Financial Frictions: Micro vs Macro Volatility *

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Abstract

We argue that consumer credit spreads matter materially for household choices and that time-varying spreads have important distributional consequences. Studying Danish household data, we show that elevated consumer credit spreads reduce indebted households' consumption and that the marginal propensity to consume is countercyclical partially due to credit spreads. We study a HANK-model in which banks provide consumer credit and corporate loans. Through countercyclical credit spreads, frictional finance amplifies aggregate shocks ***and*** induces consumption inequality. Economies with less leveraged banks may experience reduced aggregate volatility by muting the financial accelerator, but may also face higher volatility and lower welfare at the household level.

JEL Codes: C11, D12, D31, E32, E52, G51

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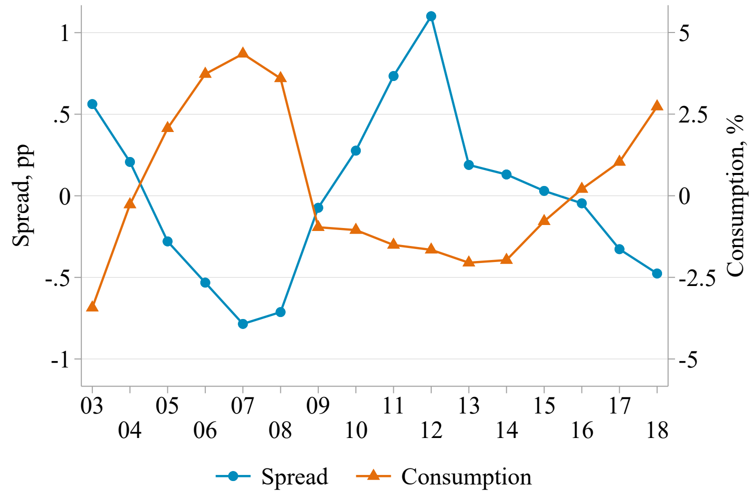
1 Introduction

Financial intermediaries play an important role in modern economies by facilitating the flows of funds from savers to borrowers. This intermediation process is associated with frictions that introduce spreads between the cost of debt faced by borrowers and the return on savings offered to savers. Much work has studied the impact of corporate borrowing spreads, especially in terms of how such spreads can amplify the effects of aggregate shocks. We broaden the focus and partially shift the attention to the consumer credit spread. Studying Danish household data, we find that elevated consumer credit spreads reduce indebted households' consumption spending, that the average marginal propensity to consume is countercylical, and that credit spreads matter for this. Using a rich Heterogeneous Agents New Keynesian (HANK) model with banking, we argue that consumer credit spreads are important for understanding the distributional effects of aggregate shocks. We also show that economies with less leveraged banks may be less prone to financial accelerator mechanisms at the aggregate level, but at the same time suffer from high volatility at the household level.

The importance of consumer credit spreads for macroeconomic outcomes and household choices has been noted before. Pissarides (1978) shows that such credit spreads invalidate the decoupling of income and consumption dynamics embedded in the permanent income hypothesis under perfect foresight. Davis, Kubler and Willen (2006) study how credit spreads affect household portfolio choices, while Kaplan and Violante (2014) focus on their impact on the marginal propensity to consume (MPC). Zeldes (1989) shows that credit cost differences between households matter for Euler equation-based tests of consumption dynamics under liquidity constraints. However, the lack of data on household-specific interest rates leads Zeldes (1989) to proxy the effect of liquidity constraints by the ratio of liquid assets to income, a practice followed in much subsequent work, including important studies that estimate the MPC such as Johnson, Parker and Souleles (2016). An important exception to this practice is Kreiner, Lassen and Leth-Petersen (2019), who study the impact of cash transfers in Denmark in 2009 and argue that differences between in "marginal interest rates" across households predict spending decisions.

We make three major contributions. First, we provide new empirical evidence on the importance of consumer credit spreads for household consumption and asset dynamics. Secondly, we study a rich HANK model with idiosyncratic and aggregate risk in which financial intermediaries simultaneously provide consumer credit and corporate loans. We quantify the model, relate it to micro-data, and examine its consequences for aggregate outcomes and for distributional issues. Third, we use the model to consider how the leverage of the banking sector matters for aggregate outcomes and for household welfare across the wealth distribution.

Our empirical analysis studies a rich household-level dataset for Denmark that contains about 18 million household $\times$ time observations for the period 2003-18. The dataset combines administrative data on household characteristics, income, and asset positions with bank-reporting data on interest



Notes: Annual consumption is imputed from household balance sheets as described in Section 2, aggregated and then detrended using a 5th order polynomial. The spread is measured as the average cross-household bank-level spread between borrowing and deposit rates.

Figure 1: The Cyclicality of Interest Rate Spreads

rates. We exploit the bank-reporting data to measure household-level consumer credit spreads by associating each household's main banking connections with the interest rates charged or offered by these banks. Figure 1 shows the time series of the cross-sectional average consumer credit spread over the sample period plotted against detrended aggregate Danish consumption spending. It is evident that the average interest rate spread is strongly countercyclical.[1]

On average, close to 9 percent of Danish households hold less net assets than two weeks income. We show that movements in and out of this "zero net wealth" state depend on household income and consumer credit spreads. There are also important links between consumption spending, income, and credit spreads. Higher income is associated with higher consumption spending across the net wealth distribution, but most strongly so for lower wealth households. The relationship of consumption and credit spreads instead depends on the net wealth position and is negative for indebted and moderately wealthy households but postive for wealthier households. Higher spreads increase the association between consumption spending and income, especially for poorer households. We derive a measure of the average consumption-to-income elasticity that varies over the business cycle as households move across net wealth states and because of cyclical movements in credit spreads. This elasticity is volatile and countercyclical and credit spreads contribute to both its volatility and cyclicality.

We formulate a novel HANK model in which banks intermediate between savers and borrowers and use it to analyze the aggregate and distributional consequences of aggregate shocks when banking frictions generate endogenously time-varying credit spreads. Households supply labor, consume, and make asset allocation choices. They are subject to idiosyncratic income risk and to aggregate shocks, can save in bonds and bank deposits, but rely on bank-intermediated consumer loans if they want

[1] The consumer credit spread is also countercyclical in the U.S., see Lee, Luetticke and Ravn (2020).

credit. The corporate sector is modeled in a standard New Keynesian fashion with capital purchases financed by corporate equity issuance. Banks invest in consumer loans and in corporate loans financed by combining household deposits with net worth. Following Gertler and Karadi (2011), an agency problem constrains banks' leverage. Finally, a central bank sets the short-term nominal interest rate, and a fiscal authority is responsible for debt, tax, and spending policies. We allow for aggregate shocks to monetary policy, total factor productivity, and capital quality, a shock that affects the net worth of banks. Due to the agency problem, interest rate spreads respond countercyclically to aggregate shocks which introduces a financial accelerator mechanism that amplifies aggregate shocks. In RANK models, the amplification occurs through the corporate borrowing spread which induces investment volatility. In our setting, there is an additional channel through the consumer credit spread. Higher credit spreads in recessions make it expensive for indebted households to borrow when income is low which destabilizes aggregate consumption and induce differences in expected consumption growth rates for borrowers and savers that are transmitted over time through asset dynamics. Moreover, households with little or no wealth are faced with a "kink" in the budget constraint which induces a mass point in the wealth distribution with high MPCs.

We calibrate the model to aggregate and household-level targets and confront it with both aggregate data and household data. The model accounts for aggregate business cycle statistics, and we show that, as in the data, the consumer credit spread is countercyclical,[2] while consumer credit is procyclical and volatile. It can also account for interesting features of the relationship between spreads and asset dynamics observed in the data. The MPC is countercyclical in the model and financial frictions matter for this because higher spreads in recessions discourage spending by debtors and increase the income sensitivity of households who are close to the kink in the budget constraint. The average MPC in the model is highly correlated with the consumption-to-income elasticity measure that we estimated in the Danish household data, thus indicating that the latter may serve as a sufficient statistic for the MPC. To our knowledge, the only other existing evidence on countercyclical MPCs is Gross, Notowidigdo, and Wang (2020), who use the removal of bankruptcy flags from credit reports to estimate MPCs in the U.S. and their time variation.

A key insight of our analysis is that financial frictions in the face of idiosyncratic risk induce heterogeneous effects of aggregate shocks across the wealth distribution. Consider, as an example, a contractionary monetary policy shock. Indebted households face higher costs of borrowing and lower labor income and therefore reduce their consumption in the short run. Wealthy households instead receive higher returns on their savings and may increase their consumption spending despite the impact of the intertemporal substitution effect and falling labor income. Thus, in the short run, consumption diverges across the wealth distribution, while over longer horizons, interest rates return to normal, and consumption responses converge across the wealth distribution. Such short-run

[2]The model also generates a countercyclical corporate borrowing spread, an implication consistent with empirical evidence, see e.g. Gilchrist and Zakrajsek (2012).

divergence and longer-run convergence are consistent with empirical evidence from household data, see e.g. Holm, Paul and Tiscbirek (2021). We also extend the baseline model with an illiquid asset, productive capital held by households, that induces "rich hand-to-mouth" households as in Kaplan and Violante (2014). We show that such heterogeneous effects of aggregate shock do not arise in the model with illiquid assets in the absence of banking frictions.

Finally, we investigate how the degree of leverage in the banking sector matters for aggregate and household outcomes. When banks are less leveraged, interest rate spreads rise, but become less cyclical which mutes the financial accelerator. In the HANK economy, higher consumer credit spreads stimulate labor supply and precautionary savings. Thus, cyclical stabilization of the economy may be accompanied by higher aggregate output. However, there are important trade-offs at the household level because higher consumer credit spreads increase the cost of household consumption smoothing in the face of idiosyncratic income shocks and, additionally, decrease the returns on savings which impacts negatively on wealthy households. Thus, while households gain from lower aggregate volatility when banking leverage falls, we find welfare costs across the wealth distribution.

Our paper contributes to the literature on financial frictions, cf. Bernanke and Gertler (1989), Carlstrom and Fuerst (1997), Christiano, Motto and Rostagno (2014), Gertler and Karadi (2011) or Gertler and Kiyotaki (2010). We add incomplete markets and heterogeneous agents to this literature, and model banks more broadly as supply both corporate loans and consumer credit. We also contribute to the literature on unsecured consumer credit, see for example Athreya (2002), Chatterjee et al (2007) or Nakajima and Rios-Rull (2019). This literature has mainly focused on the impact of consumer default risk, while ours focuses on agency problems in the financial sector as in Curdia and Woodford (2011). We argue that these factors, which Dempsey and Ionescu (2021) find empirically important for understanding variations in credit spreads, matter for consumption dynamics.

Relative to the HANK literature, cf. Bayer et al (2019), Kaplan, Moll and Violante (2018), McKay and Reis (2016), Ravn and Sterk (2017), we introduce financial intermediation in addition to the lack of insurance against idiosyncratic risk. We show that this has important consequences for the distributional impact of aggregate shocks. Fernandez-Villaverde, Hurtado and Nuno (2023) also introduce frictional financial intermediation into a heterogeneous agent framework, but focus on the impact on aggregate risk in a setting that abstracts from goods market frictions and household debt. Wang (2018) studies a model of frictional financial intermediation and household heterogeneity, where the latter derives exclusively from life-cycle issues. Most similar to us, Bigio and Sannikov (2023) consider a model with incomplete markets, sticky prices and banking frictions, and also argue that there are trade-offs between macro stabilization and micro volatility. Differently from us, these authors focus entirely on monetary policy, and, in particular, on reserve policies. Moreover, our paper provides micro evidence on financial frictions. Finally, the paper adds new insights on the impact of financial regulation, see Bianchi and Mendoza (2010), Farhi and Werning (2016), Lorenzoni (2008) or Stein (2012). Our contribution is the introduction of heterogeneous agents and idiosyncratic risk.

2 Spreads and Household Consumption: Empirical Evidence

We first provide empirical evidence on the relationship between consumption, income, assets, and credit spreads using Danish administrative data.

2.1 Data and Measurements

We study annual Danish register data provided by Statistics Denmark for the sample period 2003-2018. Basic information on age, sex, education, household characteristics, and income and wealth are compiled by Statistics Denmark by merging administrative data with income tax return data. In addition, we combine income tax return data with bank-level reporting of interest rates to Danmarks Nationalbank as part of its Monetary and Financial Institutions (MFI) data.[3]

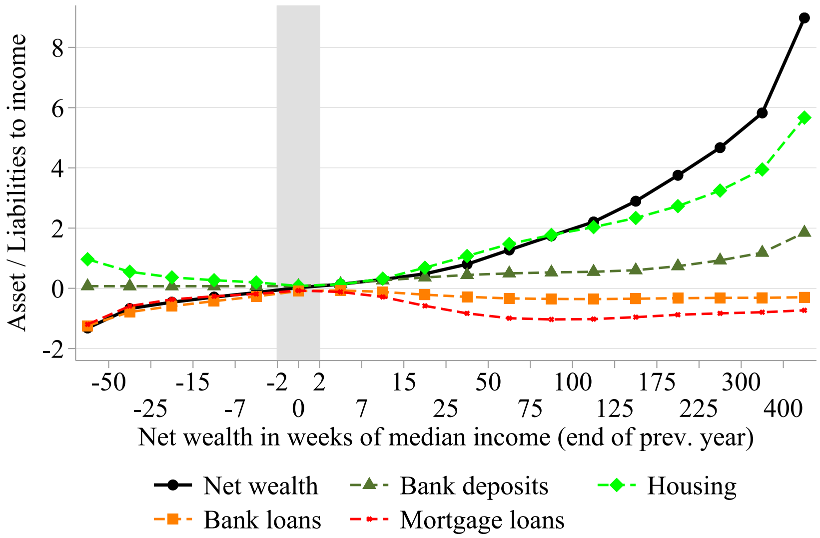
We follow the imputation method in Crawley and Kuchler (2023) to measure consumption spending of household i in year t, $C_{i,t}$:

$$C_{i,t} = Y^L_{i,t} + Y^F_{i,t} - P_{i,t} - (A_{i,t+1} - A_{i,t}) \tag{1}$$

where $Y^L_{i,t}$ is after-tax labor income net of transfers, $Y^F_{i,t}$ is after-tax financial income, $P_{i,t}$ are contributions to privately administered pension schemes, and $A_{i,t}$ is beginning of period t net assets. When imputing consumption, the net worth measure, $A_{i,t+1}$, (household net worth at the end of the year t) includes portfolio wealth, bank deposits, and bank debt all of which are reported in the household tax return data.[4] The wealth measure *does not* include net housing wealth, pension wealth or business wealth. The capital income measure excludes unrealized capital gains, but includes realized capital gains on certain securities (subject to taxation in Denmark). Following Crawley and Kuchler (2023), we make the following selection choices. First, due to the lack of data on business assets, we exclude households with self-employed members or with substantial income from private businesses. Second, because housing values are not included when imputing consumption, we exclude households involved in a housing transaction in the current or previous year, as their (net of housing) wealth estimates may jump in this window inducing unreasonable estimates of $c_{i,t}$. Third, households with negative imputed consumption expenditures are excluded. Finally, we exclude households in the bottom and top one percent of the wealth or income distribution and the first observation for each household. The nominal spending measures are deflated by the consumer price index to produce a real measure of household consumption spending, $c_{i,t}$. The total number of year $\times$ household observations is about 18 million, and summary statistics are reported in Appendix A. Aggregated across households, the imputed consumption measure matches closely survey-based national accounts estimates of consumption for Denmark, see Abildgren et al (2018).

[3]The relevant bank data have been deposited and merged at Statistics Denmark.

[4]Some large durable goods, such as cars, are also included.



Notes: The figure shows the average asset and liability to income ratios for deciles of the net wealth distribution. Average ratios are first constructed for each decile and year, then averaged over the period 2003-2018. Net wealth is the value of assets less liabilities. Assets exclude business and pension assets.

Figure 2: Net Wealth and Asset Distribution in Denmark

Figure 2 shows the net wealth distribution and its four most important components normalized by annual household income. The net wealth measure here includes housing net of mortgage debt, but not business assets and pensions. We define the bins of the net wealth distribution in terms of weeks of median income with bounds chosen so that they are roughly equal sized. The net wealth-to-income ratio goes from close to eight for the wealthiest decile to about minus one for the poorest decile. 8.7 percent of households, located in the gray shaded zone, hold no more than two weeks of median income in net assets, and typically have very few gross financial assets and liabilities as well. Those in the top decile tend to hold positive bank deposits and have little bank debt, while those in the bottom deciles hold no bank deposits but have considerable bank debt. 25.2 percent of households have negative net wealth exceeding two weeks of median income, and 66.1 percent of households have positive net wealth.

We combine tax return data and bank-level reporting of interest rates included in the MFI data to estimate household-level interest rate spreads. Danish households report the end-of-calendar year balances on all their bank accounts to the tax authorities. Deposits are mostly traditional bank accounts, but include also some slightly less liquid products. Bank loans include credit card debt, overdraft accounts, bank loans, student loans, etc. We then define each household's primary bank connections for loans and deposits separately as the banks in which they have the largest end-of-calendar year balance, and, using this, we derive a household-specific interest rate spread, $R^S_{i,t}$, as the difference between the loan rate at household i's primary loan bank and the return on deposits at its primary deposit bank in year t. We use the averages of the interest rates the banks applied during year t to measure these spreads. If a household does not have loans, we use the loan rate of the primary deposit bank. Mortgage loans in Denmark are predominantly supplied by specialized Mortgage Credit Institutions (MCIs) which do not form part of the MFI data, and interest rates on these are therefore excluded from the data. Commercial banks provide a tiny fraction of all mortgage loans (2.8 percent in 2020), and although these loans are included in our data, loans and interest rates on them should therefore be considered as referring to non-mortgage debt.

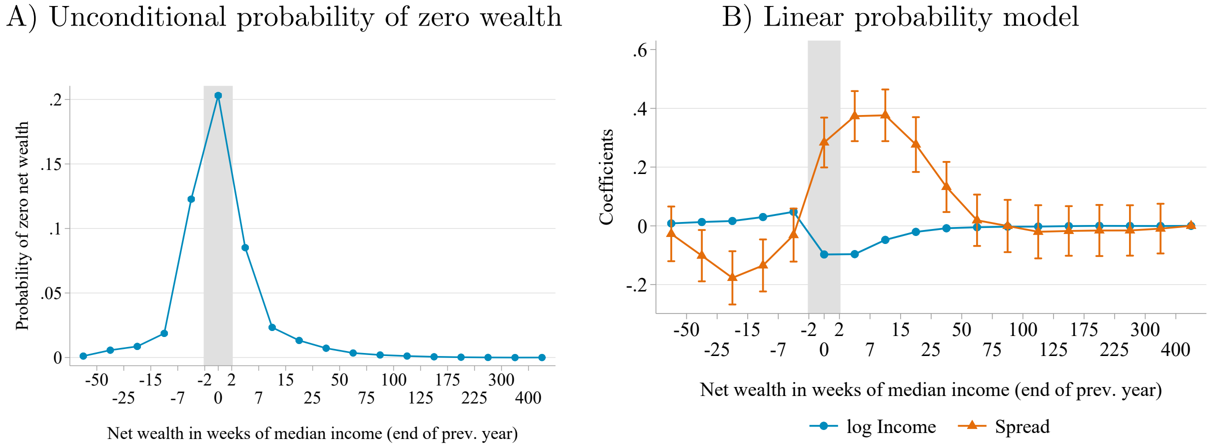
2.2 Results

Using a threshold of two weeks of median income, Figure 3 Panel A shows the fraction of households with zero net wealth at the end of the year across bins of the beginning of year net wealth distribution (again measured in terms of weeks of median income). Approximately 21 percent of households that begin the year with zero net wealth find themselves in that situation at the end of the following year. There is considerable movement into this state by households in the immediately adjacent bins of the net wealth distribution, while there is essentially no risk that households in the upper bins move into this state within one year. To understand the determinants of such wealth dynamics, we estimate:

$$\mathbf{1}_{(|A_{i,t+1}| \leq Y_i^{Crit})} = \sum_j \mathbf{1}_{(A_{i,t} \in A_j^{Net})} \beta_j X_{i,t} + \alpha_i + \gamma_t + \varepsilon_{it} \tag{2}$$

where $\mathbf{1}_{(|A_{i,t+1}| \leq Y_i^{Crit})}$ is a dummy equal to 1 for households with net wealth at the end of calendar year t below two weeks of median weekly income (in 2007), α_i is a household specific effect, and γ_t is a time-fixed effect. $X_{i,t}$ consists of a wealth bin-specific constant, household-specific interest rate spreads and residualized household income estimated as the residual from regressing log household income on household and time fixed effects and household characteristics consisting of the age of household head, household size, number and age of children, and household head education.

