Fundamental Stock Price Cycles *

Maximilian Weiß[†]

University of Tuebingen

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Abstract. News shocks about higher future capital returns can explain stock price-booms and subsequent -busts in a two-asset, heterogeneous agent New Keynesian model. The portfolio choice between more liquid and less liquid forms of capital is key, as it allows for a time-varying illiquidity premium. The arrival of investment opportunities induces capital-rich households to hold more illiquid capital at a lower premium, in anticipation of higher future returns on it. The anticipated higher consumption risk due to less liquid portfolios increases the value of more liquid assets, like stocks. When capital returns mean-revert, capital-rich households rebalance their portfolios, which increases the illiquidity premium and causes stock prices to fall. Novel evidence from survey data on portfolio choices of capital-wealthy households during stock price boom-bust cycles supports the key mechanism of the model.

JEL classification: E12, E21, E32, G11, G12, G51

Keywords: News shock, stock price booms, time-varying discount rates, HANK

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[†]Postdoctoral researcher at the University of Tuebingen (maximilian.weiss@gmail.com)

1 Introduction

Return predictability has been observed for stock market indices in many countries and across time (Cochrane, 2011, Kuvshinov, 2022). It is also directly linked to the rationalization of "excess" price-volatility through the channel of expected changes in discount rates (Cochrane, 2017). Within this rational framework, there are two open questions: first, why does the subjective discount factor of the marginal trader on the stock market fluctuate strongly enough to quantitatively explain stock price volatility? Second, why is this subjective discount factor predictably mean-reverting and counter-cyclical, causing stock price boom-bust cycles that correlate with the business cycle, as we observe in the data? In this paper, I propose an answer for both questions, by building an incomplete markets model with aggregate fluctuations. In light of the fact that publicly traded firm shares are more liquid than other forms of owning productive capital, I argue that stock price fluctuations are driven by fluctuations in an illiquidity premium that moves upon changes in investment opportunities for wealthy households.

Returns to illiquid capital are procyclical. The importance of income from illiquid asset ownership for asset pricing arises from the group of wealthy, but liquidity-poor households: so-called "wealthy hand-to-mouth" households (Kaplan et al., 2014). I find that procyclical asset income induces more consumption risk for wealthy households than procyclical wage income does for poorer households. Therefore, capital-rich households become the marginal trader on the market for liquid assets. The relevance of this mechanism for asset pricing is amplified when more households hold illiquid portfolios, which happens endogenously in anticipation of a temporary increase in capital returns. Therefore, news shocks about future investment opportunities play an important part in explaining stock price fluctuations, according to this theory.

To quantitatively assess the mechanism, I build a heterogeneous agent New Keynesian model with portfolio choice that is calibrated with survey data and fitted to U.S. business cycle fluctuations. I model public stocks as a perfectly diversified portfolio of firms' profit shares, which is directly held by households and can be traded each period. While optimal portfolio choice along the liquid-illiquid dimension is crucial, the portfolio duration of the liquid asset is indeterminate in the model, as households do not account for aggregate risk. Hence, all households hold the same long-duration liquid asset portfolio, which is comprised of public stocks and government bonds. Households have time-separable preferences and are modestly risk-averse. In a simulation exercise, I show that the model accounts for 75% of the variance in the price-dividend ratio of aggregate stock-market fluctuations in the U.S. I find that the price fluctuations are driven by discount rate news, i.e. the expectations of movements in future stock returns, only when the trading friction on privately held capital is present. Calibrating parts of the model to the "dot-com" boom of the 1990s, I find that it explains about half of the rise in stock valuation during that time.

The theory can be understood as proposing a time-varying illiquidity premium, rather than a time-varying aggregate risk premium (Campbell and Cochrane, 1999, Bansal and Yaron, 2004), as the main explanation for stock price fluctuations. I define the (ex-ante) illiquidity premium as the (expected) difference between the return on illiquid assets and the return on liquid assets[1]. The illiquidity premium varies due to the time-varying propensity to bear consumption risk at the individual level. The expectation of higher future returns on illiquid assets induces wealthy households to bear more consumption risk, by holding more illiquid assets, in the anticipation phase. Thus, the illiquidity premium is low in the anticipation phase. Once illiquid asset returns mean-revert, the illiquidity premium rises above its steady state value, since the marginal traders have more illiquid portfolios and face falling incomes, so that liquid assets become more valuable. Since public stocks are relatively liquid, compared to other capital assets, the growth in stock prices correlates negatively with the illiquidity premium. In this paper, I analyze only the effect of the illiquidity premium on the stock price cycle, and abstract from an aggregate risk premium[2].

In the model, stocks are claims to a share of the profits of the monopolistically competitive firms in the economy. Stock-supply is time-invariant (normalized to one), so that I abstract from financing decisions of firms. Hence, a stock price boom does not ease the firm's financing constraints. However, a growing stock market is "indirectly" productive

[1] In the literature, this is also called the liquidity premium, see e.g. Bayer et al. (2019).

[2] I solve the quantitative model up to first-order (the news about technologial progress is an unexpected "MIT-shock"). I conjecture that solving the model non-linearly would not diminish the role of the time-varying illiquidity premium for explaining rising stock prices: in stock price booms, the share of wealth that is held in stocks rises (mechanically, but also by active stock-investment; section 5 provides evidence for this). If stocks are risky, this increases the riskiness of households' portfolios, which in turn increases the risk premium households are willing to pay, and puts *downward* pressure on stock prices. This mechanism is well-known for consumption-based asset pricing models with aggregate risk. Chien et al. (2012) generate rising stock price booms with risky stocks by having "Mertonian" investors, who price the asset, *sell* their risky shares to intermittently rebalancing investors during a boom, which circumvents the problem. For the housing boom of the early 2000s, Favilukis et al. (2017) conclude that relaxed financing constraints, that is, an institutional change that makes housing an individually less risky asset, is needed to model a simultaneous house price boom and rising share of housing equity in households' portfolios.

in the model by the virtue of investors who use the additional liquid asset income to invest more in productive, illiquid capital[3]. I calibrate productive capital in the model to fixed assets in the U.S. Bureau of Economic Analysis tables. A third of fixed assets is housing. At the same time, Asker et al. (2014) estimate that about half of investment in the non-residential sector is carried out by noncorporate private firms. In sum, around two thirds of productive capital in the U.S. economy is not financed by stock issuance. A part of the valuation of fixed assets is also due to (unproductive) market power by firms — presumably mostly in the corporate sector — , which is passed through exclusively to stock-owners in the model.

In section 2, I demonstrate the mechanism in a highly stylized, but tractable model, showing how capital-wealthy households can be marginal traders of the stock market. In sections 3 and 4, I explore the mechanism quantitatively in a heterogeneous agent New Keynesian model with two assets. My analysis of stock price cycles in a general equilibrium setting uncovers the dependence of the stock price cycle on the elasticity of liquid asset supply. Government bonds are in less demand once news of investment opportunities arrive. Thus, the fiscal authority faces a pressure to reduce its balance sheet. I find that a boom in the anticipation phase only arises when the government obliges, and aggregate liquid asset supply is reduced. Fundamentally, higher real returns are "smoothed out" over the anticipation phase by allowing for the crowding out of less productive liquid assets by more productive capital, so that households' incomes increase long before the productivity boost. The well-known effect of temporary falling markups in New Keynesian models in response to demand shocks also plays a role in allowing the model to generate a boom (Christiano et al., 2010). In section 5, I employ the extended Survey of Consumer Finances-dataset provided by Kuhn et al. (2020) to provide evidence that households whose income mainly stems from capital income — capital-wealthy households that the model identifies as the marginal traders of the stock market — decrease their portfolio liquidity in stock price-booms, and increase it in stock price-busts, as the model predicts[4].

Related literature. Return-predictability has been demonstrated to arise in models imposing preferences with external habit (Campbell and Cochrane, 1999), or recursive

[3]Since there is a negative borrowing limit, the effect of government bond interest rates on investment is non-monotone — when the rates are expected to grow too high, households who borrow in the liquid asset will have to pay too much on their debt, which deters them from investing into illiquid assets. I revisit this case when discussing the effects of monetary and fiscal poliy.

[4]Specifically, the change in the relative portfolio liquidity of the "wealthy hand-to-mouth" over subsequently sampled years, and the growth in the stock price-dividend ratio, are negatively correlated at about -0.27. See section 5 for a discussion of the evidence.

preferences with long-run consumption risk (Bansal and Yaron, 2004), among others. A consumption-based explanation of stock prices is in line with the finding by Haddad and Muir (2021) that public equity is among the most often directly held financial assets by households, and that its returns are unpredictable by the health of intermediares. The present paper challenges the "stylized fact" that only time-varying *aggregate* risk premia can explain stock price fluctuations. In fact, I find empirically that future bond returns, in a Campbell-Shiller decomposition that also includes excess returns to long-duration bonds, are positively correlated with the dividend yield, once a secular break in the 1980s is controlled for.[5] Kuvshinov (2022) compares the risk factor that causes fluctuations in stock prices with the risk factors that drive fluctuations in returns to housing and corporate bonds. He finds that the risk factors do not comove across asset classes. This finding is inconsistent with theories that hinge on aggregate risk, which affects all those assets, as the main cause of asset price fluctuations. The present theory can accomodate this evidence: stocks differ from housing and corporate bonds in their higher liquidity.[6]

Kekre and Lenel (2022) is a recent contribution explaining stock market fluctuations with heterogeneity in risk aversion. Investment and stock prices comove in response to a monetary policy shock: when it redistributes towards households with lower risk aversion, investment rises, while the risk premium falls. In the present theory, instead, the heterogeneity in the individual riskiness of portfolios arises by means of their liquidity, which is an *endogenous* outcome of optimal portfolio choices in response to idiosyncratic and news shocks. The effectiveness of information and illiquid investment in amplifying booms in HANK models with portfolio choice is highlighted in Auclert et al. (2020). Luetticke (2021) shows the importance of the redistribution towards households with a high marginal propensity to invest for the transmission of monetary policy shocks.

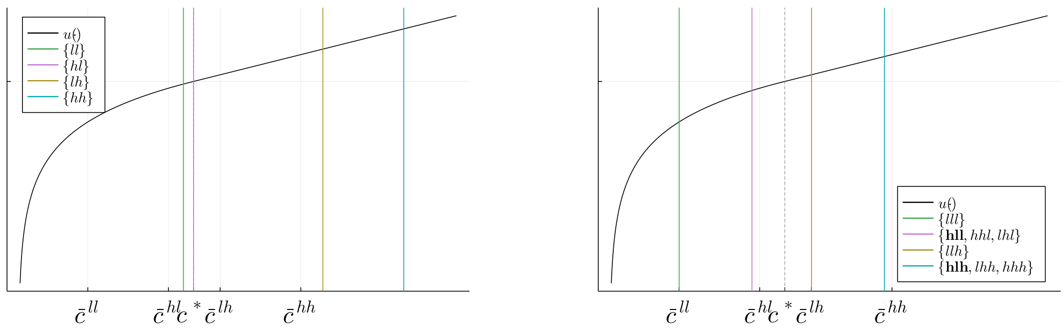
As an example of the literature deviating from the "FIRE" (full information rational expectations) framework when explaining asset price fluctuations, Adam and Merkel (2019) develop a model with learning where surprise productivity shocks can trigger an endogenous belief propagation that gives rise to boom-bust cycles in stock prices and in-

[5]The dividend yield was high before 1980, while ex-post government bond return news were low due to high inflation in the 1970s, both in comparison to the respective mean values after 1980. See section 5. Similarly, van Binsbergen (2020) finds that a long-maturity government bond portfolio performed as well as the stock market since the 1980s, calling into question the existence of an equity premium for long-duration, liquid asset portfolios.

[6]Sorensen et al. (2014) find that the illiquidity of private equity is an important component of its return risk. Sagi (2020) finds the same for investments in real estate, and rationalizes the illiquidity of the market within a search and matching model.

Figure 1: Optimal consumption levels

a. Capital rent increase ($t = 1$) b. Capital rent decrease ($t = 2$)



Notes: $\{...y_{t-1}y_t\}$ denotes the history of income shocks at time t, with $y_t \in \{l, h\}$, $l < h$. $\bar{c}^{yy'}$ denote the optimal consumption levels at all possible states $\{yy'\}$ of the ergodic wealth and income distribution.

vestment. Through the lense of the present model, and in contrast to the results in Adam and Merkel (2019) and others, the expectations about future productivity are accurate on average (I discuss noise shocks in section 5).

2 Illustration of the stock price cycle

In this section, I illustrate the mechanism how wealthy hand-to-mouth households can drive down the equilibrium return on liquid assets. For the most part, I abstract from portfolio choice between liquid and illiquid assets, and analyze a situation in which all households hold little liquid wealth relative to their income risk, i.e. they are poorly insured, while their illiquid wealth is high. In the full model, this situation applies to a small subset of households, as a result of their portfolio choice, at the end of the anticipation phase. In addition to the technology news, in this simplified setting agents are also subject to a shortage of liquidity in the anticipation phase[7]. I apply the technique by Challe and Ragot (2016) to make heterogeneous agent models with a non-degenerate wealth distribution tractable. I then argue that the main intuition goes through for the general case with poor households in the economy and illiquid portfolio choice.

Consider a unit mass of households who hold two assets, a liquid asset and a fixed amount of illiquid capital. They can borrow in the liquid asset up to the constraint $\underline{L} < 0$. Their income encompasses returns on the assets they hold, and idiosyncratic income $y \in \{l, h\}$, $l < h$, which follows a stochastic Markov process. They derive utility

[7]This is necessary to bring the market for liquidity into equilibrium: the news about future productivity lowers the demand for liquid savings. Real returns are bounded above by the inverse of the time preference rate, and therefore cannot rise enough to fully offset the lack of demand for liquid assets.

each period from consumption c, where the utility function $u(\cdot)$ is concave up to point c^*, and has a constant slope afterwards.

The steady state is calibrated[8] such that all households that receive the low income, l, consume at a level below c^*, which is so low that they like to borrow more than $\underline{L}$. On the other hand, all households that receive income h consume at a level above c^*. They like to self-insurance against the risk of receiving the low income, and hence save $\tilde{b}$ liquid assets. Since they consume at the linear segment of the utility function, their marginal utilites are all identical, so that $\tilde{b}$ is the optimal saving for all households with high income. The economy has a liquid outside asset at the positive net supply $L = \pi^l \underline{L} + (1 - \pi^l)\tilde{b}$, where π^l is the unconditional probability of receiving a low income.

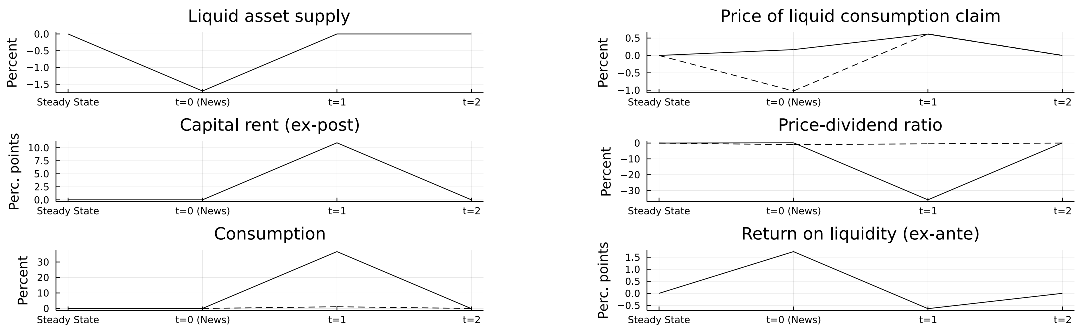
The grey lines in figure 1 show the steady state consumption allocation in the model. Since all households hold the same (positive) amount of fixed capital, the joint distribution over income and liquid asset wealth has only four mass points in steady state: $(l, \underline{L})$, $(l, \tilde{b})$, $(h, \underline{L})$, and $(h, \tilde{b})$. In a first step, I consider a surprise, one-period increase of the capital rent. I choose a rent increase such that households who change from the high to the low state, (hl), now optimally consume c^* and save a positive amount b' for self-insurance. In other words, they become unconstrained due to the higher capital income, but since they face lower capital income again in the future, they want to save part of their income gains. Since the liquid asset supply is constant, the households who receive high income today have to save less than $\tilde{b}$ this period for the bond market to clear. Equilibrium is obtained with a falling return on the liquid asset. For simplicity, I assume the income process to be symmetric[9], so that high-income households will also save the amount $b' < \tilde{b}$. As a result, next period, those households that were lifted out of the constrained state due to the higher capital income are at higher consumption levels than in steady state, while households that received high incomes last period consume slightly less (see figure 1b).

