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Stock price booms from technology news in a HANK model with portfolio choice

March 2022

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Research Area B: Inequality and the Business Cycle

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ABSTRACT

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

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

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1 Introduction

Can news about technological progress explain movements in the stock market? Campbell and Shiller (1988) show that future dividend growth explains only a small part of the variance in aggregate stock prices. Instead, they find that future stock *returns* are predictable, and that in a rational framework, most of the price-variation can be attributed to these “discount-factor news”[1]. In this paper, I show that news shocks can generate stock price booms that are predictably followed by low returns in a heterogeneous agent New Keynesian model with illiquid assets. Thereby, I offer a new explanation for time-varying, mean-reverting stock returns - that is, for boom-bust cycles of the stock market. The news are about higher future productivity. However, consistent with the finding of Campbell and Shiller (1988), part of the variation in the ensuing stock price growth is not due to dividend growth, but instead due to the expectation of lower future returns on liquid assets, like stocks. Why are returns expected to fall when productivity is expected to rise? The reason is that higher productivity also increases the return to illiquid capital. Many productive assets are illiquid, and holding these assets is especially valuable in times of accelerating technological progress. Therefore, some households will shift their portfolio towards the illiquid asset in the anticipation phase. This renders them more susceptible to idiosyncratic income risk. Hence, once the productivity boost materializes, these households want to hold more liquid assets again, which depresses the return on liquid assets then.

Instead of a time-varying aggregate risk premium, which is a common explanation for stock price fluctuations in the finance literature (Campbell and Cochrane, 1999, Bansal and Yaron, 2004), I propose that a time-varying *liquidity premium* is the main driver of boom-bust cycles on the stock market. The heterogeneous agent setting is crucial for obtaining this result, since the liquidity 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. Capital can only be traded infrequently, at individually random intervals. Therefore, capital-owners want to hold onto their capital until higher returns realize, and prefer to buffer any adverse income shocks during the

[1] This finding has been reiterated, for example, in Cochrane (2011). The rationale is that if the future interest rate is expected to be low, future dividend payments are expected to be more valuable - they are discounted by less - , which appreciates the value of the stock asset today.

anticipation phase by running down their liquid asset holdings. The wealthy households' shift from liquid assets to illiquid capital in their portfolios causes an investment-driven business cycle boom. As households anticipate higher future incomes, they demand less liquid savings. These forces lower the liquidity premium in the anticipation phase. Once the productivity boost - a persistent, but temporary acceleration in productivity growth - materializes, capital returns decline again. Therefore, capital-rich, but liquidity-poor households with high consumption risk face falling incomes at that point, and since markets are incomplete, they will demand more liquid assets for self-insurance. This depresses the return on liquid assets once productivity rises, while capital returns increase persistently; the liquidity premium rises.

The notion of infrequently traded assets is established in the literature about the importance of incomplete markets and portfolio choice for macroeconomics (see, e.g. Kaplan et al. (2018)). The innovation of this paper with respect to this literature is to divide the assets that allow households to hold a share of the profits that accrue in the production process, that is, claims to equity, in a liquid and an illiquid category. In combination with idiosyncratic income risk, this leads to public (liquid) equity being less risky than private (illiquid) equity, as in the incomplete markets-model by Angeletos (2007). While the underlying mechanism there is different[2], the main intuition is the same: a significant share of the economy's productive capital carries idiosyncratic risk, that is, an individual risk to each capital holder, as financial intermediation is imperfect. For publicly traded assets, like publicly traded stocks or government bonds, however, idiosyncratic risk is absent.

In my 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. The behavior of stock prices is solely explained by the households' demand for stocks. The value of the stock asset is determined by two properties: the expected dividend stream, and its liquidity. Since stocks are liquid, households compare it to other liquid assets, like government bonds[3]. With

[2]Angeletos (2007) assumes that private equity yields idiosyncratically risky returns, whereas public equity is perfectly diversifiable. He abstracts from other idiosyncratic income risk of the households. In my framework, private equity is riskier than public equity, although the returns to both asset classes are determined by aggregate states, since private equity increases the consumption risk of the asset-holder.

[3]Such an arbitrage condition between stocks and government bonds is assumed, e.g., in Caballero and Simsek (2020). I document that in U.S.-data, stock price-growth is positively associated with higher returns on government bonds, and yearly moving averages of stock returns and bond returns also comove (correlations are around 0.2). The low correlation is to be expected, since I use realized returns, which contain surprise shocks that add noise.

given dividends, when returns on government bonds are expected to rise, stocks become less attractive; the future dividend stream is discounted at a higher rate. As outlined above, the technology news causes a pattern of higher liquid asset returns, followed by subsequent lower liquid asset returns. Irrespective of the specific dividend stream, this pattern in the returns causes a stock price-boom and -bust cycle. At the onset of the news, the stock price appreciates, since the future dividends are expected to increase due to the productivity boost. During the anticipation phase, the value of stocks, that is, the future discounted dividend stream, rises period by period, as less and less periods are left where the dividends are discounted highly. The stock price peaks when all dividends in the near future are discounted at a low rate. Since the return to liquid assets will revert to its steady state level over time, stock prices fall from then on.

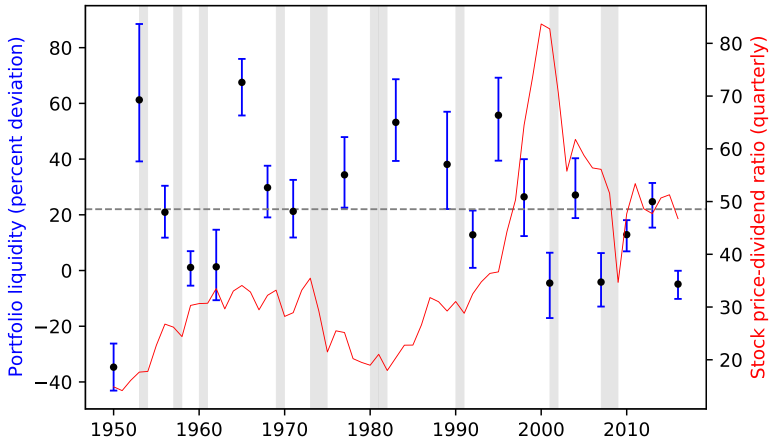
In a model with aggregate risk, risk factors on both bonds and stocks should cause differences in expected returns of these two assets over time. In this paper, I abstract from aggregate risk (the news about technologial progress is an unexpected "MIT-shock"). I conjecture, however, that solving the model non-linearly, and even allowing for time-varying aggregate risk, would not diminish the role of the time-varying liquidity premium for explaining stock price-booms, for two reasons: As is found in the literature (Devereux and Sutherland, 2010), allowing for time-varying risk changes little for the dynamics of asset returns in general equilibrium-models, when household preferences are of the CRRA-type, with a standard value for risk aversion, and do not feature habit formation, as in Campbell and Cochrane (1999)[4]. Second, 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 riskier, 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[5]. For this reason, modelling stocks as risky would imply an even *larger* role for the liquidity premium in explaining stock price-booms.

The heterogeneous agent setting is necessary to identify the conditions under which the outlined mechanism is consistent in general equilibrium. I find that it is the time-varying demand for each asset class, liquid and illiquid, together with the supply elasticity

[4]Of course, household heterogeneity could in principle alter that consensus in the literature, which was established for representative agent models.

[5]Favilukis et al. (2017) discuss this mechanism when modelling a simultaneous house price boom and rising share of housing equity in households' portfolios. They conclude that relaxed financing constraints, that is, an institutional change that makes housing an individually less risky asset, is needed to resolve the puzzle.

Figure 1: Portfolio liquidity of "capitalists" and the stock market



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 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.

of liquid assets (see below), rather than the exogenous change in technology, that drives the stock price-cycle. In particular, the time-varying liquidity premium only emerges since households at different positions of the wealth distribution, who therefore have different factor incomes and are exposed to different consumption risk, can choose different portfolios. What is more, the rich heterogeneity of the model allows to identify a subgroup of households that is crucial for the stock price variation. Putting this model-implied prediction to the test, I find that this subgroup's portfolio choice in the data comoves with the stock market in a way that is consistent with the theory.

Specifically, I identify a subset of households as the "marginal liquid savers", whose marginal willingness to hold liquid assets determines the liquid rate in the economy. They are households whose income mainly comes from capital rents (one could call them "capitalists"). Since they are capital-wealthy, their income gain from higher future capital rents is large. Hence, they expect their consumption to increase. At the same time, the high future return on selling capital incentivizes them to maintain their capital holdings. Both forces push down their stochastic discount factor in the anticipation phase, which raises the return on liquid assets in equilibrium. Since they shift from liquid to illiquid assets, the share of wealthy "hand-to-mouth" households among them (Kaplan et al., 2014) increases. Once the temporary productivity boost materializes, the "capitalists" face the steepest income decline (on average, abstracting from idiosyncratic shocks) among all households in the economy. Since their level of liquid assets is low, they are at a risky position; their stochastic discount factor is high. This depresses the equilibrium return on liquid assets. In section 2, I demonstrate the mechanism in a highly stylized, but more tractable model, that only considers this subset of households. Employing the extended Survey of Consumer Finances-dataset provided by Kuhn et al. (2020) that ranges from 1950 to 2016, I provide evidence (see figure 1) that households whose income mainly comes from capital income decrease their portfolio liquidity in stock price-booms, and increase it in stock price-busts, like the model predicts[6].

Capital-rich households are only willing to hold their capital during the anticipation phase at a lower premium, because their potential return on selling it is large[7]. Who is buying capital once productivity has increased? I find that, among the bottom 50% of the wealth distribution, the time-varying liquidity premium strongly affects the *extensive* margin of holding capital. During the anticipation phase, the share of households without capital increases by about 7%. This means that the investment boom is solely due to adjustments on the intensive margin, i.e. wealthy households who increase their capital holdings. After the boom, the liquidity premium is high: the liquid rate is depressed, while capital rents are elevated by the persistent productivity increase, and the higher aggregate capital stock. Consequently, more households want to hold capital again, which increases the capital price. To summarize, the stock price boom is an opportunity for poorer households to have higher returns on their wealth while holding only liquid assets (stocks). Once stock prices fall, more poor households decide to hold some of their wealth also in illiquid assets, to get a higher return on their saving. The higher demand for capital once productivity rises drives up the capital price, which is a reason for capital-wealthy households to increase their investment in the first place.

