

Fundamental Stock Price Cycles *

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Abstract. News shocks about higher future capital returns can explain stock price-booms and subsequent -busts in a two-asset, heterogeneous agent New Keynesian model. The portfolio choice between liquid assets (like stocks) and illiquid capital is key, as it allows for a time-varying illiquidity premium. Upon the news, capital-rich households accept to hold more illiquid capital at a lower premium, in anticipation of higher future returns on it. This increases their consumption risk, and causes stock prices to rise. After the boom, capital-rich households trade capital for liquid assets in order to self-insure against idiosyncratic income shocks, which increases the illiquidity premium, and causes stock prices to fall. Novel evidence from survey data on portfolio choices of capital-wealthy households during stock price boom-bust cycles supports the key mechanism of the model.

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

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

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1 Introduction

Why does the stock market predictably yield lower returns after a boom? Campbell and Shiller (1988) show that, due to the return predictability of the stock market, most of the fluctuations in aggregate stock prices can be explained by expected movements in the discount factor: if the future return 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. Fluctuations in future dividend growth, instead, explain only a smaller part of the variance in aggregate stock prices. This finding has been reiterated by Cochrane (2011) for the post-war U.S. economy, and has been reproduced by Kuvshinov (2022) for 17 advanced economies since 1870¹. Thus, the main driver of stock price fluctuations is return predictability — the pattern of boom-bust cycles — that is unexplained by movements in dividend growth. In this paper, I offer a novel explanation for this main empirical pattern of the stock market. I model the stock market within a business cycle model. Thereby, the theory is also able to explain the positive correlation of stock price booms with business cycle booms that I find in the data.

There are three main factors that allow the theory to explain return predictability of stocks. First, markets are incomplete. As Constantinides and Duffie (1996) show theoretically, movements in the stochastic discount factor of investors that are large enough to explain the observed stock price fluctuations can be explained by risk in the investors' incomes that is uninsured. If investors instead were only subject to aggregate risk, aggregate consumption, in order to yield similar movements in the discount factor of the representative investor, would have to fluctuate by several orders of magnitude more than empirically observed, or risk aversion would have to be unrealistically high. My theory adds to this that households' incomes in general come from various sources: households receive labor income, but also asset incomes. Since asset incomes have a procyclical pattern, this addition to the theory is crucial for explaining not just a high fluctuation in stock prices, but the structure of boom-bust cycles.

Second, households can save both in liquid and illiquid assets. Illiquid assets can only be traded infrequently. If all assets were liquid, wealthy households could never be liquidity-constrained, and uninsurable income risk could only affect households without any savings. With two asset classes, households can be wealthy in the illiquid asset and

¹Kuvshinov (2022) finds that in the sample he considers, the discount rate news and the cash flow news each explain about half of the price dividend ratio.

still be liquidity-constrained, so that the income they receive from holding their assets can influence their consumption growth, and thus their stochastic discount factor. 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 category². In combination with idiosyncratic income risk, this leads to public (liquid) equity being less risky than private (illiquid) equity, similar to the incomplete markets-model by Angeletos (2007). Sorensen et al. (2014) find that the illiquidity of private equity is an important component of its return risk. Sagi (2020) finds the same for investments in real estate, and rationalizes the illiquidity of the market within a search and matching model.

Third, households anticipate future changes in technology and productivity. Examples for this are the anticipation of the adoption of the internet in firm-customer relationships during the 1990s stock market boom, or the anticipation of the development of a vaccine during the Covid-19 pandemic. I find that such “news shocks” are much more consequential when households choose between liquid and illiquid assets in their portfolios, than in models with only liquid assets. When investing in an illiquid asset, households expect to not be able to trade it for several years. As a consequence, when households receive the information that illiquid assets are expected to yield a higher return some time in the future, they attempt to invest *early*, in order to reduce the risk of not being able to invest before the higher returns materialize. News about future higher productivity thus induces some households to shift their portfolio towards illiquid assets. This comes at the cost of higher *idiosyncratic* risk for these households.

These three pillars of the theory work together to explain a typical boom-bust cycle on the stock market, that is, as in the data, caused by time-varying discount rates. It starts with the news about a temporary increase in productivity growth some time in the future. The stock market appreciates at the onset of the news, as higher productivity implies higher dividend growth in the future. However, stock prices continue to rise during the following years, when the higher productivity has not yet materialized (the “anticipation phase”). The reason is that the equilibrium return on liquid assets is high during that

²In Alves et al. (2020), the authors analyze the implications of partly liquid profits for the transmission of monetary policy shocks in the two-asset HANK model. However, the liquid profits are not traded in that model, but accrue to households proportional to their idiosyncratic productivity. The contribution of the present paper is to analyze the valuation of *traded* liquid profits in response to news shocks.

time: households are less willing to save in liquid assets, since they expect higher future incomes, which lowers their precautionary-savings motive. The growth in labor and asset incomes occurs already during the anticipation phase, as the wealthy households' shift from liquid assets to illiquid assets in their portfolios causes an investment-driven business cycle boom. Since stocks are liquid, a higher return on liquid assets implies, for a given dividend-stream, a gradual growth in stock prices³.