In a second step, I consider the case where the capital rent increase is anticipated one period in advance. To keep the solution tractable, I require that the optimal consumption and liquid asset choices stay the same as above, once capital rents change. This implies that unconstrained households decide to fully insure themselves upon the news (since next period, even if they get low income, they will be unconstrained due to higher capital income). Therefore, the equilibrium return on liquid assets has to increase to $1/\beta - 1$ (β

[8] Table A.1 in the appendix shows the values of the parameters.

[9] I choose the conditional probabilites of losing a high income (e.g. job separation) and gaining a high income (e.g. job finding) to sum to 100%.

Figure 2: Impulse responses



Notes: Responses to a news shock about higher future capital rents, and a *simultaneous* surprise drop in the asset supply, at $t = 0$. Dashed lines are for the case with a share of $\alpha = 97\%$ perfectly insured, capital-poor households (see section 2.2).

being the time discount factor). For this to be an equilibrium outcome, bond supply has to be depressed in the period of the news shock.

Figure 2 shows the responses of the return on liquid assets (ex-ante), the price of a liquid consumption claim (i.e. the "stock" price), and its price-dividend ratio, to this experiment. The price of the consumption claim appreciates at the onset of the news. It is also higher than steady state in period $t = 1$, due to the lower liquid asset return then. The price-dividend ratio also increases upon the news. However, the increase in the dividends, once the capital rent rises in the subsequent period, has a larger effect in this calibration. Still, the result illustrates how anticipation can generate a stock price cycle as seen in the data, i.e. high stock prices followed by low returns.

2.1 Equilibrium prices from household optimization

Unlike Challe and Ragot (2016), I consider an equilibrium where the household optimization determines the return on liquid savings endogenously. I abstract from risk in aggregate variables. For all households i in the economy, it has to hold that

$$u'(c_t^i) \geq \beta R_t \, \mathbb{E}_t^i \left[u'(c_{t+1}^i) \right], \tag{1}$$

where equation (1) holds with equality for all unconstrained households (i.e. households with a high income realization in steady state), and R_t denotes the *ex ante* gross return on liquid savings. In terms of stochastic discount factors $SDF_{t+1}^i := \beta \frac{u'(c_{t+1}^i)}{u'(c_t^i)}$, the equilibrium condition can be written as

$$\frac{1}{R_t} \geq \mathbb{E}_t^i \left[SDF_{t+1}^i \right] \; \forall i. \tag{2}$$

The necessary optimality conditions for a pattern of higher than steady state liquid asset returns in $t = 0$, followed by lower than steady state liquid asset returns in $t = 1$, are thus:

- When liquid asset returns are above steady state, $R_0 > \overline{R}$, it must hold that $\mathbb{E}_0^i \left[SDF_1^i \right] < \overline{ESDF}^i$ *for all* households i[10]

- When liquid asset returns are below steady state, $R_1 < \overline{R}$, there *exists* a household j where $\mathbb{E}_1^j \left[SDF_2^j \right] > \overline{ESDF}^j$. j must be unconstrained by the borrowing limit on liquid savings.

The last condition on household j follows, as the level of the liquid asset return is always determined in equilibrium by the households where equation (2) holds with equality, i.e. by unconstrained households.

In the example above, both conditions are fulfilled: since in period $t = 1$, households at all wealth and income-positions consume more than in steady state (see figure 1a), all households discount the future by more upon the news in period $t = 0$. In period $t = 1$, there are three unconstrained household-types: those with income histories $\{hl\}$, $\{lh\}$, and $\{hh\}$, who all save the amount $b' > \underline{L}$. Since they all have the same expected marginal utility of consumption in period $t = 2$ (under the assumption of the symmetric income process), and the same marginal utility of consumption today (as they consume at the linear segment of the utility function), their expected stochastic discount factor is the same. It is given by (in terms of households with a high income realization today)

$$\mathbb{E}_1^h \left[SDF_2^h \right] = \frac{\beta}{\gamma} \left(\pi^{hl} u'(c_2^{hl}) + (1 - \pi^{hl})\gamma \right), \tag{3}$$

where $\gamma := u'(c) \; \forall \, c \geq c^*$ is the slope at the linear part of the utility function, and π^{hl} denotes the conditional probability of falling to the low income level from the high income level. The condition $\mathbb{E}_1^h \left[SDF_2^h \right] > \overline{ESDF}^h$ is then equivalent to $c_2^{hl} - \overline{c}^{hl} = R_1 b' - \overline{R}\tilde{b}$ being strictly negative. This is the case, as $R_1 < \overline{R}$ and $b' < \tilde{b}$. Intuitively, the additional income from the illiquid asset holding in period $t = 1$ allows more households to purchase

[10] $\overline{ESDF}^i$ denotes the steady state expected stochastic discount factor of household i.

consumption claims for period $t = 2$, which, by goods market clearing, implies that the high-income households expect to consume less, and are therefore willing to save the same amount at lower expected returns.

2.2 Extension: segmented markets

The fluctuation of aggregate consumption in this model economy, where all households hold a large amount of illiquid capital they cannot use to smoothe income shocks, while they are close to the borrowing constraint in liquid assets, is two orders of magnitudes too large compared to quarterly consumption fluctuations in U.S.-data. This is by design: the example was built to illustrate the consumption risk that these "wealthy hand-to-mouth" households are exposed to, who are then pricing the liquid asset. The idea that incomplete markets can generate realistic price fluctuations, while aggregate consumption remains flat, follows the seminal work by Constantinides and Duffie (1996). In order to clarify this contribution of my paper, I now insert more households into the model economy.

The newly introduced households insure themselves perfectly against idiosyncratic income shocks (trading Arrow securities amongst themselves), but cannot access "outside" financial markets, in the sense that they cannot hold capital, and cannot issue debt to households that hold capital (segmented markets). The optimality condition with respect to their liquid asset holding is then

$$\frac{1}{R_t} \geq E_t^{\alpha}\left[SDF_{t+1}^{\alpha}\right] = \beta, \tag{4}$$

where α denotes capital-poor households, who do not have consumption risk and thus have a constant discount factor β. By complementary slackness, their saving in liquid assets is zero if inequality (4) is strict. If they are indifferent (when $1/R_t = \beta$), I assume that they decide to stay at the borrowing constraint, i.e. $b_t^{\alpha} = 0$. Note that, since R_t peaks at $1/\beta$ in period $t = 0$ in the above experiment, the optimality condition (4) is always fulfilled, and the liquid asset is still priced by the uninsured households.

Let α denote the share of perfectly insured households that do not hold capital in the economy. Since they have no income besides l or h, they consume the constant $c_t^{\alpha} = \pi^l l + (1 - \pi^l)h =: \overline{y}$. Households who hold capital, but cannot trade Arrow securities to insure themselves against income shocks, consume $\tilde{c}_t := \sum_{j \in J} \pi^j c_t^j$, where J encompasses all possible income histories $\{lll\}$, $\{hll\}$, ..., $\{hhh\}$, and π^j is the probability weight of these histories. The aggregate consumption is then given by $c_t = \alpha\overline{y} + (1 - \alpha)\tilde{c}_t$. Choosing α

high enough such that the consumption of insured, capital-poor households makes up more than 90% of aggregate consumption in steady state then yields an attenuation of aggregate consumption fluctuations by almost two orders of magnitude[11], while the fluctuation in the returns to the liquid asset remain unchanged (see the dashed lines in figure 2). The movements in the price-dividend ratio are attenuated; in the quantitative model, stocks are only claims to a fraction of output, and dividend payments are smoothed out, so that return volatility will have a bigger impact on the price-dividend ratio.

2.3 General case: tradable capital

In the full model that I discuss in section 3, I do not rely on the assumption of segmented markets. Instead, a share of households with high exposure to capital income risk arises endogenously, through the portfolio choice between liquid and illiquid assets. However, the basic insight from section 2.1 about the optimality conditions that lie behind the boom-bust cycle in stock prices remains, as the following proposition shows:

Proposition 1. *Let λ be the probability that a household can trade capital k_t in period t. Capital is traded at the price q_t. Let R_t^L be the gross return on liquid assets, and R_t^K the gross return on the illiquid capital. Households assume certainty equivalence with respect to aggregate shocks. Then, it holds that*

$$ILP_t := R_t^K - R_t^L \geq \beta(1-\lambda)\frac{\mathbb{E}_t^i\left[\gamma_{t+1}^i\right]}{q_t u'(c_t^i)} \tag{5}$$

for all households i that trade capital in periode t, where ILP is the illiquidity premium, and

$$\gamma_t^i := q_t u'(c_t^{i,n}) - \beta\,\mathbb{E}_t^i\, V_{t,k}^{i'}(b_t^{i,n}, k_t^{i,n}) \geq 0 \tag{6}$$

is the shadow price of selling capital in period t, where the household cannot trade capital, i.e. $k_t^{i,n} = k_{t-1}^i$, and chooses consumption $c_t^{i,n}$ and liquid assets $b_t^{i,n}$. $V_k^i(b,k)$ denotes the marginal value of holding capital for household i.

Proof See Appendix B.

[11] Choosing $\alpha = 0.97$, which corresponds to the 2.7% of households whose income is dominated by capital income in the full model (see below), yields a peak-increase of aggregate consumption of about 1%, a factor 35 reduction from the case without insured households.

Note the similarities between equation (5) and (2): $\beta\frac{\gamma^i_{t+1}}{u'(c^i_t)}$ is similar to a stochastic discount factor, augmented by the future value of trading the illiquid asset. Upon the news of future higher returns on capital, the marginal value of holding capital in the future rises – the shadow price of selling capital falls – which is necessary for the illiquidity premium to fall. As an additional requirement for the premium to fall, the stochastic discount factors of households who do not hold capital has to decline / be sufficiently low at that point. This comes about in the full model through an investment-driven boom, that raises the labor incomes of households.

Once the higher return on capital has realized, which is temporary, capital-wealthy households face an income decline. Hence, their expected shadow price of selling capital rises, since they expect to consume less, and the marginal value of holding capital in the future declines. The existence of these households is sufficient to increase the illiquidity premium above steady state level. Fluctuations in the illiquidity premium will be mainly driven by fluctuations in the return to liquid assets, R^L, and therefore explain the boom-bust cycle in stock prices.

For the rest of the paper, I solve the response to technology news in a HANK model with portfolio choice, which is calibrated to match micro data on labor income processes and wealth inequality.

3 A HANK model of the stock market

The model economy consists of heterogeneous households, who are subject to idiosyncratic income shocks and stochastic (illiquid) capital market access, a production sector with intermediate goods producers, who hire workers and rent capital, and final goods producers, who set prices subject to price adjustment costs, and a government sector, where a monetary and a fiscal authority react to business cycle conditions by setting the nominal interest rate and the bond supply according to fixed rules. In the following, I describe each sector individually, before stating the market clearing conditions and giving the definition of the equilibrium of the model[12]. The model is partly calibrated to aggregate data of the U.S. economy from 1954 to 2015, and partly estimated by Bayesian methods (see Bayer et al. (2022)). One period denotes one quarter. $\bar{X}$ denotes the steady state value of variable X, and $\hat{X}$ the relative deviation of X from $\bar{X}$.

[12]The model setup, with the exception of the modelling of aggregate shocks and the inclusion of liquid stocks, is the same as in Bayer et al. (2022). This is a shortened version of their exposition.

3.1 Households

There is a unit mass of ex-ante identical households, indexed by i, who are infinitely lived, discount the future with the factor β, and optimize their (time-separable) preferences of the Constant Relative Risk Aversion (CRRA) type, $u(x) = \frac{1}{1-\xi}x^{1-\xi}$, over consumption, c_{it}, and leisure. Each period t, they choose consumption, labor supply n_{it}, future holdings of liquid assets, b_{it+1}, and non-negative illiquid/capital assets, k_{it+1}, subject to their budget constraint, the debt limit $\underline{B}$, and the ability of market access to the illiquid asset. Their budget is composed of (after tax) labor income, $w_t h_{it} n_{it}$, profit incomes Π_t^F (final goods firms' rents) and Π_t^U (labor union rents), and asset returns. While w_t denotes the aggregate wage rate, their individual productivity h_{it} is determined stochastically according to

$$h_{it} = \frac{\tilde{h}_{it}}{\int \tilde{h}_{it} di}, \tag{7}$$

$$\tilde{h}_{it} = \begin{cases} \exp(\rho_h \log \tilde{h}_{it-1} + \epsilon_{it}^h) & \text{with probability } 1-\zeta \text{ if } \tilde{h}_{it-1} \neq 0, \\ 1 & \text{with probability } \iota \text{ if } \tilde{h}_{it-1} = 0, \\ 0 & \text{else.} \end{cases}$$

$\tilde{h}$ follows a log-AR(1) process, with $\epsilon_{it}^h \sim \mathcal{N}(0, \sigma_{h,t}^2)$, for the times when the household is a worker. Its volatility moves endogenously in response to aggregate hours: $\sigma_{h,t}^2 = \bar{\sigma}_h^2 \exp(\hat{s}_t)$, $\hat{s}_{t+1} = \rho_s \hat{s}_t + \Sigma_Y \hat{N}_{t+1}$. ζ is the probability of becoming an entrepreneur. Entrepreneurs have no labor income ($h_{it} = 0$), but gain a share of the profits of the final goods firms, Π_t^F, and raise funds by emitting stock (see section 3.2). With probability ι, they return to being a worker with mean productivity. The average of individual productivity h is normalized to 1. In addition to their wages, workers also receive a lump-sum share of the labor union rent, Π_t^U. The existence of entrepreneurs solves the problem of the allocation of profits that occurs in HANK models. Additionally, it helps the model to match the highly skewed wealth distribution in the data.

The choice of labor supply is greatly simplified by assuming Greenwood-Hercowitz-Huffman (GHH) preferences. They are represented by subtracting the disutility of work, $G(h_{it}, n_{it})$, from the consumption good *within* the felicity function, i.e. $u(c_{it} - G(h_{it}, n_{it}))$. In this setting, an increase in working hours directly increases the marginal utility of consumption, which offsets the typical consumption-labor tradeoff that arises with separable disutility of labor, namely that more work is only compatible with a smaller consumption level. As a result, optimal labor supply is a function only of the net labor income, independent of consumption[13]. Let $x_{it} = c_{it} - G(h_{it}, n_{it})$ denote the composite demand for consumption and leisure.

Labor income of households is subject to progressive taxation as in Heathcote et al. (2017), i.e. net labor income y_{it} is given by

$$y_{it} = (1 - \tau^L)(w_t h_{it} n_{it})^{1-\tau^P}, \tag{8}$$

where w_t is the aggregate wage rate and τ^L and τ^P are the level and the progressivity of the tax schedule. Assuming that $G(h, n)$ has constant elasticity γ with respect to n, the first-order condition for labor supply yields $G(h_{it}, n_{it}) = y_{it}\frac{1-\tau^P}{1+\gamma}$. Choosing $G(h_{it}, n_{it}) = h_{it}^{1-\tau^P}\frac{n_{it}^{1+\gamma}}{1+\gamma}$ simplifies the problem further, as labor supply then is only a function of the aggregate (after tax) wage rate. This implies that every household works the same number of hours, $n_{it} = N(w_t)$.

Households can have unsecured debt (i.e. negative holdings of the liquid asset) up to the borrowing limit $\underline{B}$[14]. In this case, their payment to the lender consists of the nominal liquid rate, R_t^L, plus a wasted intermediation cost, $\overline{R}$. Each period, a household's chance of participating in the market for illiquid assets, and being able to adjust k_{it+1}, is given by the fixed probability λ. This trading friction renders capital illiquid. The capital good's price in period t is q_t. From holding capital, households earn a capital rent r_t. The household's budget constraint sums up to

$$c_{it} + b_{it+1} + q_t k_{it+1} = y_{it} + \mathbb{1}_{h_{it}\neq 0}(1-\tau)\Pi_t^U + \mathbb{1}_{h_{it}=0} y_t^e + (q_t + r_t)k_{it} + \left(\frac{R_t^L}{\pi_t} + \mathbb{1}_{\{b_{it}<0\}}\frac{\overline{R}}{\pi_t}\right) b_{it}, \tag{9}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ denotes realized gross inflation, τ is the average tax rate (see section

[13] Jaimovich and Rebelo (2009) propose a class of preferences that nests both King-Plosser-Rebelo (KPR) and GHH preferences, which was then adopted by Schmitt-Grohé and Uribe (2012) and others in their structural estimation of the impact of news shocks. The reason is that GHH preferences, that shut down the wealth effect on labor supply, are helpful in generating booms from news shocks. Hence, having a preference class where this wealth effect enters as a parameter, which can be estimated, gives news shocks a higher chance to fit the data. Schmitt-Grohé and Uribe (2012), as well as Born and Pfeifer (2014) and Bayer et al. (2022) in models without news shocks, find that close to GHH preferences provide the best fit to the data.