My analysis in the general equilibrium setting also highlights the dependence of the stock price-cycle on the elasticity of liquid asset supply. Since government bonds are liquid assets, they are in less demand once the technology news arrives: at the onset of the news, households immediately shift from bonds to stocks, since the discounted sum of future dividends increases. During the anticipation phase, wealthier households additionally shift from liquid to illiquid assets in their portfolios. Thus, the fiscal authority faces a pressure to reduce its balance sheet. However, the government can also induce higher inflation

[6]Specifically, the change in the relative portfolio liquidity of the "capitalists", and the growth in the stock price-dividend ratio, are negatively correlated at -0.33. See section 5 for a discussion of the evidence.

[7]This is why news about investment-specific technological progress, which will *lower* the price of capital, does not cause a stock price-boom in the model.

and allow for higher output gaps late in the anticipation phase, thereby raising (inflation) taxes. These policies lower asset incomes early and decrease profits late, which cuts into the income of wealthy households. Since they have the highest marginal propensity to invest, the wish to substitute liquid assets (like bonds) for capital weakens in the aggregate. While this equilibrates the bond market, it prevents the wealthier households from generating an investment-driven boom during the anticipation phase. Conversely, a policy that stabilizes inflation and "smoothes out" the increase in the real rate on liquid assets over the anticipation phase, is only consistent with a strong reduction of the aggregate liquid asset supply[8]. Fundamentally, the real interest rate is "smoothed out" over the anticipation phase by allowing for the crowding out of unproductive liquid assets by productive capital, so that households' incomes increase long before the productivity boost. This comes at a cost of increased consumption risk for wealthy households, which they are willing to trade off against the anticipated higher future return on their wealth.

I show that the expectation of a higher future return on capital can be motivated by news about two kinds of fundamentals: accelerated growth in total factor productivity (TFP), or a higher capital share in the production process. Importantly, however, these fundamental changes should be (expected to be) *temporary*, since only then investment in the anticipation phase is urgent enough to drive the business cycle. The anticipation of a temporary productivity boost can be motivated by the 1990s "dot-com" boom in the U.S., which was a R&D-investment boom (Brown et al., 2009), and is thought of by many as an anticipation-driven boom (Jermann and Quadrini, 2007, Ben Zeev, 2018). Since R&D capital, like other "intangible" capital, depreciates relatively fast (due to technological obsolescence and increased competition, c.f. Li and Hall (2020)), the households expect the future productivity acceleration to be temporary[9]. Alternatively, Karabarbounis and Neiman (2014) find that the decline in the relative price of IT investment goods lowered the labor share in recent decades. In Karabarbounis and Neiman (2019), they argue that the most plausible explanation for the "excess" value added is an increase in capital rents,

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[8]Domínguez-Díaz (2021) analyzes a HANK-model with portfolio choice, where the main provider of liquidity is the banking system. His analysis shows that, if the banks are subject to a moral hazard-problem, and are at their borrowing constraint, the supply of liquidity rises in the liquidity premium, since the banks' profitability increases with the spread between capital returns and returns on deposits. Hence, in an environment with constrained banks, the low liquidity premium during the anticipation phase of a news-induced boom would lower the supply of liquidity also through that channel, independent of the fiscal side.

[9]Bianchi et al. (2019) also interpret the 1990s boom as driven by R&D investment which provides spillover effects, and interpret the bust after 2000 as a shock to equity financing, as the value of pledgable capital falls. I will discuss disappointed expectations in section 5.

rather than an increase in firm's profits (or markups), or a large share of unmeasured, intangible capital. The present paper relates to their analysis in two ways: on the one hand, it provides a rationale for a time-varying wedge between the real interest rate of government bonds, and the capital rents necessary to account for the excess value added. Additionally, Karabarbounis and Neiman (2019) provide evidence that the share of value added attributable to IT capital declined after 2000, lending credence to the idea that the 1990s boom was driven by the expectation of a *temporary* increase in capital returns.

Related literature. In a recent contribution, Gormsen (2021) shows that the leading asset pricing models fail to simultaneously account for the average and the cyclicality of the slope of the equity term structure. Specifically, he finds that the slope is negative on average (the return falls with maturity), but becomes strongly positive in "bad times", defined as periods with a low price-dividend ratio. He relates these findings also to firm-level data, where he finds that investments in long-duration projects are cut more than those in short-duration projects during bad times. These observations fit to a model of stock price-cycles, where the demand for illiquid assets (which are, in expectation, long-maturity assets) increases in "good times", when the price-dividend ratio is high. That is, the countercyclicality of the liquidity premium is consistent with the countercyclicality of the equity term structure in the data. Additionally, Gormsen (2021) shows that the time-varying slope of the equity term structure can be generated in a model by an exogenous discount rate risk shock (the negative average slope, instead, is explained by an additional dividend shock that is mean-reverting). The mechanism presented in this paper is a microfoundation for such discount rate risk.

Following Krusell et al. (2011), the analytical literature on asset pricing in heterogeneous agent models often makes critical simplifications (e.g. Ravn and Sterk (2017), Broer et al. (2019)): the rate on the liquid asset, which is in zero net supply, is such that the "marginal saver" optimally holds no assets. Since the impact of aggregate risk on households' budgets is small, the marginal saver can be identified from the stochastic process of idiosyncratic endowments. Often, a dichotomy between "capitalists" and "workers" is introduced, where only the latter are subject to idiosyncratic shocks, so that the worker with the highest income today prices the liquid asset each period. In the analytical HANK-model of Bilbiie (2019, 2020), the roles are reversed: households that receive the returns on capital in the economy price the liquid asset, while the other households do not have access to markets and just consume labor income and transfers. Households switch roles stochastically.

The setting of Bilbiie is closer to my results from the numerical HANK model: at the peak of the stock price-cycle, the liquid rate is set by (capital)-wealthy households who want to self-insure. The main difference from the (analytically tractable) model of Bilbiie is that there is a heterogeneity among households in the unconstrained state that plays a role over the cycle: Households choose to dissave their liquid asset holdings, as they want to hold on to their capital stock, in anticipation of higher returns. Therefore, more households end up closer to the constrained state, which makes them more susceptible to income risk. Since stock price fluctuations are an aggregate phenomenon, it appears reasonable that an explanation for co-varying real rates hinges on an aggregate component of income (i.e., the dynamics of capital rents). News about a temporary increase of this income *endogenously* generates time-varying idiosyncratic risk, i.e. exposure to idiosyncratic risk that varies with the stock price-cycle, by virtue of the optimal portfolio choices of households[10]. This is crucial, as it causes the fall of the liquid rate, and thus of stock prices, once productivity has increased. To summarize, I find that time-varying idiosyncratic risk, which has been shown to generate amplification of business cycles when poor households price the asset (Ravn and Sterk, 2017), can also yield amplification when a certain subset of wealthy households prices the asset, at which point a change in capital income, instead of labor income, becomes the decisive factor.

Finally, this paper relates to the question of what drives the business cycle. There is a long-standing literature on news-driven business cycles, starting with Beaudry and Portier (2004, 2006), who employ stock prices to empirically identify news shocks[11]. In a paper most related to this, Christiano et al. (2010) show that the New Keynesian model can generate booms from news shocks when monetary policy follows a naive Taylor rule. The reason is twofold: higher future productivity anchors inflation expectations at a level below steady state, and sufficiently high price stickiness lowers prices already in the anticipation phase. As a consequence, the policy rate falls, which boosts demand. Since it is a (inefficiently) low interest rate that causes the boom, the one-asset New Keynesian model does not account for the positive correlation of real rates and stock price growth

[10]In a related paper, Bilbiie et al. (2021) place emphasis on the fact that redistributing capital income to constrained households amplifies demand shocks, as capital income is procyclical. They model the redistribution exogenously (via fiscal policy), while in the present model, anticipation generates the same kind of "redistribution" endogenously, only in reverse: households with a large share of capital income choose to become more constrained.

[11]Beaudry and Portier (2014) give a comprehensive summary. The news are typically about long-run productivity in that literature, while I consider news about a temporary productivity boost.

in the data[12]. The low real rate is inefficient, since a positive news shock, which increases consumption of households in the future, raises the natural rate today. In the model with heterogeneous agents, instead, the business cycle boom coincides with a high real rate. Liquid savings are not held down by an inefficient monetary policy; instead, households want to save less, and consume more, due to higher incomes in the anticipation phase. The economy is more productive ahead of the exogenous technology shock, as households increase their capital stock early. Households are willing to have more illiquid assets in their portfolios - at a lower premium, and a higher consumption risk - since they expect higher future returns on their wealth. For satisfying the higher demand for capital goods, output has to rise. The resource constraint of the economy is partly satisfied by the crowding out of government expenditure, and partly by higher labor supply of workers, who earn higher real wages as markups fall (the standard New Keynesian mechanism)[13].

