Data**

	Deposits	**Investor**
Deposits	0.94	0.06
Investor	0.02	0.98

B.3 Dynamics' Computation

The economy starts in the calibrated steady state with only idiosyncratic risk. I will study perfect foresight transition sequences after a small departure from steady state. By certainty equivalence, if the shock is transitory and small, the solution will be identical to the analogous economy with aggregate risk solved using conventional first-order perturbation techniques with respect to aggregate variables.

A fast and accurate methodology to solve these type of problems has been developed in Auclert, Bardóczy, Rognlie, and Straub (2021) and extended to discrete choice problems in Bardóczy (2020). The idea is to obtain the truncated Jacobians of the equilibrium equations of the model. A key assumption for the accurate implementation of this method in my model

[49] Although estimations of hand-to-mouth agents in the data can be greater than this number. See Table 2 of Boar, Gorea, and Midrigan (2021).

is the presence of random trading costs in order to make aggregate demands smooth. For details on the method refer to the cited papers.

B.4 Labor Unions

Unions adjust nominal wages subject to a quadratic adjustment cost that enters into households' utility. In particular, I will assume that the preferences of the households have an extra term arising from adjustment costs: $v(n_{ti}) + \frac{\psi}{2}\int_k \left(\frac{W_{kt}}{W_{kt-1}} - (1+\overline{\pi}_t)\right)^2 dk$ where $v(n_{ti})$ takes the functional form assumed in Section 3.7 and $\overline{\pi}_t$ is trend price inflation.[50] Total labor supplied by a household i is the aggregation over all the tasks k: $n_{ti} = \int_k n_{tik}\mathrm{dk}$[51]. It is assumed that unions use a uniform rule and call their members to work the same number of hours independently of their productivity and wealth $n_{tik} = N_{tk}$ where N_{tk} is the total hours in union k. Under this assumption the marginal cost of an extra hour supplied is equalized across households.

Given that the value of extra income is not equalized across households due to incomplete markets, union k is assumed to value income using the marginal utility of consumption valued at the average[52]. Union k set wages following,

$$(1-\tau_t)(1-\varepsilon_{wt})N_{kt}\frac{1}{P_t}u'(C) + \varepsilon_{wt}v'(N)\frac{N_{kt}}{W_{kt}} = \psi\left[\frac{W_{kt}}{W_{kt-1}} - \overline{\pi}_t\right] - \beta\psi\left[\frac{W_{kt+1}}{W_{kt}} - \overline{\pi}_{t+1}\right]\frac{W_{kt+1}}{W_{kt}^2}$$

Note that the problem is symmetric in k. Simplifying and avoiding the time notation I get the non-linear Phillips curve on wages,

$$\widehat{\pi}_w(1+\pi_w) = \frac{\varepsilon_w}{\psi}N\left[v'(N) - (1-\tau)wu'(C)\frac{\varepsilon_w - 1}{\varepsilon_w}\right] + \beta\widehat{\pi}'_w(1+\pi'_w) \tag{24}$$

where $\widehat{\pi}_w$ are deviations from price trend inflation $\widehat{\pi}_w \equiv \pi_w - \overline{\pi}$. Under flexible prices -and in steady state-:

$$v'(N) = (1-\tau)wu'(C)\frac{\varepsilon_w - 1}{\varepsilon_w}$$

[50]This assumes full indexation of wages to trend inflation at no cost

[51]Effective hours are $n_{ti} = \int_k s_{ti}n_{tik}\mathrm{dk}$

[52]This assumption has been previously used in Wolf (2021) among others and has been shown to have only negligible differences if compared to a union that maximizes the average utility of its members.

Linearizing equation (24) around steady state trend inflation gives equation (7).[53]

C Long-run Consequences of Inflation

This section complements Section 4.1 in the paper with additional results and explanations. It begins with deepening the understanding of why the passthrough from bond rates to savings rates is greater than one in the long run. Later, it presents additional results.

Response of Savings Return

From Section 3.6 we know that two key elements shape banks' optimal return on savings: the semi-elasticity of savings deposits ($\varepsilon^{\mathcal{S}}$) and the profits from checking ($\mathcal{C} \cdot (r - r_C)$).