[14] Since all households hold a share of their liquid wealth in stocks, for negative liquid wealth they symmetrically do some of their borrowing in stocks ("short-selling" stocks).

3.4) and y_t^e denotes the after-tax income of entrepreneurs (see section 3.2). Households maximize the infinite discounted sum of their utility, choosing (composite) consumption, liquid assets, and, if possible, illiquid capital holdings subject to the budget constraint and the inequalities $k_{it+1} \geq 0$ and $b_{it+1} \geq \underline{B}$.

The individual household's optimization problem can be written recursively as

$$\begin{aligned} V_t^a(b,k,h;\Theta,\mathcal{P},\Omega) &= \max_{k',b'_a}\{u[x(b,b'_a,k,k',h)] + \beta\,\mathbb{E}_t\,V_{t+1}(b'_a,k',h';\Theta',\mathcal{P}',\Omega')\}, \\ V_t^n(b,k,h;\Theta,\mathcal{P},\Omega) &= \max_{b'_n}\{u[x(b,b'_n,k,k,h)] + \beta\,\mathbb{E}_t\,V_{t+1}(b'_n,k,h';\Theta',\mathcal{P}',\Omega')\}, \end{aligned} \tag{10}$$

$$\begin{aligned} \mathbb{E}_t\,V_{t+1}(b',k',h;\Theta',\mathcal{P}',\Omega') &= \mathbb{E}_t[\lambda V_{t+1}^a(b',k',h;\Theta',\mathcal{P}',\Omega')] \\ &\quad + \mathbb{E}_t[(1-\lambda)V_{t+1}^n(b',k,h;\Theta',\mathcal{P}',\Omega')], \end{aligned}$$

where Θ stands for the distribution over asset holdings and productivity, $\mathcal{P}$ are equilibrium prices, and Ω denotes an exogenous shock.

3.2 Tradable profit-stocks

Liquid assets consist of government bonds (see section 3.4) and profit-stocks. Profit-stocks are claims to a share of smoothed profits of final goods-firms, Π_t^F (see section 3.3). The smoothing works through a fixed investment rule: A fraction ξ^Π of excess profits, defined as the deviation from steady-state profits, $\Pi_t^F - \Pi^F$, becomes available for payment to stock-holders and the entrepreneurs (who are the owners of the firms). The rest of the excess profits is saved in a common account, if positive, or withdrawn from the account, if negative. The account is invested in government bonds. Its wealth is denoted by NW_t^Π at end of period t. At times when firms are net borrowers, they do not pay the borrowing wedge that households pay, and are not subject to a borrowing constraint. On average, the account holds zero wealth, $NW^\Pi = 0$. A fraction ξ^Π of the interest payments on the wealth held in the account becomes available to stock-holders and the entrepreneurs, while the rest is reinvested. The smoothed profits then amount to

$$\tilde{\Pi}_t^F := \xi^\Pi(\Pi_t^F + NW_{t-1}^\Pi R_t^b/\pi_t) + (1-\xi^\Pi)\Pi^F \tag{11}$$

A fraction of ω^Π of the smoothed profits is traded with a unit mass of shares every period at price q_t^Π. A fraction of ι^Π of those shares retire every period and lose value, while new shares are emitted by the entrepreneurs. The real, after-tax payout to entrepreneurs then becomes

$$y_t^e := (1-\tau^L)((1-\omega^\Pi)\tilde{\Pi}_t^F + \iota^\Pi q_t^\Pi)^{1-\tau^P} \tag{12}$$

Ex-ante, the expected return on bonds, R_{t+1}^B, has to fulfill the no-arbitrage condition

$$\mathbb{E}_t \frac{R_{t+1}^B}{\pi_{t+1}} = \mathbb{E}_t \frac{q_{t+1}^\Pi(1-\iota^\Pi) + \omega^\Pi \tilde{\Pi}_{t+1}^F}{q_t^\Pi}. \tag{13}$$

With B_t denoting the total supply of government bonds at time t, the total supply of liquid assets at time t becomes $L_t = B_t + q_{t-1}^\Pi$. The average (ex-post) real return on liquid assets is then given by

$$\frac{R_t^L}{\pi_t} = \frac{B_t}{L_t} \cdot \frac{R_t^B}{\pi_t} + \frac{q_t^\Pi(1-\iota^\Pi) + \omega^\Pi \tilde{\Pi}_t^F}{L_t}. \tag{14}$$

3.2.1 Accounting of capital gains

To be in line with the data (see below), I count capital gains as part of wealth-gains instead of income. Capital gains can accrue from illiquid capital, $\frac{q_t}{q_{t-1}}$, if households can trade their capital holdings in period t, and liquid stocks, $\frac{q_t^\Pi}{q_{t-1}^\Pi}$. The budget constraint (9) is already formalized in a way that illiquid capital gains count as wealth-gains. For the liquid asset, instead, I introduce the liquid asset *value*

$$q_t^L := 1 + \frac{q_t^\Pi - q_{t-1}^\Pi}{L_t}. \tag{15}$$

Subtracting q_t^L from the ex-post real return on liquid assets, $\frac{R_t^L}{\pi_t}$, yields the net return on liquid assets (net of capital gains from stocks and stock depreciation):

$$r_t^{L,net} := \frac{R_t^L}{\pi_t} - q_t^L = \frac{B_t}{L_t} \cdot \left(\frac{R_t^B}{\pi_t} - 1\right) + \frac{\omega^\Pi \tilde{\Pi}_t^F - \iota^\Pi q_t^\Pi}{L_t} \tag{16}$$

The value of liquid assets for a household with liquid saving b_{it} can then be rewritten as

$$\left(\frac{R_t^L}{\pi_t} + \mathbb{1}_{\{b_{it}<0\}} \frac{\overline{R}}{\pi_t}\right) b_{it} = \underbrace{\left(r_t^{L,net} + \mathbb{1}_{\{b_{it}<0\}} \frac{\overline{R}}{\pi_t}\right) b_{it}}_{net\ liquid\ income} + \underbrace{q_t^L b_{it}}_{liquid\ wealth} \tag{17}$$

3.3 Production sector

The production sector of the economy is made up of labor unions and labor packers, intermediate goods producers, final goods firms, and capital goods producers. Workers sell their labor at the nominal rate W_t to a continuum of unions (indexed by j), who sell their variety of labor to labor packers (for W_{jt}), which produce and sell the final labor service at the price W_t^F. Since unions have market power, they set a price $W_{jt} > W_t$ subject to the demand curve $n_{jt} = (W_{jt}/W_t^F)^{-\zeta} N_t$, and to a Calvo-type adjustment friction. In a symmetric equilibrium, their optimization yields the wage Phillips curve (linearized around the steady state)

$$\log\left(\frac{\pi_t^W}{\bar{\pi}_W}\right) = \beta\,\mathbb{E}_t \log\left(\frac{\pi_{t+1}^W}{\bar{\pi}_W}\right) + \tilde{\kappa_w}\left(\frac{w_t}{w_t^F} - \frac{1}{\mu^W}\right), \tag{18}$$

where $\pi_t^W = \frac{W_t^F}{W_{t-1}^F}$ is the gross wage inflation, w_t and w_t^F are the real wages for households and firms, $\frac{1}{\mu^W} = \frac{\zeta-1}{\zeta}$ is the target markdown of wages, and $\tilde{\kappa_w}$ is determined by the probability of wage-adjustment, κ_w[15]. The return to the unions is then given as $\Pi_t^U = (1 - \frac{1}{\mu^W})N_t w_t^F$ in real terms.

The homogeneous intermediate good Y is produced with the constant returns to scale production function

$$Y_t = A_t N_t^{1-\alpha_t}(u_t K_t)^{\alpha_t}, \tag{19}$$

where u_t is capital utilization. As is standard, higher capital utilization implies an increased depreciation of capital, $\delta(u_t) = \delta_0 + \delta_1(u_t - 1) + \frac{\delta_2}{2}(u_t - 1)^2$, where $\delta_1, \delta_2 > 0$. A_t and α_t are the level of Total Factor Productivity (TFP) and the capital share, respectively, and follow the stochastic processes

$$\log(A_t) = \rho_A \log(A_{t-1}) + \epsilon_{t-\ell}^{A,\ell} + \epsilon_t^A, \tag{20}$$

$$\alpha_t = (1-\rho_\alpha)\overline{\alpha} + \rho_\alpha \alpha_{t-1} + \epsilon_{t-\ell}^{\alpha,\ell} + \epsilon_t^\alpha, \tag{21}$$

$$\epsilon_t^A \sim \mathcal{N}\left(0, \sigma_A^2\right),\ \epsilon_t^\alpha \sim \mathcal{N}\left(0, \sigma_\alpha^2\right).$$

Here, $\epsilon_{t-\ell}^{A,\ell}, \epsilon_{t-\ell}^{\alpha,\ell}$ denote news shocks (technology news, either about TFP or the capital share) that households receive in period $t-\ell$, and which are added to (the logarithm of)

[15] It holds that $\tilde{\kappa_w} = \zeta\kappa_w\frac{\mu^W-1}{\mu^W}$.

the fundamental process ℓ periods later (as indicated by the superscript). ℓ is called the anticipation horizon of the news. In other words, the capital share and log-TFP follow an ARMA process, where the moving average part is known ℓ periods in advance, and hence interpreted as news. This interpretation is standard in the literature (e.g. Schmitt-Grohé and Uribe (2012), Barsky and Sims (2012)). In particular, I assume the news shock to be iid. from the same distribution as the surprise shocks $\epsilon_t^A, \epsilon_t^\alpha$ (i.e., news are not autocorrelated as in Leeper and Walker (2011)).

Let mc_t denote the relative price (compared to the consumption good) at which the intermediate good is sold to final goods firms (which makes it the marginal cost of Y_t for these firms). The intermediate good producers, who operate in a perfect competition environment, set the real wage and the user costs of capital according to the marginal products of labor and capital:

$$w_t^F = (1-\alpha_t) mc_t A_t (u_t K_t / N_t)^{\alpha_t}, \;\; r_t + q_t \delta(u_t) = u_t \alpha_t mc_t A_t (N_t / u_t K_t)^{1-\alpha_t}. \tag{22}$$

Utilization is decided by the owners of the capital goods, who take the aggregate supply of capital services as given, and therefore follow the optimality condition

$$q_t \delta'(u_t) = \alpha_t mc_t A_t (N_t / u_t K_t)^{1-\alpha_t}. \tag{23}$$

Final goods firms (that are owned by the entrepreneurs) differentiate the intermediate good into final goods of the variety j, y_j. In this environment of monopolistic competition, they maximize profits subject to the demand curve $y_{jt} = (p_{jt}/P_t)^{-\eta} Y_t$ and price adjustment frictions. It is assumed that they discount the future at the same rate as the households, β. Then, their optimization yields a symmetric equilibrium that up to first order is determined by the Phillips curve

$$\log\left(\frac{\pi_t}{\bar{\pi}}\right) = \beta\, \mathbb{E}_t \log\left(\frac{\pi_{t+1}}{\bar{\pi}}\right) + \tilde{\kappa}\left(mc_t - \frac{1}{\mu^Y}\right), \tag{24}$$

where $\mu^Y = \frac{\eta}{\eta-1}$ is the target markup, and $\tilde{\kappa}$ is determined by the probability of price adjustment, κ[16]. The rent of the final goods firms is $\Pi_t^F = Y_t(1 - mc_t)$ in real terms.

Capital producers transform the investment of consumption goods into capital goods, taking as given the price of capital goods, q_t, and investment adjustment costs. They

[16] It holds that $\tilde{\kappa} = \eta\kappa\frac{\mu^Y - 1}{\mu^Y}$.

maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t I_t \left\{ q_t \left[1 - \frac{\phi}{2} \left(\log \frac{I_t}{I_{t-1}} \right)^2 \right] - 1 \right\}. \tag{25}$$

Up to first order, the problem reduces to the equation

$$q_t \left[1 - \phi \log \frac{I_t}{I_{t-1}} \right] = 1 - \beta \, \mathbb{E}_t \left[q_{t+1} \phi \log \frac{I_{t+1}}{I_t} \right], \tag{26}$$

which determines q_t from the rates of investment. Since all capital goods producers are symmetric, the law of motion for aggregate capital follows as

$$K_t - (1 - \delta(u_t))K_{t-1} = \left[1 - \frac{\phi}{2} \left(\log \frac{I_t}{I_{t-1}} \right)^2 \right] I_t. \tag{27}$$

3.4 Government sector

In the government sector, a monetary authority (the central bank) controls the nominal interest rate on bonds, while a fiscal authority (the government) issues bonds to finance deficits. The monetary policy follows a Taylor rule with interest rate smoothing:

$$\frac{R^B_{t+1}}{\bar{R}^b} = \left(\frac{R^B_t}{\bar{R}^b} \right)^{\rho_R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{(1-\rho_R)\theta_\pi} \left(\frac{Y_t}{Y^*_t} \right)^{(1-\rho_R)\theta_Y}. \tag{28}$$

$\theta_\pi, \theta_Y \geq 0$ govern the severity with which the central bank reacts to deviations in inflation and the output gap, where Y^*_t is defined as the output that would be obtained at steady state markups. The government issues bonds according to the fiscal rule

$$\frac{B_{t+1}}{B_t} = \left(\frac{B_t}{\bar{B}} \right)^{-\gamma_B} \left(\frac{\pi_t}{\bar{\pi}} \right)^{-\gamma_\pi} \left(\frac{Y_t}{Y^*_t} \right)^{-\gamma_Y}. \tag{29}$$

Let $\mathcal{B}_t := \sum_i (w_t n_{it} h_{it} + \mathbb{1}_{h_{it}=0} \Pi^F_t)$ be the tax base for the progressive tax code. The total tax revenue T_t sums up to $T_t = \tau(\mathcal{B}_t + \sum_i \mathbb{1}_{h_{it} \neq 0} \Pi^U_t)$, where the average tax rate τ satisfies

$$\tau \mathcal{B}_t = \mathcal{B}_t - (1 - \tau^L) \mathcal{B}_t^{(1-\tau^P)}. \tag{30}$$

After the fiscal rule determines the government debt, and taxes are collected, government expenditure G_t adjusts such that the government budget constraint is fulfilled in every period: $G_t = T_t + B_{t+1} - B_t \frac{R^b_t}{\pi_t}$. As a simplification, it is assumed that G_t does not provide any utility to households. This implies that in steady state, in which government expenditure is calibrated to be strictly positive, a fraction of physical production is wasted.

3.5 Market clearing and equilibrium

The labor market clears at the competitive wage in (22). The market for liquid assets clears when liquid asset demand, which is given by the households' optimal decisions, $L_t^d = \mathbb{E}[\lambda b_{a,t}^* + (1-\lambda) b_{n,t}^*]$, equals the supply of liquidity $L_{t+1} = B_{t+1} + q_t^{\Pi}$ (as L_t^d is the aggregate over positive and *negative* private liquid asset holdings, the supply of liquid assets is bigger than L_{t+1} in gross terms). Similarly, the price of capital q_t, which is determined by (26), clears the capital market when $K_{t+1} = K_t^d = \mathbb{E}[\lambda k_t^* + (1-\lambda)k_t]$ holds (households that do not adjust capital demand the same amount as last period, k_t). By Walras' law, whenever labor, bonds, and capital markets clear, the goods market also clears.

A *recursive equilibrium* is a set of policy functions $\{x_{a,t}^*, x_{n,t}^*, b_{a,t}^*, b_{n,t}^*, k_t^*\}$, value functions $\{V_t^a, V_t^n\}$, prices $\mathcal{P}_t = \{w_t, w_t^F, \Pi_t^F, \Pi_t^U, r_t, q_t, q_t^{\Pi}, \pi_t, \pi_t^W, R_t^B, R_t^L, \tau_t, \tau^L\}$, stochastic state A_t and shocks $\Omega_t = \{\epsilon_t, \epsilon_t^l\}$, aggregate capital and labor supply $\{K_t, N_t\}$, distributions Θ_t over individual asset holdings and productivity, and a perceived law of motion Γ, such that

1. Given the functional $\mathbb{E}_t V_{t+1}$ and $\mathcal{P}_t$, the policy functions $\{x_{a,t}^*, x_{n,t}^*, b_{a,t}^*, b_{n,t}^*, k_t^*\}$ solve the households' planning problem, and given the policy functions, $\mathcal{P}_t$, and $\{V_t^a, V_t^n\}$ solve the Bellman equations (10).