Figure 3 Panel B shows the estimated spread and income coefficients across net wealth bins. A positive income shock increases the flow into the zero net wealth state for households with moderate debt and reduces this flow for households with positive but moderate debt. Income shocks instead have little impact on this flow for households with large debt or with more substantial wealth. An increase in the spread increases the transition rate into the zero net wealth state for households with moderately positive net wealth at the beginning of the year and reduces the outflow rate for households already in this state. Households with moderate debt, on the other hand, appear to be less likely to transition to the zero net wealth state at the end of the year. Recall from panel A that the poorest households and those with more substantial positive net worth face essentially no risk of transitioning to the zero net wealth bin within a year; consistent with this, we also find that changes in spreads have no impact on the transition rates of these households. These estimates rely on a net wealth measure which includes housing and mortgages while credit spreads exclude mortgage rates. Figure 11 in Appendix A shows the results are very similar when excluding housing assets and mortgage debt from net wealth.



Notes: The figure shows unconditional transition probabilities to the zero net wealth state by net wealth decile (Panel A) and the change in transition probabilities with cross-sectional changes in income and spread (Panel B), estimated from Equation (2). Sampling uncertainty is indicated by vertical bars (95 percent confidence bands). See notes to Figure 2 for definition of net wealth. Zero wealth is indicated by the grey shading and defined as net assets within a range of plus/minus two weeks of median household income.

Figure 3: Zero Net Wealth Dynamics

Next, we estimate the link between consumption dynamics and changes in income and in consumer credit spreads from the following regression models:

$$\log c_{i,t} = \sum_j \mathbf{1}_{(A_{i,t} \in A_j^{Net})} \left(\eta_j + \beta_{0,j} \log y_{i,t} + \beta_{1,j} R^S_{i,t} + \beta_{2,j} R^S_{i,t} \log y_{i,t}\right) + \gamma X_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t} \tag{3}$$

where $y_{i,t}$ is real household after-tax income. We residualize consumption and income measures (using the same controls as above) and allow coefficients to differ across bins of the net wealth distribution.

Table 1 reports the results when pooling households across the wealth distribution (column 1), and when distinguishing between households with wealth above and below the median (column 2). Pooling households, we find a positive coefficient on income, a negative spread coefficient, and a positive interaction effect. Allowing coefficients to depend on wealth, the income-consumption and spread-consumption links, and the interaction effect, are all strongest for below-median wealth households. Although the results should not be given a causal interpretation,[5] they would be consistent with costly credit and liquidity constraints making consumption spending extra income sensitive for poorer households, and with higher costs of credit reducing consumption spending of poor households relative to wealthier ones. Appendix A shows that the results are robust to excluding households that have recently purchased a car, to capitalizing car expenditures, and to estimating equation (3) using a difference specification. One may also worry that the relationship between credit spreads and consumption is confounded by mortgage rates because of correlation between consumer credit

[5]For one, income and consumption choices are likely to be jointly determined.

Table 1: Consumption Regressions

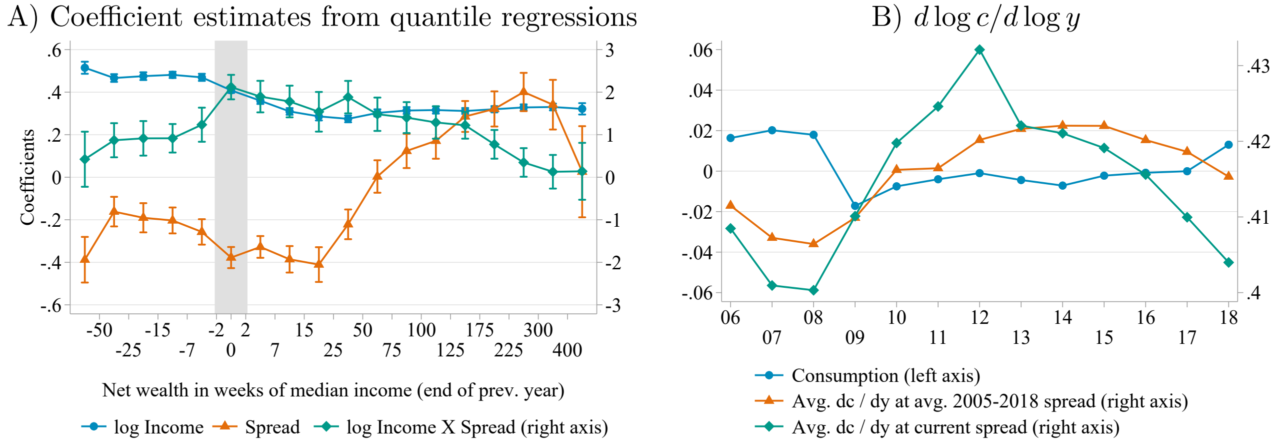
	log Consumption	log Consumption
log income	0.374***	
	(0.00307)	
Low wealth × log income		0.400***
		(0.00402)
High wealth × log income		0.335***
		(0.00382)
Spread	-0.292***	
	(0.0136)	
Low wealth × spread		-0.389***
		(0.0156)
High wealth × spread		-0.118***
		(0.0191)
log income × spread	1.311***	
	(0.0668)	
Low wealth × log income × spread		1.575***
		(0.0902)
High wealth × log income × spread		0.831***
		(0.0840)
No. of observations	17984847	17984847
R^2	0.575	0.579
RMSE	0.249	0.248

Notes: Columns (1) and (2) reports the coefficients of equation (3) estimated using the Danish household data. High net wealth denotes households above the median and low net wealth those below. Net wealth is defined as the value of assets (housing, bank deposits, financial investments (shares, bonds, etc.)) minus liabilities (any form of bank or mortgage debt). Standard errors are clustered at the household level.

spreads and mortgage rates at the household level. Institutional features specific to the Danish mortgage market minimize such concerns, as more than 97 percent of mortgages are provided by MCIs that are not included in our data. Spillovers may still happen, but only a small minority of Danish mortgages are ARMs, and, subject to loan approval, mortgage rates do not depend on the borrower's credit situation, minimizing such concerns.[6]

Panel A of Figure 4 shows the parameters when estimating (3) for five percent bins of the net wealth distribution. The income coefficients are positive across the wealth distribution and decline

[6]Mortgages supplied by MCIs in Denmark are financed by covered bonds, i.e. obligations of mortgage lenders collateralized by pools of mortgages, bought by investors in frequent auctions. MCIs operate in a very competitive market and charge very similar mortgage rates and fees. Once MCIs have approved a loan, mortgage rates are determined entirely by the market. For more details on the Danish mortgage market, see Andersen et al (2020).



Notes: Panel A illustrates the parameters estimated from Equation (3). The underlying wealth distribution is trimmed at the 3rd and 97th percentile. The error bars illustrate 95% confidence intervals. Standard errors clustered at the household level. Panel B illustrates detrended aggregate consumption together with the implied time variations in $d\log c/d\log y$ using the parameter coefficients shown in Panel A.

Figure 4: Consumption, Wealth and the Spread

with wealth, ranging from close to 0.5 for the poorest households to about 0.35 for the wealthiest households. Consumer credit rate spreads, on the other hand, have a non-monotonic relationship with consumption: Higher spreads are associated with lower consumption for households with negative, zero, and moderately positive wealth. Conversely, for households with significantly positive wealth, higher spreads are associated with higher consumption. The interaction effect between income and spreads is insignificant for the very richest households, but positive for all other households, with the largest coefficients relating to households with net wealth close to zero.

We use the parameter estimates reported in Figure 4 to derive a measure of the consumption-to-income elasticity across the wealth distribution, $d\log c_{i,t}/d\log y_{i,t} = \beta_{0,j} + \beta_{2,j} R^S_{i,t}$ (j is the asset bin of household i's net wealth at time t). The cross-sectional average of this measure varies over time because of (a) time variation in the distribution of households across the net wealth distribution and (b) changes in interest rate spreads. Panel B in Figure 4 shows detrended aggregate consumption in Denmark and the cross-sectional average of this elasticity measure when we consider, first, only the observed time variation in the allocation of households across wealth bins (line with diamonds) and, second, when adding the observed time variation in credit spreads (line with triangles). The results indicate some countercyclicality of $d\log c_t/d\log y_t$ in response to wealth fluctuations, but much stronger countercyclicality when also allowing for movements in interest rate spreads.[7] Below, we argue that while this elasticity is not a direct measure of the MPC, it strongly correlates with it. In other words, this evidence shows that the MPC is countercyclical in Denmark.

[7] When only allowing for movements across wealth bins, the percentage standard deviation of the elasticity is 1.4 percent and its cross-correlation with HP-filtered output is -0.36. When also accounting for movements in spreads, its standard deviation is 2.4 percent and its cross-correlation with output is -0.52.

3 Model

We study a HANK model in which banks provide consumer credit and corporate loans. In the baseline model, all assets are liquid. In Section 8 we extend the model with illiquid assets.

3.1 Households

There is a continuum of measure one of ex-ante identical and infinitely lived households, indexed by $i \in [0,1]$, who maximize the expected present discounted value of their utility streams, which depend on consumption, c_{it}, and hours worked, l_{it}. Households have rational expectations, discount future utility at the rate $\beta \in (0,1)$, and their flow utility functions are given by:

$$\mathrm{u}\left(c_{i,t}, l_{i,t}\right) = \frac{c_{i,t}^{1-\vartheta_c} - 1}{1-\vartheta_c} - \chi \frac{l_{i,t}^{1+1/\vartheta_l}}{1+1/\vartheta_l}, \tag{4}$$

where $1/\vartheta_c \geq 0$ is the intertemporal elasticity of consumption and $\vartheta_l \geq 0$ is the Frisch elasticity of labor supply. $\chi > 0$ is a preference weight.

Households switch stochastically between being workers and rentiers. Workers take the real wage per efficiency unit, w_t, as given, and have idiosyncratic productivity $h_{i,t} \geq 0$. A current worker household remains a worker in the next period with probability $1-\phi_w \in (0,1)$ and otherwise becomes a rentier, in which case its labor productivity goes to zero. Rentiers receive a non-tradable share $\mathcal{F}_t$ of corporate and financial sector profits, and remain in this state each period with probability $1-\phi_r \in (0,1)$ and otherwise switch to the worker state in which case its labor productivity starts at the unconditional mean of 1. Workers' idiosyncratic labor productivity follows the stochastic process:

$$h_{i,t} = \begin{cases} \exp\left(\rho_h \log h_{i,t-1} + \varepsilon_{i,t}^h\right), \varepsilon_{i,t}^h \sim \mathcal{N}\left(0, \sigma_h^2\right) & \text{with probability } 1-\phi_w \quad \text{if } h_{i,t-1} \neq 0 \\ 1 & \text{with probability } \phi_r \quad \text{if } h_{i,t-1} = 0 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

Households can save in riskless nominal government bonds, $b_{i,t+1}^G$, and in nominal bank deposits, $b_{i,t+1}^D$, which are perfect substitutes. Let $R_{N,t}$ be the nominal interest rate on government bonds and $R_{S,t}$ be the gross real return on bank deposits. By arbitrage, it follows that $\mathbb{E}_t R_{S,t+1} = \mathbb{E}_t R_{N,t+1}/\pi_{t+1}$, where π_t is the gross inflation between $t-1$ and t, and $\mathbb{E}_t x_s$ is the expected value of x_s given all the information available at time $t \leq s$. They cannot short any of these assets, but they have access to consumer credit, $b_{i,t+1}^L$, supplied by banks. The banks charge a gross real interest rate $R_{L,t}$ and impose a borrowing limit, $\underline{\mathbf{b}}$ (stricter than the natural borrowing limit):

$$\underline{\mathbf{b}} \geq b_{i,t+1}^L \geq 0, \tag{6}$$

$$b_{i,t+1}^G, b_{i,t+1}^D \geq 0, \tag{7}$$

The banking friction discussed later introduces a premium on consumer credit such that $\mathbb{E}_t(R_{L,t+1} - R_{S,t+1}) \geq 0$ and, as a result, households will only take out consumer loans if they have no assets. We present the households' dynamic problems in Appendix B.

The consumer credit spread drives a wedge between the intertemporal consumption prices faced by borrowers and savers, and induces a kink in household budget constraints at $(b^L_{i,t+1}, b^G_{i,t+1}+b^D_{i,t+1}) = (0,0)$. Consider households' savings problems (ignoring type switches for simplicity). Four possible states may occur. First, some households (type I) are savers and on their intertemporal Euler equations with a slope given by the savings rate. Other households (type II) are borrowers, not constrained by (6), and on Euler equations with a slope determined by the borrowing rate:

$$\begin{aligned} (c^{\mathrm{I}}_{i,t})^{-\vartheta_c} &= \beta \mathbb{E}_t (c^{\mathrm{I}}_{i,t+1})^{-\vartheta_c} R_{S,t+1} \\ (c^{\mathrm{II}}_{i,t})^{-\vartheta_c} &= \beta \mathbb{E}_t (c^{\mathrm{II}}_{i,t+1})^{-\vartheta_c} R_{L,t+1} \end{aligned}$$

Consumer credit spreads induce a divergence in the consumption growth rates of savers and borrowers. There are also two groups of high MPC *constrained* households not on their Euler equations, either because they are borrowing constrained (III) or because they are at the kink in the budget constraint (IV). Assuming for simplicity that households were in one of these two states at time $t-1$, their consumption levels are given by

$$\begin{aligned} c^{\mathrm{III}}_{i,t} &= (1-\tau_{h,t})\, w_t h_{i,t} l_{i,t} - (R_{L,t}-1)\underline{\mathbf{b}} \\ c^{\mathrm{IV}}_{i,t} &= (1-\tau_{h,t})\, w_t h_{i,t} l_{i,t} \end{aligned}$$

The measure of type III agents is small in most incomplete markets model, but, due to credit spread, there may be a substantial fraction of type IV agents, a fraction that is increasing in credit spreads.

3.2 Banks

There is a continuum of banks, indexed by $z \in [0, Z]$. Banks are owned by rentiers and managed by risk-neutral bankers who discount future utility at the rate β and face mortality risk $1-\theta \in (0,1)$. When a banker dies, her wealth is transferred to the rentiers, and a new banker enters the economy with a start-up fund provided by the rentiers. Banks intermediate between the household sector and the corporate sector, as well as between savers and borrowers within the household sector. Combining net worth with household bank deposits, they invest in corporate equity and consumer credit.

Mortality risk and entry of new bankers occur at the beginning of the period. Banks then receive deposits $b^z_{D,t+1}$ from households and invest the sum of deposits and net worth, n^z_t, in corporate equity $b^z_{F,t+1}$ at the price Q_t per unit, and in consumer loans $b^z_{L,t+1}$. The balance sheet is given as

$$Q_t b^z_{F,t+1} + b^z_{L,t+1} = n^z_t + b^z_{D,t+1} \tag{8}$$

Due to arbitrage, the nominal deposit rate equals the government bond rate. We abstract from borrower default so that the expected real return to the *bank* from investing in consumer loans equals the expected real return on corporate investment, $\mathbb{E}_t R_{K,t+1}$.[8] The cost to *households* of taking out a consumer loan instead exceeds the return on capital because banks face intermediation costs associated with checking borrowers' credit balances. We assume that these costs are proportional to the size of the loan and are passed on to households. Denoting the intermediation cost of consumer credit by ω_B, the interest rate on consumer loans is then

$$R_{L,t} = (1 + \omega_B) R_{K,t} \tag{9}$$

The law of motion of bank z's net worth is:

$$n^z_{t+1} = (R_{K,t+1} - R_{S,t+1}) \left(Q_t b^z_{F,t+1} + b^z_{L,t+1}\right) + R_{S,t+1} n^z_t \tag{10}$$

As in Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), bankers can divert a fraction $\lambda \in (0, 1)$ of bank assets. If they do so, depositors declare the bank bankrupt, recover the remaining fraction $1 - \lambda$ of assets, and terminate the bank. This agency problem constrains the supply of deposits to the banks. Let S_t denote the aggregate state and $\mathbf{V}^b (n^z_t, S_t)$ the value of bank z:

$$\mathbf{V}^b (n^z_t, S_t) = \max \mathbb{E}_t \beta \left((1 - \theta) n^z_{t+1} + \theta V^b \left(n^z_{t+1}\right)\right) \tag{11}$$

subject to (10) and to:

$$\lambda a^z_t \leq \mathbf{V}^b (n^z_t, S_t) \tag{12}$$

where $a^z_t = \left(Q_t b^z_{F,t+1} + b^z_{D,t+1}\right)$ are the bank's assets. (12) imposes that assets cannot exceed $\mathbf{V}^b/\lambda$, otherwise bankers would choose to divert their assets. To solve this problem, following Bocola (2016), we guess that banks' value functions are given as:

$$\mathbf{V}^b (n^z_t, S_t) = \varrho_t n^z_t \tag{13}$$

Subject to this guess, (12) can be expressed as a constraint on leverage, l^s_t:

$$l^z_t = \frac{a^z_t}{n^z_t} \leq \frac{\varrho_t}{\lambda}$$

Appendix B contains the details of how we solve this problem. A key aspect is that, when the incentive constraint binds, banks expect to earn excess returns on their investments relative to the cost of capital (the deposit rate), $\mathbb{E}_t(R_{K,t+1} - R_{S,t+1}) > 0$, otherwise they equalize. We impose that

[8] Consistent with the model, Dempsey and Ionescu (2021) document large spreads in consumer loan rates that are not accounted for by household default risk in administrative data.

the constraint binds, and subject to this, we find that:

$$\varrho_t = \frac{\mathbb{E}_t \beta \left((1-\theta) + \theta \varrho_{t+1} \right) R_{S,t+1}}{1 - \mathbb{E}_t [\beta \left((1-\theta) + \theta \varrho_{t+1} \right) \left(R_{K,t+1} - R_{S,t+1} \right) / \lambda} \tag{14}$$

$$l_t = \frac{\varrho_t}{\lambda} = \frac{\mathbb{E}_t \beta \left((1-\theta) + \theta \varrho_{t+1} \right) R_{S,t+1}}{\lambda - \mathbb{E}_t [\beta \left((1-\theta) + \theta \varrho_{t+1} \right) \left(R_{K,t+1} - R_{S,t+1} \right)} \tag{15}$$

Finally, assuming that rentiers endow new banks with the share $\zeta / (1-\theta)$ of banking sector net worth, the law of motion for aggregate banking sector net worth is given as:

$$N_{t+1} = \theta \left(l_t R_{K,t+1} + (1 - l_t) R_{S,t+1} \right) N_t + \zeta \left(Q_{t+1} B_{F,t} + B_{L,t} \right) \tag{16}$$

where $B_{F,t} = \int b^z_{F,t} dz$, $B_{L,t} = \int b^z_{L,t} dz$.

3.3 The Corporate Sector

The corporate sector consists of retailers, goods producers, intermediate goods producers, and capital producers. When firms face intertemporal problems, rentiers delegate management to a mass-zero set of risk neutral managers that discount future payoffs at the rate β. Managers are compensated by a share of the profits and do not participate in any asset markets.

3.3.1 Retailers

Competitive retailers produce a single homogeneous final good, Y_t, using a continuum of differentiated goods, $y_{r,t}$, $r \in (0,1)$, as inputs. The technology is given by a CES aggregator:

$$Y_t = \left(\int_0^1 y_{r,t}^{1-1/\eta} dj \right)^{1/(1-1/\eta)} \tag{17}$$

where $\eta > 1$ is the elasticity of substitution. Let $P^F_{r,t}$ denote the prices of the differentiated goods, $P_t = \left(\int_0^1 \left(P^F_{r,t} \right)^{1-\eta} dh \right)^{1/(1-\eta)}$ the price index of the final good, $C_t = \int_i c_{it} di$ aggregate consumption, G_t government purchases, CI_t gross investment, and $Y^n_t = Y_t - Y^{ad}_t$ where Y^{ad}_t denotes various adjustment costs. The demand functions for the differentiated goods and the final goods resource constraint are then:

$$y_{r,t} = \left(\frac{P^F_{r,t}}{P_t} \right)^{-\eta} Y_t \tag{18}$$

$$Y^n_t = C_t + G_t + CI_t \tag{19}$$

3.3.2 Good Producers

A continuum of mass one of monopolistically competitive goods producers, indexed by $r \in (0,1)$, differentiate a homogeneous intermediate good purchased at price P_t^m. They set the price of their goods subject to a Rotemberg (1981) quadratic price adjustment costs. Their real flow profit (denominated in units of the consumption good) in period t is given as:

$$\upsilon_{r,t}^G = \left(\frac{P_{r,t}^F}{P_t} - \frac{P_t^m}{P_t}\right) y_{r,t} - \frac{\eta}{2\omega_Y}\left(\log\left(\frac{P_{r,t}^F}{P_{r,t-1}^F}\right)\right)^2 Y_t \tag{20}$$

The right-hand side denotes sales, $(p_{r,t}^F/P_t)y_{r,t}$, less costs of intermediate goods, $(P_t^m/P_t)y_{r,t}$, less price adjustment costs (the last term). $\omega_Y \geq 0$ parameterizes the extent of nominal rigidities with $\omega_Y \to \infty$ denoting flexible prices. In a symmetric equilibrium, profit maximization of the goods producers induces a Phillips curve relationship (see Appendix B):

$$\log(\pi_t) = \beta \mathbb{E}_t \log(\pi_{t+1}) \frac{Y_{t+1}}{Y_t} + \omega_Y \left(\frac{P_t^m}{P_t} - \frac{\eta - 1}{\eta}\right) \tag{21}$$

3.3.3 Intermediate Goods Producers

A continuum of mass one of identical competitive intermediate goods firms, indexed by $j \in [0,1]$, produce a single homogeneous good, $m_{j,t}$, with a constant returns Cobb-Douglas technology:

$$m_{j,t} = Z_t n_{j,t}^{\alpha} \left(k_{j,t}^e\right)^{1-\alpha} \tag{22}$$

where Z_t is the level of aggregate productivity, $n_{j,t} \equiv \int h_{i,t} l_{i,t}^j di$ is the input of effective labor ($l_{i,t}^j$ denotes household i's hours worked for producer j), $k_{j,t}^e$ is the input of effective capital, and $\alpha \in (0,1]$ is the elasticity of output to labor. Labor is rented from households on a competitive spot market at the real wage w_t per efficiency unit. At $t-1$, the firm issues $b_{f,t}$ units of equity at the price Q_{t-1} and uses the revenue to purchase capital at the price Q_{t-1} per unit:

$$Q_{t-1} k_{j,t}^P = Q_{t-1} b_{f,t} \tag{23}$$

At the start of the period, firms are subject to a common capital quality shock, $\xi_t > 0$. The shock is log-normally distributed with mean 0 and variance σ_ξ^2 and impacts on the amount of effective capital available: $k_{j,t}^e = \xi_t k_{j,t}^P$.