Once the temporary acceleration in productivity growth materializes, the return on illiquid assets peaks and recedes back to its steady state value. Therefore, households who hold most of their wealth in the illiquid asset and thus are subject to high idiosyncratic risk at the same time face falling incomes — due to their declining asset income. Consequently, they demand more liquid assets for self-insurance, which depresses the return on liquid assets in equilibrium. This implies that stock prices, for a given dividend-stream, persistently fall after the productivity growth has peaked. The theory thus identifies the marginal trader of the stock price cycle: households with high illiquid wealth, who face the largest consumption fluctuations due to changes in illiquid asset returns, which cause large fluctuations (in absolute terms) in their asset income. The appreciation of the stock market during the anticipation phase is in part due to higher expected dividend growth, and in part due to the expected movements in the equilibrium return on liquid assets — the rate at which stock dividends are discounted.

The theory can be understood as proposing a time-varying *illiquidity premium*, rather than a time-varying aggregate risk premium (Campbell and Cochrane, 1999, Bansal and Yaron, 2004), as the main explanation for stock price fluctuations. I define the (ex-ante) illiquidity premium as the (expected) difference between the return on illiquid assets and the return on liquid assets⁴. The illiquidity premium varies due to the time-varying propensity to bear consumption risk at the *individual* level. The expectation of higher future returns on illiquid assets induces wealthy households to bear more consumption risk, by holding more illiquid assets, in the anticipation phase. Thus, the illiquidity premium is low in the anticipation phase. Once the investment and stock price boom subsides, the illiquidity premium rises above its steady state value, since the marginal traders have more illiquid portfolios and face falling incomes, so that liquid assets become

³It is important to note that the higher return on liquid assets is *expected* by households. As long as the return on liquid assets is expected to remain high, the demand for stocks is reduced, due to a no-arbitrage condition. The closer one gets to the moment where the return falls, the higher is the demand for stocks, and the higher is the stock price.

⁴In the literature, this is also called the liquidity premium, see e.g. Bayer et al. (2019).

more valuable. Since stocks are liquid, the growth in stock prices correlates negatively with the illiquidity premium. Kuvshinov (2022) compares the risk factor that causes fluctuations in stock prices with the risk factors that drive fluctuations in returns to housing and corporate bonds. He finds that the risk factors do not comove across asset classes. This finding is inconsistent with theories that hinge on aggregate risk, which affects all those assets, as the main cause of asset price fluctuations, while my theory can accommodate this evidence: stocks differ from housing and corporate bonds in their higher liquidity. In this paper, I analyze only the effect of the illiquidity premium on the stock price cycle, and abstract from an aggregate risk premium⁵.

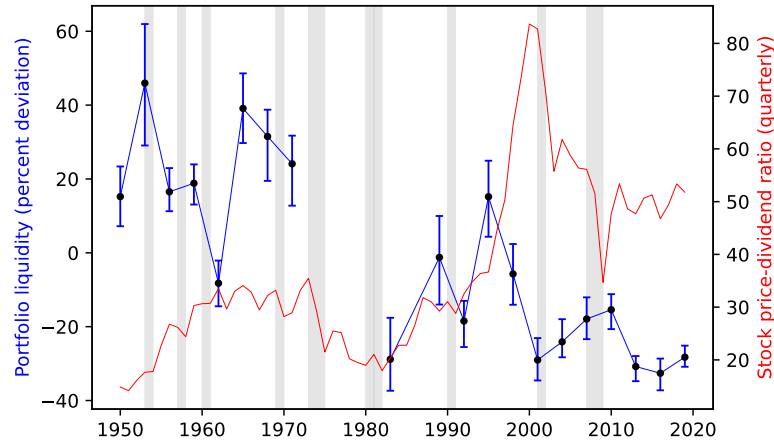
In my model, stocks are claims to a share of the profits of the monopolistically competitive firms in the economy. Stock-supply is time-invariant (normalized to one), so that I abstract from financing decisions of firms. The behavior of stock prices is solely explained by the households' demand for stocks. 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 bonds⁶. A consumption-based explanation of stock prices is in line with the empirical finding that among all commonly traded financial assets, public equity is directly held by households the most, followed by treasury bonds (Haddad and Muir, 2021). The authors also find that excess returns on stocks and treasury bonds are the least predictable — with a coefficient close to 0 — by the health of intermediaries in the economy. Hence, a theory that explains price fluctuations with frictions on the level of financial intermediaries, or institutional frictions, is less convincing for the case of stocks.