2. The labor, the final goods, the bond, the capital and the intermediate good markets clear, and interest rates on bonds are set according to the central bank's Taylor rule.

3. The actual and the perceived law of motion Γ coincide, i.e. $\Theta' = \Gamma(\Theta, \Omega')$.

To solve the model, I use the methods developed by Bayer and Luetticke (2020)[17].

[17] For the implementation of the methods, I make use of and extend the Julia package "BASEforHANK" by Bayer et al. (2022), available on `https://github.com`.

3.6 Definitions and parameter choice

3.6.1 Classification in liquid and illiquid assets

For the classification of assets in the data into the liquid and illiquid categories, I largely follow Kaplan et al. (2014): Illiquid assets, which are assumed to be productive in the model, consist of positive wealth in housing[18], other real estate, pensions and life insurance assets, certificates of deposit, and saving bonds. To compute the net illiquid asset position in the data, illiquid debt is subtracted, namely housing debt on owner-occupied real estate, and other real estate debt. I abstract from car wealth in the analysis[19].

Conversely, liquid assets comprise the sum of checking, savings and call/money market accounts, as well as holdings in mutual funds, equity and other managed assets, and bonds other than saving bonds. For cash holdings, I use the estimate by Kaplan et al. (2014). To arrive at net liquid wealth, I subtract credit card debt. As data source, I use the extension of the Survey of Consumer Finances (SCF), SCF+, by Kuhn et al. (2020), which yields 20 years of cross-sectional data between 1950 and 2016. I restrict the household head to be in working age, i.e. between 22 and 65 years of age.

3.6.2 Parameter choice

The portfolio adjustment probability λ is calibrated at 6.5% so that the mean liquidity in households' portfolios roughly matches the data (see table 1). This adjustment probability implies an average waiting time of almost four years until capital holdings can be adjusted. This is also consistent with the interpretation of capital holdings as investments in projects that include R&D, in the following sense: as noted by Li and Hall (2020), the average gestation lag is two years, and the yearly depreciation of R&D in the late 1990s and early 2000s is between 20% and 60% in most sectors[20]. Assuming an initial R&D phase of two years on average, in which intangible capital is produced (while physical capital is pledged as collateral), followed by the phase in which goods are produced using the physical capital and the depreciating intangible capital, I arrive at an

[18] This is in accordance with the definition in NIPA, where "the ownership of the house [...] is treated as a productive business enterprise" (U.S. Bureau of Economic Analysis, 2019).

[19] Consumer durables like cars represent a significant share of poorer households' portfolios (e.g. Guiso and Sodini (2013)); however, they are rather evenly distributed across the wealth distribution, so that leaving them out should not bias the results systematically.

[20] Fittingly, Adam and Weber (2023) estimate from product data in the UK the median quarterly turnover rate of consumer products as 13.7%.

Table 1: Calibrations

Targets	Calibration	Data	Source
Mean illiquid assets (K/Y)	11.04	11.44	NIPA
Mean gvmt bonds (B/Y)	0.8	1.66 (1.1)	FRED
Government share (G/Y)	0.18	0.21	FRED
Top 10% wealth share	0.68	0.66	WID
Mean portfolio liquidity	0.22	0.25	SCF+
Fraction without capital	0.14	0.22	SCF+
Fraction borrowers	0.125	0.115	SCF+

Notes: In general, data values denote long-run averages from 1950 to 2016. When subtracting federal debt held outside the U.S. from total federal debt held by the public (data availabe since 1970), the debt-to-quarterly-GDP ratio of 1.1 is closer to the model-implied. The wealth share of the top 10% of the wealth distribution is available from the World Inequality Database since 1962. Portfolio liquidity is defined as the ratio of net liquid wealth by total net wealth. To compute it in the data, I delete all observations of households with positive liquid wealth, but non-positive total wealth (0.7% of total observations). Borrowers are defined as households holding a negative net position of liquid wealth.

average holding time of physical capital of four years. In line with the interpretation of the TFP news shock as anticipated spill-over from intangible capital, I likewise set the persistence $\rho_A = 1.0 - 2 \cdot 6.5\%$, i.e. log-TFP depreciates at a quarterly rate of 13%. The steady state capital share in production is set as in Bayer et al. (2022), $\overline{\alpha} = 0.32$. For the persistence of the shock to the capital share, $\rho_\alpha = 0,9552$, I use the mean probability for firms of losing a low labor-share status within 5 years, as estimated by Kehrig and Vincent (2021).

The size of both of the news shocks will be two times the standard deviations of the surprise shocks (see table 2). For TFP, this is the estimated value from Bayer et al. (2022). For the capital share, I calibrate the size of the news shock to fit to the increase of the capital share from the mid 1990s to 2000. To get an estimate of the capital share, I use the NIPA table 1.12 (National Income by Type of Income) and attribute the components to either profit income ($(1 - mc)Y$ in the model), wage income (wN in the model), or capital income (rK in the model). Importantly, corporate profits do not enter into capital income (in the model, profit income and capital income are different), while proprietors' income counts towards capital income. While the concrete estimates differ, this exercise is close in spirit to Karabarbounis and Neiman (2019). I find that, between 1995 and 2000, the capital share increased by about 1 percentage point.

The degree of profit smoothing is calibrated to match the standard deviation of quar-

Table 2: Estimated parameters (selected)

Parameter	Description	Value
ϕ	Capital adj. costs	0.218
κ	Price stickiness	0.105
μ^Y	Target markup final goods	1.08
κ_w	Wage stickiness	0.133
μ^W	Target markdown wages	1.1
ρ_R	R^B autocorr.	0.803
θ_π	Taylor: inflation	2.614
θ_Y	Taylor: output gap	0.078
γ_B	Fiscal: smoothing	0.157
γ_π	Fiscal: inflation	8.57
γ_Y	Fiscal: output gap	5.73
σ_A	TFP std. dev.	0.00608
σ_α	capital share std dev.	0.005

terly dividend growth of the S&P 500 at $\xi^\Pi = 0.05$[21]. The fractions ω^Π and ι^Π are calibrated to yield a share of liquid assets held in stocks of 39%[22] and a quarterly stock price-dividend ratio of 144[23], which implies $\omega^\Pi = 4.7\%$ and $\iota^\Pi = 0.074\%$. I set $\bar{\eta} = 13.5$ and $\bar{\zeta} = 11$, which implies price and wage markups of 8% and 10%, respectively. The real liquid rate is chosen to be 2.5% p.a., while the borrowing penalty $\bar{R}$ is set to 7.5% p.a. in order to roughly match the share of borrowers with the data. The steady state capital rent is $\bar{r} = 3.7\%$ p.a., implying a steady state illiquidity premium of 1.2% p.a. As estimate for the capital rent, I take the series by Gomme et al. (2011) (including housing, without capital gains, after-tax), which has an average yearly return of 5.6% from 1950 to 2016. Since the model abstracts from long-run technological growth, 2% yearly growth should be substracted from the couterpart of the illiquid rate in the data. The model liquid asset is composed both of government bonds, and more risky equity. Computing real (pre-tax) returns on the S&P stock index, 10 year treasury bonds (data source: Robert Shiller)

[21] The standard deviation is calculated from simulating the model subject to random innovations in capital share-news shocks, and (suprise) markup and TFP shocks; see section 5.

[22] From estimations by Saez and Zucman (2016), when defining bonds as fixed income assets plus net deposits and currency, and stocks as equities (other than S corporations), I get a stockshare of 45% in 1995. From the SCF wave of 1995 (see e.g. Guiso and Sodini (2013)), when defining bonds as cash and fixed income, and stocks as directly held equity, I compute a stockshare of 30%.

[23] This is the mean of the S&P 500 stock price divided by dividends amassed over the quarter, from 1948 to 2016. Its inverse, the dividend yield, implies an average return on stocks *without* capital gains of 2.9% annualized. Net of stock depreciation, the return becomes 2.5% p.a., as for all liquid assets in the model economy.

and 3-months treasury bills, I compute average yearly returns of 8.3%, 2.5%, and 0.7%, respectively, over the period from 1950 to 2016. The liquid rate in the model should be considered as a weighted average of these rates[24].

Tax progressivity $\tau^P = 0.18$ is taken from Heathcote et al. (2017), while the tax level $\tau^L = 0.1$ is set to achieve a government share of rougly 18%. With respect to the parameters that Bayer et al. (2022) estimated, I choose those estimates where inequality data was included in the estimation (the HANK* specification). Importantly, I deviate with respect to the fiscal rule, where I estimate γ_π and γ_Y so that the ratio of the magnitude of the profits- and the magnitude of the bonds-response in the anticipation phase of the news shock matches the respective ratio in the late 1990s[25]. Table 2 lists the chosen values for a selection of parameters in the model.

4 A news-induced stock price cycle

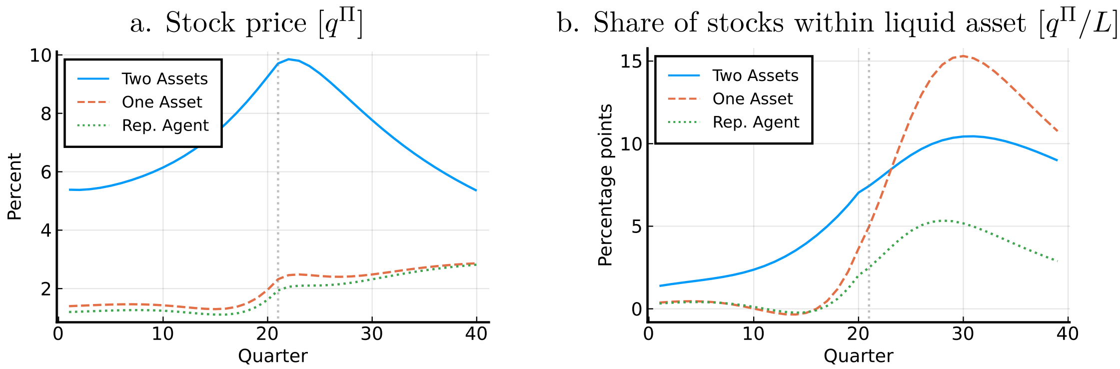
I consider the following experiment: with an anticipation horizon of 5 years ($\ell = 20$)[26], households become aware that the capital share will increase (by two times its standard deviation). As outlined in the introduction, one can interpret the capital share increase as a temporary change in the production process due to, e.g., more firms employing IT capital. In section 4.2, I show that I obtain almost the same impulse responses if the news is instead about a temporary increase in TFP. The reason is that for both news shocks, the expectation of a higher future return on holding capital is identical, which is the decisive impulse to cause the investment-driven boom. The higher expected life-time income that induces households to increase their consumption in the anticipation phase is mainly produced by the higher capital stock, which is accumulated in both scenarios when households rebalance their portfolio towards the productive asset.

[24]The introduction of aggregate risk, that would allow to differentiate among the classes of liquid assets by their model-implied riskiness, would be an advantage for this part of the calibration. For stock holdings, one should account for the capital gains tax rate of 15-25% over the sample for wealthy households, and discount dividends by 2% long-run growth. Additionally, the financial intermediation wedge of 1.5-2% as calculated by Philippon (2015) reduces the effective rate of financial assets for households.

[25]I define the magnitude of the impulse response as the distance between the maximum and the minimum of the percent deviations in the anticipation phase. I constrain both γ_π and γ_Y to the interval $[-10.0, -0.01]$, and search for a global minimum using a Simulated Annealing-algorithm. The estimated bond supply is much more elastic, i.e. the government stabilizes inflation and the output gap more aggressively, than what was estimated by Bayer et al. (2022) for the whole period since 1960. The reason is that in the late 1990s, the U.S. government strongly reduced their debt.

[26]I choose an anticipation horizon of five years to be close to the dotcom-boom example: Karnizova (2012) estimates increased "productivity prospects" around 1995, while in 2000, the NASDAQ peaks.

Figure 3: Response of stocks across model classes



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).

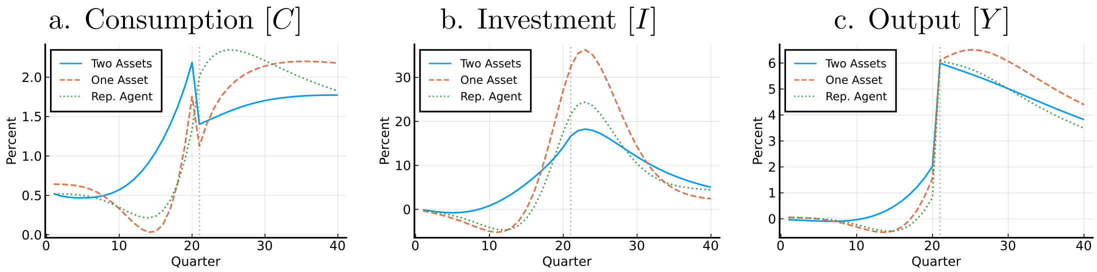
Figures 3 and 4 present the response of the stock price and business cycle variables across three model variants: *Two Assets* denotes the baseline model with heterogeneous agents and portfolio choice between liquid and illiquid assets. *One Asset* retaines the market incompleteness, but takes away the portfolio choice: every household holds a representative portfolio, which is determined by the bond supply rule and the ex-ante illiquidity premium being fixed at a steady state level of zero[27]. This implies that capital becomes liquid in this setting. *Rep. Agent* additionally takes away market incompleteness, and is thus a model of the RANK variety[28].

Only the HANK model with portfolio choice exhibits a peak in the stock price around the time of the capital share increase (quarter 21), and generates the uniformly accelerating stock price growth that is typical for stock price booms. It is clear that the decisive difference for whether the news drives the business cycle is the portfolio choice. In the full HANK model, richer households start shifting their portfolio towards the illiquid capital after around 2.5 years. This crowds out government bonds (which increases the share of stocks within liquid assets) and thus government expenditures. The higher goods-demand increases wages (since prices are sticky) and lowers the negative labor gap (since wages are sticky), so that households increase their labor supply. Aggregate consumption rises on impact as households expect to have a higher lifetime income, and increases gradually with higher incomes. This gradual consumption increase (by most households) supports

[27]The ex-ante illiquidity premium is defined up to first order as the difference between the expected return on capital and the expected return on liquid assets, $\frac{\mathbb{E}_t(q_{t+1}+r_{t+1})}{q_t} - \frac{R_t^b}{\mathbb{E}_t\,\pi_{t+1}}$.

[28]The household's time-preference β is calibrated in the RANK and the One Asset-varieties such that the real rate on the asset in steady state equals that of the baseline Two Asset-model. This implies that also the steady state stock price-dividend ratio is equal across all three varieties.

Figure 4: Response of the business cycle across model classes



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).

a higher real interest rate in equilibrium.

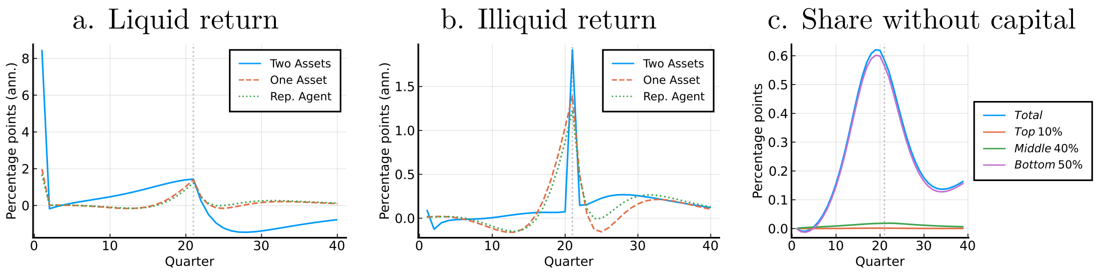
Figure 5 shows the response of the (ex-post) returns to the two asset classes, liquid and illiquid assets, across the model varieties. It is clear that without a time-varying illiquidity premium, the expected returns are the same between asset classes (the liquid asset return jumps up at the onset of the news, as the stock appreciates unexpectedly). In contrast, with illiquid capital, the illiquidity premium declines during the anticipation period (the return on liquid asstes increases) and rises after the stock price-peak (the return on liquid assets falls). I also show the change in the share of households without capital. While rich households increase their capital holdings during the boom (intensive margin), poor households are deterred of holding capital by the lower premium (extensive margin). Since the liquiditiy premium rises after the boom, the demand for capital rises, which increases the capital price.