The stochastic processes for total factor productivity is:

$$\exp(Z_t) = \exp(\rho_Z Z_{t-1} + \varepsilon_{Z,t}) \tag{24}$$

where $\varepsilon_{Z,t} \sim \mathcal{N}(0, \sigma_Z^2)$ and $\rho_Z \in (-1, 1)$. After production, firms pay its equity owners any remaining profits and the market value of its capital stock net of maintenance costs. Thus, labor demand and the return on equity satisfy:

$$w_t = P_t^m \alpha Z_t n_{j,t}^{\alpha-1} \left(k_{j,t}^e\right)^{1-\alpha} \tag{25}$$

$$R_{K,t} = \frac{\left(r_{K,t} + Q_t - \delta\right) \xi_t}{Q_{t-1}} \tag{26}$$

where $r_{K,t} = (1-\alpha) P_t^m Z_t n_{j,t}^{\alpha} \left(k_{j,t}^e\right)^{-\alpha}$ is the marginal product of "effective" capital.

3.3.4 Capital Goods Producers

Capital goods are produced by competitive capital goods producers. Depreciated capital is refurbished costlessly, while new capital goods are produced subject to quadratic adjustment costs that we parametrize by $\omega_I > 0$. Let Q_t denote the relative price of new capital goods (in units of the final good), and net investment by $I_{n,t}$. Net revenue of capital producer is then:

$$\upsilon_t^I = (Q_t - 1) I_{n,t} - \frac{\omega_I}{2} \left(\log \left(\frac{I_{n,t} + \psi}{I_{n,t-1} + \psi} \right) \right)^2 (I_{n,t} + \psi) \tag{27}$$

where $\psi \geq 0$ is a constant. Q_t is determined as (see Appendix B):

$$\frac{Q_t - 1}{\omega_I} = \log \left(\frac{I_{n,t} + \psi}{I_{n,t-1} + \psi} \right) + \frac{1}{2} \left(\log \left(\frac{I_{n,t} + \psi}{I_{n,t-1} + \psi} \right) \right)^2 - \beta \mathbb{E}_t \left(\log \left(\frac{I_{n,t+1} + \psi}{I_{n,t} + \psi} \right) \right) \frac{I_{n,t+1} + \psi}{I_{n,t} + \psi} \tag{28}$$

Denote gross new capital by I_t, and CI_t total resources spent on capital production. It follows that:

$$K_{t+1} - \xi_t K_t = I_{n,t}, \tag{29}$$

$$I_t = I_{n,t} + \delta \xi_t K_t, \tag{30}$$

$$CI_t = I_t + \frac{\omega_I}{2} \left(\log \left(\frac{I_{n,t} + \psi}{I_{n,t-1} + \psi} \right) \right)^2 (I_{n,t} + \psi) . \tag{31}$$

3.4 The Government

A fiscal authority collects taxes, purchases final goods, and has a target for debt, $\overline{B}^G$. The law of motion of real government debt, B_{t+1}^G issued in period t is:

$$B_{t+1}^G = R_{S,t} B_t^G + G_t - T_t \tag{32}$$

where T_t are real tax revenues in period t: $T_t = \tau_{h,t}(w_t H_t + \mathcal{F}_t)$. We assume that spending responds to government debt so as to ensure government solvency:

$$\frac{G_t}{\overline{G}} = \left(\frac{B_t^G}{\overline{B}^G}\right)^{-\kappa_G} \tag{33}$$

A monetary authority sets the short-term interest rate using the simple rule:

$$\left(\frac{R_{S,t}^N}{\overline{R}^N}\right) = \left(\frac{R_{S,t-1}^N}{\overline{R}^N}\right)^{\kappa_R} \left(\frac{\pi_t}{\overline{\pi}}\right)^{\kappa_\pi(1-\kappa_R)} \exp(\varepsilon_t^m) \tag{34}$$

$\overline{R}^N$ is the long-run level of the short-term nominal interest rate, $\kappa_R \in (0,1)$ allows for interest rate smoothing, $\overline{\pi}$ is the inflation target, and $\kappa_\pi > 1$ determines interest rate responses to deviations of inflation from its target. $\varepsilon_t^m \sim \mathcal{N}(0, \sigma_m^2)$ is a monetary policy shock.

3.5 Market Clearing

Let $\Theta_t(b,h)$ denote the date t joint distribution of household assets (including bank loans) and productivity. The labor market, savings, credit and capital market clearing conditions are then:

$$\int_h \int_b l^*(b,h)\, h\Theta_t(b,h)\, db dh = \left(\frac{w_t}{P_t^m Z_t \alpha}\right)^{1/(\alpha-1)} K_t^e \tag{35}$$

$$\int_h \int_{b*>0} b^*(b,h)\,\Theta_t(b,h)\, db dh = B_{t+1} = B_{D,t+1} + B_{G,t+1} \tag{36}$$

$$N_t + B_{D,t+1} = Q_t K_{t+1} + \int_h \int_{b^*<0} b^*(b,h)\,\Theta_t(b,h)\, db dh \tag{37}$$

$$\frac{\Delta K_{t+1}}{K_t} = \Gamma(Q_t - 1, \mathbb{E}_t I_{n,t+1}) - \delta K_t \tag{38}$$

where $l^*(b,h)$ denotes households labor supply policy function and $K_t^e = \int k_{j,t}^e dj$ is the aggregate "effective" capital stock, $b^*(b,h)$ denotes the households' optimal policy functions for assets and bank loans, $B_{D,t+1}$ are aggregate supply bank deposits, and Γ is implicitly defined in (28)-(29). Finally, goods market clearing implies that:

$$\left(1 - \frac{\eta}{2\omega_Y}\log(\pi_t)^2\right) Y_t = C_t + CI_t + G_t + (\omega_b - 1) B_{L,t+1} \tag{39}$$

where the term in parentheses on the left hand side corrects for price adjustment costs and the last term on the right hand side is the intermediation cost of lending to consumers. Added to these is the government budget constraint which holds by Walras' law.

4 Calibration

We solve the model by first-order perturbation using the method of Bayer and Luetticke (2020). A period is a quarter. Given the use of Danish micro data in Section 2, we calibrate the model to Denmark. A subset of the parameters are chosen using conventional values from the literature. A second subset is fitted directly to the data. A third set of parameters is matched to targets listed in Table 3, which come from Danish micro data and Danish National Accounts. The sample period is 2003-2018 unless otherwise stated. The values of the parameters are given in Table 2.

We set the intertemporal elasticity of substitution, $1/\vartheta_c = 2/3$, consistent with empirical estimates from household consumption studies such as Attanasio and Weber (1995) or aggregate data such as Eichenbaum, Hansen and Singleton (1988). Based on estimates in Chetty et al (2011), we set the Frisch labor supply elasticity $\vartheta_l = 0.75$. The preference weight χ is calibrated so that steady-state hours worked (averaged across households) is one third. We adopt Guvenen, Ozkan and Song (2014)'s estimates of the probability of households leaving the top one percent of the income distribution and set $1 - \phi_r = 6.25$ percent.[9] We calibrate $(\beta, \underline{\mathbf{b}}, \phi_w, \omega_B) = (0.9875, 8\bar{Y}, 0.0022, 0.0075)$ to the moments of the Danish wealth distribution in Table 3. We target an annual aggregate capital-output ratio of 252 percent, a fraction of households with debt exceeding two weeks of income of 25 percent, a consumer credit spread of four percent annually, and that the top decile of the wealth distribution holds 55 percent of total wealth.

We assume that the output elasticity to labor, $\alpha = 0.67$, and the depreciation rate, $\delta = 0.02$, standard values in the literature. The investment adjustment cost parameter, ω_I=0.96, is calibrated to target the ratio of the standard deviation of aggregate consumption to the standard deviation of aggregate output (0.94, see Table 5). The elasticity of substitution between goods in the final goods sector, $\eta = 21$, is calibrated to imply a five percent steady-state markup. Exploiting the equivalence of the Calvo and Rotemberg models in terms of implied price Phillips curves, we set the price adjustment cost $\omega_Y = 0.10$ to target that prices adjust on average every four quarters.

We follow Gertler and Karadi (2011) and assume that bankers can divert 38.1 percent of bank assets, $\lambda = 0.381$, and the survival rate of bankers is $\theta = 0.972$ per quarter (so their planning horizon is about 9 years). To calibrate the transfer to new banks, we target a leverage ratio of 2.93 for Danish banks (see Table 3), which gives us $\zeta = 0.4$ percent of bank assets.

Denmark pegs its exchange rate to the Euro and is closely integrated with the European Union through trade. Rather than introducing open economy features, we simply adopt standard values for the monetary policy part of the model. We assume that the central bank pursues price stability, $\overline{\pi} = 1$, that $\kappa_\pi = 1.5$, and set the degree of interest rate smoothing equal to 0.7, close to the estimates of Gerali et al (2010) for the Euro area. Steady-state government spending, $\overline{G}$, is calibrated to target

[9] Guvenen, Ozkan and Song (2014) estimates this probability at 25 percent annually. So we set $\phi_r = 0.25/4$, which is an approximation that works well because ϕ_w is very close to zero in our calibration.

Table 2: Baseline Model Parameterization

	Description	Value		Description	Value
Households			**Monetary and fiscal policy**		
β	Discount factor	0.9875	$\overline{\pi}$	Inflation target	1.00
χ	Disutility weight of labor	0.20	κ_π	Response to inflation	1.50
$1/\vartheta_c$	Intertemp. elasticity	2/3	κ_R	Int.rate smoothing	0.70
ϑ_l	Frisch elasticity	0.75	$\overline{G}/\overline{Y}$	Gov. spending share	0.26
ϕ_w	Transition prob. to rentier	0.0022	$\overline{B}^G/\overline{Y}$	Gov. debt ratio	0.39
ϕ_r	Transition prob. to worker	0.0625	τ_h	tax rate	0.37
$\underline{\mathbf{b}}$	Borrowing constraint	$8\ \overline{Y}$	κ_G	Response of G to debt	0.10
Supply side			**Stochastic shocks**		
α	Output elasticity to labor	0.67	ρ_h	Persistence of HH income shocks	0.948
δ	Depreciation rate	0.02	ρ_z	Persistence of TFP shocks	0.970
ω_I	Adjustment costs	0.90	σ_h^2	Variance of HH income shocks	0.097^2
η	Elasticity of substitution	21	σ_z^2	Variance of TFP shocks	0.022^2
ω_Y	Price stickiness	0.10	σ_ξ^2	Variance of cap.q. shocks	0.022^2
			σ_R^2	Variance of mon.pol. shocks	0.002^2
Banking					
λ	Divertible fract. of assets	0.38	θ	Bank survival rate	0.972
ζ	Funds new managers	0.004	ω_B	Consumer loan cost	0.0075

a ratio of government spending to GDP of 26 percent, see Table 3, and the level of government debt in the long run, $\overline{B}^G$, targets an average Danish government debt-to-GDP ratio of 39 percent, see Table 3. Given these values, the income tax rate, τ_h, is 37 percent. Finally, to ensure government solvency in the long run, government spending responds negatively to government debt, $\kappa_G = 0.1$.

To calibrate the idiosyncratic income process, we estimate an income process for residualized log household income, $y_{i,t}$, assuming it is given as the sum of a persistent and a transitory component:

$$\begin{aligned} y_{i,t} &= \delta_t + \delta_z Z_{i,t} + \tilde{y}_{i,t} \\ \tilde{y}_{i,t} &= x_{i,t} + \varepsilon_{i,t} \\ x_{i,t} &= \rho_x x_{i,t-1} + e_{i,t} \end{aligned}$$

where δ_t is a time fixed effect, $Z_{i,t}$ is a vector of household characteristics, $\tilde{y}_{i,t}$ is residualized household income, $x_{i,t}$ is the persistent component of household income with the innovation $e_{i,t} \sim \mathcal{N}(0, \sigma_e^2)$, and $\varepsilon_{i,t} \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ is a transitory shock which we, in line with the literature, interpret as classical

Table 3: Calibration Targets

Targets	Data	Model	Source	Parameter
Capital to annual output	252%	252%	NA	Discount factor
Government debt to output	39%	39%	NA	Share in household net wealth
Fraction of borrowers	25%	22%	Micro data	Borrowing limit
Borrowing spread	4%	4%	Micro data	Borrowing penality
Top 10% wealth share	55%	55%	Micro data	Fraction of entrepreneurs
Banking leverage	293%	293%	DN	Banking friction
Consumption volatility relative to output	94%	94%	NA	Investment adjustment costs
Government spending to output	26%	26%	NA	Tax rate

Notes: 'Micro data' refers to register data administered by Statistics Denmark, 'NA' refers to National Account data, https://www.statbank.dk/, 'DN' to the financial statistics dataset administered by Danmarks Nationalbank, https://nationalbanken.statistikbank.dk. Banking leverage is computed as assets/(assets - deposits) using the banking balance sheet data for the Monetary and Financial Institutions (DNBALA).

measurement error. We estimate $(\rho_x, \sigma_e, \sigma_\varepsilon)$ with GMM using moment conditions for the auto-covariance of $\tilde{y}_{i,t}$ of order 0-2, see Appendix C. To estimate residual income we control for age and education of the household head, and for the number and age of children. We find $(\widehat{\rho}_x, \widehat{\sigma}_e, \widehat{\sigma}_\varepsilon) = (0.807, 0.180, 0.041)$. We then translate $(\widehat{\rho}_x, \widehat{\sigma}_e)$ to the quarterly frequency giving us a persistence of idiosyncratic income shocks of 0.948, and a variance of the idiosyncratic income shocks of 0.097^2.[10]

We set $\sigma_R = 0.2$ percent in line with Gerali et al (2010). We calibrate the persistence of TFP shocks, $\rho_Z = 0.97$, by estimating an AR(1) process for detrended log total factor productivity data for Denmark.[11] We then set the variance of the TFP and capital quality shocks, $\sigma_Z = \sigma_\xi = 2.2$, constraining them to be identical, to imply a standard deviation of (HP-filtered) aggregate real GDP of 1.83 percent per quarter as in the Danish data. Table 4 reports net wealth shares across deciles of the Danish household data and for the stationary distribution of the model. The model closely matches the net wealth share distribution, apart from the very poorest decile, whose net indebtedness we underestimate. With this calibration, the real return on saving is 3.8 percent per annum, the annual real return on capital is 4.7 percent, while the borrowing rate is 7.9 percent.

[10] Let z_t be an AR(1) process at the quarterly frequency, $z_t = \rho z_{t-1} + e_t$ which implies that at the annual frequency $z_t = \rho^4 z_{t-4} + e_{a,t}$ where $e_{a,t} = e_t + \rho e_{t-1} + \rho^2 e_{t-2} + \rho^3 e_{t-3}$. Hence, $\sigma^2 = \sigma_a^2/(1 + \rho^2 + \rho^4 + \rho^6)$.

[11] We fit an AR(1) process to the log of annual TFP estimates produced by Statistics Denmark, linearly detrended. The estimate of the annual persistence parameter is 0.885, which we convert to the quarterly rate.

Table 4: Wealth Shares by Decile

	1	2	3	4	5	6	7	8	9	10
Data	-8.1	-1.7	-0.3	0.3	1.3	4.3	9.1	15.4	24.8	54.9
Model	-4.2	-0.9	0.3	1.6	3.3	5.3	7.8	11.6	20.4	54.8

Notes: Wealth shares are calculated from Danish register data and refer to averages between 2003 and 2018. Wealth is measured as in Section 2. The model moments correspond to the stationary distribution.

5 Aggregate Fluctuations

5.1 Business Cycle Moments

An important check on the properties of the model is the extent to which it generates aggregate fluctuations with properties that resemble those in the data.[12] Table 5 reports business cycle statistics for Danish data and for stochastic simulations of the model. We filter both the actual data and the model data with a Hodrick-Prescott filter (with a smoothing parameter of 1,600).[13]

By construction, the model matches the volatility of aggregate output and aggregate consumption. However, it also captures very well the relative volatility of investment and the significant procyclicality of both aggregate consumption and investment. Of particular interest for our exercise are the moments of consumer credit and interest rate spreads. In the data, the credit spread is countercyclical with a cross-correlation with output of -0.69.[14] The model generates a somewhat less countercyclical spread with a cross-correlation with output of -0.29. In the model, as discussed below, banking frictions generate such countercyclical movements in spreads. In the data, aggregate consumer credit is more than twice as volatile as output and procyclical, with a cross-correlation with output of 0.56.[15] The model accounts for both the volatility of consumer credit and its procyclicality. The countercyclical spread is important for this as it makes borrowing more expensive in recessions. In a sophisticated model with a strategic default motive and aggregate shocks, Nakajima and Rios-Rull (2019) show that default probabilities fall in expansions generating procyclical credit. However, such models typically imply very smooth consumer credit. Nevertheless, it would be interesting to combine the mechanism stressed in their analysis with the banking frictions we focus on, but this goes beyond the scope of this paper.

[12] In Appendix D we further report forecast error variance decompositions of selected variables.

[13] Following Ravn and Uhlig (2002), use a smoothing parameter of 6.25 for annual data. The consumption-to-income elasticity is not filtered because the data series is very short creating issues with the end-points of the data. Model moments are computed by filtering simulated data from a very long sample, and removing the initial periods.

[14] The data moments for the spread refer HP-filtered data of quarterly spreads derived from the MFI data for a subset of the banks for which quarterly data is available.

[15] In U.S. data, the volatility of the consumer credit spread (relative to output) is about twice the estimate reported in Table 5 for Denmark and less countercyclical. Consumer credit in the U.S. is even more volatile than in Denmark, but somewhat less procyclical, see Lee, Luetticke and Ravn (2020).

Table 5: Business Cycle Moments

Moments	Data	Model	Moments	Data	Model
σ_Y (target)	1.83	1.83	$corr(Y)$	1.00	1.00
σ_C/σ_Y (target)	0.94	0.94	$corr(C,Y)$	0.75	0.62
σ_I/σ_Y	3.62	4.20	$corr(I,Y)$	0.84	0.69
σ_{B_L}/σ_Y	2.11	1.55	$corr(B_L,Y)$	0.56	0.65
$\sigma_{R_L-R_S}/\sigma_Y$	0.11	0.34	$corr(R_L-R_S,Y)$	-0.69	-0.29
σ_{DCDY}/σ_Y *	1.90	1.05	$corr(DCDY,Y)$*	-0.52	-0.40
σ_{MPC}/σ_Y *		2.53	$corr(MPC,Y)$*		-0.61

Notes: B_L is aggregate consumer credit, $R_L - R_S$ is the consumer credit spread, $DCDY$ is the consumption-income elasticity computed as in Figure 4. σ_x is the percentage standard deviation of x, $corr(x,y)$ is the correlation of x and y. Both data and model moments are computed for HP-filtered quarterly data. Model moments are in response to TFP, monetary and capital quality shocks. (*) $DCDY$ and MPC are based on annual data. Both are logged but not HP-filtered.