How does the semi-elasticity of savings deposits ($\varepsilon^{\mathcal{S}}$) change in the new equilibrium and why? Remember from the analysis of Section 3.6 that the elasticity of deposits is the weighted sum of individual elasticities. I can decompose equation (14) into an average component and a covariance

$$\varepsilon^{\mathcal{S}} = \mathbb{E}\left[\varepsilon^{\mathcal{S}}(s,a)\right] + \operatorname{cov}\left(\varepsilon^{\mathcal{S}}(s,a), \frac{d^{\mathcal{S}}(s,a)}{\mathcal{S}}\right) \tag{25}$$

where the expectations are taken over the distribution of states $\Psi(s,a)$ and $d^{\mathcal{S}}(s,a)$ are the average holdings of savings deposits by households with states (s,a). The increase in inflation redistributes funds towards wealthy investors, which from Figure 6 we know are also the elastic households. This, pushes up the covariance term in equation (25). In the new steady state, the funds in the savings deposit market are now in the hands of the more elastic households, which pushes up the interest rate in equilibrium.[54]

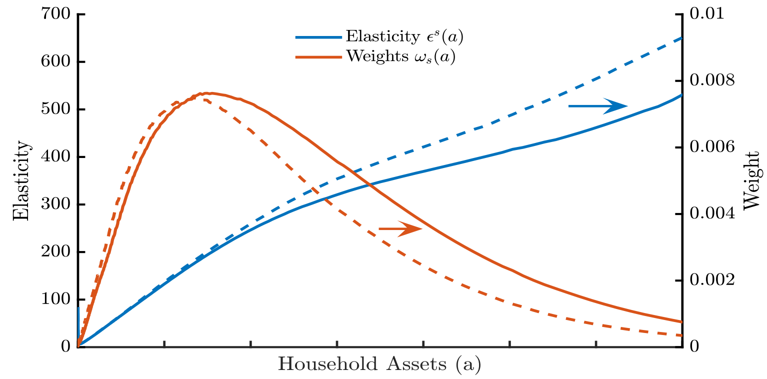
We can also reproduce Figure 6 again under high inflation to see how the new equilibrium shifts the holdings of savings deposits. The dashed line of Figure 30 reproduces the benchmark equilibrium and the solid the new under high inflation.

Additionally, the fall in checking rates disincentivizes households from keeping funds in

[53] Note that in the linearization it is assumed that $\pi_w \approx 0$ and short run movements in tax rate are excluded. This decision does not have any substantial implication for my results and is just to get a standard Phillips curve. Some papers assume that short run tax adjustments are done using a different set of taxes, and not the labor tax, which is sufficient to get the derived Phillips curve.

[54] In fact, almost the entire rise in the elasticity is due to the increase in the covariance term.

Figure 30: Decomposition of aggregate semi-elasticity of savings funds



Note: Figure shows the two components of aggregate savings deposits elasticity from equation (14). The solid lines represent the high inflation steady state and the dashed ones the calibrated benchmark.

the form of checking deposits. Therefore, even though the profits per unit of checking deposit $(r - r_{\mathcal{C}})$ increased, the quantity of checking deposits fall by more, reducing the incentives to lower the rate on savings in order to keep the funds in the form of checking. This force adds to the higher elasticity of savings deposits in pushing up the rate on savings in equilibrium.

Additional Results

Table 12 shows additional results in the equilibrium under high inflation and compares them with the benchmark economy.

D Short-run Consequences of Inflation

This section complements Section 4.2 in the paper with additional results and explanations.

Consumption Response

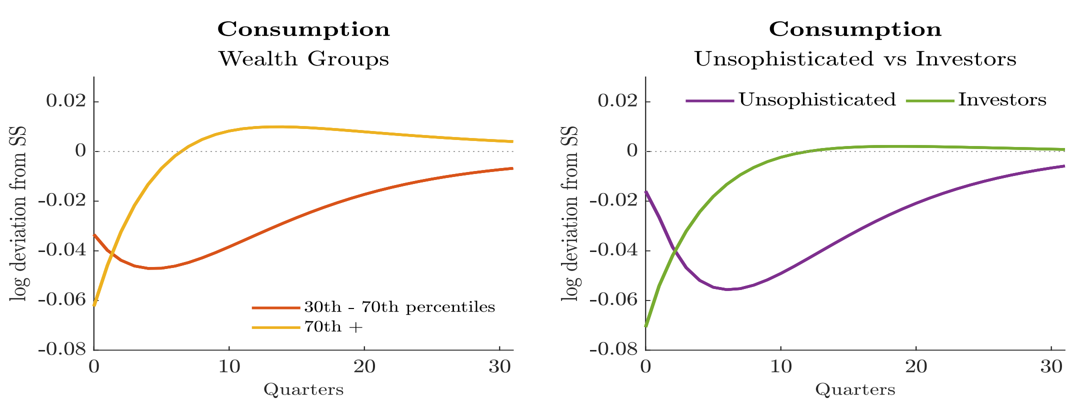
Figure 31 shows the response of consumption for different wealth groups and types of households after the shock studied in Section 4.2. The different pattern in the consumption response arises because households are exposed to different paths of real rates. In particular, households cut down consumption due to the decrease in income, but mid-wealth households