Liquid assets, like stocks or bonds, do not enter into the production function of the representative firm. Since I abstract from the firm's financing choices and frictions in the model, a stock price boom also does not ease the firm's financing constraints. Illiquid

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

⁶Such an arbitrage condition between stocks and government bonds is assumed, e.g., in Caballero and Simsek (2020).

Figure 1: Portfolio liquidity of “rentiers” 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.

assets, instead, aggregate to the capital stock in the economy, which is the most important production factor for the firm. In that sense, stocks in the model are “unproductive”. However, the only reason why liquid assets have value in the economy is a financial friction on the household side, namely, that capital is illiquid. When the returns on liquid assets like stocks rise during a stock price boom, households can afford to shift more wealth to the illiquid asset. Hence, a growing stock market is *indirectly* productive in the model by the virtue of households who use the additional liquid asset income to invest more in productive capital⁷. I calibrate capital in the model to fixed assets in the U.S. Bureau of Economic Analysis tables. A third of fixed assets is housing. At the same time, Asker et al. (2014) estimate that about half of investment in the non-residential sector is carried out by noncorporate private firms. In sum, around two thirds of productive capital in the U.S. economy is not financed by stock issuance. A part of the valuation of fixed assets is also due to (unproductive) market power by firms, which is passed through exclusively to stock-owners in the model. For these reasons, I view the modeling of stocks as unproductive assets as a useful approximation to the data.

The mechanism I propose to explain stock price boom-bust cycles has several testable implications. First, the theory hinges on a no-arbitrage condition between government

⁷Since there is a negative borrowing limit, the effect of government bond interest rates on investment is non-monotone — when the rates are expected to grow too high, households who borrow in the liquid asset will have to pay too much on their debt, which deters them from investing into illiquid assets. I revisit this case when discussing the effects of monetary and fiscal policy.

bonds and stocks. 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. Second, falling stock prices should coincide with falling capital rents, since the latter cause the fall in asset incomes of the marginal traders in the model. I find a positive correlation of about 0.26 in the data. Finally, 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 stems from capital income — the “rentiers” in the economy, who I identify as the marginal traders of the stock market — decrease their portfolio liquidity in stock price-booms, and increase it in stock price-busts, like the model predicts⁸.

In section 2, I demonstrate the mechanism in a highly stylized, but tractable model, that only considers the capital-wealthy subset of households that are the marginal traders of the stock market. In section 3, I explore the mechanism quantitatively in a heterogeneous agent New Keynesian (“HANK”) model with two assets. My analysis of stock price cycles in a general equilibrium setting uncovers the dependence of the stock price cycle on the elasticity of liquid asset supply. Since government bonds are liquid assets, they are in less demand once the news about higher productivity 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 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 in the anticipation phase, 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

⁸Specifically, the change in the relative portfolio liquidity of the “rentiers” over subsequently sampled years, and the growth in the stock price-dividend ratio, are negatively correlated at about -0.27 . See section 5 for a discussion of the evidence.

with a strong reduction of the aggregate liquid asset supply⁹. 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 wealth¹⁰.

I show that a sizable share of stock price fluctuations can be quantitatively accounted for by two alternative news shocks 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 temporary¹¹. 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, 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

⁹Domínguez-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 illiquidity 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 illiquidity 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.

¹⁰The effectiveness of investment in amplifying booms in HANK models with portfolio choice, where capital is illiquid, is highlighted in Auclert et al. (2020). Luetticke (2021) shows the importance of the redistribution towards high marginal propensity to invest (MPI) households for the transmission of monetary policy shocks.

¹¹Bianchi 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.

for the excess value added — the illiquidity premium. 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. Smith et al. (2019) document a rising share of value added that accrues to business owners who pass through firm profits to their own (capital) income, making them the top earners in the economy. My findings suggest that these households are the marginal traders of the stock market.