The increasing real interest rate in the anticipation period does not depress the economy; to the contrary, it stabilizes the income of richer households by increasing their return on liquidity (figure 6), which enables the middle class (households in between median wealth and the highest wealth decile) to invest in capital, inducing the boom. Is the investment boom driven by the middle class? Households in the top 10% of the wealth distribution own 70% of the capital stock in the economy, so that their incentive to invest in new capital is low. However, if the profit losses of entrepreneurs were higher, or interest income lower, more of the richest household would sell capital to offset their income losses, thereby depressing aggregate investment.

4.1 Comparison to the dotcom-boom

Since both the capital share shock as well as several parameters were calibrated to the 1990s in the U.S., I can make a quantitative comparison of the shock responses to the

Figure 5: Response of *ex-post* returns and capital holding across model classes



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21). The return on capital includes capital gains. Wealth groups in Panel c) are defined in the *cross-section* each quarter.

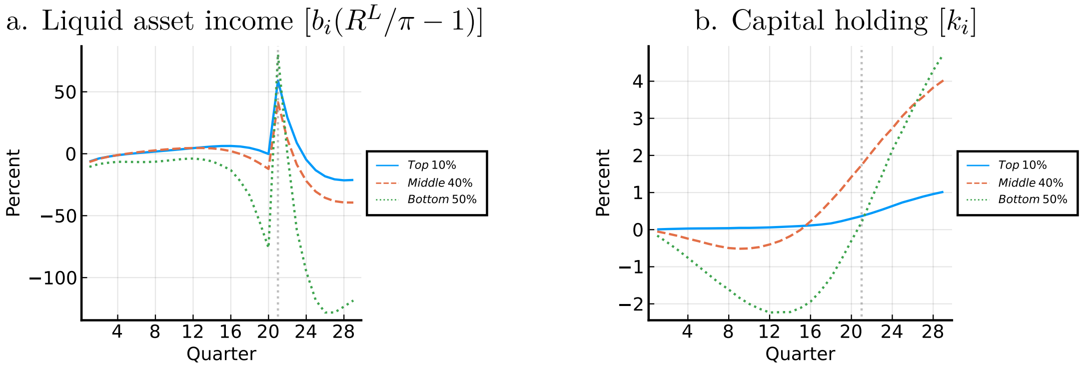
aggregate observations from 1995 to 2000[29]. In terms of real business cycle variables, the model exactly replicates the 6% rise in output and the 15% increase in investment, while it only accounts for one third to one half of the observed increase in consumption. As noted above, I calibrate the fiscal rule so that the model responses match the ratio of the decline in U.S. government debt to the decline in corporate profits during the late 1990s. In absolute size, the model explains about 75% of the observed declines in government bonds and profits (notably, federal debt held by the public declined by 20% during that time).

The shortcoming with respect to aggregate consumption may be due to the fixed debt limit in the model, while in reality, financial innovation related to collateral borrowing might have allowed households to consume more. Considering only unsecured borrowing, I find that the model accounts for half of the 30% increase in consumer credit. In the model, the increase in borrowing, mostly by the bottom 50% of households, contributes to the overall increase in wealth inequality during the anticipation period. From the World Inequality Database, the Gini index of wealth increased by 1.25% in that time span; the model explains about half of this increase[30]. Finally, with respect to the share of stocks within the liquid asset class, using the estimates by Saez and Zucman (2016), during the dotcom boom this share increased by 20 percentage points. The model accounts for

[29] I detrend all time series by a constant growth rate of 2%, following McGrattan and Prescott (2010), and deflate nominal series with the GDP deflator [GDPDEF].

[30] This is remarkable, since the model does not feature heterogeneous stock shares; in the data, rich households gain disproportionally from stock price booms, see Kuhn et al. (2020).

Figure 6: Response of income and investment over the wealth distribution



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21). Wealth-groups are defined from their position *at period 0*.

around a 25% of this increase[31].

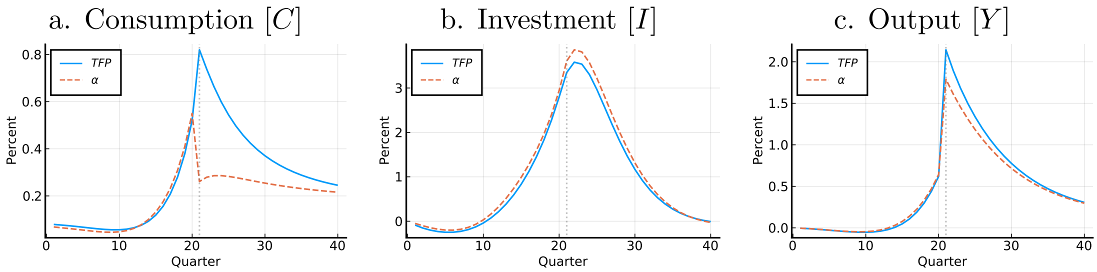
4.2 Alternative news shock

Figure 7 compares the response of the business cycle to news about a temporary TFP-increase with the response to the capital share-news (I adjust size and persistence of the shocks to make them comparable). The responses are virtually identical in the anticipation phase. This shows that the portfolio rebalancing towards capital, which is incentivized in both cases by the expectation of higher future returns on holding capital, drives the boom also in consumption and output. Differences only occur once the fundamental shock realizes: a higher capital share redistributes from households with a high marginal propensity to consume to those with a low propensity, so that consumption falls, while higher TFP implies more income for all households. Therefore, output also rises a little less in the case of the capital share increase. Still, in the long run, the levels of consumption and output converge across the two shock responses. The reason is that, when the direct effect of the transitory shocks subsides, the indirect effect of the higher capital stock, built up during the identical anticipation phase, dominates.

In a further clarifying exercise, I also shock the model economy with news about future transitory increases in the markup μ (i.e., market power), and news about future increases in investment-specific technology productivity, which increases the marginal productivity of the transformation from consumption to capital goods. Both variables are prominent

[31] A more detailed model of stocks and their difference compared to other liquid assets, namely the different aggregate risk they carry, could help explaining this gap. Institutional changes, or agents that learn about the fundamentals over time, receiving observed prices as signals, would be other possible explanations.

Figure 7: Response of business cycle to alternative news shock



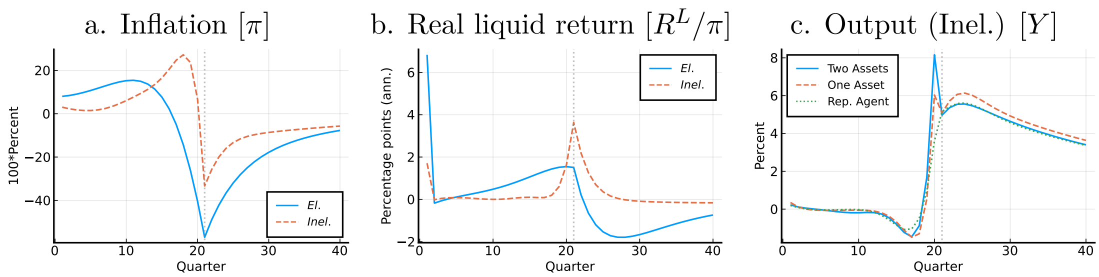
Notes: Model impulse responses are to news about a temporary TFP-increase in 5 years, and to news about a temporary capital share-increase in 5 years (both quarter 21). The size of the capital share-impulse is scaled to fit to the TFP news shock (given by two times σ_A). For comparability, the persistence of the capital share-process is adjusted to ρ_A.

candidates in the literature to explain the secular decline (increase) in the labor (capital) share (e.g. in Karabarbounis and Neiman (2014), Greenwald et al. (2019)). I find that both news shocks depress the economy in the anticipation phase. The markup shock implies an expected redistribution from capital to profit income, which disincentivizes the holding of capital, so that investment falls. On the other hand, the investment-specific technology shock increases the capital rent, but it lowers the cost of capital; therefore, households wait with the investment until capital becomes cheap. This illustrates how only the anticipation of high rents *and* returns for capital causes an investment-driven business cycle and stock price boom in the model.

4.3 Importance of the fiscal rule

The investment boom is enabled by an elastic bond supply and a government that is willing to temporarily reduce its expenditure. To illustrate this point, I compare the response of inflation and the real liquid return in the baseline model with the impulse responses in an alternative environment (*Inel.*), where the government does not stabilize the output gap, and stabilizes inflation less strongly (figure 8). With the alternative fiscal rule that allows for a prolonged rise of inflation during the anticipation phase, middle class households do not invest enough to start the business cycle (and stock price) boom. The reason is that inflation depresses asset returns and magnifies the increase in the marginal costs of firms (affecting the entrepreneurs) and of unions (affecting the workers) late in the anticipation phase. The expectation of being exposed to these income losses discourages the households' capital investment earlier in the cycle. As a result, even in the model with portfolio choice, government expenditure is crowded out too late to drive the boom, and therefore all three model variants exhibit roughly the same output-response (as well

Figure 8: Responses for different bond supply elasticities.



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).
The changed fiscal rule parameters of the *Inelastic* specification are $\gamma_Y = 0.007, \gamma_\pi = 6.58$.

as consumption-response) to the news shock.

4.4 Wealthy hand-to-mouth households

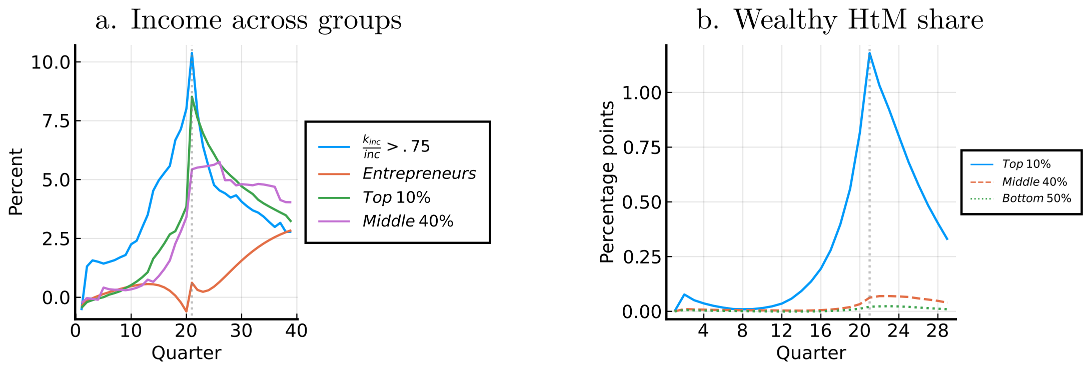
Following Kaplan et al. (2014), wealthy hand-to-mouth households are households that have non-zero wealth in the illiquid asset ($k_i > 0$), while being at a kink in the budget set: either at zero liquid savings ($b_i = 0$), or at the borrowing limit ($b_i = \underline{B}$). Motivated by my numerical findings, I focus on the case when households hold the illiquid asset, while being at the borrowing constraint. Kaplan et al. propose a stylized 3-period life-cycle model without uncertainty to highlight the conditions under which it is optimal for households to be wealthy hand-to-mouth: Suppose that in the first period, households allocate their initial endowment between the liquid and the illiquid asset. Next period, they receive income and can sell their liquid asset (or borrow) to increase their consumption, but can not sell the illiquid asset until the third (and last) period, where they consume their income and the return to all asset holdings.

In this setup, households are more likely to be wealthy hand-to-mouth at the end of the second period if:

1. the capital rent and price in the last period are high relative to the borrowing rate,
2. their initial endowment is high, and both capital rent and their income are increasing from the second to the last period.

The news shock raises the expected capital rent and prices in the future. As I argued in section 4.3, extreme profit swings towards the end of the cycle depress investment. Part of the reason is that a big output gap late in the cycle requires monetary policy to hike the nominal rate, so that the real rate spikes in the last quarter before the TFP increase. This makes it more expensive to finance illiquid asset holdings with debt accumulated over

Figure 9: Response of income and shares of wealthy hand-to-mouth



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).
Left panel: $\frac{k_{inc}}{inc} > .75$ denotes households whose main source of income ($> 75\%$) is capital rents ($[r]$ in the model). All groups are defined in the *cross-section* each quarter.
Right panel: Wealth-groups are defined from their position *at period 0*.

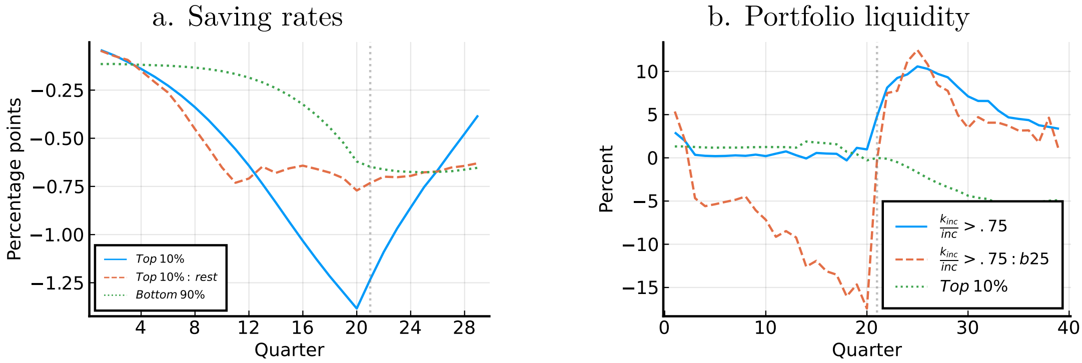
the anticipation period, so that more households will refrain from doing so (as discussed above, higher real rates *earlier* in the cycle instead are beneficial for investment).

While the income of the average household in the upper half of the wealth distribution rises during the stock price boom, the most income gains are incurred by households whose income is dominated by capital rents (see figure 9a). Entrepreneurs, who receive the profit income, experience an income rise at the onset of the capital share increase, but lose in the anticipation period. Therefore, entrepreneurs are less likely to become wealthy hand-to-mouth households in the anticipation phase[32]. Hence, by virtue of capital rents, holding (a high amount of) the illiquid asset and experiencing income gains reinforces each other, making point 2) more likely to hold.

For these reasons, it is mostly households at the top of the wealth distribution who become wealthy hand-to-mouth households during the anticipation phase (see figure 9b). In steady state, only 0.2% of households are wealthy hand-to-mouth (at the borrowing limit). 73% of those households are in the top 10% of the wealth distribution. I find that during the stock price boom, the share of wealthy hand-to-mouth households among the wealthiest decile grows by 10%. Hence, by far the largest inflow into the group of wealthy hand-to-mouth households comes from capital-wealthy households, who optimally choose to get at or near the borrowing constraint so that they can hold on to the capital a little longer.

[32]What is more, entrepreneurs on average hold much larger liquid asset stocks than workers, as they face the largest idiosyncratic risk (becoming a worker).

Figure 10: Response of portfolio choice across groups of households



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).
Left panel: The saving rate is defined as $1 - c_{it}/\{\text{cash at hand}_{it}\}$, where

$$\text{cash at hand}_{it} = y_{it} + b_{it} R_t^L / \pi_t + k_{it}(r_t + \mathbb{1}_{\{k \text{ adjustable}\}} q_t) - \underline{B}.$$

Wealth-groups are defined from their position *at period 0.*
Right panel: Portfolio liquidity is with respect to the *chosen* portfolio, i.e., households' wealth position next period. $\frac{k_{inc}}{inc} > .75$ denotes households whose main source of income ($> 75\%$) is capital rents ([r] in the model). $\frac{k_{inc}}{inc} > .75 : b25$ denotes the mean of the *lowest quartile* of the portfolio liquidity-distribtion for these households. All groups are defined in the *cross-section* each quarter.

4.5 Marginal traders

How can it be known whether the mechanism highlighted in section 2 is at work in the full HANK model? To show this, I split up households into those that were wealthy hand-to-mouth at some period s after the news shock, and became unconstrained at the subsequent period $s+1$, and the *rest*. The idea is that it should be the saving behavior of the first group, and not of the *rest* of households, that explains the time-varying returns on liquid assets during the cycle. Figure 10a reports the response of the households' saving rate (defined as the fraction that is saved of all funds available to the household in a given period) to the news shock across the wealth distribution. It shows the average response of all households in the top 10% and bottom 90% of the wealth distribution, and only that of the *rest* in the top 10%. Clearly, within the top wealth decile, wealthy hand-to-mouth households save less during the anticipation period, and save more after the capital share increase. In particular, it is the only group of households where the saving rate is trending upwards strongly after the 5th year, which indicates that these households drive down the return on liquid assets[33]. Note that, since the aggregate supply of liquid assets is down,

[33]One may be worried that, since aggregate consumption also decreases after the temporary shock to the capital share, the lower rates are due to a general decline in consumption. However, the results are robust for a news shock about a very persistent TFP increase ($\rho_A = 0.992$). In that scenario, almost

also a saving rate below its steady state-level can depress the return on liquid assets in equilibrium.