Table 12: Distributional Consequences of High Inflation

	Benchmark ($\bar{\pi} = 3\%$)	**High-inflation ($\bar{\pi} = 13\%$)**
Government bonds/Output	130%	126%
Share assets Unsophisticated	5.5%	2.8%
Share deposits Unsophisticated	34.5%	18%
Share assets 50-80th percentiles	11%	10%
Share assets bottom 50%	1.1%	0.5%
Bank-Dependent households	63.5%	64.1%
Share of deposits in total assets	15.8%	17.9%
Share of checking in deposits	23.6%	8.3%
Bank profits/Output	0.76%	0.62%
S.d. Consumption	0.516	0.523
S.d Consumption Unsophisticated	0.54	0.56
S.d Consumption Investors	0.497	0.496

decide to drain their assets and prevent a sharper drop because they are exposed to negative real rates.

Figure 31: Consumption Response to a Supply Shock

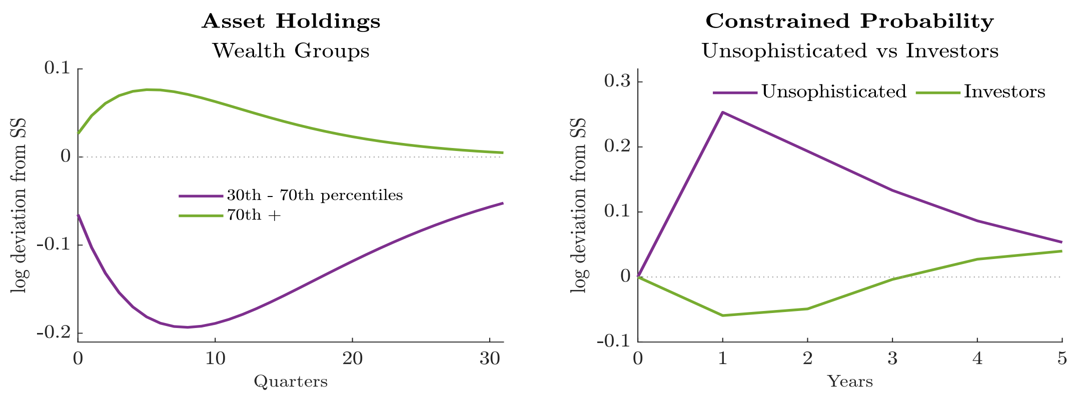


Note: The figure shows the response of consumption after a shock to the Phillips curve (7) with persistence. Wealth groups are computed before the shock hits and the response of these same households are tracked.

Households Types Response

Figure 32 shows the average response to the shock studied in Section 4.2 but now splitting the population between the two ex-ante heterogeneous households. Note that the pattern is very similar to the case study in the body of the paper: Unsophisticated households are mainly poor households who save in the form of deposits and are exposed to negative real rates.

Figure 32: Groups Response to a Supply Shock



Note: The figure shows the response of average asset holdings and constrained probability after a shock to the Phillips curve (7) with persistence.