Related literature. Some of the channels through which time-varying idiosyncratic risk and heterogeneous portfolios affect equilibrium prices in this paper are also present in the more stylized model by Fernández-Villaverde et al. (2022): There, a representative financial expert rents capital to firms, financed via the issuance of risk-free bonds, and consumes nothing but the returns from her investment. At the same time, households that are subject to idiosyncratic income risk can save in the bonds issued by the financial expert, but are not able to access the capital market on their own. The critical financial friction is that the financial expert cannot share her capital risk with the other households. Similarly to my model, the dominance of capital income in the financial expert’s budget provides a strong incentive to increase their investment, by issuing more debt, upon the expectation of higher excess returns on capital. Fernández-Villaverde et al. (2022) solve the model globally and show that in the “high leverage”-stochastic steady state, recessions caused by negative aggregate capital shocks are more severe than in the “low leverage”-stochastic steady state. While that paper focuses on “supercycles”, where the state of the economy fluctuates between these two stochastic steady states, I analyze the effect of these channels at the business cycle-frequency, with a special focus on anticipation and the valuation of liquid assets, and in a richer general equilibrium-setting.

Papers within the consumption-based asset pricing framework have shown to be able to generate stock return-predictability by imposing special preferences (Campbell and Cochrane, 1999), or special stochastic processes that households face (Bansal and Yaron, 2004), among others¹². Kekre and Lenel (2022) explain the stock market response to a monetary policy shock through its effect on the risk premium within a HANK model with portfolio choice, and calibrate it using the Survey of Consumer Finances, as I do in this paper. They assume heterogeneity in risk aversion, which allows for the comovement of investment and stock prices: when a shock redistributes towards households with lower

¹²In many models, a reduced-form “discount rate shock” is introduced instead; see for a discussion of the leading asset pricing models also Gormsen (2021).

risk aversion, investment rises, while the risk premium falls. In my model, the heterogeneity in the *individual* riskiness of portfolios, by means of their liquidity, comes about endogenously (as an outcome of optimal portfolio choices in response to idiosyncratic and aggregate shocks).

A burgeoning literature challenges the assumption of rational expectations in explaining asset price fluctuations, and especially asset price “puzzles”, on the basis of survey data (Adam et al., 2017, Bordalo et al., 2020, Beutel and Weber, 2022). This literature finds evidence for irrational optimism about future stock returns during stock price booms. As solution, variants of subjective expectations that have an extrapolative component, and may be rational for forecasting future stock prices under information asymmetry, are proposed by many authors. However, in this forecasting exercise, households would form only partial equilibrium expectations, instead of forming conditional expectations, given the observed positive correlation of stock price- with business cycle-booms. Adam and Merkel (2019) develop a model with learning where surprise productivity shocks can trigger an endogenous belief propagation that gives rise to boom-bust cycles in stock prices and investment. The mechanism I propose abstracts from learning, as the anticipation of higher future returns on capital is modelled as an exogenous news shock. Through the lense of my model, and in contrast to the results in Adam and Merkel (2019), the expectations about temporarily higher future productivity are accurate on average (I discuss noise shocks in section 5). While my model fails to generate observed irrational swings in expectations¹³, it matches observed patterns in households portfolios over the stock price cycle.

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 trader (or “marginal saver”) optimally holds no assets. Since the impact of aggregate risk on households’ budgets is small, the marginal trader 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

¹³However, Bordalo et al. (2020) gives empirical support to the importance of long-run expectations about fundamentals during stock price-booms.

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 returns on liquid assets 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 households¹⁴. In sum, 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 shocks¹⁵. 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 in the data (see section 5). The low real

¹⁴In a related paper, Bilbiie et al. (2022) 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.

¹⁵Beaudry 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.

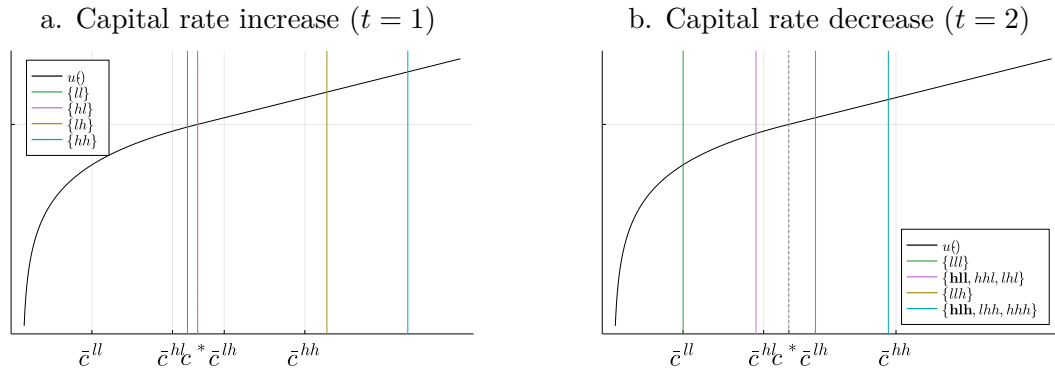
rate is inefficient, since a positive news shock, which increases consumption of households in the future, raises the natural rate today. In the model with heterogeneous agents, instead, the business cycle boom coincides with a high real rate. Liquid savings are not held down by an inefficient monetary 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)¹⁶.