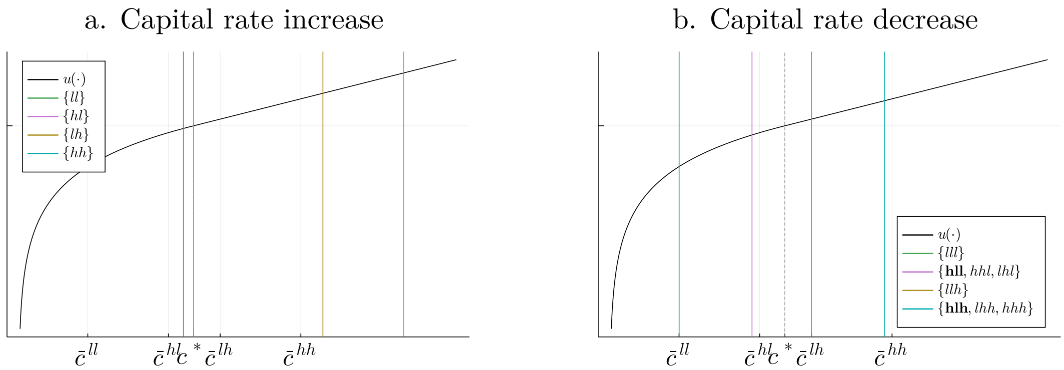
The structure of my paper is as follows: In section 2, I illustrate the main mechanism to generate a stock price cycle from anticipation in a simple, tractable heterogeneous agent model, making use of the stylized framework developed by Challe and Ragot (2016). In section 3, I describe the full quantitative HANK model, which is taken from the literature[14] and ammended to include liquid stocks and news shocks. In section 4, I show that technology news - either about TFP or factor share shifts - generate a stock-price and business cycle boom in this model, and analyze the importance of the hetereogeneous agent and two-asset structure (liquid and illiquid assets) for obtaining the results. In section 5, I document that aggregate data on asset returns, as well as survey data of households' portfolio choices over time, are consistent with the mechanism I propose, and discuss the main drivers of stock prices in the model under different specifications of dividend cyclicality and news accuracy. Section 6 concludes.

[12]See section 5. Adam and Merkel (2019) also provide a model where stock price cycles and business cycles coincide. They find, however, that low interest rates increase the likelihood of boom-bust cycles.

[13]Instead of the time-varying markups of the New Keynesian model framework, one could adopt other explanations for rising labor hours during the anticipation phase of a news-induced boom. McGrattan and Prescott (2010) argue that the 1990's increase in labor hours *preceding* higher wages can be explained by workers investing "sweat capital". In a similar vein, the notion of illiquidity could be widened to include (a part of) human capital, which workers would be willing to invest into more when the expected returns are high. However, real wages *did* rise, and corporate profits *did* fall, in the late phase of the 1990s boom.

[14]I am building on the HANK model with portfolio choice by Bayer et al. (2020) which is estimated using U.S. business cycle and inequality data from 1954 onwards.

Figure 2: Optimal consumption levels



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.

2 Illustration of the stock price cycle

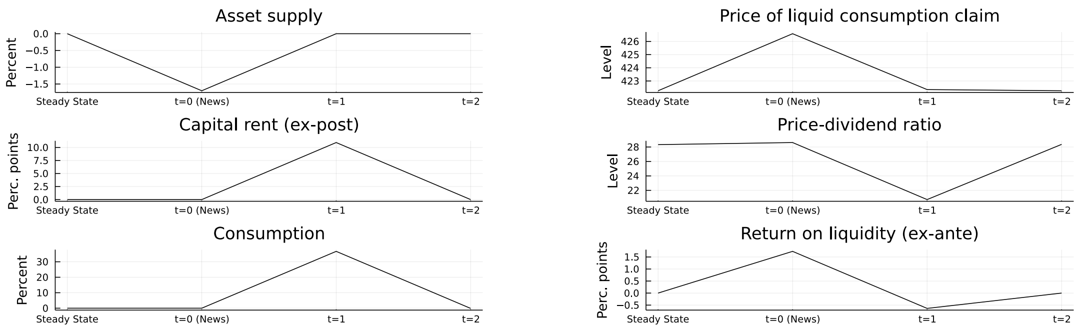
In this section, I illustrate the mechanism how wealthy hand-to-mouth households can drive down the equilibrium real rate. I abstract, however, from portfolio choice between liquid and illiquid assets. I analyze a situation in which all households hold little liquid wealth relative to their income risk, 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[15]. I apply the technique by Challe and Ragot (2016) to make heterogeneous agent models with a non-degenerate wealth distribution tractable.

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 interest on the assets they hold, and idiosyncratic income $y \in \{l, h\}$, $l < h$, which follows a stochastic Markov process. They derive utility each period from consumption, where the utility function is concave up to point c^*, and has a constant slope afterwards.

The steady state is calibrated 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

[15]This is necessary to bring the market for liquidity into equilibrium: the news about future productivity lowers the demand for liquid savings. The real rate is 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.

Figure 3: Impulse responses



Notes: Responses to a news shock about higher future capital rents, and a *simultaneous* surprise drop in the asset supply, at $t = 0$.

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 $L = \pi^l \underline{L} + \pi^h \tilde{b}$, where π^l, π^h are the unconditional probabilities of receiving a low or high income.

The grey lines in figure 2 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 interest rate. For simplicity, I assume the income process to be symmetric[16], 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 2b).

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

[16] I choose the conditional probabilites of losing a high income (e.g. job separation) and gaining a high income (e.g. job finding) to be complementary.

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 interest rate has to increase to $1/\beta - 1$ (β 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 3 shows the responses of the interest rate 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 1, due to the lower interest rate 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 Interpretation

The liquid asset can be thought of as incorporating both, a share of a publicly traded firm, and government bonds. Let B/L denote the aggregate share of government bonds within the liquid asset class. The share of the publicly traded firm yields the return $(q_t^{\Pi} + c_t)/q_{t-1}^{\Pi}$, where q^{Π} denotes the share price, and consumption c is the dividend that the publicly traded firm pays. The analysis above can be thought of as the limit case $B \to L$, since it abstracts from the income effect of the jump of the share price upon the positive news. Still, since both government bonds and stocks are liquid assets, and there is no aggregate risk (the news shock is unexpected), the sequence of prices q^{Π} is determined through the no-arbitrage condition on the ex-ante returns on stocks: $\mathbb{E}_t(q_{t+1}^{\Pi} + c_{t+1})/q_t^{\Pi} = \mathbb{E}_t\, r_{t+1}^b$, where r^b denotes the real gross return on bonds. This condition arises from the Euler equation with respect to the liquid asset from household optimization. The expected increase in the future dividend appreciates, ceteris paribus, today's stock price. This leads to a "front-loading" of the future expected return of the liquid asset. However, if also the expected future returns on bonds change, the response of the stock price is altered. In the main model, where the news horizon is longer, the initial increase in the stock price due to the news shock is attenuated by an increase in the return to bonds during the subsequent anticipation phase. This comes about through a decrease in the stochastic discount factor of households: the investment boom lets incomes rise, so that households want to save less in the liquid asset. In order for the real rate not to increase too much, government bond supply has to fall in the anticipation period: $B_0 < B_{SS}$. In the full model, a fiscal rule determines the bond supply endogenously, reacting to inflation by lowering the supply of bonds. Once the higher capital rent has materialized, households' precautionary savings motive depresses the return to bonds, which increases the preceding stock price.

The capital, on the other hand, can be thought of as a share of a private firm, which is illiquid (alternatively, it can be thought of as a financial asset with a long maturity, like a share in a pension fund, or a physical asset, like a house, that can only be traded infrequently/at a high cost). In this simple example, the return to capital increases exogenously. In the full model, while the capital rent increases due to an exogenous increase in productivity, capital gains increase endogenously: poorer households want to hold the illiquid asset after the stock price-boom, when the liquidity premium increases. However, these anticipated high returns are *not* front-loaded via intertemporal arbitrage, as for the liquid asset. The reason is the illiquidity of capital. In this section, capital was fixed. In the full model, capital can only be traded each period with some probability. Therefore, in the anticipation period, households do not want to realize possible capital gains of their illiquid asset, since by selling capital, they might forfeit the chance to hold the asset once the capital returns increase.

This is, thus, one fundamental reason why the liquidity premium falls upon the news of higher future productivity: the higher future returns on liquid assets obtain already in anticipation, while the higher future returns on illiquid assets do not. The other fundamental reason is that illiquid assets are productive; hence, households that hold onto them increase the productivity of the economy, and thereby cause a boom, which raises the return on liquid assets in the anticipation phase.

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 The full model

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[17]. 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. (2020)). One period denotes one quarter. $\bar{X}$ denotes the steady state value of variable X, and $\hat{X}$ the relative deviation of X from $\bar{X}$.

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

$$h_{it} = \frac{\tilde{h}_{it}}{\int \tilde{h}_{it} di}, \tag{1}$$

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

$\tilde{h}$ 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 (after tax) profits

[17] 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. (2020). This is a shortened version of their exposition.

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[18]. 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

$$y_{it} = (1 - \tau^L)(w_t h_{it} n_{it})^{1-\tau^P}, \tag{2}$$

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 $\underline{B}$[19]. In this case, their payment to the lender consists of the nominal

[18] 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. (2020) in models without news shocks, find that close to GHH preferences provide the best fit to the data.

[19] Since all households hold a share of their liquid wealth in stocks, for negative liquid wealth they

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

$$c_{it} + b_{it+1} + q_t k_{it+1} = y_{it} + \mathbb{1}_{h_{it}\neq 0}\Pi_t^U + \mathbb{1}_{h_{it}=0}\Pi_t^F + (q_t + r_t)k_{it} + \left(\frac{R_t^L}{\pi_t} + \mathbb{1}_{\{b_{it}<0\}}\frac{\overline{R}}{\pi_t}\right) b_{it}, \tag{3}$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ denotes realized gross inflation. 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

$$\begin{aligned}
V_t^a(b,k,h;\Theta,\mathcal{P},\Omega) &= \max_{k',b'_a}\{u[x(b,b'_a,k,k',h)] + \beta\,\mathbb{E}_t\,V_{t+1}(b'_a,k',h';\Theta',\mathcal{P}',\Omega')\},\\
V_t^n(b,k,h;\Theta,\mathcal{P},\Omega) &= \max_{b'_n}\{u[x(b,b'_n,k,k,h)] + \beta\,\mathbb{E}_t\,V_{t+1}(b'_n,k,h';\Theta',\mathcal{P}',\Omega')\}, \qquad (4)\\
\mathbb{E}_t\,V_{t+1}(b',k',h;\Theta',\mathcal{P}',\Omega') &= \mathbb{E}_t[\lambda V_{t+1}^a(b',k',h;\Theta',\mathcal{P}',\Omega')]\\
&\quad + \mathbb{E}_t[(1-\lambda)V_{t+1}^n(b',k,h;\Theta',\mathcal{P}',\Omega')],
\end{aligned}$$

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. A fraction of ω^Π of the profits Π_t^F 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 payout to entrepreneurs then becomes

$$(1-\omega^\Pi)\Pi_t^F + \iota^\Pi q_t^\Pi. \tag{5}$$

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symmetrically do some of their borrowing in stocks ("short-selling" stocks).