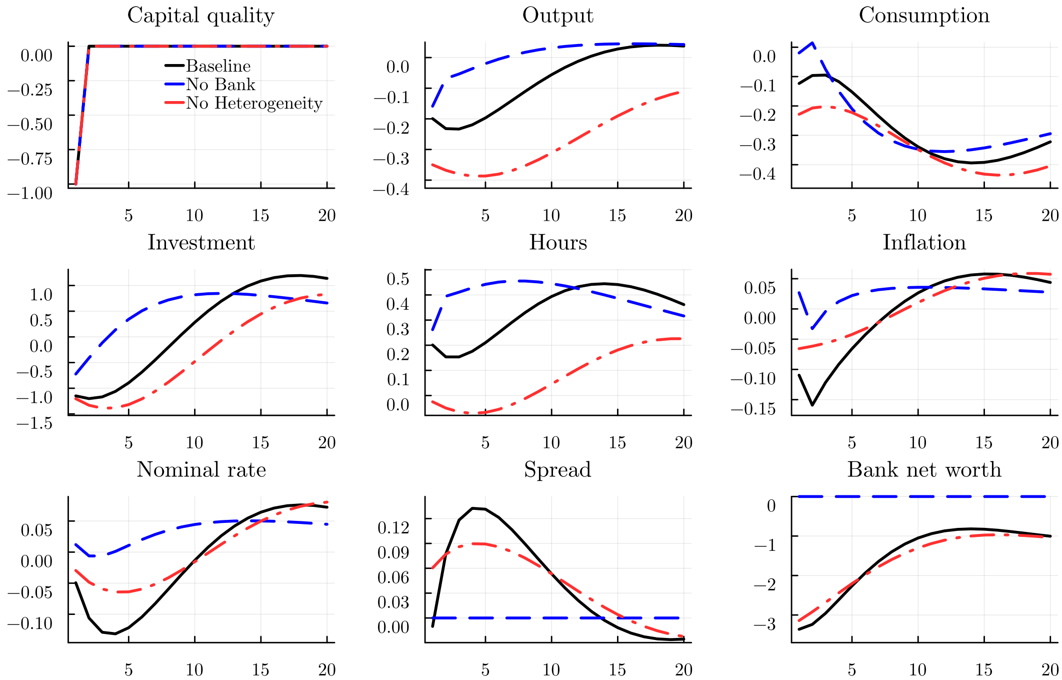
5.2 The Impact of Aggregate Shocks

We now examine the aggregate impact of the aggregate shocks. We compare the baseline model to a RANK model with banking frictions, and to a HANK model with no banking friction but where we impose a constant spread (matching the stationary value in the baseline model). The baseline model is shown in black, the RANK economy in red, and the HANK model without banks in blue.

5.2.1 Capital Quality Shocks

We first look at the capital quality shock, which Gertler and Karadi (2011) argue was an important factor in the global financial crisis.[16] Figure 5 illustrates the impact of a one percent decrease in ξ_t. The shock destroys a fraction of the capital stock, is recessionary, and reduces corporate sector equity values. Since banks own corporate equity, banking sector net worth declines. The shock is deflationary, causing the central bank to lower nominal interest rates. Nevertheless, the decline in banks' net worth forces them to reduce their supply of consumer credit and their purchases of corporate sector equity, which is accompanied by an increase in spreads. This leads to a significant decline in aggregate investment of about 1 percent in the baseline model. After the initial decline, investments gradually recover, but remain depressed for about 2.5 years. The destruction of the capital stock also reduces household income. The combination of higher spreads and lower incomes leads to a

[16] Note that we assume no persistence in the capital quality shocks, while Gertler and Karadi (2011) allow for substantial persistence.



Notes: Impulse responses to a one percent negative capital quality shock. 'Baseline' refers to the baseline model, 'No Bank' to a HANK model without frictional financial intermediation. 'No Heterogeneity' refers to the representative household model with frictional financial intermediation.

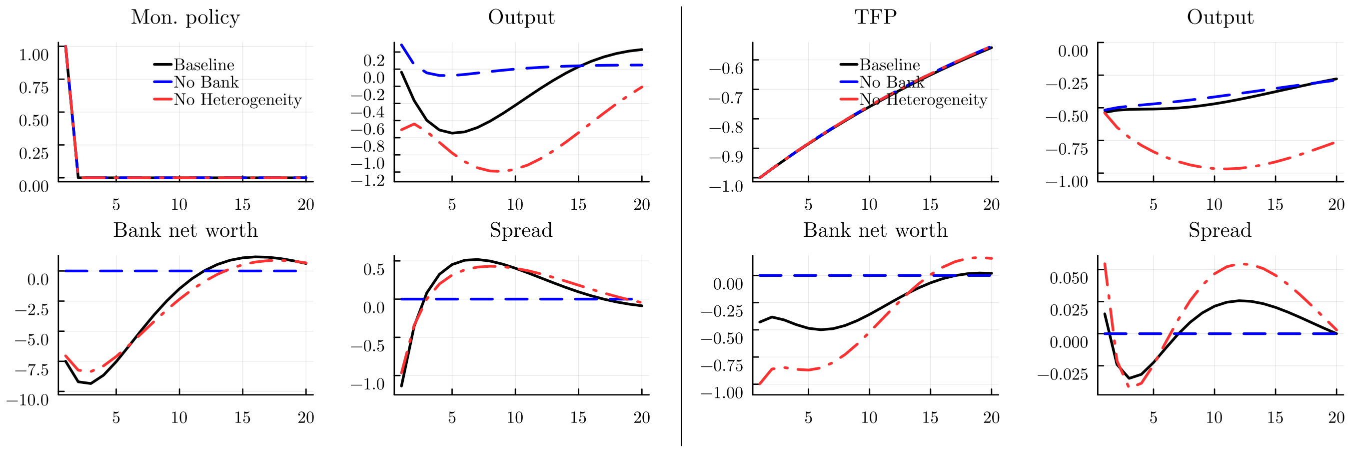
Figure 5: Aggregate Effects of a Capital Quality Shock

significant and very persistent reduction in aggregate consumption. The response of consumption in the HANK model is very similar to a representative agent model, while aggregate investment declines slightly less. This is due to an increase in labor supply in the incomplete markets model, which helps households insure their consumption in the face of higher credit spreads. Compared to the model with incomplete markets and a constant spread, there is a significant amplification of capital quality shocks, as rising spreads discourage investment. Thus, the model retains a financial accelerator in the face of capital quality shocks, although it is reduced relative to a RANK setting.

In Figure 12 in Appendix D, we illustrate a partial equilibrium decomposition of the aggregate consumption response to the capital quality shock into the separate effects on consumption of the various price and income determinants in the economy. The decomposition shows that the main determinant of the fall in aggregate consumption is a fall in wages, while the dynamic adjustment is dictated by the saving rate. Below we show that movements in the spread means that such dynamics of aggregate consumption is not representative for all parts of the distribution.

5.2.2 TFP and Monetary Policy Shocks

Figure 6 shows the responses to shocks traditionally studied in the business cycle literature, a one percentage point positive monetary policy shock (left panel) and a one percent negative TFP shock



Notes: Impulse responses to a one percentage point positive shock to the nominal interest rate (left panel) and a one percent negative shock to TFP (right panel). See Figure 5 for legend.

Figure 6: Aggregate Effects of TFP and Monetary Shocks

(right panel).[17] An increase in the policy rate is recessionary and causes inflation to fall, leading to a reversal of the policy rate after 4 quarters. The monetary shock leads to a sharp decline in aggregate investment and a large and persistent decline in output. The monetary shock is accompanied by a decline in equity returns, which reduces banking sector net worth and, with a lag, increases interest rate spreads. Due to the rise in spreads, the monetary policy shock is amplified by banking frictions, while the heterogeneous agent aspects lead to some stabilization due to a smaller fall in hours worked in the incomplete markets model.

A reduction in aggregate TFP is recessionary and induces persistent drops in aggregate output, investment, and consumption. Lower productivity drives up marginal costs, inflation rises, and the short-term interest goes up due to the monetary policy response. The shock is also associated with a drop in banking sector net worth, but, relative to the capital quality shock and the monetary policy shock, the impact on banks is quite minor. One factor behind this is that households raise their labor supply due to a wealth effect on their labor supply. Therefore, changes in spreads appear to play a minor role in response to TFP shocks. It follows that we find little amplification of TFP shocks when comparing the impact to the HANK model with a constant spread. Note that in the RANK model, TFP shocks *are* amplified since the labor supply rise is muted in this economy in our calibration.

In summary, capital quality shocks and monetary policy shocks are amplified at the aggregate level through a financial accelerator mechanism that works through interest rate spreads. This effect is less evident for TFP shocks. Thus, at the aggregate level, the heterogeneous agents aspect appears to be less important, a finding consistent with the results in Berger, Bocola and Dovis (2020).

[17] A plot of the full set of variables shown for the capital quality shock is shown in Appendix D.

6 MPCs and Inequality

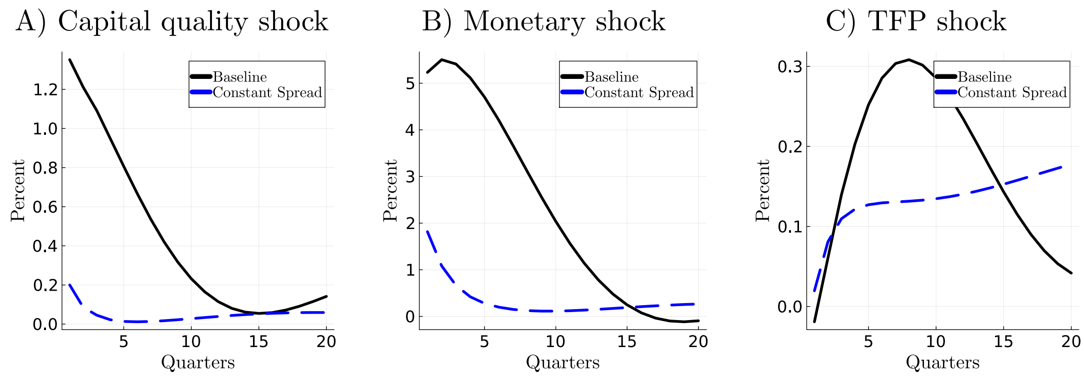
Inequality has been raised as a concern for economic policy, c.f. Feiveson et al (2020), which was part of the Federal Reserve's recent review of monetary policy strategy. We now exploit the HANK model to examine such distributional issues.

6.1 Asset Distribution, Consumption Dynamics and the MPC

We first confront the model with the sophisticated untargeted conditional moments estimated in Section 2. Figure 16 in Appendix D reports the results of estimating equation (2) using data from stochastic simulations of a partial equilibrium version of the model in which there are idiosyncratic spread and income shocks.[18] Overall, the model is quite successful in accounting for key features of the empirical estimates. First, as in the data, positive income innovations increase the rate of transitions into the zero net wealth state for indebted households and decrease it for those with positive wealth. The sensitivity of the transition rate to income is higher in the model than in the data, but the patterns of the income-transition rate relationship across the wealth distribution are very similar. In the model, since income shocks are (persistent but) temporary, households save parts of the rise in their income so that their assets go up. Secondly, as in the data, higher credit spreads have no impact on the transition rates for the wealthiest and most indebted households because they are unlikely to face a transition to the zero net wealth state within a year. Third, as in the data, households with moderate wealth or no net wealth face a higher transition rate into the zero net wealth state when credit spreads rise. In the model, such households are exposed to a larger kink in their budget constraint which reduces their asset mobility.

The model does not account for all aspects of the conditional moments, though. First, there is a difference in the sign of the impact on the transition rate of income shocks for households with zero net wealth, but the difference in the actual size of the coefficient is minor and derives from the distribution of households within this bin. Secondly, the empirical estimates indicate that when spreads rise, the transition rate of moderately indebted households into the zero net wealth state declines, but in the model this flow rises. Indebted households face opposing wealth and intertemporal substitution effects when borrowing rates increase. Our calibration implies a strong intertemporal substitution and households reduce their debt. While it goes beyond the scope of our paper to examine this issue in details, we have confirmed through model simulations that a stronger wealth effect induces some decline in the transition rate for indebted households. One interpretation is that

[18]The estimates in Section 2 correspond to household-specific spreads because we control for a time-fixed effect. We compute the model statistics by simulating households subject to idiosyncratic income and spread shocks to mimic this. We assume that borrowing and savings rates are generated by a common factor model with a persistence matched to the idiosyncratic spreads in the data. The loading of borrowing rates dominates that of the savings rates meaning that a rise in the spread corresponds to a stronger rise in borrowing rates than in savings rates. Appendix D contains further details on the design.



Notes: The figure shows the responses of the average MPC to the three aggregate shocks. The MPC is calculated as the integral over the slope of the consumption function. The black line shows the baseline model, the blue line is the baseline model with a constant consumer credit spread.

Figure 7: Impulse Responses of the MPC

there is some preference heterogeneity in the population that we do not capture.

Figure 17 in Appendix D shows the outcome of estimating equation (3) on simulated model data in response to idiosyncratic income and credit spread shocks. As in the data, we find that the income elasticity parameter is positive and smaller for wealthier households than poorer one. The elasticity is marginally smaller in the model than in the data, but differences are small. The model is also consistent with higher credit spreads reducing consumption for indebted and moderately wealthy households. In the data, the interaction effect between income and credit spreads indicates that higher spreads strengthens the relationship between income and consumption and particularly so for households close to the zero net wealth state. Although the interaction effect is weaker in the model than in the data, the shape of the relationship across the wealth distribution is very similar to its empirical counterpart.

One discrepancy between the model and the data concerns the relationship between consumption and credit spreads for wealthier households. This relationship is positive in the data but close to zero in the model. For such households, the spread channel works mainly through the return on savings. Higher returns on savings induce a substitution effect which lowers consumption and a wealth effect that increases consumption. The wealthier are households, the more important is the second channel. However, because the impact on savings rate is relatively weak, the model does not account for the positive impact of spreads on consumption in the right tail. Figure 18 in the appendix illustrates this by means of the consumption policy functions across the wealth distribution in response to spread movements. We show later that introducing illiquid assets addresses this issue (and implies an income elasticity practically identical to the one in the data).

We can go further and examine the model's implications for the MPC. In the model, the MPC is countercyclical in response to each of the three aggregate shocks, see Figure 7. An important reason for this is that there is a mass point in the wealth distribution at zero net wealth, which increases as the consumer credit spread rises. Households at or near this kink in the budget constraint have high MPCs. Therefore, the model implies that the MPC is unconditionally countercyclical with a cross-correlation of output of -0.60, see Table 5.[19]

We do not have a direct empirical estimate of the MPC, yet we estimated a time-varying consumption-income elasticity measure in Section 2 which we found to be countercyclical. We can compute the model-equivalent of this measure by estimating the coefficients in (3) using simulated data. Doing so and backing out the elasticity measure implies a cross-correlation with output of -0.38 at the annual rate. This elasticity is more volatile than the MPC in the model, but the two measures are highly correlated with a cross-correlation of 88 percent at the annual rate.[20] Thus, the empirical results strongly suggest that the average MPC is countercyclical and that a central reason for this is the countercyclical movements in credit spreads. This adds an important new fact to the empirical literature that is very scarce on findings regarding the cyclicality of the MPC. Exceptions include Holm, Paul and Tiscbirek (2021), who find that the MPC in Norway rises in response to contractionary monetary policy shocks. As Figure 7 shows, this is consistent with our model. Gross, Notowidigdo, and Wang (2020) measure the MPC by estimating how the removal of bankruptcy flags from credit reports of 160,000 bankruptcy filers affects credit card limits and balances. They find that the MPC was higher for households that had their bankruptcy flags removed during the Great Recession than for those that received the same treatment before or after the downturn.

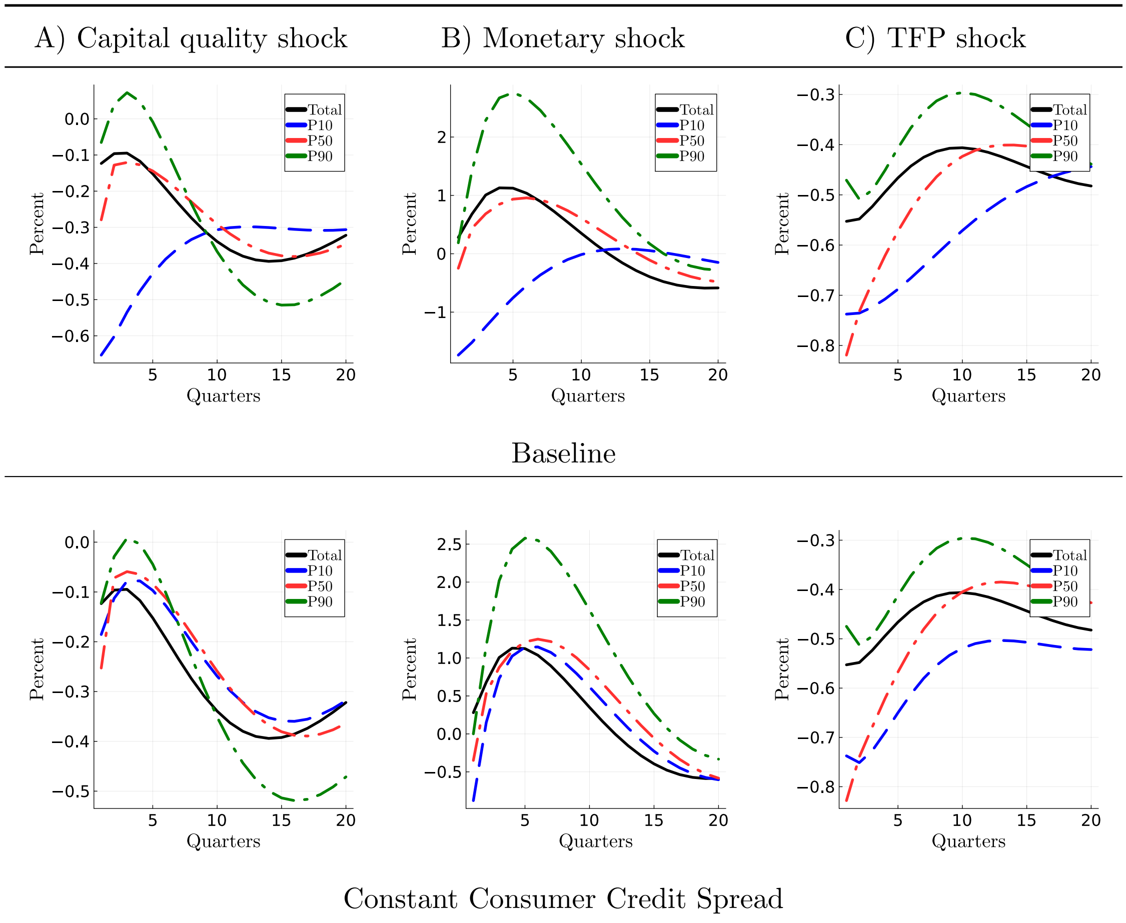
6.2 Consumption Dispersion and Aggregate Shocks

We now examine the impact of aggregate shocks across the wealth distribution. Figure 8 shows the consumption responses to the three aggregate shocks for households at the 10th percentile of the consumption distribution (who are indebted), the 50th percentile and the 90th percentile, along with aggregate per capita consumption. The top row reports results for the baseline economy, and the bottom row shows the HANK model with banks but a constant consumer credit spread.

The first column of Figure 8 shows the impact of a one percent decline in capital quality on consumption across the wealth distribution. Lower capital quality induces a reduction in real wages, which depresses consumption across the wealth distribution. In the baseline economy, the capital quality shock is accompanied by higher borrowing rates while savings rates decline. The higher spread exaggerates the kink in the budget constraint faced by agents, and higher borrowing rates lead to a large reduction in consumption spending by indebted households. Thus, banking crises have distributional effects in this economy because of the response of interest rate spreads. In contrast, when the spread is constant, saving and borrowing rates fall in tandem, and household consumption

[19] The MPC is countercyclical but close to constant when a constant spread is assumed. Eliminating the spread altogether implies an acyclical MPC, see Table 12 in Appendix D.

[20] Appendix D shows the close relationship between these measures by means of a scatterplot.



Notes: Impulse responses of aggregate consumption and the 10th, 50th and 90th percentiles of the consumption distribution. The top panel is the baseline model, while the bottom panel assumes a constant consumer credit spread. The shocks are a one percent decline in capital quality (column A), a one percentage point increase in the nominal interest rate (column B), and a one percent decline in TFP (column C).

Figure 8: Consumption Impulse Responses by Consumption Percentiles

growth rates therefore move in parallel, and we see little consumption dispersion in this economy.

There is empirical evidence that monetary policy shocks induce consumption inequality, see for example Coibion et al (2017) or Holm, Paul and Tiscbirek (2021). The latter authors show how contractionary monetary policy shocks stimulate consumption by rich households in the short run, but lead to a sharp contraction in spending by poor households, while the longer run responses are similar across the distribution. In the model, contractionary monetary policy shock not only reduces the labor income of poor households in the short run, but increases their borrowing costs. Wealthy households instead enjoy higher real returns on their savings and their consumption rises in the short run. Over time, the economy recovers and the consumption responses of households with different wealth levels converge as spreads return to their normal levels. Assuming instead constant spreads, implies that consumption paths move in parallel across the distribution, with only small differences between the 90th and 10th percentiles at the time of the shock.