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 literature¹⁷ and amended 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 heterogeneous 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 I investigate the quantitative success of the mechanism as the main driver of stock price fluctuations in a simulation exercise under different specifications of dividend cyclicity and news accuracy. Section 6 concludes.

¹⁶Görtz et al. (2022) build a RANK model with financial frictions and show that a financial accelerator enables news to cause a business cycle boom. In an estimation exercise, they find that news shocks account for about half of the fluctuations in real business cycle variables. 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.

¹⁷I am building on the HANK model with portfolio choice by Bayer et al. (2022) which is estimated using U.S. business cycle and inequality data from 1954 onwards.

Figure 2: Optimal consumption levels



Notes: $\{\dots y_{t-1} y_t\}$ 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 return on liquid assets. 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 phase¹⁸. I apply the technique by Challe and Ragot (2016) to make heterogeneous agent models with a non-degenerate wealth distribution tractable.

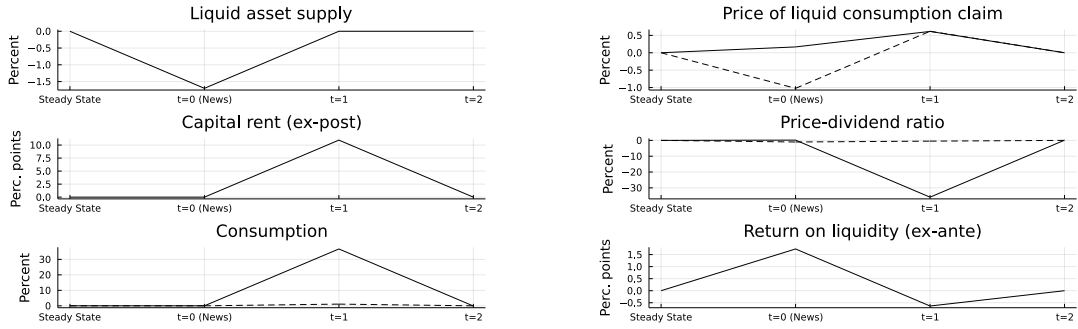
Consider a unit mass of households who hold two assets, a liquid asset and a fixed amount of illiquid capital. They can borrow in the liquid asset up to the constraint $\underline{L} < 0$. Their income encompasses interest on the assets they hold, and idiosyncratic income $y \in \{l, h\}$, $l < h$, which follows a stochastic Markov process. They derive utility each period from consumption c , where the utility function $u(\cdot)$ is concave up to point c^* , and has a constant slope afterwards.

The steady state is calibrated¹⁹ such that all households that receive the low income, l ,

¹⁸This 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.

¹⁹Table A.1 in the appendix shows the values of the parameters.

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 $t = 0$. Dashed lines are for the case with a share of $\alpha = 97\%$ perfectly insured, capital-poor households (see section 2.2).

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

The grey lines in figure 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 return on the liquid asset. For simplicity, I assume the income process to be symmetric²⁰, 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).

²⁰I choose the conditional probabilities of losing a high income (e.g. job separation) and gaining a high income (e.g. job finding) to sum to 100%.

In a second step, I consider the case where the capital rent increase is anticipated one period in advance. To keep the solution tractable, I require that the optimal consumption and liquid asset choices stay the same as above, once capital rents change. This implies that unconstrained households decide to fully insure themselves upon the news (since next period, even if they get low income, they will be unconstrained due to higher capital income). Therefore, the equilibrium return on liquid assets has to increase to $1/\beta - 1$ (β 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 return on liquid assets (ex-ante), the price of a liquid consumption claim (i.e. the “stock” price), and its price-dividend ratio, to this experiment. The price of the consumption claim appreciates at the onset of the news. It is also higher than steady state in period $t = 1$, due to the lower liquid asset return then. The price-dividend ratio also increases upon the news. However, the increase in the dividends, once the capital rent rises in the subsequent period, has a larger effect in this calibration. Still, the result illustrates how anticipation can generate a stock price cycle as seen in the data, i.e. high stock prices followed by low returns.

2.1 Equilibrium prices from household optimization

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

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

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

$$\frac{1}{R_t} \geq \mathbb{E}_t^i [SDF_{t+1}^i] \quad \forall i. \quad (2)$$

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

- When liquid asset returns are above steady state, $R_0 > \bar{R}$, it must hold that $\mathbb{E}_0^i [SDF_1^i] < \overline{ESDF}^i$ for all households i ²¹
- When liquid asset returns are below steady state, $R_1 < \bar{R}$, there *exists* a household j where $\mathbb{E}_1^j [SDF_2^j] > \overline{ESDF}^j$. j must be unconstrained by the borrowing limit on liquid savings.