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

$$\mathbb{E}_t \frac{R^B_{t+1}}{\pi_{t+1}} = \mathbb{E}_t \frac{q^\Pi_{t+1}(1-\iota^\Pi) + \omega^\Pi \Pi^F_{t+1}}{q^\Pi_t}. \tag{6}$$

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

$$\frac{R^L_t}{\pi_t} = \frac{B_t}{L_t} \cdot \frac{R^B_t}{\pi_t} + \frac{q^\Pi_t(1-\iota^\Pi) + \omega^\Pi \Pi^F_t}{L_t}. \tag{7}$$

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, $\frac{q^\Pi_t}{q^\Pi_{t-1}}$. The budget constraint (3) 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*

$$q^L_t := 1 + \frac{q^\Pi_t - q^\Pi_{t-1}}{L_t}. \tag{8}$$

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

$$r^{L,net}_t := \frac{R^L_t}{\pi_t} - q^L_t = \frac{B_t}{L_t} \cdot \left(\frac{R^B_t}{\pi_t} - 1\right) + \frac{\omega^\Pi \Pi^F_t - \iota^\Pi q^\Pi_t}{L_t} \tag{9}$$

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

$$\left(\frac{R^L_t}{\pi_t} + \mathbb{1}_{\{b_{it}<0\}} \frac{\overline{R}}{\pi_t}\right) b_{it} = \underbrace{\left(r^{L,net}_t + \mathbb{1}_{\{b_{it}<0\}} \frac{\overline{R}}{\pi_t}\right) b_{it}}_{\textit{net liquid income}} + \underbrace{q^L_t b_{it}}_{\textit{liquid wealth}} \tag{10}$$

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)

$$\log\left(\frac{\pi_t^W}{\bar{\pi}_W}\right) = \beta\,\mathbb{E}_t \log\left(\frac{\pi_{t+1}^W}{\bar{\pi}_W}\right) + \kappa_w\left(\frac{w_t}{w_t^F} - \frac{1}{\mu^W}\right), \tag{11}$$

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 κ_w is determined by the probability of wage-adjustment. The homogeneous intermediate good Y is produced with the constant returns to scale production function

$$Y_t = A_t N_t^{1-\alpha_t}(u_t K_t)^{\alpha_t}, \tag{12}$$

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

$$\log(A_t) = \rho_A \log(A_{t-1}) + \epsilon_{t-\ell}^{A,\ell} + \epsilon_t^A, \tag{13}$$

$$\alpha_t = (1-\rho_\alpha)\overline{\alpha} + \rho_\alpha \alpha_{t-1} + \epsilon_{t-\ell}^{\alpha,\ell} + \epsilon_t^\alpha, \tag{14}$$

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

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) 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:

$$w_t^F = (1-\alpha_t) mc_t A_t (u_t K_t / N_t)^{\alpha_t}, \; r_t + q_t \delta(u_t) = u_t \alpha_t mc_t A_t (N_t / u_t K_t)^{1-\alpha_t}. \tag{15}$$

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

$$q_t \delta'(u_t) = \alpha_t mc_t A_t (N_t / u_t K_t)^{1-\alpha_t}. \tag{16}$$

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

$$\log\left(\frac{\pi_t}{\bar{\pi}}\right) = \beta \, \mathbb{E}_t \log\left(\frac{\pi_{t+1}}{\bar{\pi}}\right) + \kappa_Y \left(mc_t - \frac{1}{\mu^Y}\right), \tag{17}$$

where $\mu^Y = \frac{\eta}{\eta-1}$ is the target markup, and κ_Y is determined by the probability of price adjustment.

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 maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t I_t \left\{ q_t \left[1 - \frac{\phi}{2} \left(\log \frac{I_t}{I_{t-1}} \right)^2 \right] - 1 \right\}. \tag{18}$$

Up to first order, the problem reduces to the equation

$$q_t \left[1 - \phi \log \frac{I_t}{I_{t-1}} \right] = 1 - \beta \, \mathbb{E}_t \left[q_{t+1} \phi \log \frac{I_{t+1}}{I_t} \right], \tag{19}$$

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

$$K_t - (1-\delta(u_t))K_{t-1} = \left[1 - \frac{\phi}{2}\left(\log \frac{I_t}{I_{t-1}}\right)^2\right] I_t. \tag{20}$$

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:

$$\frac{R^B_{t+1}}{\bar{R}^b} = \left(\frac{R^B_t}{\bar{R}^b}\right)^{\rho_R} \left(\frac{\pi_t}{\bar{\pi}}\right)^{(1-\rho_R)\theta_\pi} \left(\frac{Y_t}{Y^*_t}\right)^{(1-\rho_R)\theta_Y}. \tag{21}$$

$\theta_\pi, \theta_Y \geq 0$ 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

$$\frac{B_{t+1}}{B_t} = \left(\frac{B_t}{\bar{B}}\right)^{-\gamma_B} \left(\frac{\pi_t}{\bar{\pi}}\right)^{-\gamma_\pi} \left(\frac{Y_t}{Y^*_t}\right)^{-\gamma_Y}. \tag{22}$$

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

$$\tau\mathcal{B}_t = \mathcal{B}_t - (1-\tau^L)\mathcal{B}_t^{(1-\tau^P)}. \tag{23}$$

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 (15). The market for liquid assets clears when liquid asset demand, which is given by the households' optimal decisions, $L^d_t = \mathbb{E}[\lambda b^*_{a,t} + (1-\lambda)b^*_{n,t}]$, equals the supply of liquidity $L_{t+1} = B_{t+1} + q^\Pi_t$ (as L^d_t 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 (19), 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 (4).

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)[20].

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[21], 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[22].

[20]For the implementation of the methods, I make use of and extend the Julia package "HANKEstim" by Bayer et al. (2020), available on `https://github.com/BenjaminBorn/HANK_BusinessCycleAndInequality`.

[21]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).

[22]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.

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	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. 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.

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[23]. 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

[23] Fittingly, Adam and Weber (2020) estimate from product data in the UK the median quarterly turnover rate of consumer products as 13.7%.

Table 2: Estimated parameters (selected)

Parameter	Description	Value
ϕ	Capital adj. costs	0.218
κ	Price stickiness	0.105
κ_w	Wage stickiness	0.133
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	8.15
γ_Y	Fiscal: output gap	3.01
σ_A	TFP std. dev.	0.00608
σ_α	capital share std dev.	0.005

produced using the physical capital and the depreciating intangible capital, I arrive at an 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. (2020), $\overline{\alpha} = 0.32$. 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. (2020). 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 fractions ω^Π and ι^Π are calibrated to yield a share of liquid assets held in stocks of 39%[24], which implies $\omega^{\Pi} = 15\%$ and $\iota^{\Pi} = 1.6\%$. 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 liquidity 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) and the federal funds rate, I compute average yearly returns of 8.3%, 2.5%, and 1.2%, respectively, over the period from 1950 to 2016. The liquid rate in the model should be considered as a weighted average of these rates[25].

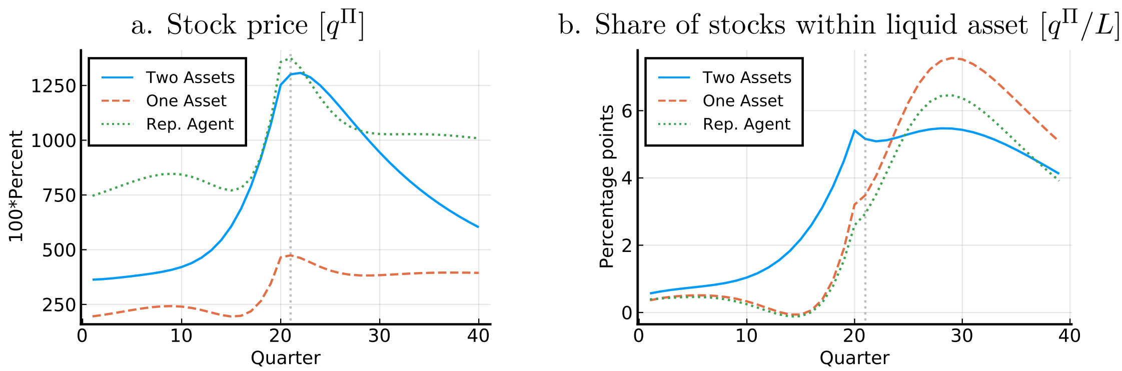
Tax progressivity $\tau^P = 0.18$ is taken from Heathcote et al. (2017), while the tax level $\tau^L = 0.1$ is set to achieve a government share of rougly 18%. With respect to the parameters that Bayer et al. (2020) estimated, I choose those estimates where inequality data was included in the estimation (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[26]. Table 2 lists the chosen values for a selection of parameters in the model.

[24]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%.

[25]The introduction of aggregate risk, that would allow to differentiate among the classes of liquid assets by their model-implied riskiness, along the lines of Devereux and Sutherland (2010), 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.

[26]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. (2020) for the whole period since 1960. The reason is that in the late 1990s, the U.S. government strongly reduced their debt.

Figure 4: Response of stocks across model classes



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

4 A news-induced stock price boom

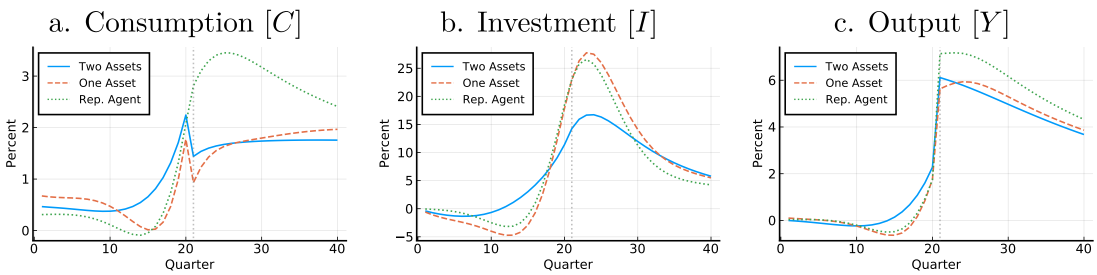
I consider the following experiment: with an anticipation horizon of 5 years ($\ell = 20$)[27], households become aware that the capital share will increase (by two times its standard deviation). As outlined in the introduction, one can interpret the capital share increase as a temporary change in the 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.