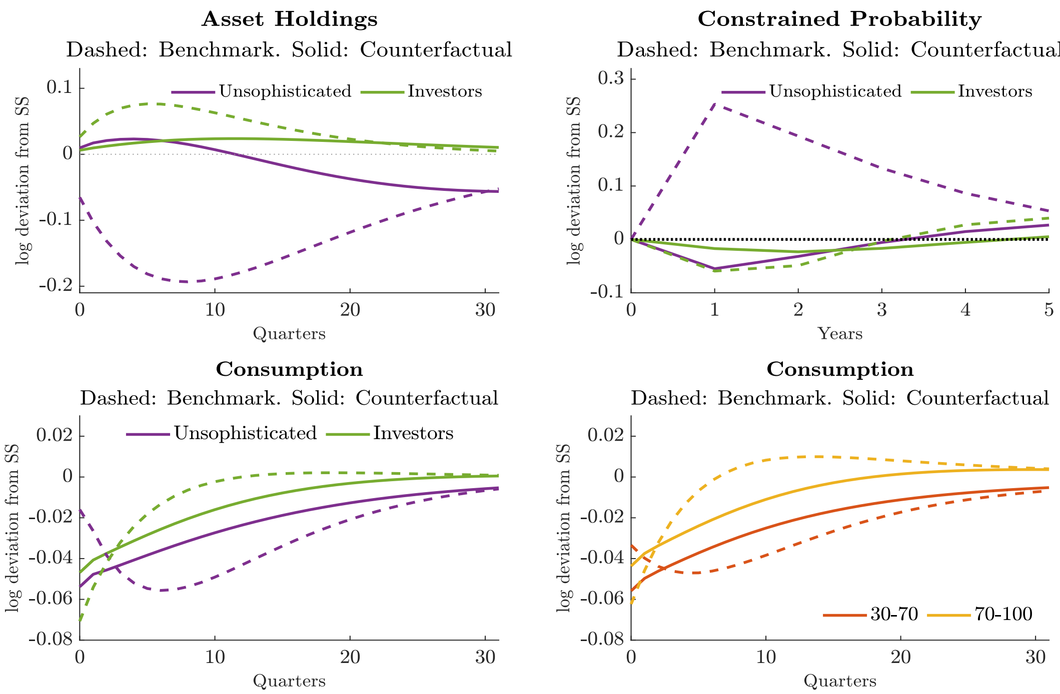
Full Passthrough Counterfactual

Figure 33 shows the response of additional variables to the supply shock and compares them with the counterfactual scenario that features full passthrough from market returns to deposit rates. The two bottom panels show how differently consumption responds when al;l interest rates move together. In particular, it is clear that mid-wealth households do not have extra incentives to reduce their asset holdings when there is full passthrough.

Full Passthrough: Unpacking the Different Response

In Section 4.2 it was shown that the same recession under full passthrough generates different paths of asset accumulation and constrained probability for mid-wealth households. However,

Figure 33: Groups Response to a Supply Shock



Note: The figure shows the response of the movements in average asset holdings, changes in the probability of hitting the borrowing constraint, and consumption after a shock to the Phillips curve (7) with persistence. The benchmark economy refers to the calibrated version. The counterfactual assumes that movements in interest rates are equalized (full passthrough). Wealth groups are computed before the shock hits and the response of these same households are tracked.

the different path of bond rates between the two economies also generates a different path of taxes. This section decomposes the contribution of interest rates and taxes in driving the different responses between the two economies. For illustrative purposes, I focus here on the drivers of the path for average asset holdings.

The left panel of Figure 34 shows the path of average asset holdings for mid-wealth households in the benchmark and counterfactual economy. I will argue that the heterogeneous path of the interest rate plays an important role in driving the difference between the solid and dashed lines.

To decompose the effect between taxes and returns, I compute the response of average asset holdings of mid-wealth households fitting the path of taxes and returns, one at a time. That is, consider the path of interest rates and taxes in the benchmark economy $\{dr, dr_S, dr_C, d\tau\}$

and in the counterfactual economy $\{d\widehat{r}, d\widehat{r}_S, d\widehat{r}_C, d\widehat{\tau}\}$. Label the average path for mid-wealth asset holdings along the path $d\mathcal{A}(dr, dr_S, dr_C, d\tau, dS)$.

The violet bars in the right panel show the size of the distance between the solid and the dashed line in the left panel if only interest rates change between economies. That is, $d\mathcal{A}(d\widehat{r}, d\widehat{r}_S, d\widehat{r}_C, d\tau) - d\mathcal{A}(dr, dr_S, dr_C, d\tau)$. The yellow bars in the right panel show the size of the distance between the solid and the dashed line in the left panel if only taxes change between economies. That is, $d\mathcal{A}(dr, dr_S, dr_C, d\widehat{\tau}) - d\mathcal{A}(dr, dr_S, dr_C, d\tau)$. The sum of the violet and yellow bars add to the linear distance between the solid and dashed lines in the left panel.

What we can see in the figure is that the changes in the interest rates are the main driver, especially in early periods, of the extra asset accumulation by mid-wealth households in the counterfactual economy that features full passthrough.

Figure 34: Decomposing the Role of Interest Rates and Taxes