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

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

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

where $\gamma := u'(c) \forall c \geq c^*$ is the slope at the linear part of the utility function, and π^{hl} denotes the conditional probability of falling to the low income level from the high income level. The condition $\mathbb{E}_1^h [SDF_2^h] > \overline{ESDF}^h$ is then equivalent to $c_2^{hl} - \bar{c}^{hl} = R_1 b' - \bar{R} \bar{b}$ being strictly negative. This is the case, as $R_1 < \bar{R}$ and $b' < \bar{b}$. Intuitively, the additional income from the illiquid asset holding in period $t = 1$ allows more households to purchase consumption claims for period $t = 2$, which, by goods market clearing, implies that the high-income households expect to consume less, and are therefore willing to save at a lower rate.

2.2 Extension: segmented markets

The fluctuation of aggregate consumption in this model economy, where all households hold a large amount of illiquid capital they cannot use to smoothe income shocks, while

²¹ \overline{ESDF}^i denotes the steady state expected stochastic discount factor of household i .

they are close to the borrowing constraint in liquid assets, is two orders of magnitudes too large compared to quarterly consumption fluctuations in U.S.-data. This is by design: the example was built to illustrate the consumption risk that these “wealthy hand-to-mouth” households are exposed to, who are then pricing the liquid asset. The idea that incomplete markets can generate realistic price fluctuations, while aggregate consumption remains flat, follows the seminal work by Constantinides and Duffie (1996). In order to clarify this contribution of my paper, I now insert more households into the model economy.

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

$$\frac{1}{R_t} \geq E_t^\alpha [SDF_{t+1}^\alpha] = \beta, \quad (4)$$

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

Let α denote the share of perfectly insured households that do not hold capital in the economy. Since they have no income besides l or h , they consume the constant $c_t^\alpha = \pi^l l + (1 - \pi^l)h =: \bar{y}$. Households who hold capital, but cannot trade Arrow securities to insure themselves against income shocks, consume $\tilde{c}_t := \sum_{j \in J} \pi^j c_t^j$, where J encompasses all possible income histories $\{lll\}, \{hll\}, \dots, \{hhh\}$, and π^j is the probability weight of these histories. The aggregate consumption is then given by $c_t = \alpha \bar{y} + (1 - \alpha)\tilde{c}_t$. Choosing α high enough such that the consumption of insured, capital-poor households makes up more than 90% of aggregate consumption in steady state then yields an attenuation of aggregate consumption fluctuations by almost two orders of magnitude²², while the fluctuation in the returns to the liquid asset remain unchanged (see the dashed lines in figure 3). The

²²Choosing $\alpha = 0.97$, which corresponds to the 2.7% of households whose income is dominated by capital income in the full model (see below), yields a peak-increase of aggregate consumption of about 1%, a factor 35 reduction from the case without insured households.

movements in the price-dividend ratio are attenuated; in the quantitative model, stocks are only claims to a fraction of output, and dividend payments are smoothed out, so that return volatility will have a bigger impact on the price-dividend ratio.

2.3 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 $B \rightarrow L$, 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 quantitative 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 in 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 illiquidity 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 illiquidity 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 A HANK model of the stock market

The model economy consists of heterogeneous households, who are subject to idiosyncratic income shocks and stochastic (illiquid) capital market access, a production sector with intermediate goods producers, who hire workers and rent capital, and final goods producers, who set prices subject to price adjustment costs, and a government sector, where a monetary and a fiscal authority react to business cycle conditions by setting the nominal interest rate and the bond supply according to fixed rules. In the following, I describe each sector individually, before stating the market clearing conditions and giving the definition of the equilibrium of the model²³. The model is partly calibrated to aggregate data of the U.S. economy from 1954 to 2015, and partly estimated by Bayesian methods (see Bayer et al. (2022)). One period denotes one quarter. \bar{X} denotes the steady state value of variable X , and \hat{X} the relative deviation of X from \bar{X} .

²³The model setup, with the exception of the modelling of aggregate shocks and the inclusion of liquid stocks, is the same as in Bayer et al. (2022). This is a shortened version of their exposition.