Figures 4 and 5 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 liquidity premium being fixed at a steady state level of zero[28]. This implies that capital becomes liquid in this setting. *Rep. Agent* additionally takes away market incompleteness,

[27] 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.

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

Figure 5: 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).

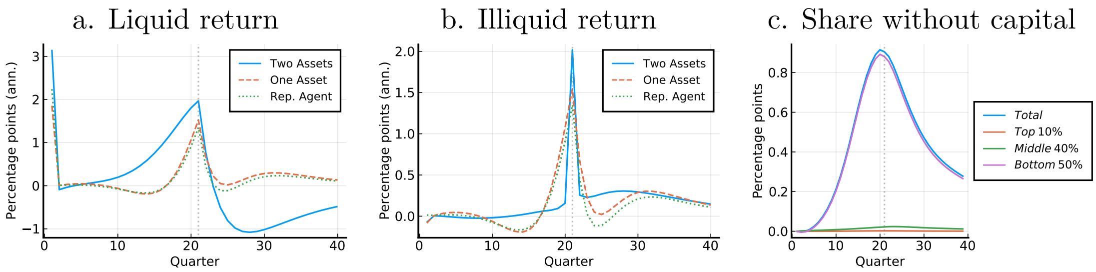
and is thus a model of the RANK variety.

While all model varieties exhibit a peak in the stock price one quarter before the capital share increase (quarter 20), only the HANK model with portfolio choice 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 a higher real interest rate in equilibrium.

Figure 6 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 liquidity 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 liquidity premium declines during the anticipation period (the real rate increases) and rises after the stock price-peak (the real rate 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 econ-

Figure 6: 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. Groups in Panel c) are defined in the *cross-section* each quarter.

omy; to the contrary, it stabilizes the income of richer households by increasing their return on liquidity (figure 7), 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

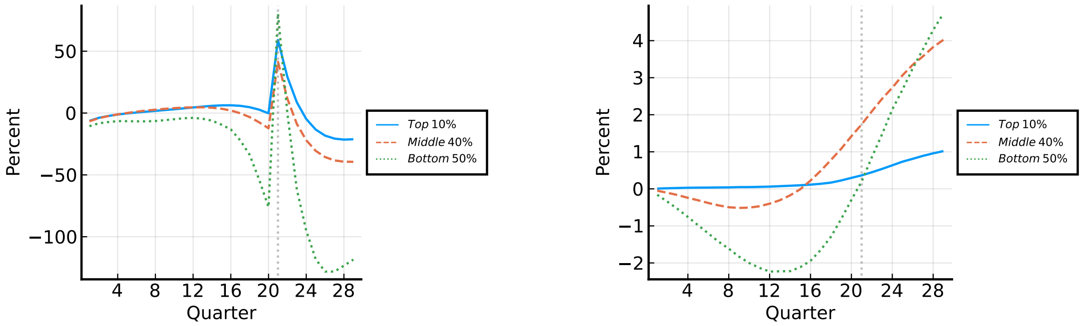
Since both the capital share shock as well as several parameters were calibrated to the 1990s in the U.S., I can make a quantitative comparison of the shock responses to the aggregate observations from 1995 to 2000[29]. In terms of real business cycle variables, the model exactly replicates the 6% rise 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

[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].

Figure 7: Response of income and investment over the wealth distribution

a. Liquid asset income $[b_i(R^L/\pi - 1)]$ b. Capital holding $[k_i]$



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.*

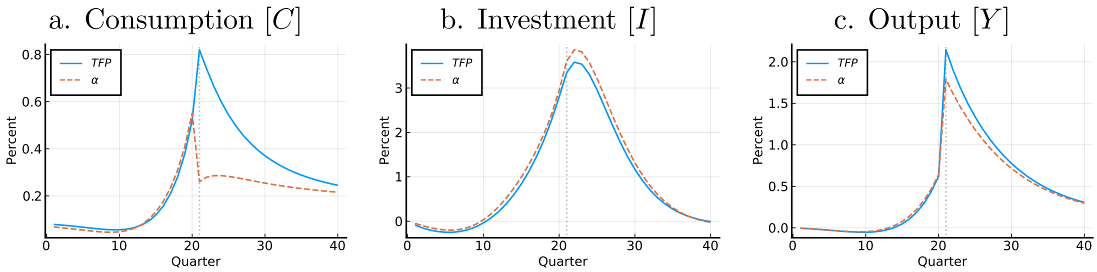
might have allowed households to consume more. Considering only unsecured borrowing, I find that the model accounts for half of the 30% increase in consumer credit. In the model, the increase in borrowing, mostly by the bottom 50% of households, contributes to the overall increase in wealth inequality 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 around a 25% of this increase. Institutional changes, speculative motives, or exuberant optimism about stock returns could be possible candidates to explain this gap.

4.2 Alternative news shock

Figure 8 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

[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 8: 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.

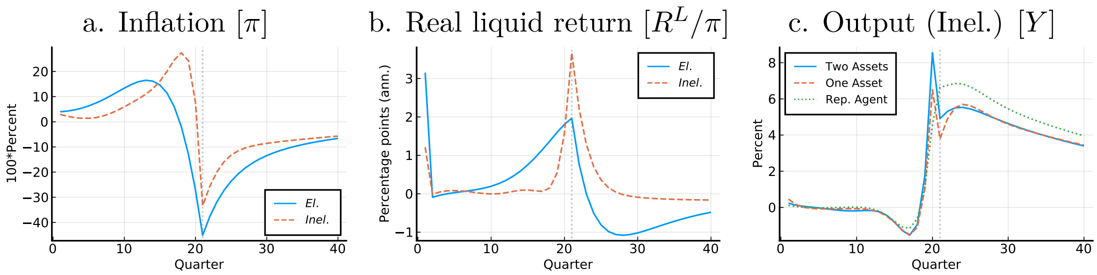
less in the case of the capital share increase. Still, in the long run, the levels of consumption and output converge across the two shock responses. The reason is that, when the direct effect of the transitory shocks subsides, the indirect effect of the higher capital stock, built up during the identical 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 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 9). With the alternative fiscal

Figure 9: 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 $\gamma_Y = 0.007, \gamma_\pi = 6.58$.

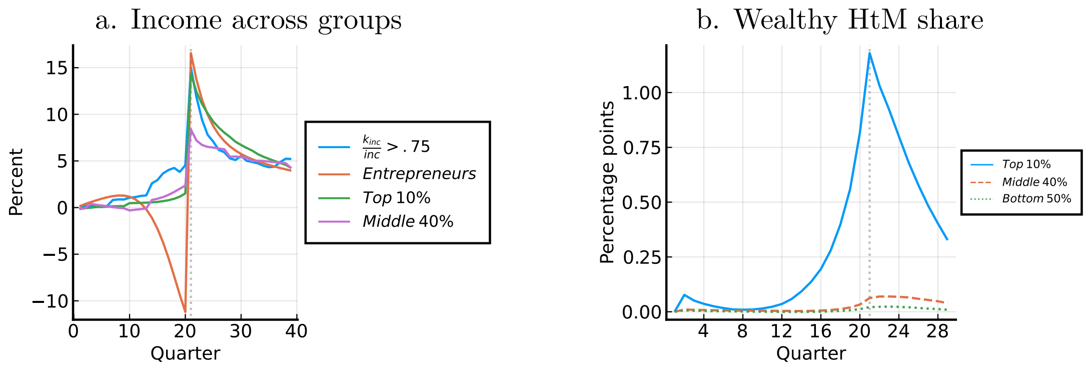
rule that allows for a prolonged rise of inflation during the anticipation phase, middle class households do not invest enough to start the business cylce (and stock price) boom. The reason is that inflation depresses asset returns and magnifies the increase in the marginal costs of firms (affecting 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 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:

Figure 10: 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*.

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.

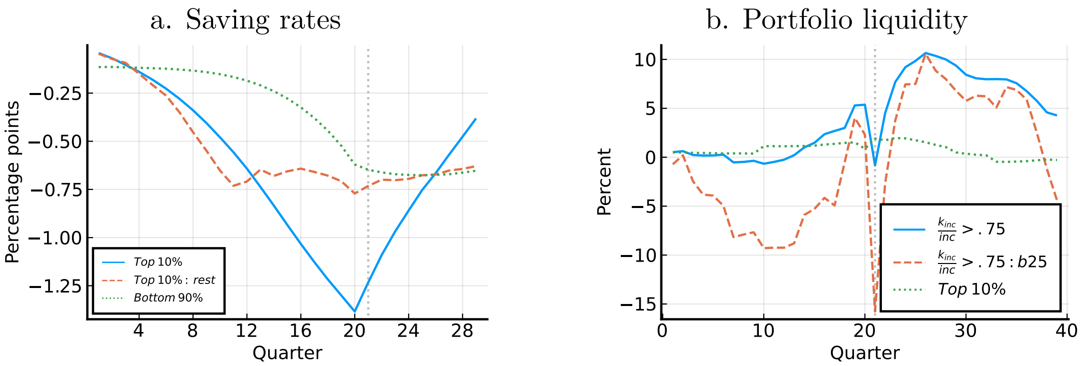
The news shock raises the expected capital rent and prices in the future. As I argued in section 4.3, extreme profit swings towards the end of the cycle depress investment. Part of the reason is that a big output gap late in the cycle requires monetary policy to hike the nominal rate, so that the real rate spikes in the last quarter before the TFP increase. This makes it more expensive to finance illiquid asset holdings with debt accumulated over 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 10a). While entrepreneurs, who receive the profit income, experience the largest income rise at the onset of the capital share increase, they lose in the anticipation period, and are therefore less likely to become wealthy hand-to-mouth households[31]. 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 10b).

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

Figure 11: 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.

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 households grows by 10%. Hence, by far the largest inflow into this group 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.