For TFP shocks, the impact on consumption inequality is smaller because, as discussed earlier, spreads do not move much in response to this shock. A fall in TFP reduces real wages, which puts downward pressure on consumption across the wealth distribution. Wealthier households are better insured against these shocks, so their consumption falls less than that of poor households. Thus, TFP shocks do affect consumption inequality, but the role of movements in spreads is less important.

7 Banking Sector Leverage: Micro vs. Macro Volatility

We now examine how banking sector leverage impact on the economy. Specifically, we compare moments of the baseline economy with an alternative economy in which we change the severity of the moral hazard problem, λ, so that bank leverage declines by 10 percent. One may think of this in terms of the impact of financial regulation aimed at stabilizing the financial accelerator through capital requirements,[21] although an important caveat is that, for computational reasons, we do not allow the incentive constraint faced by banks to be occasionally binding nor for countercyclial capital buffers as in e.g. Gertler et al (2020).

7.1 Long Run Aggregate Effects and Cyclical Dampening

Table 6 reports the long-run effects of reducing banking sector leverage. We compare the HANK model with a RANK model identical to the HANK model apart from the absence idiosyncratic income risk. This comparison teases out the effects of introducing incomplete markets.

Regardless of the household modeling, when banks are less leveraged, interest rate spreads rise because banks are more constrained in their asset investments. In the RANK setting, the deterministic steady-state rate of return on saving is determined by the intertemporal discount rate, β, independently of the banking sector. Thus, a higher credit spread must come from an increase in the return on capital which induces a reduction in the steady-state capital stock, output and consumption. Quantitatively, the annual spread rises by 25 basis points, and the aggregate capital stock, output and consumption decline by 2.4, 0.5, and 0.8 percent, respectively. In the HANK model, credit spreads rise by 40 basis points. Here, the increase in the spread is instead mainly due to a reduction in the return on deposits. The reason is that higher credit spreads make borrowing for consumption smoothing more costly inducing households to increase their labor supply and their precautionary savings. Thus, the return on savings declines (from 3.8 percent annually to 3.5 percent) and, while the capital stock declines marginally, the higher labor supply induces an *increase* in aggregate consumption and output in the long-run.

[21] Banking sector capital requirements is a standard instrument considered in the financial regulation literature, see e.g. the discussion in Galati and Moessner (2012).

Table 6: Moments: Baseline and Restricted Leverage

	Baseline		No Heterogeneity	
	Baseline	Low leverage	Baseline	Low leverage
Leverage	2.93	2.64	2.93	2.64
	Interest rates			
Return on capital (R_K, %)	4.69	4.82	5.58	5.83
Return on savings (R_S, %)	3.81	3.54	5.16	5.16
Lending interest rate (R_L, %)	7.87	8.00	-	-
	Aggregates			
Output	4.89	4.91	4.39	4.37
Capital	49.26	48.93	41.42	40.44
Labor supply	1.44	1.45	1.43	1.43
Consumption	2.64	2.70	2.45	2.43
	Household distribution			
At kink (%)	4.03	4.82	-	-
Borrowers (%)	21.95	24.47	-	-
Gini wealth	77.50	82.02	-	-
Gini consumption	15.67	16.46	-	-
Gini income	28.53	30.11	-	-

Notes: We compare the baseline steady state to one with 10% less leverage (diversion parameter λ going from 0.381 to 0.445). The last two columns do so for the model with a representative household.

The decline in banking sector leverage reduces the financial accelerator and stabilizes the aggregate economy, see Table 7. We find a reduction in the standard deviations of output and investment by 5 percent and 14.5 percent, respectively, in the HANK model which are both larger than in the RANK economy, and occur without any detrimental effects on long-run consumption and output. Thus, from the perspective of macroeconomic aggregates, less banking leverage stabilizes the economy with apparently no long-run output costs.[22]

7.2 Distributional Consequences and Welfare

In the heterogeneous agents model, we can also study the distributional consequences. The bottom part of Table 6 reports the impact on various measures of inequality, and Panel A of Figure 20 in Appendix D illustrates the stationary wealth distribution conditional on λ. The economy with less leveraged banks experiences an increase in the share of households with near-zero net wealth, and,

[22] Jensen, Hove Ravn, and Santoro (2017) find that tighter financial regulation can induce *higher* aggregate volatility in a model with occasionally binding collateral constraints.

Table 7: Standard Deviations of Aggregate Variables

	Baseline	Low leverage	% Decline in volatility
Variable		**Baseline**	
Output	1.83	1.73	4.9%
Consumption	1.73	1.76	-2.3%
Investment	7.67	6.89	14.5%
Credit spread	0.62	0.57	8.1%
Variable		**No Heterogeneity**	
Output	2.68	2.58	3.7%
Consumption	2.35	2.40	-2.1%
Investment	12.15	11.54	5.0%
Credit spread	0.60	0.55	8.3%

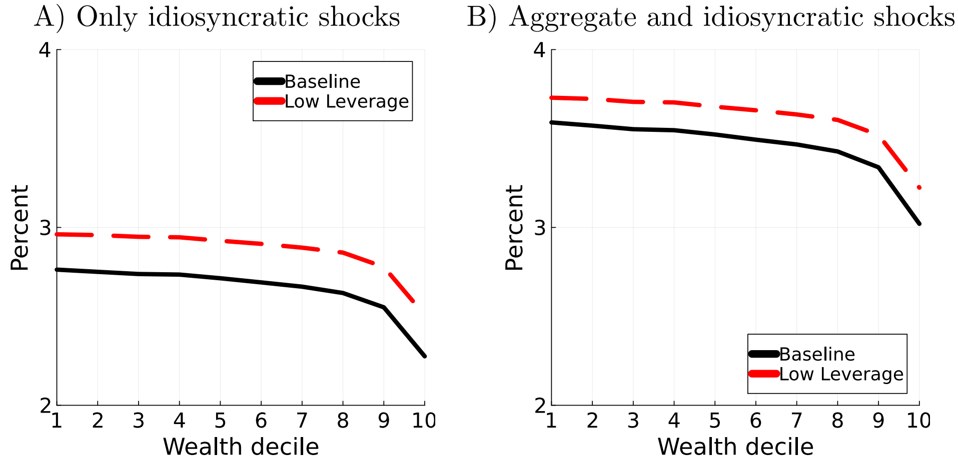
Notes: We report percentage standard deviations of quarterly aggregate variables in response to TFP, monetary, and capital quality shocks after HP(1600)-filtering.

perhaps counterintuitively, the share of borrowers increases because there are more households close to the kink in the budget set. Panel B in this figure shows that a large fraction of the population experiences a significant increase in their MPC.

Figure 9 shows the standard deviation of household consumption growth over a five-year horizon conditional on initial wealth, allowing either for only idiosyncratic shocks (Panel A) or also for aggregate shocks (Panel B). Focusing first on the stationary equilibrium, consumption volatility increases across the distribution when banks are less leveraged.[23] The increase in the standard deviation over the five-year horizon, is substantial, going from 8 percent for the poorest households to 10 percent for the 90th decile. For poorer households, it is the increase in the cost of credit that reduces their ability to smooth consumption. Wealthy households are instead mainly affected by the reduction in the return on their savings, which induces a more rapid drift down the wealth distribution once they experience a negative idiosyncratic income shock. When we add aggregate shocks, consumption volatility remains higher across the distribution. However, the increase in consumption volatility is muted because the credit spread now responds less to aggregate shocks, see Table 7.

These results suggest that households may benefit from the decline in the financial accelerator. On the other hand, those depending on credit experience a reduction in the ability to insure against idiosyncratic shocks and wealthy agents are exposed to the decline in the return on savings. To examine this in detail, we compute consumption-equivalent welfare measures across deciles of the

[23] There is ample evidence that changes in the cost of credit affect household consumption, see for example Leth-Petersen (2010), who finds substantial consumption responses to lower credit costs.



Notes: We report the average standard deviation of quarterly household consumption growth rates over a five-year horizon computed over 100,000 households and 1,000 periods and averaged across wealth deciles.

Figure 9: Micro Consumption Volatility by Wealth Deciles

Table 8: Welfare and Banking Sector Leverage

	Baseline Model		**3-Asset Model**	
Shocks	idiosyncratic	+ aggregate	idiosyncratic	+aggregate
1. Wealth decile	-0.28%	-0.02%	-0.19%	0.00%
2. Wealth decile	-0.24%	-0.03%	-0.22%	-0.03%
3. Wealth decile	-0.24%	-0.02%	-0.27%	-0.14%
4. Wealth decile	-0.26%	-0.02%	-0.26%	-0.07%
5. Wealth decile	-0.30%	-0.06%	-0.27%	-0.03%
6. Wealth decile	-0.36%	-0.12%	-0.29%	-0.02%
7. Wealth decile	-0.43%	-0.19%	-0.35%	-0.05%
8. Wealth decile	-0.55%	-0.31%	-0.43%	-0.12%
9. Wealth decile	-0.95%	-0.75%	-0.61%	-0.31%
10. Wealth decile	-4.28%	-4.25%	-6.90%	-6.76%
Average	-0.79%	-0.58%	-0.98%	-0.75%

Notes: We report the fraction of lifetime consumption that households are willing to give up to stay in the baseline economy relative to a counterfactual economy with 10% less leverage. Columns 2-3 report results for the 2 asset baseline model; columns 4-5 report results for the 3-asset model. Aggregate welfare is calculated as $\omega_i = \left[\frac{v(s_{i,t},S_t)+\frac{1}{1-\beta}\frac{1}{1-\vartheta_c}+\hat{v}_l(s_{i,t},S_t)}{\hat{v}_c(s_{i,t},S_t)}\right]^{1/(1-\vartheta_c)} - 1$, for each decile of the initial wealth distribution.

wealth distribution based on solving the model with a second-order perturbation.[24] We report the welfare measures in Table 8, with negative numbers indicating welfare losses when banks are more constrained. In the face of idiosyncratic risk only, we find losses across the distribution. Quantitatively, welfare losses are fairly similar across the first seven deciles of the wealth distribution, ranging from 0.24 to 0.43 percent of consumption. For the wealthiest households, the losses are even higher due to the lower return on savings. At the aggregate level, we find a welfare loss equivalent to 0.8 percent of consumption. Adding aggregate shocks, the welfare effects remain negative across the distribution, but they are now substantially smaller for the poorest 80 percent of the population. This suggests that the reduced sensitivity of spreads to aggregate shocks in the face of higher capital requirements brings some benefits. Wealthy households, on the other hand, remain negative affected when aggregate shocks are included because they are exposed to the return on their savings. In combination, aggregate welfare loss remains as high as 0.58 percent of consumption. In summary, our findings therefore indicate trade-offs between macro-stabilization and micro-volatility.

8 Illiquid Assets

Parts of the HANK literature have highlighted the importance of illiquid assets, see e.g. Kaplan, Moll and Violante (2018) or Bayer et al (2019). Illiquid assets may also matter for our results and in particular for the role banking frictions play in inducing consumption inequality.

Thus, we now introduce an illiquid asset. Households can purchase capital, $k_{i,t+1}$, at the price Q_t (denominated in units of consumption), and earn income by renting their capital holdings, $k_{i,t}$, to firms at the real capital rental rate, $r_{k,t}$. Each period, households can carry out capital maintenance (depreciation), but *active* adjustments can only be done with probability, $\phi_k \in (0,1)$. We assume that the expected return on illiquid assets is above the bond and deposit returns, but below the expected cost of consumer credit. Intermediate goods producers rent a part of the capital stock from households and finance the remaining part through corporate equity issues to banks. Equity held by banks is assumed to be liquid, and capital quality shocks affect only the fraction of capital that is financed by equity, see Appendix E for further details. We calibrate ω_I by targeting the ratio of bank deposits to output in the stationary equilibrium (34 percent in the Danish economy). This implies that $\phi_k = 0.0025$ per quarter. Assuming instead that illiquid assets consist of housing and targeting the ratio of the value of illiquid household assets to total assets (excluding business assets and pensions, 79 percent in Denmark), yields almost the same calibration. Table 13 in Appendix E summarizes the three-asset model calibration.

In this economy, when a household is given the opportunity to adjust its illiquid assets, it will

[24]As is standard practice, the welfare measures are computed assuming that consumption is compensated while hours worked remain at their equilibrium level.

either choose to hold none (if it is sufficiently poor) or to adjust to a "long-run" Euler equation:

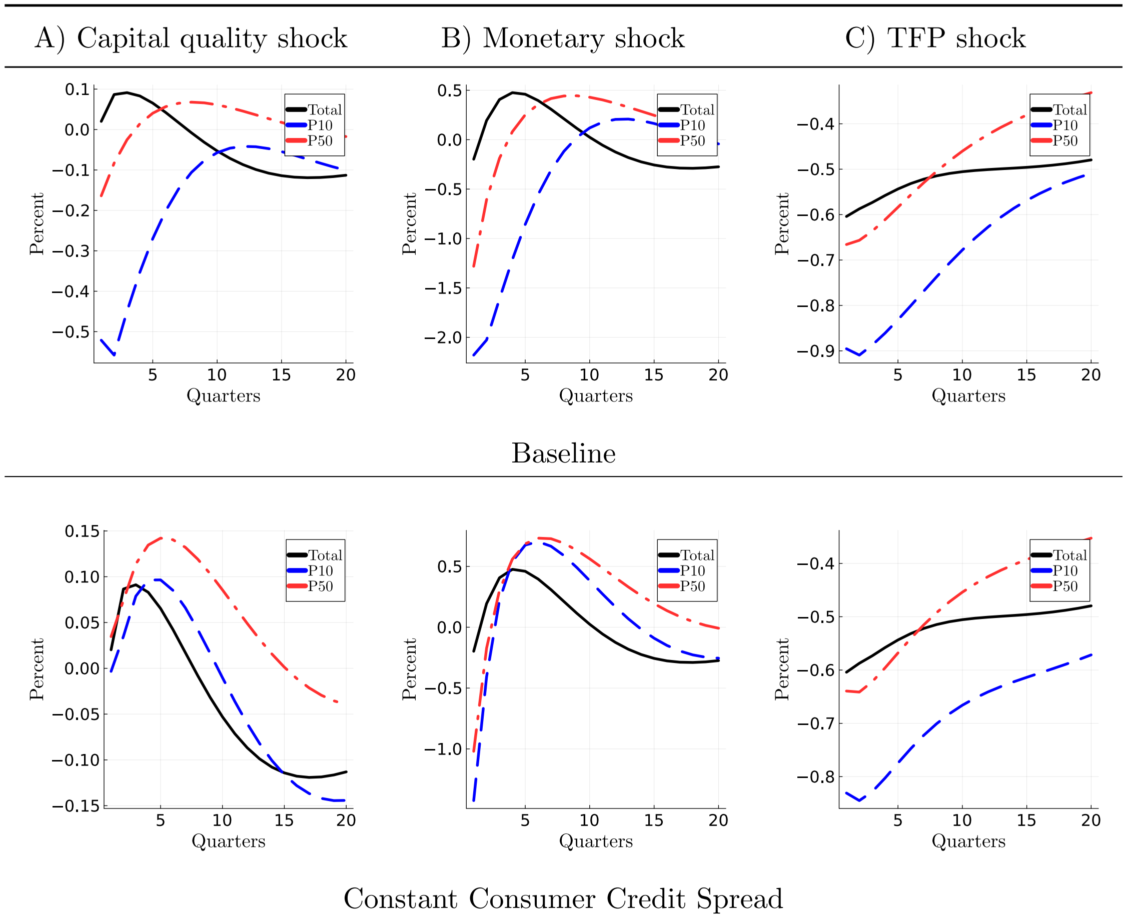
$$
\begin{aligned}
Q_t(c_{i,t}^a)^{-\vartheta_c} &= \beta\sum_{s=1}^{\infty}(\beta(1-\phi_k))^{s-1} \\
&\quad \mathbb{E}_t\left[\phi_k(Q_{t+s}+r_{K,t+s}-\delta)(c_{i,t+s}^a)^{-\vartheta_c}+(1-\phi_k)(r_{K,t+s}-\delta)(c_{i,t+s}^n)^{-\vartheta_c}\right]
\end{aligned}
$$

where we use the index 'a' to denote the state in which the illiquid asset can be adjusted and 'n' to denote the complement state. Households discount future payoffs by β due to impatience and by $1-\phi_k$ due to illiquidity. The term in square brackets is a weighted average of the period $t+s$ return on the asset when the household can adjust its illiquid position and when it cannot (in which case the return excludes capital gains and losses).

When we introduce illiquid assets, we account for some of the discrepancies between the predictions of the baseline model and the micro data discussed in Section 6.1. Figure 21 in the appendix reports the coefficients on income and the spread when estimating equation (2) on simulated data for the 3-asset model. In these simulations, we assume that the spread between borrowing rates and the return on illiquid assets is fixed at its steady-state value. Appendix Figure 22 reports the coefficients when estimating equation (3) on the simulated model that. We find that the consumption-to-income elasticity parameter now is extremely similar to the one estimated in the micro data both in terms of its dependence on wealth and in terms of its size. Moreover, when credit spreads rise, we now find that the wealthiest households increase their consumption. The reason is that the wealth effect now is sufficiently strong to dominate the substitution effect for these households, see also Figure 18 in the appendix which illustrates the consumption policy function.

In this setting, due to the illiquid asset, a household may be liquidity constrained even if it has positive net wealth and it is the liquid asset position that matters for whether households are constrained, i.e. there can be both rich and poor hand-to-mouth households, cf. Kaplan and Violante (2014). However, if the household finds itself with zero liquid assets, it will liquidate its illiquid assets (or parts of them) whenever it has the chance to do so. The likelihood of being at the kink in the budget constraint depends on the composition of asset portfolios, which here is affected by both the consumer credit spread, and by the spread of illiquid assets over liquid assets.

Given the impact of illiquid assets on consumption, one may wonder if the heterogeneous effects of aggregate shocks that we have discussed can arise even when the consumer credit spread is constant. Figure 10 illustrates consumption responses for the median and the 10th and 90th percentiles to the three aggregate shocks in this economy, assuming either a constant consumer credit spread or allowing this spread to adjust due to banking friction. Holding constant the credit spread, consumption moves in parallel across the distribution while movements in the consumer credit spread induce heterogeneous consumption dynamics across the distribution in response to the capital quality shock and the monetary policy shock. Thus, countercyclical spreads account for the heterogeneous impact



Notes: Impulse responses of the consumption distribution in the 3-asset model (black solid line) and the 3-asset model with constant consumer credit spread.

Figure 10: Consumption Impulse Responses by Consumption Percentiles

of aggregate shocks because consumer credit is the principal means of insurance against adverse income shocks.

Due to the richer asset structure, it is interesting to examine the welfare effects of a reduction in banking sector leverage discussed in Section 7. Table 14 in Appendix E reports the impact on the stationary equilibrium. As in the baseline model, when banks are less leveraged, the consumer credit spread rises. In the model with illiquid assets, however, the rise in the spread is achieved chiefly through a reduction in the return on liquid assets, while the consumer credit rate and the return on capital are approximately unchanged in the stationary equilibrium. The last two columns of Table 8 report the consumption-equivalent welfare measures for this economy. The results are very similar to those in the baseline model although for the very poorest households, the lower volatility of spreads over the business cycle actually implies that the policy is close to welfare neutral. The richest decile of households experience a significant drop in welfare because they hold more liquid assets and are therefore more sensitive to the decline in the return on these assets.

9 Summary and Conclusions

We examine the role of consumer credit spreads for macro and micro outcomes. We provide empirical evidence from high-quality household data that consumer credit spreads affect household wealth dynamics and consumption decisions. Our analysis suggests that households with low net wealth that are exposed to higher consumer credit spreads are more likely to remain in such a low net wealth state. Moreover, higher consumer credit spreads are correlated with lower consumption spending by low wealth households, while stimulating consumption by wealthy households. We derive a time-varying measure of the consumption-income elasticity which we argue correlates highly with the MPC. We show that this elasticity is countercyclical, and that the consumer credit spread is an important component of this countercyclicality.

We then introduce frictional financial intermediation into a HANK model where banks provide funds for corporate investment and consumer credit at a spread over the return they offer on savings. This spread moves countercyclically due to agency friction. The consumer credit spread creates a kink in households' budget sets, induces a mass point of low net wealth households, and drives a wedge between the intertemporal prices faced by borrowers and savers. We show that the model generates a financial accelerator relative to a model with a constant spread in the face of shocks to banking sector net worth and monetary policy shocks. However, the amplification is somewhat more moderate than in a RANK setting due to labor supply responses to recessionary shocks.