Figure 10b shows the portfolio liquidity of households in the richest decile in the cross section. Among the rich households, it is the households whose income is dominated by capital income who decrease their portfolio liquidity early on. During the anticipation phase, the distribution of portfolio choices of households with dominating capital income widens. One of the reasons is a *composition effect*: households with less capital wealth enter the group by virtue of higher capital rents during the business cycle boom. This alone drives up the portfolio liquidity of households in this group compared to the steady state[34]. Therefore, I also show the mean response of the lowest quartile in the portfolio liquidity distribution of these households. The marginal traders will be in this region of the distribution during the anticipation phase. I find that households with high capital income in that region of the distribution lower their portfolio liquidity during the anticipation phase. After the boom, the "rentiers" increase their liquid saving - their portfolio liquidity rises - as they are exposed to high consumption risk at that point. This depresses the real rate on liquid assets in equilibrium.

5 Asset returns, heterogeneous portfolio choices, and the stock market

In this section, I provide empirical evidence for the relation between the returns on liquid and illiquid assets and stocks, and the relation between portfolio choices of households and stocks, using micro-level data. Then, I simulate the model in order to assess the quantitative success of the model in explaining stock price fluctuations. Additionally, I use the Campbell-Shiller decomposition of the model stock price to highlight the effects of different assumptions about the cyclicality of dividends and the accuracy of the news for the explanatory power of the mechanism.

The theory implies that news about future returns on liquid assets, like government

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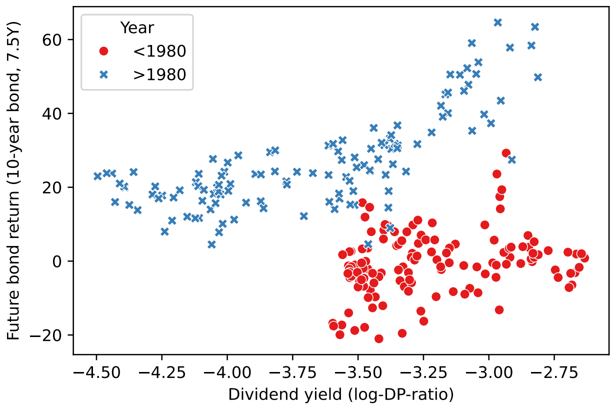
all households in the economy *decrease* their savings after the TFP increase, as their incomes continue to rise (and aggregate consumption rises as well). Only the wealthy hand-to-mouth households within the top decile of the wealth distribution increase their savings. The results are available from the author upon request.

[34]In the data, this composition effect rather goes in the opposite direction: since empirically, capital rents increase less in stock price booms than real bond rates, there is some evidence that the overall share of households with dominant capital income decreases in stock price booms. However, this does not drive the overall reduction in portfolio liquidity: see section 5.

Figure 11: Liquid return news and dividend yield



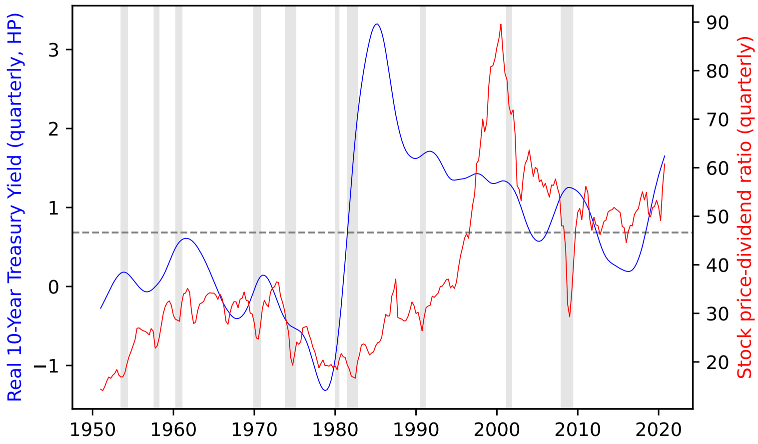
Notes: Data by Robert Shiller (S&P and 10 year treasury bond). All returns are ex-post (realized) quarterly observations from 1955.Q4 to 2016.Q4. The future real 10 year treasury yield is a weighted sum over the next 7.5 years, with discount factor $\rho = 0.96$ computed as in Campbell and Shiller (1988). Ex-post real returns are computed using realized inflation.

bonds, causes today's dividend yield of the stock market to rise. The asset pricing literature (Cochrane, 2005) finds that this relation is instead negative, and that therefore the discount rate channel exclusively runs through excess stock returns (the "risk premium"). Figure 11 shows visually that this finding flips when accounting for a secular break in 1980: real bond returns fell in the 1970s due to high inflation, implying mostly negative liquid return news before 1980. At the same time, the dividend yield was higher in the earlier part of the sample. This stark secular pattern causes the relation over the whole sample to be negative. However, splitting the sample in 1980 and running a Campbell and Shiller (1988)-decomposition on the two time periods separately, I find that future bond returns correlate positively with the dividend yield, and explain part of its variance, especially in the period since 1980.[35] Plotting the real 10 year treasury yield, smoothed with the Hodrick-Prescott filter, together with the stock price-dividend ratio along the time-dimension gives an impression of the relevance of this correlation as evidence for my theory (Figure 12). It shows that the larger swings in stock prices in the last decades, namely the downturns in the 1970s and 2000s, and the booms in the 1980s and 1990s, all occur in times of lower than average, respectively higher than average, real interest rates.

Next, I take the capital return series by Gomme et al. (2011) as a proxy for returns on illiquid assets (no capital gains, after-tax), and look whether the change in capital

[35] Concretely, I find that the share of the variance of the S&P 500 dividend yield explained by future bond returns amounts to 8% in the pre-1980 sample (compared to 81% variance share explained by excess return-news), while future bond returns explain 21% of the dividend yield since 1980 (compared to 29% for excess return-news).

Figure 12: Real 10-year treasury yield and the stock market



Notes: Stock market data from S&P500 (Robert Shiller), recession years (grey areas) by NBER. The real 10 year treasury bond yield is computed with realized inflation and smoothed using HP-filter ($\lambda = 1600$). The dotted line marks the average quarterly real 10 year treasury bond yield over the sample (0.68 pp).

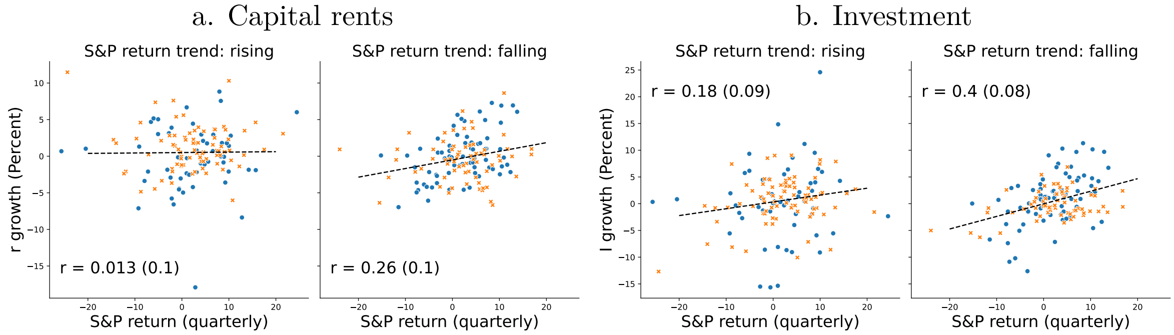
returns is related to stock returns, as in the theory. Specifically, the proposed mechanism hinges on capital-wealthy households to drive down the return on liquid assets, and thus also stock returns, when capital returns fall. Figure 13a shows the correlations. During the boom phase, there is no correlation, but when stock prices are falling, there is a weak correlation. For investment growth, the correlations are more strongly positive. In a regression exercise (see appendix C.1), I check that the positive correlations are unaffected by the inclusion of dividends and other business cycle variables. In sum, the data is consistent with a theory of investment-driven stock price-booms, where a fall in capital rents depresses stock returns after the boom.

5.1 Evidence from survey data

Turning to heterogeneous portfolio choice, which is a crucial part of the proposed theory, I use the SCF+ by Kuhn et al. (2020) to isolate the group of households for whom capital income (excluding capital gains) is the main share (at least 75% in the baseline) of their overall income[36]. On average over all sampled years, 2.3% of households are in that category (2.7% in the model). The theory implies that their portfolio choice is decisive in affecting the illiquidity premium, and thus stock prices, over the cycle. In order to abstract from secular trends in the portfolio liquidity of the different wealth groups, I

[36] In the older waves of the Survey of Consumer Finances before 1983, capital income is only available as a measure that lumps together income from illiquid and liquid investments (like dividend income), while only the former counts as capital income in the model. Therefore, I treat separately the time periods before and after 1983. See appendix C.2.

Figure 13: Capital rents and investment over the stock price-cycle



Notes: Data by Robert Shiller (S&P 500) and Gomme et al. (2011) (capital rents). Quarterly observations (1948.Q2 - 2016.Q4). S&P return trend computed using HP-filter ($\lambda = 1600$). Blue dots: before 1980. Orange crosses: after 1979. Newey-West standard errors (1 lag) in parentheses.

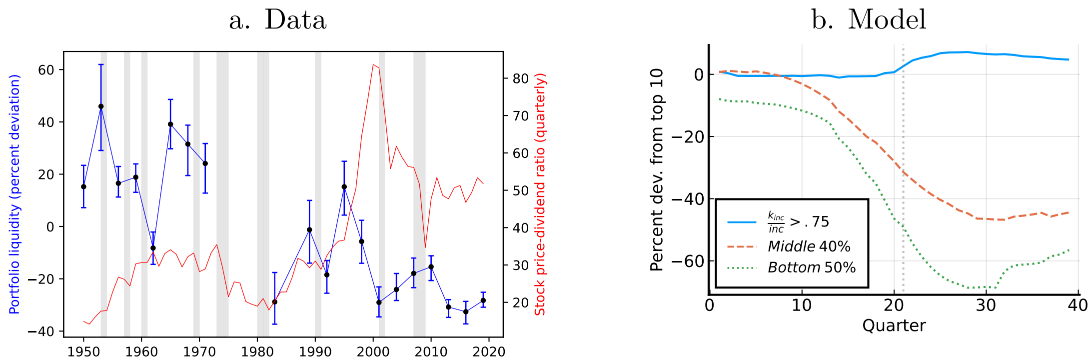
take the relative portfolio liquidity of the households with high capital incomes compared to the portfolio liquidity of the top 10% of the wealth distribution as the main measure of comparison between model and data[37].

While in the model, households with high capital incomes are all in the top decile of the wealth distribution, in the data, only 41% are in that wealth group, while 39% have wealth that lies between the median and the top 10% of the wealth distribution. The likely reason for this discrepancy is that the model abstracts from negative illiquid assets: mortgage debt in particular systematically lowers the net worth of households with high capital income in the data. Due to this overlap of the "rentiers" with lower wealth groups, I also compute the relative portfolio liquidity of the bottom 50% and middle 40% relative to the top 10%. This allows me to see if movements in the relative portfolio liquidity of the households with high capital incomes are spuriously driven by movements across the wealth groups.

The left panel of Figure 14 shows the relative portfolio liquidity of "rentiers" over time, and in comparison to the stock price-dividend ratio of the S&P 500. The right panel shows the model-implied prediction of the relative portfolio liquidities following a news shock. The model predicts that in response to the news, households in the bottom 90% of the wealth distribution reduce their portfolio liquidity relative to the top 10% as well. Different from the households with high capital income, however, they do not increase their portfolio liquidity (as much) in the years after the boom, especially so for the middle class.

[37] I show the time series of the portfolio liquidities of the different groups, as well as other characteristics of their portfolio choices over time, in appendix C.2.

Figure 14: Relative portfolio liquidity in model and data



Notes: Survey evidence from SCF+ (Kuhn et al., 2020), stock market data from S&P500 (Robert Shiller), recession years (grey areas) by NBER. Portfolio liquidity is defined as the ratio of liquid assets by total wealth.
Left panel: Left axis shows the relative deviation of portfolio liquidity of households whose main share of income (>75%) is capital income, from portfolio liquidity of the top 10% of wealth distribution. Whiskers are 68%-confidence intervals.
Right panel: Model responses of relative portfolio liquidity deviations (with respect to top 10%) across groups in the cross section. Responses are net of steady state deviation.

To put this prediction to the test, I conduct the following exercise: let $\{y_i\}_i$ denote the sequence of two sets of subsequently sampled years, respectively, contained in the SCF+: years between 1950 and 1971, and years between 1983 and 2019. For each sequence of the relative portfolio liquidities of households in group g, computed from the survey data, denoted by $\{\text{pflq}^g(y_i)\}_i$, I compute the difference between subsequent years: $\Delta_i \text{pflq}^g = \text{pflq}^g(y_i) - \text{pflq}^g(y_{i-1})$. I also collect the stock price-dividend ratios for the years where survey data is available, and compute the same differenced sequence, $\Delta_i \frac{q^\Pi}{\Pi^F} = \frac{q^\Pi}{\Pi^F}(y_i) - \frac{q^\Pi}{\Pi^F}(y_{i-1})$. Then, I combine the differenced variables of both sets of years into one pooled sample. Column (I) in table 3 shows the results of regressing $\Delta_i \frac{q^\Pi}{\Pi^F}$ on the change in relative portfolio liquidity $\Delta_i \text{pflq}^g$ of the groups $g \in \{\text{high capital income}, \text{middle } 40\%, \text{bottom } 50\%\}$. As predicted by the model, the relative portfolio liquidity of households with high capital income comoves negatively with stock price-dividend growth, with a correlation of -0.37 (standardized), when controlling for the portfolios of the other two wealth groups. Notably, the relative portfolio liquidity of the poor half of the wealth distribution also correlates negatively with the stock market. Appendix C.2 shows that this is due to secular patterns in the ratio of the portfolio liquidity of the bottom 50% and the top 10% over the sample that correlates with secular trends in the stock price-dividend ratio. I find that the portfolio liquidity of the "rentiers" and the bottom 50% explain mostly different parts of the variation, as leaving the latter out of the regression yields largely the same result for the "rentiers".

Table 3: Regression of price-dividend growth on relative portfolio liquidities

Variables	(I)	(II)	(III)	(IV)	(V)
high cap. inc.	-0.37* (0.2)	-0.3 (0.21)	-0.5** (0.23)	-0.35 (0.2)	-0.51** (0.2)
middle 40%	0.42 (0.24)	-0.07 (0.09)	0.45 (0.27)	0.33 (0.21)	0.31 (0.23)
bottom 50%	-0.75** (0.29)	-	-0.77** (0.32)	-0.66** (0.22)	-0.64** (0.24)
rel. stock share	-	-	0.34** (0.15)	-	0.47** (0.15)
in top 10% share	-	-	-	-0.23 (0.17)	-0.38* (0.18)
Adj. R-squared	0.2	-0.05	0.26	0.2	0.35

Notes: The baseline regression equation is $\Delta_i \frac{q^\Pi}{\Pi^F} = \alpha + \sum_g \beta_g \Delta_i \text{pflq}^g + \epsilon_i$, $i = 1, .., 18$. I divide all variables by their standard deviation. Specifications (III) and (V) include the change in the ratio of the stock share of high capital-households by the stock share of households in the top 10% as a regressor. Specifications (IV) and (V) include the change in the share of high capital-households in the top 10% as a regressor. Newey-West (one lag) standard errors in parentheses. Asterisks indicate that the t-statistic of the coefficient is above the 5% (**) or 10% (*) level.

One potential issue with the interpretation of the results is that they could arise mechanically, through a composition effect with respect to stock shares: On average over the sampled years, households in the top 10% of the wealth distribution hold 13.4% of their total wealth in stocks, while households whose income is dominated by capital income hold 10% of their wealth in stocks[38]. Since stocks are liquid, the higher valuation of stock wealth during stock price-booms mechanically increases the liquid wealth and, ceteris paribus, also the portofolio liquidity of the top 10% relative to the households with high capital incomes. To check if this mechanism drives the results, I add the relative stock share of the "rentiers" compared to the top 10% as an additional regressor, where the stock share is defined as the ratio of the wealth held in equity and other managed assets by total wealth of the household. Columns (III) and (V) in table 3 show the results. When controlling for the stock share, the evidence for a negative relation between the relative portfolio liquidity of the high capital income-households and the stock market becomes stronger. The reason is that, during stock price booms, the share of stock wealth in total wealth of the "rentiers" *increases* compared to that of the top 10%, even though the top 10% own more stocks on average. This effect — which cannot arise in the model, since it abstracts from aggregate risk — attenuates the negative relation between the relative portfolio liquidity and the stock market in the baseline specification.