4.5 Marginal savers

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 rates during the cycle. Figure 11a 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 real rate[32]. Note that, since the aggregate supply of liquid assets is down, also a saving rate below its steady state-level can depress the liquid rate in equilibrium.

Figure 11b 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[33]. Therefore, I also show the mean response of the lowest quartile in the portfolio liquidity distribution of these households. The "marginal saver" households 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 most of the anticipation phase (most pronounced just before the expected productivity increase). After the boom, the "capitalists" 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

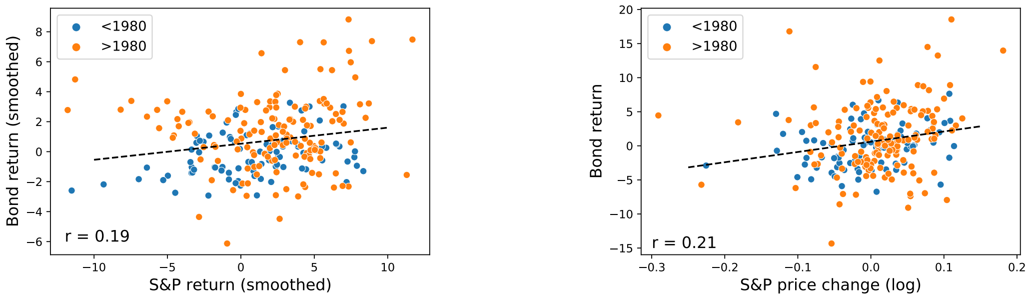
In this section, I provide empirical evidence for the relation between the returns on liquid and illiquid assets and stocks, and the relation between portfolio choices of households

[32]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 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.

[33]In the data, this composition effect rather goes in the opposite direction: since capital rents do not increase in stock price booms, while real bond rates do, there is weak 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 12: Correlations among liquid asset returns

a. Bond return and S&P return (smoothed)　　b. Bond return and S&P price change



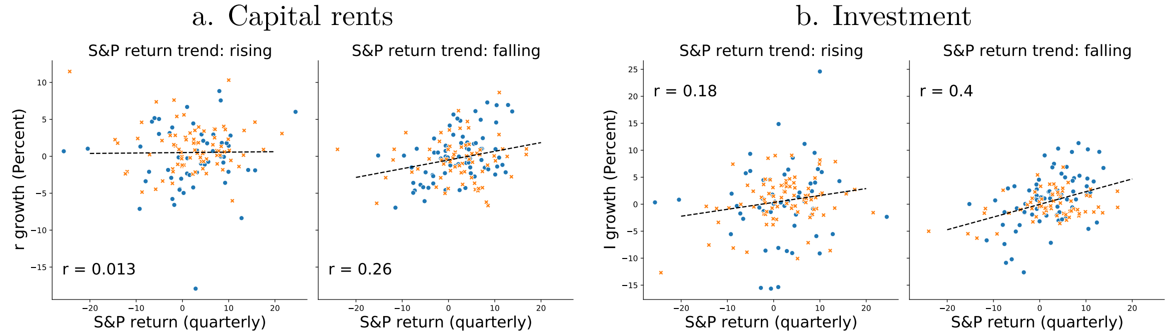
Notes: Data by Robert Shiller (S&P and 10 year treasury bond). All returns are ex-post (realized) quarterly observations from 1955.Q4 to 2016.Q4. Smoothed series were computed by taking a moving average with a 4-quarter window. Lower maturity-bonds have a weaker positive correlation with stock prices: the respective correlation coefficients for the (smoothed) real federal funds rate are 0.13 (left panel) and 0.05 (right panel, without outlier 2008.Q3).

and stocks. Additionally, I use the Campball-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 the expected real rate on a liquid asset is positively correlated with the expected stock return. Relatedly, the expected real rate on liquid assets should covary positively with the expected change in the stock price. Figure 12 shows that ex-post returns in the data provide weak evidence for these links. In order to cancel out noise, which is mainly driven by innovations in dividends, I compute a moving average when comparing bond returns and stock returns. The results are robust to different specifications, with longer maturity bonds, or a larger moving average-window, leading to higher correlations with stock returns.

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 returns is related to stock returns, as in the theory. Specifically, the proposed mechanism hinges on capital-wealthy households to drive down the liquid rate, 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 A.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.

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



Notes: Data by Robert Shiller (S&P) 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.

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. On average over all sampled years, only 1.23% of households are in that category (2.7% in the model). Yet, the theory implies that their portfolio choice is decisive in affecting the liquidity 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 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[34].

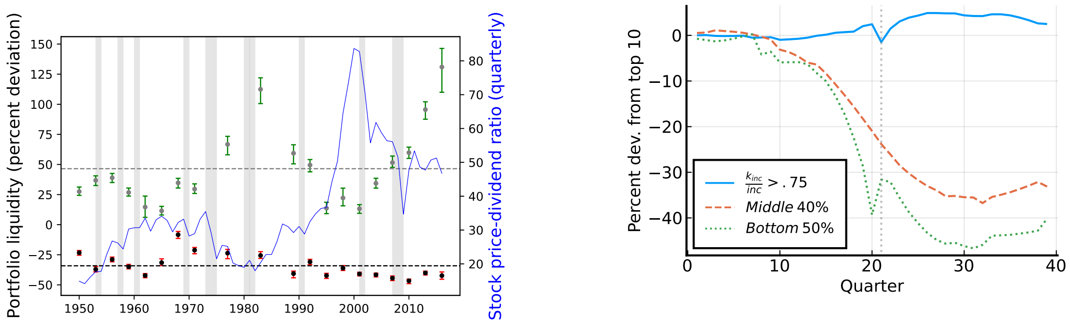
While in the model, households with high capital incomes are all in the top decile of the wealth distribution, in the data, only 40% are in that wealth group, while 33% have wealth that lies between the median and the top 10% of the wealth distribution. The likely reason for this discrepancy is that 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 "capitalists" 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 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.

[34] 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 A.2.

Figure 14: Relative portfolio liquidity in model and data

a. Data: lower wealth groups

b. Model



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 in the bottom 50% (grey dots, green CIs) / middle 40% (black dots, red CIs) 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.

Figure 1 shows the relative portfolio liquidity of "capitalists" over time, and in comparison to the stock price-dividend ratio of the S&P 500. Figure 14 shows the same plot for the relative portfolio liquidities across wealth groups (left panel), as well as the model-implied prediction of the relative portfolio liquidities following a news shock (right panel). 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 in the years after the boom. As a consequence, their relative portfolio liquidity should be more persistent, and be a less acute indicator of stock price booms caused by news shocks.

To put this prediction to the test, I conduct the following exercise: let $\{y_i\}_i$ denote the sequence of all years contained in the SCF+. For each sequence of relative portfolio liquidities 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, $\Delta_i \frac{q^\Pi}{\Pi^F} = \frac{q^\Pi}{\Pi^F}(y_i) - \frac{q^\Pi}{\Pi^F}(y_{i-1})$. The first row 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 -0.29, when controlling for the

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

Specifications	high cap. inc.	middle 40%	bottom 50%	rel. stock share	R^2
baseline	-0.290 (0.213)	0.113 (0.117)	-0.442** (0.118)	-	0.262
w/o bottom 50%	-0.361 (0.235)	-0.089 (0.109)	-	-	0.113
binary regressors	-0.477* (0.228)	0.824* (0.409)	-0.27 (0.266)	-	0.269
w. rel. stock share	-0.381** (0.168)	0.086 (0.116)	-0.481** (0.133)	0.420* (0.228)	0.420
rel. st.sh. & binary	-0.876* (0.483)	0.482 (0.310)	-0.237 (0.242)	0.679 (0.520)	0.384

Notes: The baseline regression equation is $\Delta_i \frac{q^{\Pi}}{\Pi^F} = \sum_g \beta_g \Delta_i \text{pflq}^g + \epsilon_i,\ i = 1,..,19.$ All variables are standardized. In *binary* specifications, all regressors are instead indicator variables $\mathbb{I}_{\{\Delta_i \text{pflq}^g > 0\}}$ (not standardized). Specifications with the *relative stock share* include the growth of the ratio of the stock share of high capital-households by the stock share of 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.

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, and is the only regressor with a statistically significant effect. The reason is that the difference of portfolio liquidity between the bottom 50% and the top 10% exhibits a strong secular pattern: it rises in the 1970s, falls in the 1990s, and increases since then. This is roughly consistent with the secular trends in the stock price-dividend ratio, with a trough in 1980 and a peak in 2000. First, I check that the portfolio liquidity of the "capitalists" and the bottom 50% explain mostly different parts of the variation by leaving the latter out of the regression, which yields largely the same result for the "capitalists". Second, I run the regression with the indicator variables $\mathbb{I}_{\{\Delta_i \text{pflq}^g > 0\}}$ as regressors. Thereby, I abstract from the larger relative swings in the relative portfolio liquidity of the poorer half of households. Row 3 in table 3 shows the results. The negative correlation of changes in the relative portfolio liquidity of the "capitalists" now is statistically significant (p=5.3%), while the result for the bottom 50% is attenuated. This suggests that the relative portfolio liquidity of households with high capital income is a more precise indicator for stock price booms and busts. Specifically, the indicator picks up the boom from 1953 to the early 1960s, the bust in 1974, the 1980s boom, and the boom-bust cycles of the 1990s and 2000s.

5.1.1 Robustness checks

One 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 12.9% of their total wealth in stocks, while households whose income is dominated by capital income only hold 9.6% of their wealth in stocks. Since stocks are liquid, the higher 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 "capitalists" 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. The last two rows in table 3 show the results. If anything, the evidence for the 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 "capitalists" *increases* compared to that of the top 10%, even though the top 10% own more stocks on average. This is consistent with the idea that due to the expected higher capital returns, the "capitalists"' willingness to bear more consumption risk rises during stock price-booms.

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 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[35]. In the appendix (A.2.1), I consider this possibility, by including the share of households with dominant capital income within the top 10% as additional regressor. I find that, while there is evidence that the share of "capitalists" is indeed countercyclical, the negative correlation between relative portfolio liquidity and the stock market remains virtually unchanged.