3.1 Households

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

$$h_{it} = \frac{\tilde{h}_{it}}{\int \tilde{h}_{it} di}, \quad (5)$$

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

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

The choice of labor supply is greatly simplified by assuming Greenwood-Hercowitz-Huffman (GHH) preferences. They are represented by subtracting the disutility of work, $G(h_{it}, n_{it})$, from the consumption good *within* the felicity function, i.e. $u(c_{it} - G(h_{it}, n_{it}))$. In this setting, an increase in working hours directly increases the marginal utility of consumption, which offsets the typical consumption-labor tradeoff that arises with separable

disutility of labor, namely that more work is only compatible with a smaller consumption level. As a result, optimal labor supply is a function only of the net labor income, independent of consumption²⁴. 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

$$y_{it} = (1 - \tau^L)(w_t h_{it} n_{it})^{1 - \tau^P}, \quad (6)$$

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} ²⁵. In this case, their payment to the lender consists of the nominal liquid rate, R_t^L , plus a wasted intermediation cost, \bar{R} . Each period, a household's chance of participating in the market for illiquid assets, and being able to adjust k_{it+1} , is given by the fixed probability λ . This trading friction renders capital illiquid. The capital good's price in period t is q_t . From holding capital, households earn a capital rent r_t . The household's budget constraint sums up to

$$c_{it} + b_{it+1} + q_t k_{it+1} = y_{it} + \mathbb{1}_{h_{it} \neq 0} (1 - \tau) \Pi_t^U + \mathbb{1}_{h_{it} = 0} y_t^e + (q_t + r_t) k_{it} + \left(\frac{R_t^L}{\pi_t} + \mathbb{1}_{\{b_{it} < 0\}} \frac{\bar{R}}{\pi_t} \right) b_{it}, \quad (7)$$

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

²⁴Jaimovich and Rebelo (2009) propose a class of preferences that nests both King-Plosser-Rebelo (KPR) and GHH preferences, which was then adopted by Schmitt-Grohé and Uribe (2012) and others in their structural estimation of the impact of news shocks. The reason is that GHH preferences, that shut down the wealth effect on labor supply, are helpful in generating booms from news shocks. Hence, having a preference class where this wealth effect enters as a parameter, which can be estimated, gives news shocks a higher chance to fit the data. Schmitt-Grohé and Uribe (2012), as well as Born and Pfeifer (2014) and Bayer et al. (2022) in models without news shocks, find that close to GHH preferences provide the best fit to the data.

²⁵Since all households hold a share of their liquid wealth in stocks, for negative liquid wealth they symmetrically do some of their borrowing in stocks ("short-selling" stocks).

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

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

$$\begin{aligned} V_t^a(b, k, h; \Theta, \mathcal{P}, \Omega) &= \max_{k', b'_a} \{u[x(b, b'_a, k, k', h)] + \beta \mathbb{E}_t V_{t+1}(b'_a, k', h; \Theta', \mathcal{P}', \Omega')\}, \\ V_t^n(b, k, h; \Theta, \mathcal{P}, \Omega) &= \max_{b'_n} \{u[x(b, b'_n, k, k, h)] + \beta \mathbb{E}_t V_{t+1}(b'_n, k, h; \Theta', \mathcal{P}', \Omega')\}, \quad (8) \\ \mathbb{E}_t V_{t+1}(b', k', h; \Theta', \mathcal{P}', \Omega') &= \mathbb{E}_t[\lambda V_{t+1}^a(b', k', h; \Theta', \mathcal{P}', \Omega')] \\ &\quad + \mathbb{E}_t[(1 - \lambda)V_{t+1}^n(b', k, h; \Theta', \mathcal{P}', \Omega')], \end{aligned}$$

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

3.2 Tradable profit-stocks

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

$$\tilde{\Pi}_t^F := \xi^\Pi(\Pi_t^F + NW_{t-1}^\Pi R_t^b / \pi_t) + (1 - \xi^\Pi)\Pi^F \quad (9)$$

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

then becomes

$$y_t^e := (1 - \tau^L)((1 - \omega^\Pi)\tilde{\Pi}_t^F + \iota^\Pi q_t^\Pi)^{1-\tau^P} \quad (10)$$

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

$$\mathbb{E}_t \frac{R_{t+1}^B}{\pi_{t+1}} = \mathbb{E}_t \frac{q_{t+1}^\Pi(1 - \iota^\Pi) + \omega^\Pi \tilde{\Pi}_{t+1}^F}{q_t^\Pi}. \quad (11)$$

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

$$\frac{R_t^L}{\pi_t} = \frac{B_t}{L_t} \cdot \frac{R_t^B}{\pi_t} + \frac{q_t^\Pi(1 - \iota^\Pi) + \omega^\Pi \tilde{\Pi}_t^F}{L_t}. \quad (12)$$