To interpret the results as evidence for portfolio choice, one should also account for another composition effect: As shown above, stock price booms coincide with higher

[38]The share of wealth that the top 50% of the wealth distribution holds in stocks decreases markedly from the first to the second half of the sample, see appendix C.2.

returns on liquid assets and business cycle booms. Hence, the overall income of households rises on average in stock price booms. If at the same time, capital rents do not rise (as much), the share of households whose income mainly comes from capital income falls. As a consequence, those households that *remain* above the threshold (>75% of income is capital income) have higher illiquid wealth, and thus a lower portfolio liquidity. The negative correlation of the portfolio liquidity of those households with the stock market would then be a mere restatement of the relation between the stock price cycle and factor incomes[39]. In the columns (IV) and (V), I consider this possibility, by including the change in the share of households with dominant capital income within the top 10% as an additional regressor. I find that, while there is evidence that the share of "rentiers" among the wealthiest households is indeed countercyclical, the negative correlation between relative portfolio liquidity and the stock market remains virtually unchanged. To summarize, the predicted fall in the liquidity of the portfolios of households with high capital incomes and households in the bottom half of the wealth distribution during stock price booms is supported by the evidence from the Survey of Consumer Finances.

5.1.1 Who are the marginal traders?

The survey data can be used to investigate main characteristics of the high capital income-households, who the model predicts to be the marginal traders of the stock market. For this, I take averages over all sampled years for the "rentiers" and the rest. I find that 40% of high capital income households report no wage income, compared to 20% of the rest. Only 16% of the "rentiers" report positive income from self-employment, while among the rest of households, 21% report such income. At the same time, 42% of the high capital income households are professionals or managers, while this is only the case for 29% of the other households. "Rentiers" hold 26% of their wealth in business wealth, while this share is only 6% on average for the rest of the households. With their high capital income, 32% of these households are in the top 10% of the income distribution.

These characteristics align well with the description of "modern capitalists" by Smith et al. (2019): they find that in the last decades, the top 1% of the income distribution is mostly populated by pass-through business owners. They have a tax incentive to receive compensation through their share of their firm's profits rather than through wages. Typical pass-through firms are private, single-establishment or regional firms in skill-

[39]Note that, in the household survey, capital gains from equity do not count as income. I use the same accounting in the model. Therefore, stock price booms do not mechanically raise liquid incomes.

Table 4: Unconditional moments in data and simulated model

Variables	Data	(I)	(II)	(III)	(IV)	(V)
$mean(P/D)$	152*	151	148	147	146	149
$\sigma(P/D)$	63	48	35	28	28	42
$\rho(P/D)$	0.98	0.986	0.985	0.99	0.996	0.96
$\rho(\Delta P/D)$	0.99	0.11	0.01	0.41	0.41	-0.04
$\sigma(\Delta D)$	1.75%*	1.74%	1.27%	1.81%	1.49%	1.46%
$\rho(I/Y, P/D)$	15.2%	62%	32%	-5%	-24%	41%
$\rho(\Delta I/Y, \Delta P/D)$	17.5%	34%	29%	4.8%	-22%	64%
$\rho(\Delta C/Y, \Delta P/D)$	15.4%	2.1%	-58%	7.9%	-72%	64%
$\rho(R^b/\pi, R^{stocks})$	0.13-0.19	0.24	0.24	0.05	-0.11	0.3
$\sigma(R^{stocks})$	7.28%	5.07%	4.27%	1.63%	1.45%	7.84%
$\sigma(R^{stocks})/\sigma(R^b/\pi)$	1.7-8.9	2.9	5.3	3.7	4.26	12.2

Notes: Unconditional moments in U.S. data, 1950-2016, and in the model. $\sigma(x)$ and $\rho(x)$ denote the standard deviation and the autocorrelation, respectively, of variable x. $\rho(x, y)$ denotes the correlation of x and y. Δx denotes the growth rate of x. Appendix C.3 lists the composition of the aggregate variables. Stock market data by Robert Shiller (S&P 500). The model variants are as follows: (I): Two-Asset HANK with News; (II): Two-Asset HANK without News; (III): One-Asset HANK with News; (IV): One-Asset HANK without News; (V): Two-Asset HANK, only Noise
(*) denotes moments that were targeted during the calibration.

intensive industries, like law firms, dentists, or auto dealers.

5.2 Simulation

In order to evaluate the ability of the quantitative model to explain unconditional moments of the stock market and its correlation with the business cycle, I simulate the model. For the baseline, I pick three shocks: surprise TFP shocks ϵ^A, a surprise shock to the target price markup μ^Y, and the capital share news shock at the 5-year-horizon, $\epsilon^{\alpha,20}$. I set the standard deviation of the price markup shock to 0.01645, taken from the estimation by Bayer et al. (2022). In one simulation variant, I implement a *noise shock* instead of a news shock. In practice, this is achieved by adding a surprise capital share shock ϵ^α to the system in every period where the capital share change was expected to take place. The surprise capital share shock exactly offsets the effect of the capital share news shock (Chahrour and Jurado, 2018). In other simulation variants, I leave out any anticipatory shocks. I assume all shocks to be normally distributed around zero.

Table 4 shows the simulation results for various model variants and shock combinations, and compares them to the unconditional moments of the data. The main result is that the baseline variant, column (I), explains around 75% of the fluctuation in the price-dividend ratio of the S&P 500. The comparison with columns (II) and (III) shows that

Table 5: Campbell-Shiller decomposition in data and model

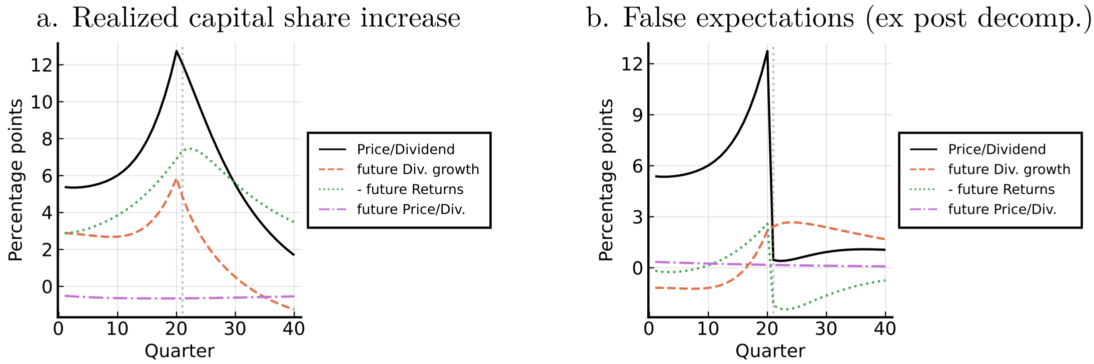
Source / Variant	Dividends	Discount rate	PD-ratio
Cochrane (2011)	0.11	1.01	0.11
Kuvshinov (2022)	0.55	0.45	-
Baseline	0.39	0.52	0.08
One-Asset	0.97	-0.04	0.07
No News	0.29	0.44	0.28
Only Noise	0.25	0.57	0.18

Notes: Variance shares of the Campbell-Shiller decomposition. For the model variants, I use the method by Cochrane (2011) to calculate the variance shares, with a time horizon of 15 years. "No News" and "Only Noise" are two-asset model variants.

news shocks and portfolio choice between liquid and illiquid assets are both important for explaining stock price fluctuations. Only the two-asset model allows for a time-varying illiquidity premium, which leads to larger fluctuations in the return to liquid assets and induces comovement between bond returns and stock returns (see the low set of rows). In the one-asset economy, the correlation between stock returns and bond returns turns zero or negative, as surprise TFP and markup shocks cause surprise changes in dividend payments that are orthogonal to government bond returns. News shocks cause the illiquidity premium to fluctuate even more, but in a structured way: they add the boom-bust cycle. Thereby, news shocks can explain higher volatility of the price-dividend ratio, while at the same time generating some *momentum* $\rho(\Delta P/D)$, i.e. the autocorrelation in growth rates, which is a salient feature of the data, and causing comovement of the stock price cycle with aggregate consumption. The model predicts that investment and the stock market are more positively correlated than in the data. Adam and Merkel (2019) show that a subset of investment in fixed assets, namely non-residental investment and investment in non-residential structures, correlates more with the stock market. However, since housing is the most important illiquid asset of the majority of households in the data, I cannot abstract from it in my quantitative model. Finally, as presented in column (V), noise shocks are almost equally successful in explaining stock price fluctuations. However, they imply that stock returns fluctuate 12 times more than returns on government bonds, at least a third higher than what is realistic, and fail to generate any momentum.

Next, I use the Campbell and Shiller (1988) decomposition to analyze the degrees to which the model variants explain the salient feature of stock prices (and asset prices in general): return predictability. It is a log-linear approximation of the price-dividend ratio

Figure 15: Campbell-Shiller decomposition with countercyclical dividends (model)



Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).
In b), the news is offset by a negative capital share surprise shock in quarter 21.

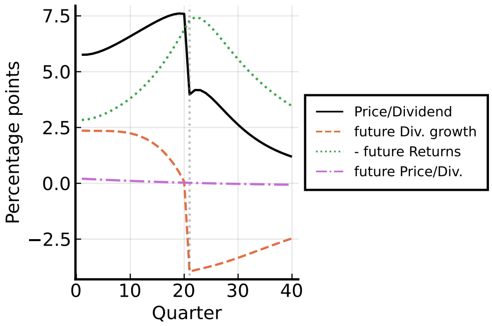
around its (proposed) stationary value, and is given by

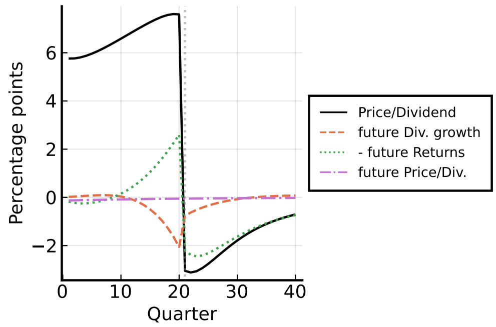
$$\log(q_t^{\Pi}/\Pi_t^F) = c + \mathbb{E}_t \sum_{j=0}^{\infty} \rho^j \left[\underbrace{\hat{\Pi}_{t+1+j}^F}_{\text{dividend growth news}} \underbrace{-r_{t+1+j}^L}_{\text{discount rate news}} \right], \tag{31}$$

where c and ρ are constants that are computed from long-run averages, and $r_t^L = R_t^L/\pi_t - 1$ is defined as the net real return on the liquid asset (where I assume that the no-arbitrage condition holds up to first order, i.e. r^L is also the expected net return on the stocks). The composition shows that the contemporaneous price-dividend ratio is determined by dividend growth news and negative discount rate news up to first order (in the formula with a finite horizon, a future price-dividend ratio also enters).

Table 5 shows the results of decomposing the variance of the log price-dividend ratio into the variances of the two news components and the future price-dividend ratio, in both data and the model variants. In the baseline model, discount rate news explain about half of the variance in the price-dividend ratio. The results for the one-asset variant with news shocks and for the two-asset variant without news shocks show that the main cause of return predictability in the model are not news shocks, but the financial friction on the household side: the existence of wealthy, liquidity-constrained households, whose subjective discount factor varies with asset returns, is the key to generating time-varying discount rates. Naturally, the existence of news increases the predictive power of both dividend growth- and discount rate-news, while noise shocks are able to generate an even higher importance for the discount rate-component, at the expense of the predictive power of the "news".

Figure 16: Campbell-Shiller decomposition with procyclical dividends





Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).
In b), the news is offset by a negative capital share surprise shock in quarter 21.
The hypothetical asset yields dividends $\omega^{\Pi} Y$.

Why is such a large share of stock price fluctuations in the model explained by expected future dividend growth? In panel a) of figure 15, I plot the Campbell-Shiller decomposition as an impulse response to a capital share news shock. One can see that the price-dividend ratio correlates with future dividend growth. The reason is that dividends are countercyclical in the model (although profit smoothing mitigates this), so that a stock price boom that coincides with a business cycle boom automatically implies positive dividend growth news. In panel b), I plot the impulse response to a noise shock. Specifically, the contemporaneous price-dividend ratio, which up to the 21st quarter is driven by the wrong expectation of a capital share increase, is plotted together with the true future components that are known ex-post. Now, of course, the Campbell-Shiller decomposition does not hold in the anticipation period, as the price is based on a wrong expectation. Indeed, as the real rate also falls after the news-disappointment in the model, the future returns-component can “rationalize” some of the excess price-dividend ratio relative to future dividend growth. Due to profit smoothing, future dividend growth fails to ex-post rationalize the variation of the price-dividend ratio over the cycle.

In order to illustrate the impact of the cyclicality of dividends for the results, I also compute the Campbell-Shiller decomposition for an alternative asset, where the dividend is simply given by a fraction of output (see figure 16). For this type of stock, the future returns-component explains the smooth increase of the price-dividend ratio in the anticipation phase, and its smooth decline in the subsequent bust-phase. Future dividends instead explain the jumps in the price-dividend-ratio, one at the onset of the news, and one at the onset of the productivity change. With constant returns (or discount rates), a forward-looking price would already incorporate the future expected decline in dividends at the onset of the news, and thus be mostly declining in the anticipation phase. But since the future dividends will also be discounted less as the demand for liquidity will rise, the price-dividend ratio rises in the anticipation phase. In figure 16b, I show that if the capital share-expectation is disappointed, the future returns (which increase quickly after the news-disappointment, as the price level shoots up and then declines slowly) explain most of the subsequent lower stock price, while the future dividend-component converges back to its steady state-level.

6 Conclusion

What is the reason for the return predictability on the stock market? I propose a mechanism to explain this pervasive empirical pattern that hinges on incomplete markets and the existence of illiquid assets. I show in a quantitative business cycle model with time-separable preferences that the mechanism can account for a large part of the return predictability, as well as for other unconditional data moments of stock prices and the business cycle. The main intuition behind the result is that the model accounts for the existence of wealthy marginal traders: wealthy households can be liquidity-constrained when they own mostly illiquid assets. In turn, asset income correlates with the business cycle, which induces a cyclicality of the stochastic discount factor of the marginal traders. Together with anticipation, these factors generate realistic stock price cycles.

The empirical evidence is in line with the proposed mechanism: first, returns on liquid and illiquid assets correlate with the stock market as expected. Second, I show using survey data that households who earn mostly capital income shift their wealth towards illiquid assets in stock price booms, and increase the liquidity of their portfolio in the subsequent stock price bust, as predicted by the model. Matching a heterogeneous agent model to micro-level data, I ascribe a large part of stock price fluctuations to the stock-trading of owners of private businesses who are in the top 10% of the income and wealth distribution. This hypothesis should be investigated further, ideally using household-level data on both consumption and investment.

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A Challe-Ragot model

Preferences	
β	0.95
σ (risk preference)	1
c^*	10
Environment	
y^l	2
y^h	14
$\mathbb{P}(h \to l)$	10%
$\mathbb{P}(l \to h)$	90%
μ	1
k	50
$\bar{r}$	4%
$\bar{L}$	3
Steady state	
$\mathbb{P}(h)$	90%
$R - 1$	3.53%
$\tilde{b}$	3.44

Table A.1: Calibration of the model parameters and steady state-levels of variables.

B Proof of Proposition 1

It is to show that

$$R_t^K - R_t^L \geq \beta(1-\lambda)\frac{\mathbb{E}_t^i\left[\gamma_{t+1}^i\right]}{q_t u'(c_t^i)} \tag{32}$$

for all households i that trade the illiquid asset in period t, where

$$\gamma_t^i := q_t u'(c_t^{i,n}) - \beta\,\mathbb{E}_t^i\, V_{t+1,k}(b_t^{i,n}, k_t^{i,n}, h_{t+1}) \geq 0, \tag{33}$$

and R^K and R^L are gross returns on illiquid and liquid assets, respectively, which, as the rest of the variable notation, follows the model description in section 3. In addition to that notation, I add superscripts n or a also to variables that denote optimal choices of households that are ***not*** able to adjust their capital holdings that period, or are able to ***a****djust* their capital holdings that period, respectively. For the sake of readibility, I eschew superscript i that identifies household i in the following proofs.

The proof boils down to deriving a "Basic Pricing Equation for illiquid assets" out of first-order optimality conditions for households that can adjust their capital holdings, and combining that with the standard Euler equation for liquid assets. The inequality accounts for households that are financially constrained. All expectations are only with respect to idiosyncratic uncertainty, as certainty equivalence holds with respect to aggregate variables.