Credit frictions have important consequences. Because spreads respond to shocks, aggregate shocks have heterogeneous effects across the wealth distribution, and induce countercyclical and volatile MPCs, which are highly correlated with the measure of consumption-income elasticity that we estimate in the household data. Moreover, banks provide insurance to households and one may therefore need to consider micro aspects of bank regulation.

We did not attempt to estimate theory-consistent consumption dynamics using the unique data on household-specific interest rates, but this would be of obvious interest for a better understanding of household behavior. It would also be interesting to consider market power in the banking sector instead of the agency friction that we have adopted, as this would allow one to account for the imperfect pass-through from policy rates to deposit rates observed in the data. We leave these and other extensions to future research.

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10 Appendices

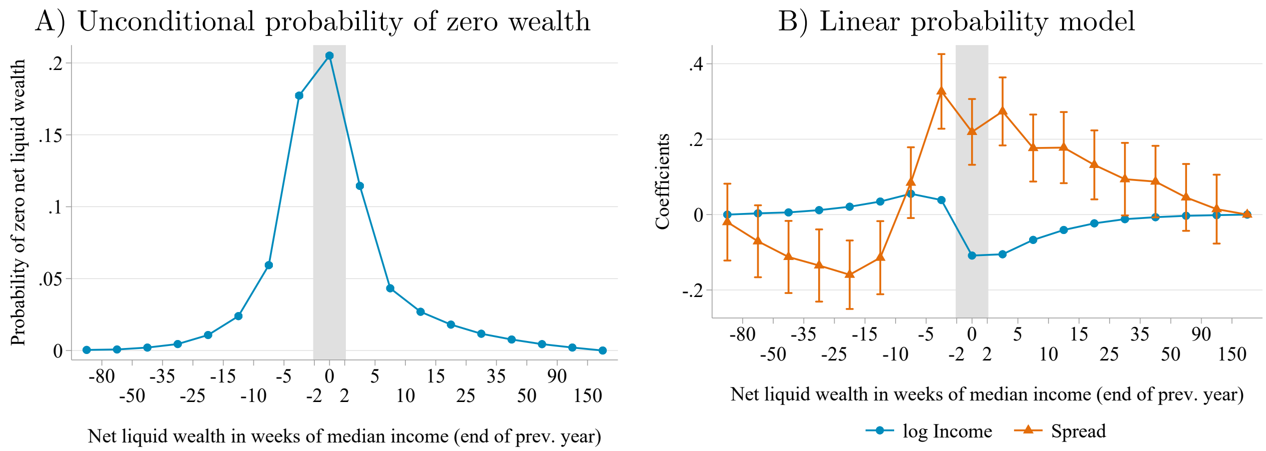
10.1 Appendix A: Additional Results and Information for Section 2

Table 9 reports some characteristics of the household dataset examined in Section 2. The average age of the household head and the average household size are both stable over the sample. The Danish economy entered a cyclical downturn at the onset of the financial crisis, and has been recovering since 2014. The cyclical dynamics are reflected in average consumption expenditure and in fluctuations in asset values. The average ratio of net household wealth to disposable income shows considerable fluctuations over time, while the ratio of net liquid assets to disposable income excluding housing and mortgages is stable and close to one on average.

Table 9: Descriptive statistics

	(1) 2007 mean	(2) 2012 mean	(3) 2017 mean
Net wealth	747,251.61	448,838.04	567,918.01
Assets	1,188,575.63	927,978.87	1,012,632.15
Debt	441,324.02	479,140.83	444,714.13
Liquid wealth	279,290.77	248,087.95	248,530.79
Share net zero wealth	0.08	0.10	0.11
Disposable income	242,772.93	250,876.25	261,013.50
Labor income	246,299.02	235,152.34	241,692.47
Consumption	257,785.87	233,279.09	248,923.70
Age of household head	51.16	50.93	50.86
Household size	1.85	1.84	1.81
N	2,145,397	2,316,459	2,395,008

Notes: Net wealth is defined as the sum of housing wealth, portfolio wealth, bank deposits, and bank and mortgage debt, as well as some major durable goods such as cars. Assets are gross assets, liabilities are gross liabilities. Liquid assets are defined as net wealth less housing and mortgages. Unless otherwise stated, all numbers are averages and deflated to 2003 Danish Kroner.



Notes: The figure shows unconditional transition probabilities to the zero net wealth state by net wealth decile (Panel A) and the change in transition probabilities with cross-sectional changes in income and spread (Panel B), estimated from Equation (2). Sampling uncertainty is indicated by vertical bars (95 percent confidence bands). The net wealth measure here excludes housing assets and mortgage debt. Zero wealth is indicated by the grey shading and defined as net assets within a range of plus/minus two weeks of median household income.

Figure 11: Wealth Dynamics Excluding Housing and Mortgages

Table 10 reports the results of estimating Equation (3) when either capitalizing car expenditures or excluding households that purchase a car from the data in the year of the purchase. As is evident, the coefficient estimates are robust to the treatment of car spending and similar to those reported in Table 1.

Table 10: Robustness: Different Treatment of Car Purchases

	(1)	(2)	(3)	(4)
log income	0.375***		0.358***	
	(0.00308)		(0.00325)	
Low net wealth × log Income		0.400***		0.384***
		(0.00398)		(0.00429)
High net wealth × log Income		0.339***		0.320***
		(0.00391)		(0.00402)
Spread	-0.268***		-0.251***	
	(0.0151)		(0.0145)	
Low net wealth × Spread		-0.339***		-0.286***
		(0.0177)		(0.0164)
High net wealth × Spread		-0.123***		-0.145***
		(0.0208)		(0.0204)
log income × Spread	1.131***		1.131***	
	(0.0671)		(0.0714)	
Low net wealth × log Income × Spread		1.357***		1.409***
		(0.0893)		(0.0975)
High net wealth × log Income × Spread		0.737***		0.647***
		(0.0864)		(0.0887)
#Observations	17,935,813	17,935,813	15,177,507	15,177,507
R^2	0.580	0.584	0.613	0.616
RMSE	0.269	0.268	0.234	0.233

Notes: The table illustrates the relationship of consumption with income, consumer credit spreads and their interaction, estimated from Equation (3). High net wealth denotes households above the median and low net wealth those below. Standard errors clustered at the household level. In columns (1) and (2) we capitalize cars using their official tax value. In (3) and (4) we exclude households that have purchased a car in the current or previous year from the sample.

Table 11 reports the results from estimating:

$$\Delta \log c_{i,t} = \sum_j \mathbf{1}_{(A_{i,t} \in A_j^{Net})} \left(\beta_{0,j} \Delta \log y_{i,t} + \beta_{1,j} R_{i,t}^S + \beta_{2,j} R_{i,t}^S \Delta \log y_{i,t}\right) + \eta X_{i,t} + \alpha_i + \gamma_t + \varepsilon_{i,t} \quad (40)$$

We also experiment with including or excluding a household fixed effect. The results are similar to those reported in Table 1 except for the effect of the spread on above-median wealth households when we first differenced consumption and omitted the household fixed effect.

Table 11: Robustness: Results for First-Difference Specification

	(1)	(2)	(3)	(4)
$\triangle$log income	0.296***		0.311***	
	(0.00440)		(0.00530)	
Low net wealth $\times$ $\triangle$log income		0.322***		0.347***
		(0.00566)		(0.00705)
High net wealth $\times$ $\triangle$log income		0.248***		0.264***
		(0.00648)		(0.00750)
Spread	-0.197***		-0.346***	
	(0.00562)		(0.0151)	
Low net wealth $\times$ spread		-0.268***		-0.519***
		(0.00804)		(0.0196)
High net wealth $\times$ spread		-0.0868***		-0.110***
		(0.00880)		(0.0205)
$\triangle$log income $\times$ spread	2.327***		2.171***	
	(0.107)		(0.128)	
Low net wealth $\times$ $\triangle$log income $\times$ spread		2.462***		2.286***
		(0.137)		(0.169)
High net wealth $\times$ $\triangle$log income $\times$ spread		1.893***		1.826***
		(0.160)		(0.183)
#Observations	17,313,355	17,313,355	16,546,917	16,546,917
R^2	0.0616	0.0634	0.124	0.133
RMSE	0.348	0.347	0.364	0.362

Notes: The table illustrates the relationship of consumption with income, consumer credit spreads and their interaction, estimated from Equation (3). High net wealth denotes households above the median and low net wealth those below. Columns (1) and (2) for specifications that exclude household specific trends, columns (3) and (4) include household specific trends. Standard errors clustered at the household level.

10.2 Appendix B: Choice Problems

10.2.1 Households

The dynamic programs faced by households can be formulated as follows. First, to simplify notation, remove time-subscripts and let $\mathbf{b}_i = (b_i^G, b_i^D, b_i^L)$ denote household i's beginning of period asset portfolio, and $\mathbf{S}$ the vector of relevant aggregate state variables. Let $\mathcal{V}_i^s$ denote the value functions for a worker household ($s = w$) and for a rentier ($s = r$). A worker's Bellman equation is given as:

$$\mathcal{V}_i^w(\mathbf{b}_i, h_i, \mathbf{S}) = \max\left[\mathrm{u}(c_i, l_i) + \beta\mathbb{E}((1-\phi_w)\mathcal{V}i^w(\mathbf{b}_i', h_i', \mathbf{S}') + \phi_w\mathcal{V}_i^r(\mathbf{b}_i', \mathbf{S}'))\right],$$

subject to (6)-(7) and to the flow budget constraint:

$$c_i + (b_i^G)' + (b_i^D)' - (b_i^L)' \leq (1 - \tau_h)\, w h_i l_i + R_S \left(b_i^G + b_i^D\right) - R_L b_i^L,$$

where τ_h is a proportional income tax rate and a prime denotes next period. For rentiers instead:

$$\mathcal{V}_i^r (\mathbf{b}_i, 0, \mathbf{S}) = \max \left[u (c_i, l_i) + \beta \mathbb{E}(\phi_r \mathcal{V}_i^w (\mathbf{b}_i', 1, \mathbf{S}') + (1 - \phi_r) \mathcal{V}_i^r (\mathbf{b}_i', 0, \mathbf{S}'))\right],$$

subject to (6)-(7) and to the flow budget constraint:

$$c_i + (b_i^G)' + (b_i^D)' - (b_i^L)' \leq (1 - \tau_h)\, \mathcal{F} + R_S \left(b_i^G + b_i^D\right) - R_L b_i^L.$$

10.2.2 Banks

Banks face the following optimization problem:

$$\mathbf{V}^b (n_t^z, S_t) = \max \mathbb{E}_t \beta \left((1 - \theta)\, n_{t+1}^z + \theta V^b \left(n_{t+1}^z\right)\right)$$

subject to (10) and to:

$$\lambda a_t^z \leq \mathbf{V}^b (n_t^z, S_t)$$

where $a_t^z = \left(Q_t b_{F,t+1}^z + b_{D,t+1}^z\right)$ are the bank's assets. (12) imposes that assets cannot exceed $\mathbf{V}^b/\lambda$ since bankers otherwise would choose to divert their assets.

To solve this, guess that:

$$\mathbf{V}^b (n_t^z, S_t) = \varrho_t n_t^z$$

Subject to this guess, (12) can be expressed as a constraint on leverage, l_t^s:

$$l_t^z = \frac{a_t^z}{n_t^z} \leq \frac{\varrho_t}{\lambda}$$

Substituting (10) into (13), we can then express the bank's value as:

$$\begin{aligned} \varrho_t n_t^z &= \max \mathbb{E}_t [\beta ((1 - \theta) + \theta \varrho_{t+1}) (R_{K,t+1} - R_{S,t+1})\, a_t^z \\ &\quad + \beta ((1 - \theta) + \theta \varrho_{t+1})\, R_{S,t+1} n_t^z] \end{aligned}$$

The first-order necessary conditions and the envelope condition are:

$$
\begin{aligned}
\mu_t^z \lambda &= \mathbb{E}_t[\beta\left((1-\theta)+\theta\varrho_{t+1}\right)\left(R_{K,t+1}-R_{S,t+1}\right) \\
0 &= \mu_t^z\left[\varrho_t n_t^z - \lambda a_t^z\right] \\
\varrho_t &= \frac{\mathbb{E}_t\beta\left((1-\theta)+\theta\varrho_{t+1}\right)R_{S,t+1}}{1-\mu_t^z}
\end{aligned}
$$

where $\mu_t^z \geq 0$ is the Kuhn-Tucker multiplier on (12). When the incentive constraint binds, banks expect to earn excess returns on their investments relative to the cost of capital (the deposit rate), $\mathbb{E}_t(R_{K,t+1}-R_{S,t+1})>0$, otherwise they equalize. We now impose that the incentive constraint binds so that leverage is equalized across banks. Given this, the Kuhn-Tucker multiplier is identical across banks and given as:

$$
\mu_t = \max\left(1-\frac{\mathbb{E}_t\beta\left((1-\theta)+\theta\varrho_{t+1}\right)R_{S,t+1}N_t}{\lambda A_t},0\right)\in(0,1)
$$

where $N_t=\int n_t^z dz$, $A_t=\int a_t^z dz$. This confirms the guess on the value function and implies:

$$
\begin{aligned}
\varrho_t &= \frac{\mathbb{E}_t\beta\left((1-\theta)+\theta\varrho_{t+1}\right)R_{S,t+1}}{1-\mathbb{E}_t[\beta\left((1-\theta)+\theta\varrho_{t+1}\right)\left(R_{K,t+1}-R_{S,t+1}\right)/\lambda} \\
l_t &= \frac{\varrho_t}{\lambda}=\frac{\mathbb{E}_t\beta\left((1-\theta)+\theta\varrho_{t+1}\right)R_{S,t+1}}{\lambda-\mathbb{E}_t[\beta\left((1-\theta)+\theta\varrho_{t+1}\right)\left(R_{K,t+1}-R_{S,t+1}\right)}
\end{aligned}
$$

The equilibrium law of motion of an individual bank z's net worth is then:

$$
n_{t+1}^z=\left(l_t R_{K,t+1}+(1-l_t)R_{S,t+1}\right)n_t^z
$$

The aggregate banking sector net worth now follows from noting that l_t is independent of net worth.

10.2.3 Goods Producers

Let $\mathbf{V}_r^F\left(P_{r,t-1}^F,S_t\right)$ denote the expected present value of real profits of a producer that charged the nominal price $P_{r,t-1}^F$ last period. Goods producers then solve the problem:

$$
\mathbf{V}_r^F\left(P_{r,t-1}^F,S_t\right)=\max_{P_{r,t}^F}\left(\upsilon_{r,t}^G+\beta\mathbb{E}_t\mathbf{V}_r^F\left(P_{r,t}^F,S_{t+1}\right)\right)
$$

subject to (18).

The first order condition for $P^F_{r,t}$ and the envelope condition are given as:

$$\left(1-\eta\left(1-\frac{P^m_t}{P^F_{r,t}}\right)\right)\frac{1}{P_t}y_{r,t} = \frac{\eta}{\omega_Y}\frac{1}{P^F_{r,t}}\log\left(\frac{P^F_{r,t}}{P^F_{r,t-1}}\right)Y_t - \beta\mathbb{E}_t\frac{\partial \mathbf{V}^F_f\left(P^F_{r,t},S_{t+1}\right)}{\partial P^F_{r,t}}$$
$$\frac{\partial \mathbf{V}^F_r\left(P^F_{r,t-1},S_t\right)}{\partial P^F_{r,t-1}} = \frac{\eta}{\omega_Y}\frac{1}{P^F_{r,t-1}}\log\left(\frac{P^F_{r,t}}{P^F_{r,t-1}}\right)Y_t$$

which implies that:

$$\log\left(\pi_{h,t}\right) = \beta\mathbb{E}_t\log\left(\pi_{h,t+1}\right)\frac{Y_{t+1}}{Y_t} + \kappa_Y\frac{p_{h,t}}{P_t}\left(\frac{P_{m,t}}{p_{h,t}} - \frac{\eta-1}{\eta}\right)\frac{y_{h,t}}{Y_t}$$

Combining these and focusing on a symmetric equilibrium gives us Equation (21).

10.2.4 Capital Producers

Capital producers solve the following dynamic problem:

$$V^K\left(I_{n,t-1},S_t\right) = \max_{I_{n,t}}\left(\upsilon^I_t + \beta\mathbb{E}_tV^K\left(I_{n,t},S_{t+1}\right)\right)$$

The first-order necessary condition for $I_{n,t}$ and the envelope condition are given as:

$$\left(Q_t-1\right)+\beta\mathbb{E}_t\frac{\partial V^K\left(I_{n,t},S_{t+1}\right)}{\partial I_{n,t}} = \omega_I\log\left(\frac{I_{n,t}+\psi}{I_{n,t-1}+\psi}\right)+\frac{\omega_I}{2}\left(\log\left(\frac{I_{n,t}+\psi}{I_{n,t-1}+\psi}\right)\right)^2 \quad (41)$$
$$\frac{\partial V^K\left(I_{n,t-1},S_t\right)}{\partial I_{n,t-1}} = \omega_I\left(\log\left(\frac{I_{n,t}+\psi}{I_{n,t-1}+\psi}\right)\right)\frac{I_{n,t}+\psi}{I_{n,t-1}+\psi} \quad (42)$$

Combining these gives us Equation (28).

10.3 Appendix C: Estimation of the Household Income Process

Assume that log household income is determined as:

$$\begin{aligned} y_{i,t} &= \delta_t + \delta_Z Z_{i,t} + \tilde{y}_{i,t} \\ \tilde{y}_{i,t} &= x_{i,t} + \varepsilon_{i,t} \\ x_{i,t} &= \rho x_{i,t-1} + e_{i,t} \\ \varepsilon_{i,t} &\sim N(0, \sigma_\varepsilon^2) \\ e_{i,t} &\sim N(0, \sigma_e^2) \end{aligned}$$

where δ_t is a time fixed effect, $Z_{i,t}$ is a vector of household characteristics, $x_{i,t}$ is a persistent idiosyncratic income component, and $\varepsilon_{i,t}$ is a transitory income shock. The autocovariances of residualized household income of order 0-2 are given as:

$$m_{1,t} = \mathbb{E}(\tilde{y}_{i,t} \cdot \tilde{y}_{i,t}) = \frac{1}{1-\rho^2}\sigma_e^2 + \sigma_\varepsilon^2 \quad (43)$$

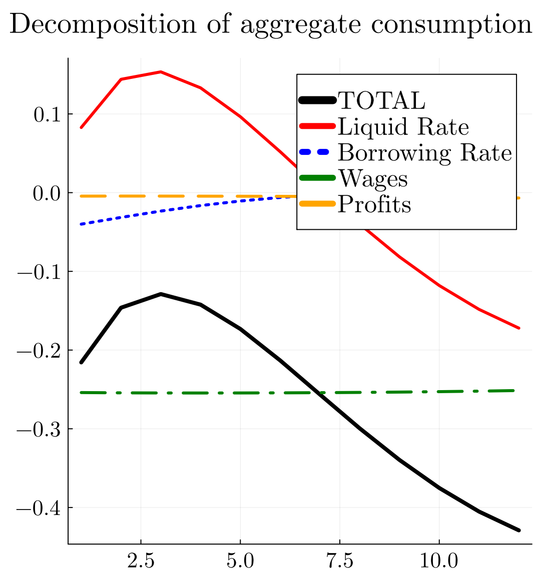
$$m_{2,t} = \mathbb{E}(\tilde{y}_{i,t} \cdot \tilde{y}_{i,t-1}) = \frac{\rho}{1-\rho^2}\sigma_e^2 \quad (44)$$

$$m_{3,t} = \mathbb{E}(\tilde{y}_{i,t} \cdot \tilde{y}_{i,t-2}) = \frac{\rho^2}{1-\rho^2}\sigma_e^2 \quad (45)$$

These three moments identify jointly $\Gamma = (\rho, \sigma_e, \sigma_\varepsilon)$. We estimate Γ with GMM using an identity weighting matrix.