I also test the explanatory power of the relative portfolio liquidity for higher frequency data. Specifically, instead of partly merging the survey waves that are available in the SCF+ before 1977 in order to be in line with the triannual frequency of the modern SCF, such as in Kuhn et al. (2020), I use the older surveys at a higher frequency (see appendix

[35]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.

A.2.1). I find that the overall explanatory power of the regressors is reduced due to the higher frequency of changes in the stock price-dividend ratio. However, the results with respect to the relative portfolio liquidity of households with high capital income are robust for the binary specifications. There, the effect of the relative portfolio liquidity becomes even more economically significant: I find that rising relative portfolio liquidity of households with dominant capital income is related to a one standard deviation-decrease in the stock price-dividend ratio.

5.2 Campbell-Shiller decomposition

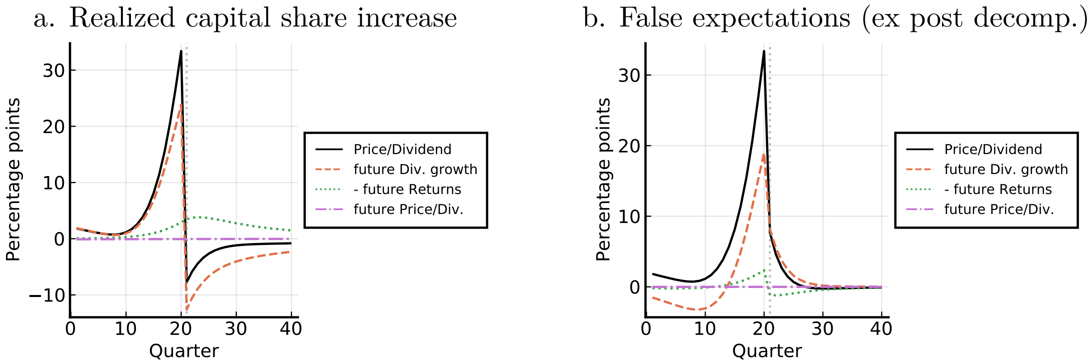
The Campbell and Shiller (1988) decomposition is a log-linear approximation of the price-dividend ratio around its (proposed) stationary value, and is given by

$$\log(q_t^{\Pi}/\Pi_t^F) = c + \mathbb{E}_t \sum_{j=0}^{\infty} \rho^j \left[\underbrace{\hat{\Pi}_{t+1+j}^F}_{\text{dividend growth news}} \underbrace{-r_{t+1+j}^L}_{\text{discount rate news}} \right], \tag{24}$$

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 rate 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). In a regression exercise, Cochrane (2011) shows that discount rate news, rather than dividend growth news, explain most of the variation in the price-dividend ratio.

In a next step, I decompose the stock-price response to a news shock in the model into the components *future dividend growth*, - *future returns*, and *future price/dividend* (as in the data, the horizon of future variables is five years). Since the response to the news shock is solved up to first order, the Campbell-Shiller decomposition exactly holds. In panel a) of figure 15, one can see that most of the price-dividend ratio is explained by future dividend growth. The reason is that dividends are strongly countercyclical in the model, so that they dominate the future returns component over the cycle (the latter slightly increases the stock price). In panel b), I consider the possibility that households systematically expect productivity growth that does not materialize. 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

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



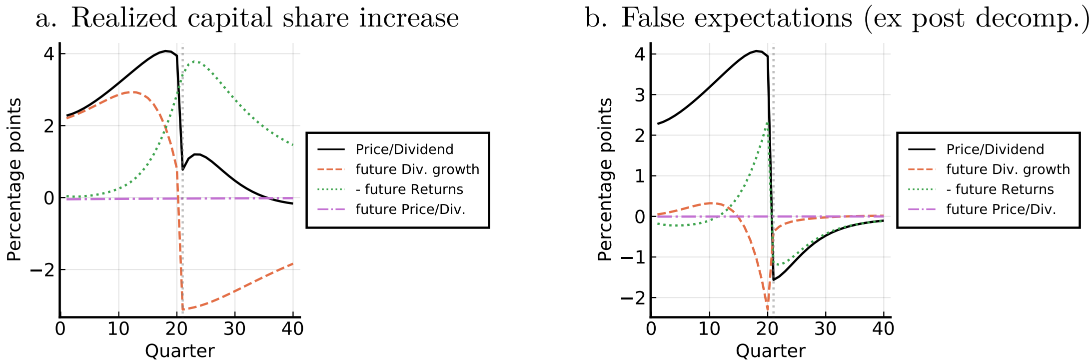
Notes: Model impulse responses are to news about a temporary capital share-increase in 5 years (quarter 21).
In b), the news is offset by a negative capital share surprise shock in quarter 21.

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. Still, the swings in profits "explain" (i.e., provide an ex-post rationalization of) most of the variation over the cycle, as profits fall strongly in the anticipation period, and revert to the steady state value after the news-disappointment.

Since it is not clear that firms pass on their profits to shareholders one-to-one, and countercyclical dividends may appear unreasonable, 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 most of the increase of the price-dividend ratio in the anticipation phase. The reason is that, from the future dividend growth-component alone, a forward-looking price would already incorporate the future expected decline in output. However, since the future output will also be discounted less as the demand for liquidity will rise, the high price-dividend ratio can be rationalized. If the capital share-increase materializes, the high output level explains most of the drop in the price-dividend ratio in the second half of the cycle. If the capital share-expectation is disappointed, however, 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.

Importantly, a complete disappointment of expectations does *not* generate lower *expected* returns on liquidity, but just a drop in the *realized* return (a one-time fall in the stock price) upon the surprise shock. Therefore, having all news be disappointed does not

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 $\omega^{\Pi} Y$.

concur with the facts, either, as it does not induce a persistent decline in stock prices after the boom. In sum, analyzing the Campbell-Shiller decomposition of the model-implied price-dividend ratio for the extremes in two dimensions, namely cyclicality of dividends and accuracy of expectations, suggests that the best data fit, which takes into account both the empirical relevance of discount rate news as well as the observed dividend- and liquid return time series, will be provided by an intermediate point on this plane. I reserve such an estimation exercise for future work.

6 Conclusion

Stock price-booms are often thought of as periods where people are more risk-loving with respect to their portfolio choices. With this paper, I offer a more nuanced perspective: rising stock prices are indicative of the anticipation of higher future returns on capital. For capital-wealthy households, it is therefore a time where they are willing to hold their capital at a lower premium, and indeed bear more consumption risk. For poorer households, instead, the lower liquidity premium is an opportunity to have higher returns on their liquid wealth, like publicly traded stocks. The theory gives a natural explanation for a subsequent fall in stock prices: any acceleration in productivity growth will end. This will prompt capital-wealthy households to "deleverage", which will increase the liquidity premium. At that point, some of the poorer households will start holding capital again, as liquid assets, like publicly traded stocks, yield lower returns.

While I deviate from the asset pricing literature by abstracting from aggregate risk premia, the mechanism I propose is not contradicting that literature. In fact, I present a microfoundation for discount rate risk, which is an indispensible ingredient for models that explain the cyclical behavior of asset prices. While stock returns in the model are not risky, capital returns are *individually* risky, since the illiquidity of the capital asset implies consumption risk for the household. I interpret “good” states of the world - periods where the price-dividend ratio is not only high, but also rising - as periods where the anticipation of higher future returns leads the capital-rich to increase their individual consumption risk. The higher riskiness in their portfolios depresses the real rate - or increases the “discount rate” - in the subsequent “bad” state, when stock prices fall.

Possible extensions of the model are manyfold. First, the modelling of anticipation as a single news shock, which implies a sudden influx of knowledge about the technological frontier far in the future, is not to be taken literally. Using the degrees of freedom in the size and horizon of news (and noise) shocks is a natural extension for fitting the model to the (stock price-)data. The literature also suggests changes to the rational expectations framework, like rational inattention, which yields “information smoothing” for short-run news (Maćkowiak and Wiederholt, 2021), or irrational expectation formation (Bordalo et al., 2020), to explain news-driven booms (and busts). The mechanism presented here is largely complementary to these theories; in fact, the evidence on survey expectations shown in Bordalo et al. (2020) gives empirical support to the importance of long-run expectations about fundamentals during stock price-booms.

Additionally, solving the model with aggregate risk would allow for the modelling of different stock-shares over the wealth distribution. This would admit a finer analysis of the implications of stock price fluctuations for wealth inequality, and for welfare in general, and be thus a fruitful area for future research.

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A Empirical evidence

A.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:	11:58:24	**Log-Likelihood:**	-180.15
No. Observations:	135	**AIC:**	374.3
Df Residuals:	128	**BIC:**	394.6
Df Model:	7		

	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:	11:58:24	**Log-Likelihood:**	-178.93
No. Observations:	140	**AIC:**	371.9
Df Residuals:	133	**BIC:**	392.4
Df Model:	7		

	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:	11:58:24	**Log-Likelihood:**	-185.04
No. Observations:	140	**AIC:**	382.1
Df Residuals:	134	**BIC:**	399.7
Df Model:	6		

	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:

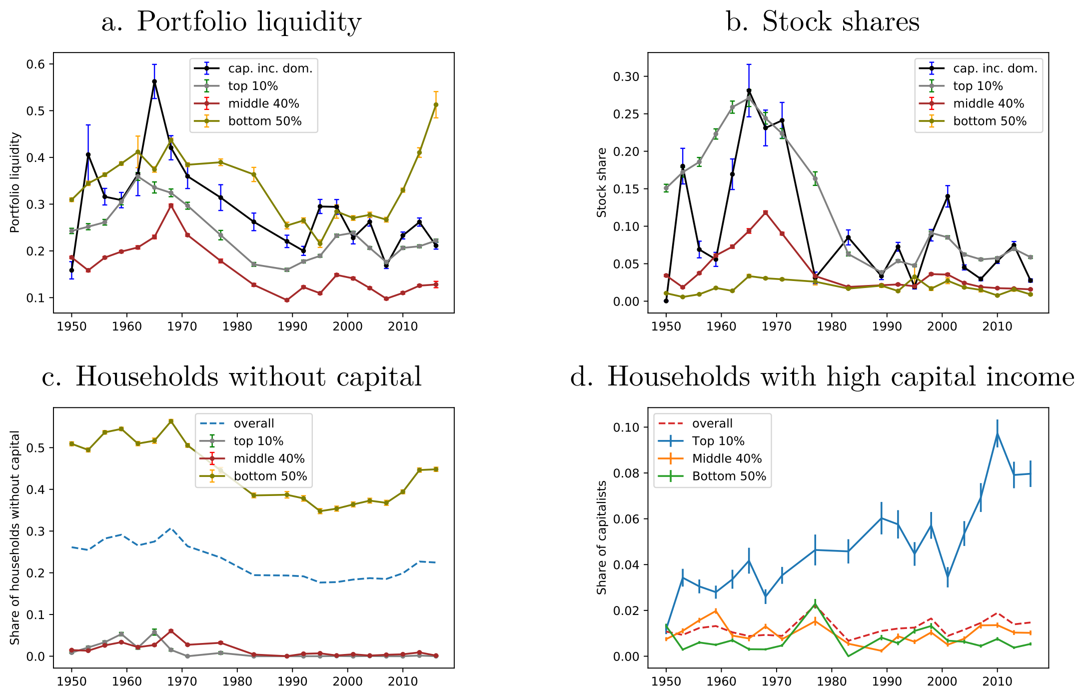
[1] R^2 is computed without centering (uncentered) since the model does not contain a constant.