Lemma 1. *For a household that is financially unconstrained in period $t-1$, the "Basic Pricing Equation for illiquid assets"*

$$1 = R_t^K \beta \, \mathbb{E}_{t-1}\left[\frac{u'(c_t^a) - (1-\lambda)\frac{\omega_t}{q_t + r_t}}{u'(c_{t-1}^a)}\right] \tag{34}$$

holds, where

$$\omega_t := (q_t + r_t)u'(c_t^a) - (r_t u'(c_t^n) + \beta \, \mathbb{E}_{t,h_t} V_{t+1,k}(b_t^n, k_t^n, h_{t+1})) \tag{35}$$

is the expected marginal benefit for the household of being able to adjust their illiquid portfolio holdings in period t.

Proof It holds that

$$\begin{aligned}
\mathbb{E}_{t-1,h_{t-1}} V_{t,k}(b,k,h_t) =& \, \mathbb{E}_{h_t|h_{t-1}}\left[\lambda V_{t,k}^a(b,k,h_t) + (1-\lambda)V_{t,k}^n(b,k,h_t)\right] && (36)\\
=& \, \mathbb{E}_{h_t|h_{t-1}}[\lambda(q_t + r_t)u'(c_t^a) + \\
& \, (1-\lambda)(r_t u'(c_t^n) + \beta \, \mathbb{E}_{h_{t+1}|h_t} V_{t+1,k}(b_t^n, k, h_{t+1}))] && (37)\\
=& \, \mathbb{E}_{h_t|h_{t-1}}[-(1-\lambda)(\omega_t - r_t(u'(c_t^a) - u'(c_t^n))) + q_t u'(c_t^a) + \\
& \, r_t(\lambda u'(c_t^a) + (1-\lambda)u'(c_t^n))] && (38)\\
=& \, \mathbb{E}_{h_t|h_{t-1}}\left[(q_t + r_t)u'(c_t^a) - (1-\lambda)\omega_t\right] && (39)
\end{aligned}$$

where the second equation follows from the envelope theorem.

Optimal illiquid asset choice in period $t-1$ requires that

$$q_{t-1}u'(c_{t-1}^a) = \beta \, \mathbb{E}_{t-1,h_{t-1}} V_{t,k}(b_{t-1}^a, k_{t-1}^a, h_t) \tag{40}$$

With $R_t^K = \frac{q_t + r_t}{q_{t-1}}$, substituting equation (39) into equation (40) gives the claim of the lemma. □

Note that the Euler equation with respect to the liquid asset requires

$$1 = R_t^L \beta \, \mathbb{E}_{t-1} \left[\frac{\lambda u'(c_t^a) + (1-\lambda) u'(c_t^n)}{u'(c_{t-1}^a)} \right] \tag{41}$$

for financially unconstrained households. Combining this and the equation from Lemma 1, one gets

$$\frac{1}{R_t^L} - \frac{1}{R_t^K} = \beta(1-\lambda) \frac{\mathbb{E}_{t-1} \left[\frac{\omega_t}{q_t + r_t} - (u'(c_t^a) - u'(c_t^n)) \right]}{u'(c_{t-1}^a)} \tag{42}$$

$$= \beta(1-\lambda) \frac{\mathbb{E}_{t-1} \left[u'(c_t^n) - \frac{r_t u'(c_t^n) + \beta \, \mathbb{E}_{t,h_t} V_{t+1,k}(b_t^n, k_t^n, h_{t+1})}{q_t + r_t} \right]}{u'(c_{t-1}^a)} \tag{43}$$

$$= \beta(1-\lambda) \frac{\mathbb{E}_{t-1} \left[q_t u'(c_t^n) - \beta \, \mathbb{E}_{t,h_t} V_{t+1,k}(b_t^n, k_t^n, h_{t+1}) \right]}{(q_t + r_t) u'(c_{t-1}^a)} \tag{44}$$

Multiplying by R_t^K yields

$$\frac{R_t^K - R_t^L}{R_t^L} = \beta(1-\lambda) \frac{\mathbb{E}_{t-1}[\gamma_t]}{q_{t-1} u'(c_{t-1}^a)} \tag{45}$$

As noted above, γ_t has the interpretation of the shadow price of the financial friction that prohibits households from trading their illiquid assets. It is positive for households that cannot adjust their illiquid asset holdings, as optimality condition (40) is not fulfilled in that case (the case where the amount of the existing illiquid asset k remains optimal is a zero probability event). Since quarterly returns to liquid assets are close to one in most calibrations, the above equation approximately gives the quarterly (ex-ante) illiquidity premium $ILP := R_t^K - R_t^L$ that obtains in equilibrium, as determined by the optimization of households that are financially unconstrained in period $t-1$. For households at the borrowing constraint, the Euler equation (41) is violated in the direction of higher marginal utility today, which implies the claimed inequality. □

C Empirical evidence

C.1 Stock returns, capital rents, and business cycle variables

This section presents regressions of quaterly S&P 500 stock returns (data by Robert Shiller) on the growth of after-tax capital rents (Gomme et al., 2011) and other variables. The sample is split in two, periods where the trend of the S&P 500 return is rising, and periods where it is falling. The trends of the S&P stock return, inflation growth, and GDP are computed using the Hodrick-Prescott filter with a smoothing parameter of 1600. All variables are standardized.

Findings:

- In periods of stock returns trending upwards (panel a)), stock returns are statistically significantly correlated with consumption growth (5% level), and weakly statistically significantly correlated with falling inflation and deviations of GDP from trend (10% level). There is no correlation with capital rents.
- In periods of stock returns trending downwards (panels b) and c)), stock returns are statistically significantly correlated with investment growth and dividend growth (1% level). Capital returns are weakly negatively correlated. However, without investment as regressor, capital returns become positively correlated with stock returns. This shows that investment and capital returns explain similar parts of the variance in downturns.

a) Subset of observations where S&P return-trend is rising

Dep. Variable:	Stock return	**R-squared (uncentered):**	0.149
Model:	OLS	**Adj. R-squared (uncentered):**	0.103
Method:	Least Squares	**F-statistic:**	2.999
Date:	-	**Prob (F-statistic):**	0.00599
Time:	15:50:33	**Log-Likelihood:**	-180.15
No. Observations:	135	**AIC:**	374.3
Df Residuals:	128	**BIC:**	394.6
Df Model:	7		
Covariance Type:	HAC		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
Cap.rent growth	-0.0945	0.114	-0.829	0.409	-0.320	0.131
Consmpt. growth	0.2247	0.106	2.127	0.035	0.016	0.434
Investm. growth	0.1410	0.104	1.350	0.179	-0.066	0.348
Before 1980	0.0513	0.090	0.573	0.568	-0.126	0.228
Rising Infl.	-0.1436	0.086	-1.673	0.097	-0.313	0.026
GDP deviation	-0.1788	0.103	-1.736	0.085	-0.383	0.025
Dividend growth	-0.0034	0.092	-0.037	0.971	-0.186	0.180

Omnibus:	6.483	**Durbin-Watson:**	1.907
Prob(Omnibus):	0.039	**Jarque-Bera (JB):**	7.238
Skew:	-0.330	**Prob(JB):**	0.0268
Kurtosis:	3.922	**Cond. No.**	1.77

Notes:

[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.

[2] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

b) Subset of observations where S&P return-trend is falling

Dep. Variable:	Stock return	**R-squared (uncentered):**	0.240
Model:	OLS	**Adj. R-squared (uncentered):**	0.200
Method:	Least Squares	**F-statistic:**	9.300
Date:	-	**Prob (F-statistic):**	2.41e-09
Time:	15:50:33	**Log-Likelihood:**	-178.93
No. Observations:	140	**AIC:**	371.9
Df Residuals:	133	**BIC:**	392.4
Df Model:	7		
Covariance Type:	HAC		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
Cap.rent growth	-0.0299	0.124	-0.241	0.810	-0.275	0.215
Consmpt. growth	0.1405	0.095	1.484	0.140	-0.047	0.328
Investm. growth	0.3318	0.097	3.422	0.001	0.140	0.524
Before 1980	-0.0507	0.072	-0.700	0.485	-0.194	0.093
Rising Infl.	-0.0892	0.069	-1.285	0.201	-0.227	0.048
GDP deviation	-0.1175	0.091	-1.287	0.200	-0.298	0.063
Dividend growth	0.1760	0.064	2.759	0.007	0.050	0.302

Omnibus:	13.595	**Durbin-Watson:**	2.285
Prob(Omnibus):	0.001	**Jarque-Bera (JB):**	23.130
Skew:	-0.455	**Prob(JB):**	9.49e-06
Kurtosis:	4.771	**Cond. No.**	2.40

Notes:

[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.

[2] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

c) Subset of observations where S&P return-trend is falling; leave out investment

Dep. Variable:	Stock return	**R-squared (uncentered):**	0.171
Model:	OLS	**Adj. R-squared (uncentered):**	0.134
Method:	Least Squares	**F-statistic:**	7.819
Date:	-	**Prob (F-statistic):**	3.16e-07
Time:	15:50:33	**Log-Likelihood:**	-185.04
No. Observations:	140	**AIC:**	382.1
Df Residuals:	134	**BIC:**	399.7
Df Model:	6		
Covariance Type:	HAC		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
Cap.rent growth	0.1267	0.124	1.021	0.309	-0.119	0.372
Consmpt. growth	0.1624	0.095	1.714	0.089	-0.025	0.350
Before 1980	-0.0217	0.080	-0.273	0.785	-0.179	0.136
Rising Infl.	-0.0554	0.071	-0.776	0.439	-0.197	0.086
GDP deviation	-0.1578	0.101	-1.565	0.120	-0.357	0.042
Dividend growth	0.2288	0.068	3.375	0.001	0.095	0.363

Omnibus:	24.887	**Durbin-Watson:**	2.230
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	50.473
Skew:	-0.767	**Prob(JB):**	1.10e-11
Kurtosis:	5.510	**Cond. No.**	2.00

Notes:

[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.

[2] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 1 lags and without small sample correction

C.2 Survey evidence

C.2.1 Data selection and definitions

This section presents more evidence about heterogeneous portfolio choice in the U.S. over time. I use the 20 years available in the SCF+ (Kuhn et al., 2020) between 1950 and 2019. I split the sample into two subgroups of years: from 1950 to 1971, and from 1983 to 2019. Year 1977 is left out in the analysis in the main text for two reasons: first, the gap to sampled years before and after 1977 is 6 years, which is double the gap between most of the sampled years in the survey (3 years). Hence, computing differences between sampled years is less consistent when including the year 1977. Second, I find that 1977 is an outlier in terms of the main object of analysis in this paper, the group of households with high capital income: while the share of households with high capital income who are in the top 10% of the wealth distribution is 42% in the median year, it is only 13% in 1977. Conversely, the share of these households who are in the bottom half of the distribution is 19% in the median year, and 61% in 1977. The likely reasons for this discrepancy are issues with the imputations of total and capital income. Over all remaining years, N=84430 households are in the survey.

The first subgroup from 1950 to 1971 is from the older waves of the SCF, where capital income lumps together asset incomes from the following sources:

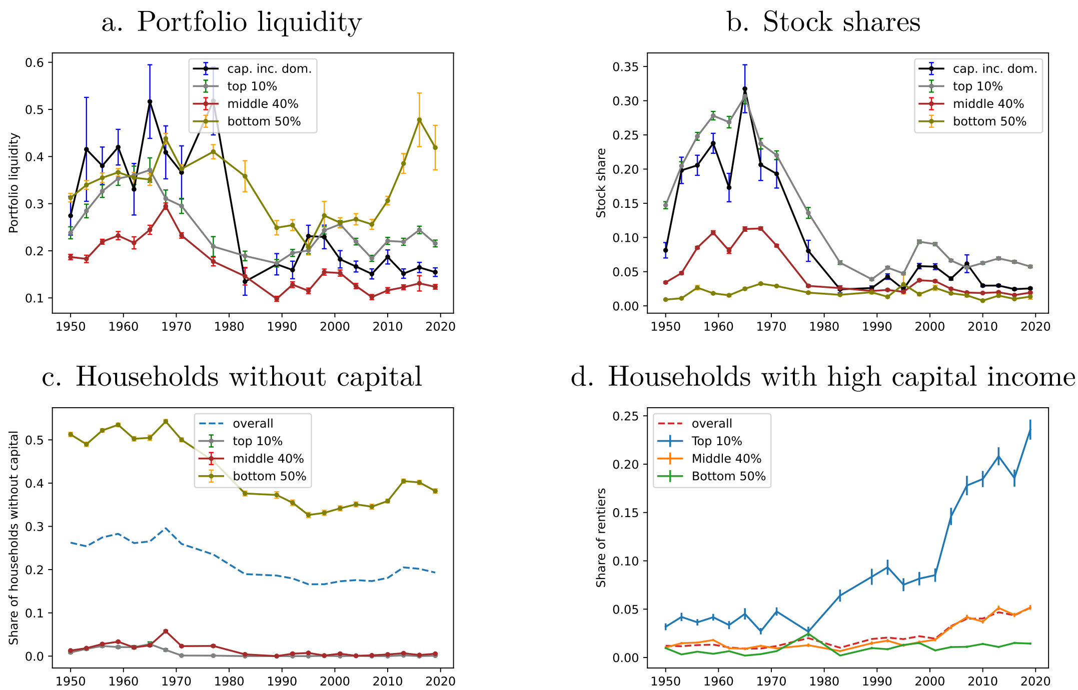
1. non-taxable investments (e.g. municipal bonds)
2. other interest
3. dividends
4. other business or investments, net rent, trusts, or royalties

Since asset incomes number 2 and 3 likely stem from more liquid sources, namely treasury bonds and stocks, this definition of capital income does not fit to the dichotomy between liquid and illiquid assets suggested by the analysis in the main text. Therefore, starting from year 1983 (the modern waves of the SCF), I sum up as a measure of capital income only income from the sources number 1 and 4.

In line with the quantitative model, I define as high capital income those households where capital income is at least 75% of their total income. In order to make this definition comparable across the old and modern waves of the SCF, where only the modern waves allow to compute the model-consistent definition of capital income, I proceed in the following way: From the modern waves, I calculate the average share of asset income from sources number 1 and 4 among asset income from all sources, which equals 0.19. Then, I categorize households into the high capital income-group in the *older* waves if at least 75% of their total income stems from the original cpaital income measure (with all sources), while for the *modern* waves, households' income must stem from sources number 1 and 4 at least at the rate of $75\% \cdot 0.19 = 15\%$ to be classified as high capital income. The similarity of the average share of households with high capital income in the data with their share in the model economy justifies this procedure.

C.2.2 Portfolio choice over time

Figure C.1: Heterogeneous portfolio choice over time



Notes: Survey evidence from SCF+ (Kuhn et al., 2020). *Portfolio liquidity* is defined as the ratio of liquid assets by total wealth. *Stock shares* are defined as the ratio of stock wealth by total wealth. Households *without capital* are defined as households with zero illiquid wealth. Households with *high capital income* are households who earn a large share of capital income ($> 75\%$) compared to their overall income. Whiskers are 68%-confidence intervals.

Several secular trends are noticeable:

- For households in the top half of the wealth distribution, portfolio liquidity peaks in the 1960s, and declines since then. Some of this development is due to a larger share of wealth held in stocks in the first half of the sample.

- For the bottom half of the wealth distribution, stocks are mostly irrelevant, and up to half of the households in that wealth category do not hold illiquid assets. The share of households without capital decreases from the 1970s on, and increases again since the Great Recession. Also, the portfolio liquidity of the poorer households increases markedly since 2008.
- While the overall share of households with high capital income stays mostly constant over time, their share within the richest decile increases steadily since the 1970s. Since 2000, more households in the U.S. are becoming high capital income households overall, a trend that is driven by the middle class.

C.3 Business cycle data

All series are available at quarterly frequency from the St.Louis FED - FRED database:

Output, Y: Sum of gross private domestic investment (GPDI), personal consumption expenditures for nondurable goods (PCND), durable goods (PCDG), and services (PCESV), and government consumption expenditures and gross investment (GCE) divided by the GDP deflator (GDPDEF) and the civilian noninstitutional population (CNP16OV).

Consumption, C: Sum of personal consumption expenditures for nondurable goods (PCND), durable goods (PCDG), and services (PCESV) divided by the GDP deflator (GDPDEF) and the civilian noninstitutional population (CNP16OV).

Investment, I: Gross private domestic investment (GPDI) divided by the GDP deflator (GDPDEF) and the civilian noninstitutional population (CNP16OV).