10.4 Appendix D: Further Results for the Baseline Model

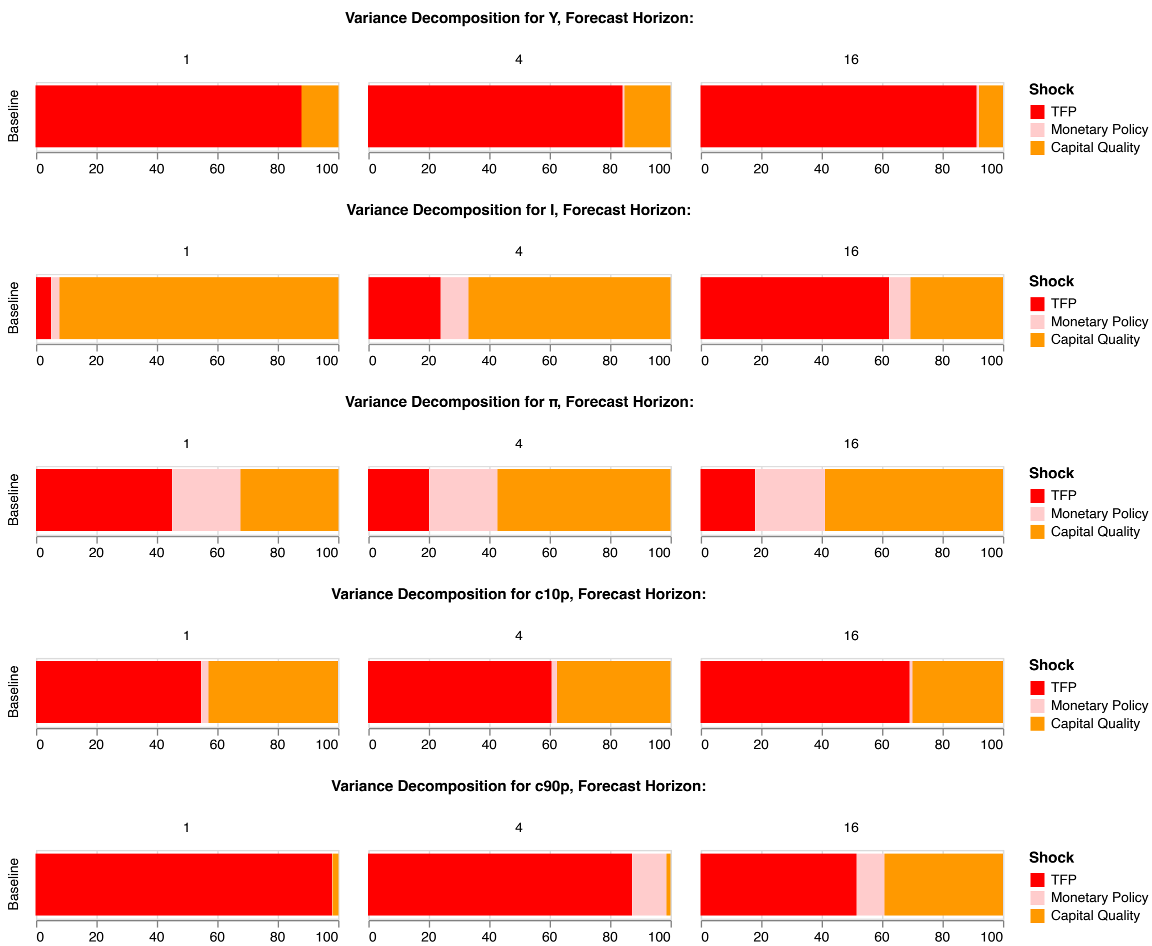
Figure 12 decomposes the transmission of capital quality shocks to aggregate consumption into the effect of each price. Figures 14 and 15 show additional impulse responses to monetary and TFP shocks. Figure 13 shows the variance decomposition of output, investment, inflation, and consumption at horizon 1, 4, and 16 quarters for the baseline model and calibration. Aggregate output is heavily influenced by TFP shocks both at short and longer forecast horizons. Aggregate investment is sensitive to capital quality shocks in the short run, more by TFP in the long run, and with some importance of monetary policy shocks in the medium run. Inflation is sensitive to all three shocks in the short run, but with a smaller importance of TFP in the longer run. Consumption of the rich is heavily dominated by TFP in the short run while the poor are sensitive to capital quality shocks (and to monetary shocks) at such short horizons. In the medium run, monetary policy shocks (which impact on savings rates) are instead important for wealthier households.



Notes: The figure plots the decomposition of the response of aggregate consumption to a one percent negative capital quality shock into the effect of each price sequence by using household policy functions.

Figure 12: Transmission to Consumption: Capital quality shock

Figures 16 presents the results of estimating Equation 2, which captures transitions to zero wealth, using model-generated data. Figure 17 shows the corresponding results for Equation 3, reflecting the consumption response. For this analysis, we solve households' optimal responses to idiosyncratic income and spread shocks, simulating 100 panels of 20,000 households each. In each panel, households are subjected to the same spread shock, mimicking a scenario where all households in that panel are served by a single bank. This approach parallels the identification strategy in the empirical section, which relies on household and time fixed effects.



Notes: Conditional variance decomposition at quarter 1,4,16 for selected variables in the baseline calibration of the model and shocks.

Figure 13: Conditional Variance Decomposition

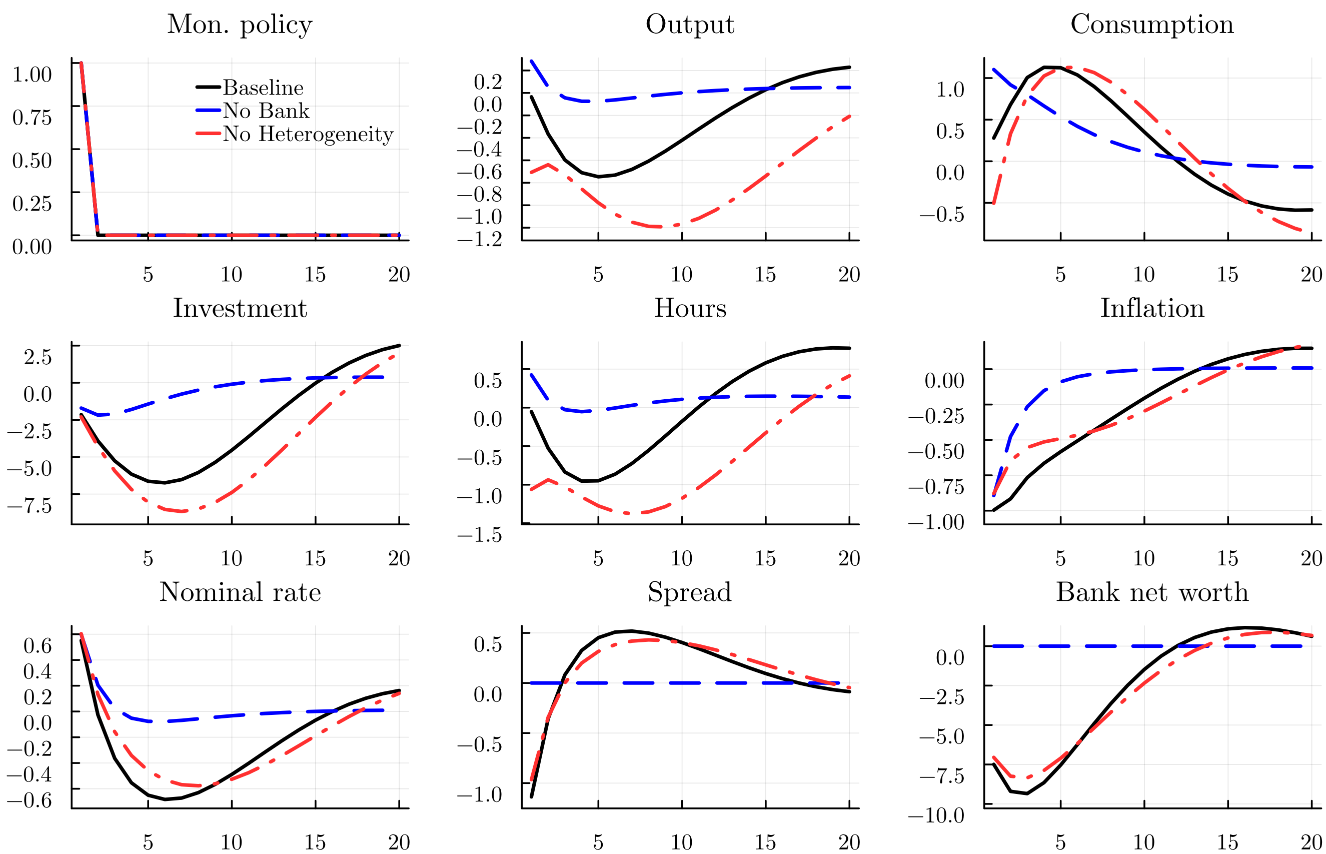
The size and persistence of spread shocks are identified from Danish bank-level interest rate data. We model the loan rate ($R_{L,t}$) and deposit rate ($R_{S,t}$) as linear functions of a common factor (z_t). Specifically, the model is defined as:

$$R_{S,t} = a \cdot z_t, \quad R_{L,t} = b \cdot z_t,$$

where the spread between the loan and deposit rates is given by: $\text{Spread}_t = R_{L,t} - R_{S,t} = (b - a) \cdot z_t$. The common factor z_t follows a stationary AR(1) process:

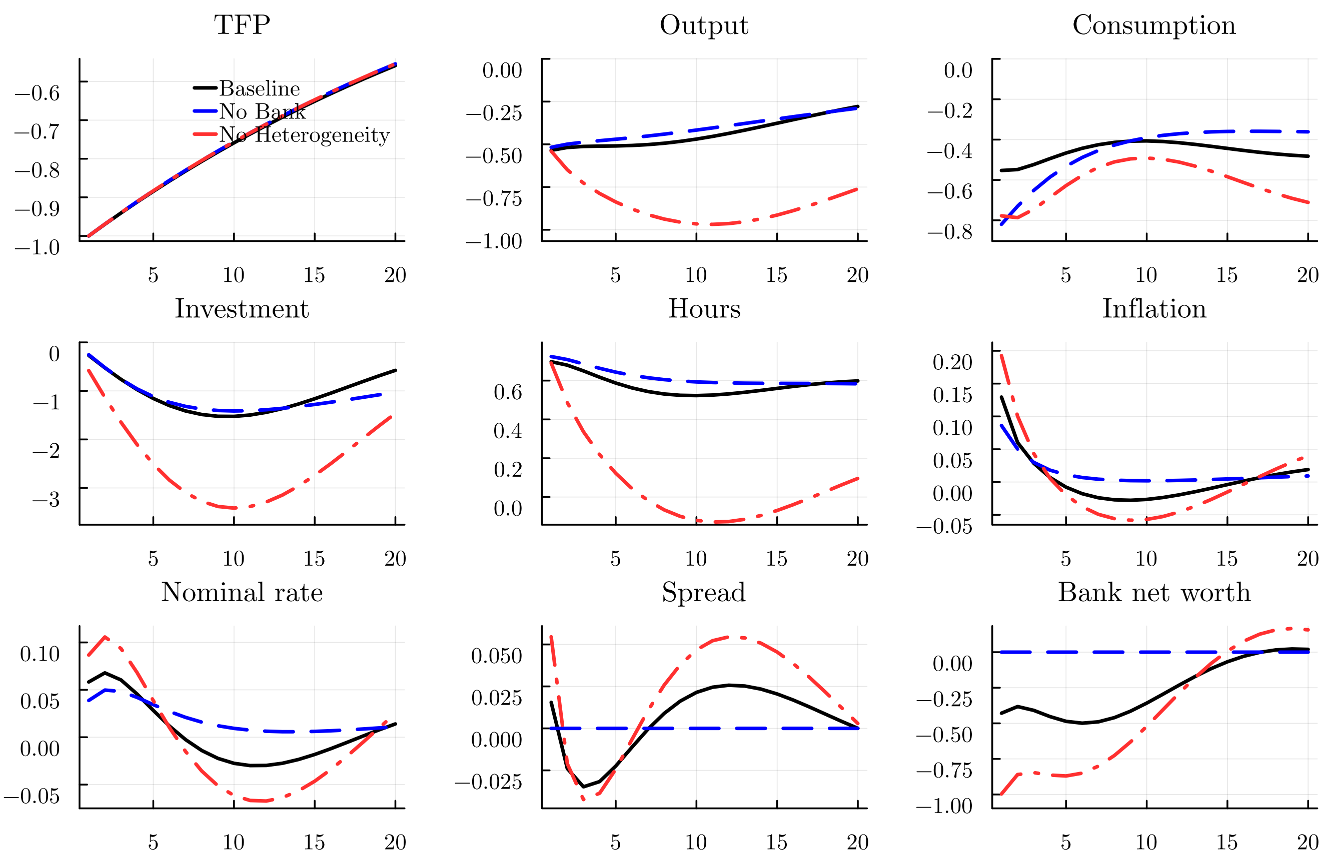
$$z_t = \rho \cdot z_{t-1} + \eta_t, \quad \eta_t \sim \mathcal{N}(0, \sigma_\eta^2),$$

with $\rho = 0.85$ governing its persistence. The coefficient on the deposit rate is $a = 0.177$ and the coefficient on the loan rate is $b = 3.195$.



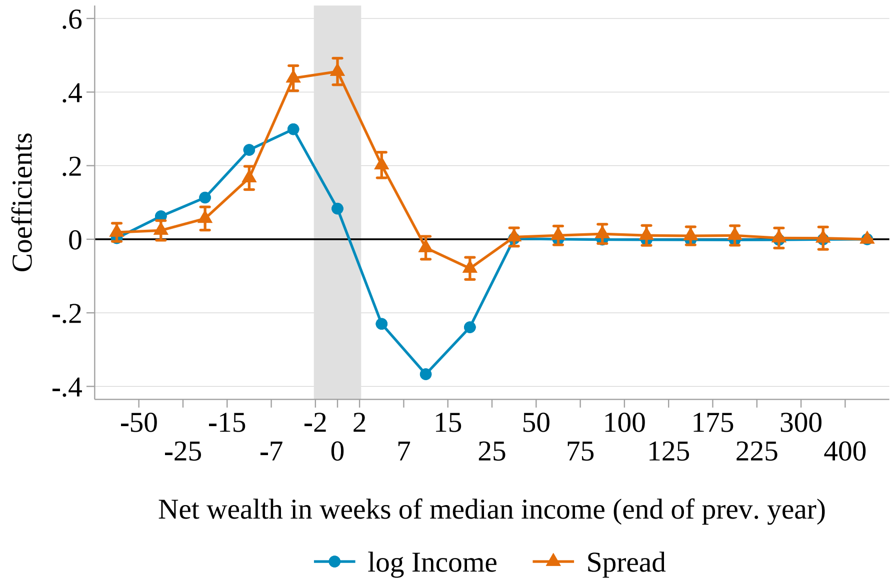
Notes: Impulse responses to a one percentage point positive nominal interest rate shock. See Figure 5 for legend.

Figure 14: Aggregate Effects of a Monetary shock



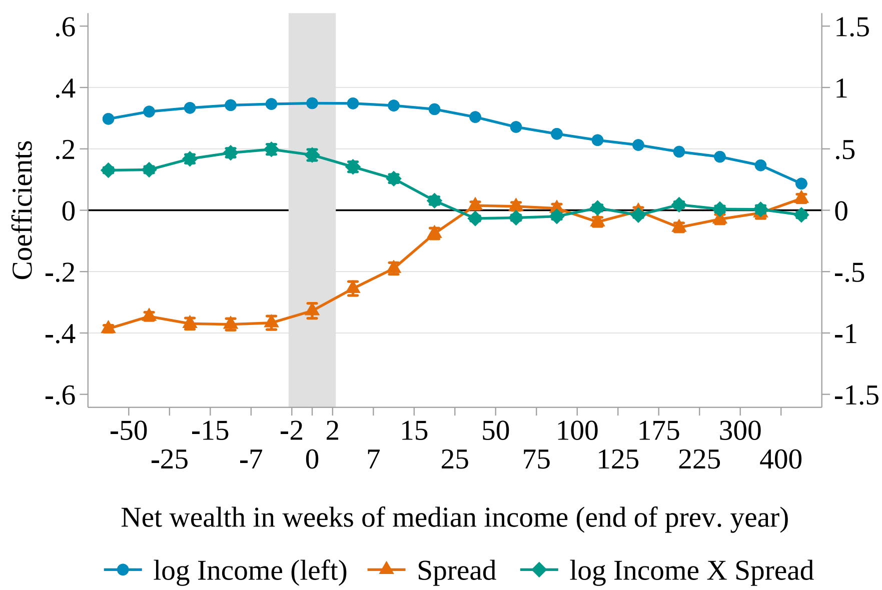
Notes: Impulse responses to a one percent negative TFP shock. See Figure 5 for legend.

Figure 15: Aggregate Effects of a TFP shock



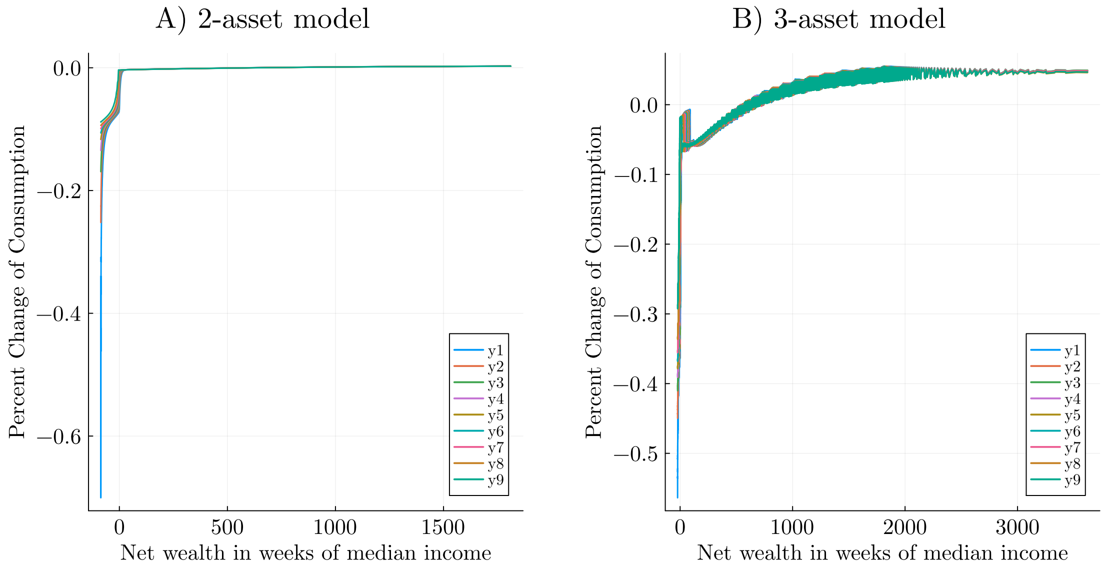
Notes: The figure shows the change in transition probabilities into the zero net wealth state with cross-sectional changes in income and the consumer credit spread (estimated from Equation (2)). Zero net wealth is defined as net assets within a range of plus/minus two weeks of median household income.

Figure 16: Zero Net Wealth Dynamics



Notes: The figure illustrates the parameters estimated from Equation (3) on model simulated data in response to idiosyncratic income and spread shocks. The underlying wealth distribution is trimmed at the 3rd and 97th percentile. The error bars illustrate 95% confidence intervals. Standard errors clustered at the household level.

Figure 17: Consumption and the Spread in the Model



The figure illustrates the impact of spreads on consumption conditional on wealth and the income state. Panel A shows the baseline model, Panel B the three-asset model.

Figure 18: Policy Functions for Consumption

Table 12: Business Cycle Moments: MPC Comparison

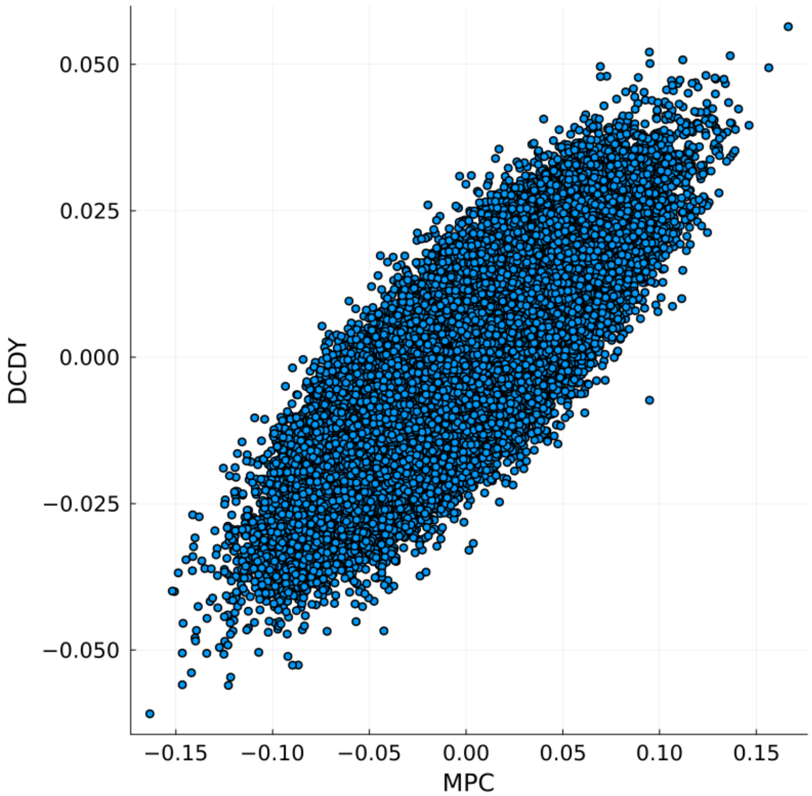
Moments	Baseline	Constant Spread	No bank
σ_{MPC}/σ_Y	0.63	0.06	0.17
$corr(MPC, Y)$	-0.60	-0.56	0.03

Notes: σ_x denotes the percentage standard deviation of x, $corr(x, y)$ is the correlation of x and y. Model moments computed for HP-filtered data. Model moments are in response to TFP, monetary, and capital quality shocks. Standard deviations and correlations for the MPC are based on annual data.