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

A.2 Portfolio choice over time

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 2016. Several secular trends are notable:

Figure 17: 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.

- For households in the top 50% of the wealth distribution, portfolio liquidity peaked in the 1960s, and declined since then. Some of this development is due to larger stock shares in the first half of the sample.
- For the bottom 50% 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 decreased in the 1970s, 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 whose income is dominated by capital income stays constant over time, their share within the richest decile increases steadily.

Table 4: Regression of price-dividend growth on relative portfolio liquidities

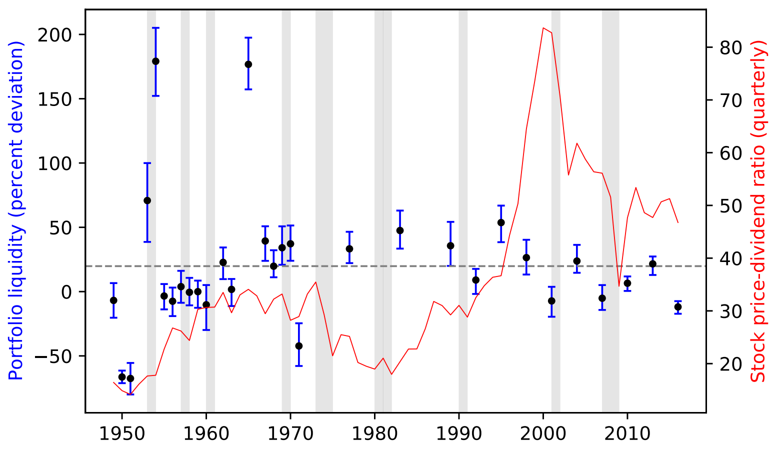
Specifications	high cap. inc.	middle 40%	bottom 50%	rel. stock share	high cap. share	R^2
baseline	0.014 (0.165)	0.339 (0.277)	-0.427* (0.247)	-	-	0.038
w/o bottom 50%	-0.07 (0.178)	0.001 (0.110)	-	-	-	0.005
binary regressors	-0.451* (0.246)	0.520 (0.337)	-0.077 (0.339)	-	-	0.128
w. rel. stock share	-0.095 (0.230)	0.436 (0.354)	-0.335 (0.343)	0.356 (0.295)	-	0.137
rel. st.sh. & binary	-0.967* (0.474)	0.206 (0.261)	0.038 (0.303)	0.775* (0.443)	-	0.279
all controls	0.151 (0.212)	0.253 (0.310)	-0.614* (0.332)	0.433 (0.297)	-0.533** (0.233)	0.244
all contr. & binary	-0.948* (0.462)	0.181 (0.245)	0.085 (0.273)	0.896* (0.472)	-0.254 (0.311)	0.299
all controls (N=19)	-0.322* (0.178)	0.013 (0.153)	-0.45** (0.117)	0.415* (0.214)	-0.223 (0.192)	0.457
all ctr.&bin.(N=19)	-0.877* (0.485)	0.484 (0.322)	-0.24 (0.211)	0.677 (0.535)	0.007 (0.289)	0.384

Notes: The baseline regression equation is $\Delta_i \frac{q^\Pi}{\Pi^F} = \sum_g \beta_g \Delta_i \text{pflq}^g + \epsilon_i,\ i = 1,..,30$. All variables are standardized. In *binary* specifications, all regressors are instead indicator variables $\mathbb{I}_{\{\Delta_i \text{pflq}^g > 0\}}$ (not standardized). Specifications with *relative stock share* include the growth of the ratio of the stock share of high capital-households by the stock share of households in the top 10% as regressor. Specifications with *high cap. share* include the growth of the share of "capitalists" within the top 10% as regressor. *N=19* uses the sample with merged years before 1977 (as in main text). Newey-West (one lag) standard errors in parentheses. Asterisks indicate that the t-statistic of the coefficient is above the 5% (**) or 10% (*) level.

A.2.1 SCF with all years

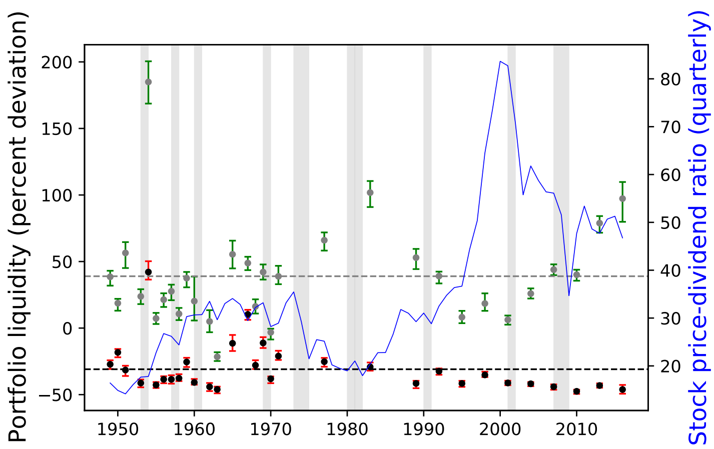
In this section, I show the same regression and plots as in the main text for higher frequency survey data. The data is from the SCF+ (Kuhn et al., 2020). 11 years are added before 1977. The unconditional correlation of the change in relative portfolio liquidity of "capitalists" with the change in the stock price-dividend ratio reduces to -0.07. However, table 4 shows that in the binary specifications, when including the relative portfolio liquidities of the bottom 90% as well as other controls as regressors, the negative relation is statistically and economically significant. The figures 18,19 and 20 reproduce the figures shown above and in the main text, but with the more finegrained data set.

Figure 18: Portfolio liquidity of "capitalists" and the stock market



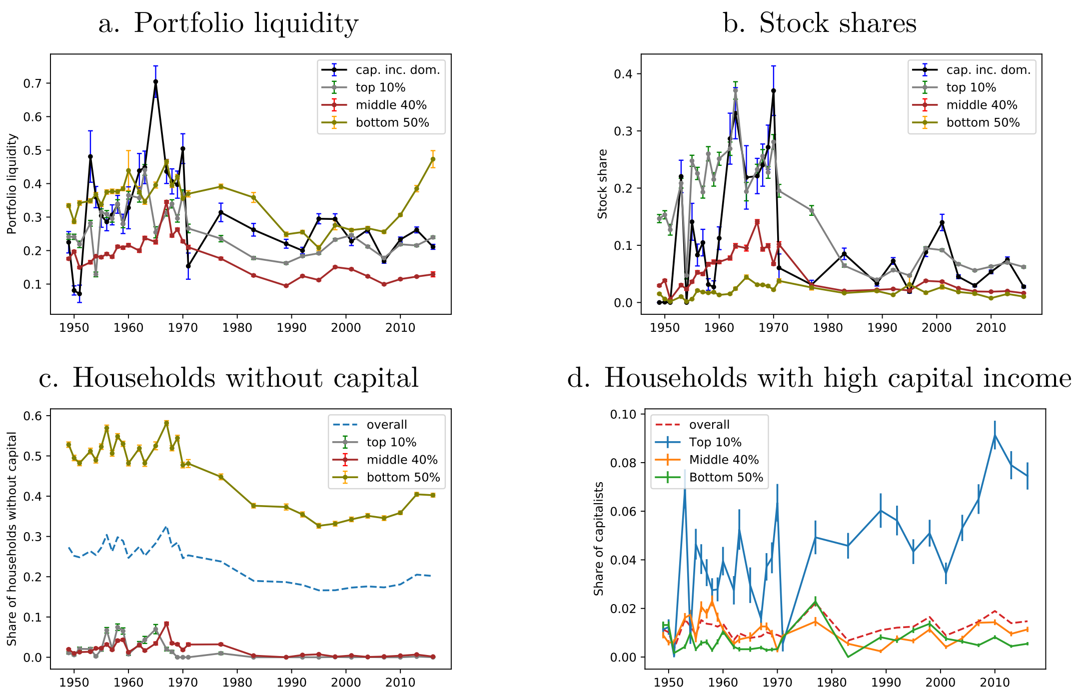
Notes: Survey evidence from SCF+ (Kuhn et al., 2020), stock market data from S&P500 (Robert Shiller), recession years (grey areas) by NBER. Portfolio liquidity is defined as the ratio of liquid assets by total wealth. Left axis shows the relative deviation of portfolio liquidity of households whose main share of income (>75%) is capital income, from portfolio liquidity of the top 10% of wealth distribution. Whiskers are 68%-confidence intervals.

Figure 19: Relative portfolio liquidity of bottom 90% and the stock market



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 axis shows the relative deviation of portfolio liquidity of households in the bottom 50% (grey dots, green CIs) / middle 40% (black dots, red CIs) from portfolio liquidity of the top 10% of wealth distribution. Whiskers are 68%-confidence intervals.

Figure 20: 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.