10.5 Appendix E: The Three Asset Model

Here we discuss the relevant parts of the three-asset model studied in Section 8. We focus on the elements that differ from the baseline two asset model presented in Section 3.

Households: In the three asset model, households can hold capital, $k_{i,t}$ which they rent directly to firms at the real capital rental rate $r_{k,t}$. Households cannot go short on the illiquid asset $k_{i,t+1} \geq 0$. They can carry out maintenance every period which corresponds to depreciation at the constant proportional rate $\delta \in (0, 1)$. However, in a given period, they can adjust capital holdings *actively*



Notes: Simulation of model implied average MPC and DCDY (HP-filtered) in response to TFP, monetary, and capital quality shocks. DCDY is calculated using the model regression coefficients from Table 1. The correlation between the two series is 88 percent.

Figure 19: Scatter Plot: DCDY and MPC

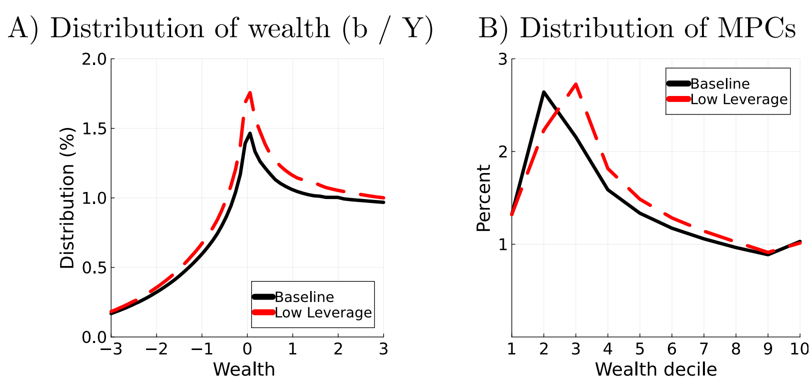


Figure 20: Distributions: Baseline and Restricted Leverage

only with the probability $\phi_k \in (0,1)$ which is constant across time and households. Households that actively change their capital stock, purchase new capital at the price Q_t (relative to the price of consumption). Thus, the one-period expected return on the illiquid asset is $\mathbb{E}_t R_{I,t+1} = \mathbb{E}_t(r_{K,t+1} +$

$Q_{t+1} - \delta)/Q_t$.[25] As long as $\phi_k < 1$, households will only hold capital if $\mathbb{E}_t(R_{I,t+1} - R_{S,t+1}) > 0$.

Let $\mathbf{b}_{i,t} = (b^G_{i,t}, b^D_{i,t}, k_{i,t}, b^L_{i,t})$ denote household i's beginning of period asset portfolio, $\mathbf{S}_t$ the vector of relevant aggregate state variables, and $\mathcal{V}^{w,a}_i$ the value function for a household that can adjust its illiquid bond holding. The Bellman equation for such a household is given as:

$$\begin{aligned}
\mathcal{V}^{w,a}_i(\mathbf{b}_{i,t}, h_{i,t}, \mathbf{S}_t) &= \max[\mathrm{u}(c_{i,t}, l_{i,t}) \\
&+ \beta\mathbb{E}_t((1-\phi_w)(\phi_k \mathcal{V}^{w,a}_i(\mathbf{b}_{i,t+1}, h_{i,t+1}, \mathbf{S}_{t+1}) + (1-\phi_k)\mathcal{V}^{w,n}_i(\mathbf{b}_{i,t+1}, h_{i,t+1}, \mathbf{S}_{t+1})) \\
&+ \phi_w(\phi_k \mathcal{V}^{r,a}_i(\mathbf{b}_{i,t+1}, \mathbf{S}_{t+1}) + (1-\phi_k)\mathcal{V}^{r,n}_i(\mathbf{b}_{i,t+1}, \mathbf{S}_{t+1})))]
\end{aligned} \tag{46}$$

subject to (6)-(7) and to the flow budget constraint:

$$\begin{aligned}
c_{i,t} + b^G_{i,t+1} + b^D_{i,t+1} + Q_t(k_{i,t+1} - k_{i,t}) - b^L_{i,t+1} \leq \\
(1-\tau_{h,t})\, w_t h_{i,t} l_{i,t} + R_{S,t}\left(b^G_{i,t} + b^D_{i,t}\right) + (r_{K,t} - \delta)k_{i,t} - R_{L,t} b^L_{i,t}
\end{aligned} \tag{47}$$

$\mathcal{V}^{w,n}_i$ is the value function of a household that cannot adjust illiquid assets this period, while $\mathcal{V}^{r,s}_i$ denotes the rentiers' value functions. $\mathcal{V}^{w,n}_i$ is given as:

$$\begin{aligned}
\mathcal{V}^{w,n}_i(\mathbf{b}_{i,t}, h_{i,t}, \mathbf{S}_t) &= \max[\mathrm{u}(c_{i,t}, l_{i,t}) \\
&+ \beta\mathbb{E}_t((1-\phi_w)(\phi_k \mathcal{V}^{w,a}_i(\mathbf{b}_{i,t+1}, h_{i,t+1}, \mathbf{S}_{t+1}) + (1-\phi_k)\mathcal{V}^{w,n}_i(\mathbf{b}_{i,t+1}, h_{i,t+1}, \mathbf{S}_{t+1})) \\
&+ \phi_w(\phi_k \mathcal{V}^{r,a}_i(\mathbf{b}_{i,t+1}, \mathbf{S}_{t+1}) + (1-\phi_k)\mathcal{V}^{r,n}_i(\mathbf{b}_{i,t+1}, \mathbf{S}_{t+1})))]
\end{aligned} \tag{48}$$

subject to (6)-(7) and to the flow budget constraint:

$$\begin{aligned}
c_{i,t} + b^G_{i,t+1} + b^D_{i,t+1} - b^L_{i,t+1} \leq \\
(1-\tau_{h,t})\, w_t h_{i,t} l_{i,t} + R_{S,t}\left(b^G_{i,t} + b^D_{i,t}\right) + (r_{K,t} - \delta)k_{i,t} - R_{L,t} b^L_{i,t}
\end{aligned} \tag{49}$$

The rentiers' value function is the solution to:

$$\begin{aligned}
\mathcal{V}^{r,a}_i(\mathbf{b}_{i,t}, h_{i,t}, \mathbf{S}_t) &= \max[\mathrm{u}(c_{i,t}, l_{i,t}) \\
&+ \beta\mathbb{E}_t((1-\phi_r)(\phi_k \mathcal{V}^{w,a}_i(b_{i,t+1}, h_{i,t+1}, S_{t+1}) + (1-\phi_k)\mathcal{V}^{w,n}_i(b_{i,t+1}, h_{i,t+1}, S_{t+1})) \\
&+ \phi_r(\phi_k \mathcal{V}^{r,a}_i(b_{i,t+1}, S_{t+1}) + (1-\phi_k)\mathcal{V}^{r,n}_i(b_{i,t+1}, S_{t+1})))]
\end{aligned} \tag{50}$$

subject to (6)-(7) and to the flow budget constraint:

$$c_{i,t} + b^G_{i,t+1} + b^D_{i,t+1} + b^I_{i,t+1} - b^L_{i,t+1} \leq (1-\tau_{h,t})\,\mathcal{F}_t + R_{S,t}\left(b^G_{i,t} + b^D_{i,t}\right) + R_{I,t} b^I_{i,t} - R_{L,t} b^L_{i,t} \tag{51}$$

[25] Note that $R_{I,t}$ includes a capital gain. For a household that cannot adjust its capital stock, the net-of-capital-gains return is $R_{I,t} - Q_t/Q_{t-1}$.

Finally, the dynamic programme of a rentier who cannot adjust their illiquid bonds is given as:

$$\begin{aligned}\mathcal{V}_i^{r,n}\left(\mathbf{b}_{i,t},h_{i,t},\mathbf{S}_t\right) &= \max[\mathrm{u}\left(c_{i,t},l_{i,t}\right) \\ &+ \beta\mathbb{E}_t((1-\phi_r)\left(\phi_k\mathcal{V}_i^{w,a}\left(\mathbf{b}_{i,t+1},h_{i,t+1},\mathbf{S}_{t+1}\right)+(1-\phi_k)\mathcal{V}_i^{w,n}\left(\mathbf{b}_{i,t+1},h_{i,t+1},\mathbf{S}_{t+1}\right)\right) \\ &+ \phi_r\left(\phi_k\mathcal{V}_i^{r,a}\left(\mathbf{b}_{i,t+1},\mathbf{S}_{t+1}\right)+(1-\phi_k)\mathcal{V}_i^{r,n}\left(\mathbf{b}_{i,t+1},\mathbf{S}_{t+1}\right)\right))] \end{aligned} \tag{52}$$

subject to (6)-(7) and to the flow budget constraint:

$$c_{i,t}+b_{i,t+1}^G+b_{i,t+1}^D-b_{i,t+1}^L \leq (1-\tau_{h,t})\,\mathcal{F}_t+R_{S,t}\left(b_{i,t}^G+b_{i,t}^D\right)+(R_{I,t}-1)b_{i,t}^I-R_{L,t}b_{i,t}^L \tag{53}$$

In this economy, households may again be constrained or not, but it is their liquid wealth that matters. First, the household may be a saver and on a "short run" Euler equation with a slope determined by the return on liquid assets. Alternatively, the household may be a borrower and not constrained by (6) and on an Euler equation with slope determined by the borrowing rate:

$$\begin{aligned}(c_{i,t}^{\mathrm{I}})^{-\vartheta_c} &= \beta\mathbb{E}_t(c_{i,t+1}^{\mathrm{I}})^{-\vartheta_c}R_{S,t+1} \\ (c_{i,t}^{\mathrm{II}})^{-\vartheta_c} &= \beta\mathbb{E}_t(c_{i,t+1}^{\mathrm{II}})^{-\vartheta_c}R_{L,t+1}\end{aligned}$$

using the same notation as in Section 3. There are also two groups of *constrained* households with high marginal propensities to consume. Households may be indebted and up against the borrowing constraint, or they may hold no liquid wealth and neither want to save nor borrow. Assuming for simplicity that households were in either of these states at date $t-1$, their consumption levels are given as:

$$\begin{aligned}c_{i,t}^{\mathrm{III}} &= (1-\tau_{h,t})\,w_t h_{i,t} l_{i,t}+(r_{K,t}-\delta)k_{i,t}-(R_{L,t}-1)\underline{\mathbf{b}} \\ c_{i,t}^{\mathrm{IV}} &= (1-\tau_{h,t})\,w_t h_{i,t} l_{i,t}+(r_{K,t}-\delta)k_{i,t}\end{aligned}$$

Here there may be a substantial amount of type IV agents and such households may be wealthy due to illiquid asset holdings. When credit spreads rise, the kink exaggerates and a larger measure of agents will find themselves with no liquid assets and high MPCs.

Intermediate Goods Producers: Intermediate goods producers rent part of their capital input from households. The effective capital input is given as:

$$k_{j,t}^e = \xi_t k_{j,t}^P + k_{j,t}^R \tag{54}$$

where $k_{j,t}^R$ denotes capital rented from households. We assume that the capital quality shock, $\xi_t > 0$

impacts only equity financed capital. The demand for labor and rented capital input solve:

$$\upsilon_{j,t}^{m}=\max_{n_{j,t},k_{j,t}^{R}}\left(P_{t}^{m}m_{j,t}-w_{t}n_{j,t}-r_{K,t}k_{j,t}^{R}\right)$$

which implies that:

$$\begin{aligned} w_t &= P_t^m \alpha Z_t n_{j,t}^{\alpha-1}\left(k_{j,t}^{e}\right)^{1-\alpha} && (55)\\ r_{K,t} &= P_t^m \left(1-\alpha\right) Z_t n_{j,t}^{\alpha}\left(k_{j,t}^{e}\right)^{-\alpha} && (56)\end{aligned}$$

Having paid households for the cost of rental of labor and capital, the firm pays its equity holders its profits and the market value of its capital stock net of maintenance costs:

$$\varsigma_{j,t}^{m}=\upsilon_{jt}^{m}+Q_t\xi_t k_{jt}^{p}-\delta\xi_t k_{jt}^{p}$$

where $\upsilon_{jt}^{m}=\left(1-\alpha\right)P_t^m Z_t n_{j,t}^{\alpha}\left(k_{j,t}^{e}\right)^{1-\alpha}\left(1-k_t^R/k_t^e\right)$. Thus, the return on equity offered is:

$$R_{K,t}=\frac{\left(r_{K,t}+Q_t-\delta\right)\xi_t}{Q_{t-1}} \tag{57}$$

where $r_{K,t}=\left(1-\alpha\right)P_t^m Z_t n_{j,t}^{\alpha}\left(k_{j,t}^{e}\right)^{-\alpha}$ is the marginal product of "effective" capital. To get Equation (57), define the return $R_{K,t}=\varsigma_{j,t}/(Q_{t-1}k_{j,t}^{P})$ and note that $\upsilon_{j,t}^{m}=r_{K,t}(k_{j,t}^{e}-k_{j,t}^{R})=r_{K,t}\xi_t k_{j,t}^{P}$.

Capital Goods Producers: The law of motion of aggregate capital is:

$$K_{t+1}-\left(K_t^r+\xi_t K_t^p\right)=I_{n,t}. \tag{58}$$

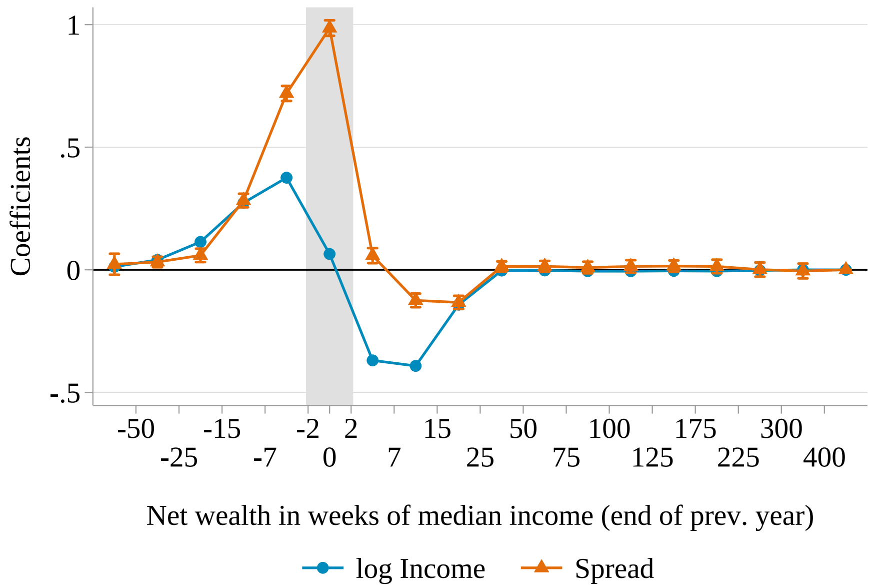
and I_t and CI_t then follow as:

$$\begin{aligned} I_t &= I_{n,t}+\delta\left(K_t^r+\xi_t K_t^p\right), && (59)\\ CI_t &= I_t+\frac{\omega_I}{2}\left(\log\left(\frac{I_{n,t}+\psi}{I_{n,t-1}+\psi}\right)\right)^2\left(I_{n,t}+\psi\right). && (60)\end{aligned}$$

where K_t^r is the aggregate amount of capital held directly by households and rented to firms, and K_t^p is the aggregate amount of capital that intermediate firms finance through equity issues.

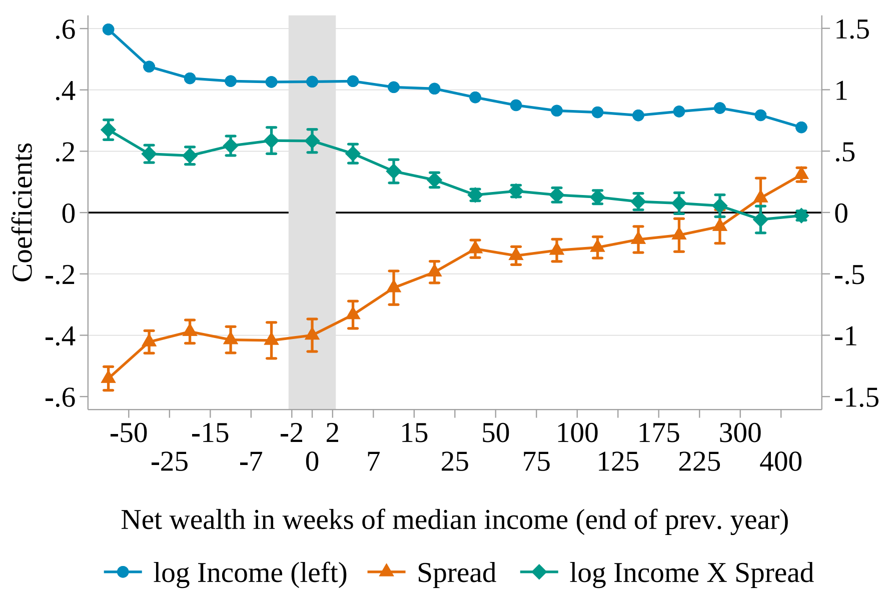
Table 13: Three Asset Model Parameterization

	Description	Value		Description	Value
Households			**Monetary and fiscal policy**		
β	Discount factor	0.9855	$\overline{\pi}$	Inflation target	1.00
χ	Disutility weight of labor	0.20	κ_π	Response to inflation	1.50
$1/\vartheta_c$	Intertemp. elasticity	2/3	κ_R	Int.rate smoothing	0.70
ϑ_l	Frisch elasticity	0.75	$\overline{G}/\overline{Y}$	Gov. spending share	0.26
ϕ_w	Transition prob. to rentier	0.001	$\overline{B}^G/\overline{Y}$	Gov. debt ratio	0.39
ϕ_r	Transition prob. to worker	0.0625	τ_h	tax rate	0.38
$\underline{\mathbf{b}}$	Borrowing constraint	$1\ \overline{Y}$	κ_G	Response of G to debt	0.10
ϕ_k	Illiquidity of capital	0.0025			
Supply side			**Stochastic shocks**		
α	Output elasticity to labor	0.67	ρ_h	Persistence of HH income shocks	0.948
δ	Depreciation rate	0.02	ρ_z	Persistence of TFP shocks	0.967
ω_I	Adjustment costs	3.15	σ_h^2	Variance of HH income shocks	0.097^2
η	Elasticity of substitution	21	σ_z^2	Variance of TFP shocks	0.022^2
ω_Y	Price stickiness	0.10	σ_ξ^2	Variance of cap.q. shocks	0.022^2
			σ_R^2	Variance of mon.pol. shocks	0.002^2
Banking					
λ	Divertible fract. of assets	0.38	θ	Bank survival rate	0.972
ζ	Funds new managers	0.0037	ω_b	Consumer loan cost	0.0075



Notes: The figure shows in the 3-asset model the change in transition probabilities into the zero net wealth state with cross-sectional changes in income and the consumer credit spread (estimated from Equation (2)). Zero net wealth is defined as net assets within a range of plus/minus two weeks of median household income.

Figure 21: Zero Net Wealth Dynamics in the 3-Asset Model



Notes: This figure illustrates the relationship in the 3-asset model between consumption and income, borrowing spreads and their interaction, estimated from Equation (3) based on model-simulated data in response to idiosyncratic income and spread shocks. We here allow the return on illiquid assets to move when credit spreads change.

Figure 22: Consumption and the Spread in the 3-Asset Model

Table 14: Moments: Baseline and Restricted Leverage

	Baseline		**3-asset model**	
	Baseline	Low leverage	Baseline	Low leverage
Leverage	2.93	2.64	2.93	2.63
	Interest rates			
Return on capital (R_K, %)	4.69	4.82	4.65	4.62
Return on bonds and deposits (R_S, %)	3.81	3.54	3.30	2.70
Lending interest rate (R_L, %)	7.87	8.00	7.83	7.80
	Aggregates			
Output	4.89	4.91	4.88	4.90
Capital	49.26	48.93	49.31	49.63
Labor supply	1.44	1.45	1.45	1.46
Consumption	2.64	2.70	2.68	2.66
	Household distribution			
At kink (%)	4.03	4.82	8.94	10.21
Borrowers (%)	21.95	24.47	27.91	31.86
Gini wealth	77.50	82.02	76.33	77.07
Gini consumption	15.67	16.46	17.84	17.85
Gini income	28.53	30.11	25.34	25.24

Notes: We compare the baseline steady state to one with 10% less leverage (diversion parameter λ going from 0.381 to 0.445). The last two columns do so for the model with household portfolios consisting of 3 assets.