3.2.1 Accounting of capital gains

To be in line with the data (see below), I count capital gains as part of wealth-gains instead of income. Capital gains can accrue from illiquid capital, $\frac{q_t}{q_{t-1}}$, if households can trade their capital holdings in period t , and liquid stocks, $\frac{q_t^\Pi}{q_{t-1}^\Pi}$. The budget constraint (7) is already formalized in a way that illiquid capital gains count as wealth-gains. For the liquid asset, instead, I introduce the liquid asset *value*

$$q_t^L := 1 + \frac{q_t^\Pi - q_{t-1}^\Pi}{L_t}. \quad (13)$$

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

$$r_t^{L,net} := \frac{R_t^L}{\pi_t} - q_t^L = \frac{B_t}{L_t} \cdot \left(\frac{R_t^B}{\pi_t} - 1 \right) + \frac{\omega^\Pi \tilde{\Pi}_t^F - \iota^\Pi q_t^\Pi}{L_t} \quad (14)$$

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

$$\left(\frac{R_t^L}{\pi_t} + \mathbb{1}_{\{b_{it} < 0\}} \frac{\bar{R}}{\pi_t} \right) b_{it} = \underbrace{\left(r_t^{L,net} + \mathbb{1}_{\{b_{it} < 0\}} \frac{\bar{R}}{\pi_t} \right) b_{it}}_{\text{net liquid income}} + \underbrace{q_t^L b_{it}}_{\text{liquid wealth}} \quad (15)$$

3.3 Production sector

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

$$\log\left(\frac{\pi_t^W}{\bar{\pi}_W}\right) = \beta \mathbb{E}_t \log\left(\frac{\pi_{t+1}^W}{\bar{\pi}_W}\right) + \tilde{\kappa}_w \left(\frac{w_t}{w_t^F} - \frac{1}{\mu^W}\right), \quad (16)$$

where $\pi_t^W = \frac{W_t^F}{W_{t-1}^F}$ is the gross wage inflation, w_t and w_t^F are the real wages for households and firms, $\frac{1}{\mu^W} = \frac{\zeta-1}{\zeta}$ is the target markdown of wages, and $\tilde{\kappa}_w$ is determined by the probability of wage-adjustment, κ_w ²⁶. The return to the unions is then given as $\Pi_t^U = (1 - \frac{1}{\mu^W})N_t w_t^F$ in real terms.

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

$$Y_t = A_t N_t^{1-\alpha_t} (u_t K_t)^{\alpha_t}, \quad (17)$$

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

$$\log(A_t) = \rho_A \log(A_{t-1}) + \epsilon_{t-\ell}^{A,\ell} + \epsilon_t^A, \quad (18)$$

$$\alpha_t = (1 - \rho_\alpha)\bar{\alpha} + \rho_\alpha \alpha_{t-1} + \epsilon_{t-\ell}^{\alpha,\ell} + \epsilon_t^\alpha, \quad (19)$$

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

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)

²⁶It holds that $\tilde{\kappa}_w = \zeta \kappa_w \frac{\mu^W - 1}{\mu^W}$.

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

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

$$w_t^F = (1 - \alpha_t)mc_t A_t (u_t K_t / N_t)^{\alpha_t}, \quad r_t + q_t \delta(u_t) = u_t \alpha_t mc_t A_t (N_t / u_t K_t)^{1 - \alpha_t}. \quad (20)$$

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

$$q_t \delta'(u_t) = \alpha_t mc_t A_t (N_t / u_t K_t)^{1 - \alpha_t}. \quad (21)$$

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

$$\log\left(\frac{\pi_t}{\bar{\pi}}\right) = \beta \mathbb{E}_t \log\left(\frac{\pi_{t+1}}{\bar{\pi}}\right) + \tilde{\kappa} \left(mc_t - \frac{1}{\mu^Y} \right), \quad (22)$$

where $\mu^Y = \frac{\eta}{\eta-1}$ is the target markup, and $\tilde{\kappa}$ is determined by the probability of price adjustment, κ^{27} . The rent of the final goods firms is $\Pi_t^F = Y_t(1 - mc_t)$ in real terms.

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

²⁷It holds that $\tilde{\kappa} = \eta \kappa \frac{\mu^Y - 1}{\mu^Y}$.

maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t I_t \left\{ q_t \left[1 - \frac{\phi}{2} \left(\log \frac{I_t}{I_{t-1}} \right)^2 \right] - 1 \right\}. \quad (23)$$

Up to first order, the problem reduces to the equation

$$q_t \left[1 - \phi \log \frac{I_t}{I_{t-1}} \right] = 1 - \beta \mathbb{E}_t \left[q_{t+1} \phi \log \frac{I_{t+1}}{I_t} \right], \quad (24)$$

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

$$K_t - (1 - \delta(u_t))K_{t-1} = \left[1 - \frac{\phi}{2} \left(\log \frac{I_t}{I_{t-1}} \right)^2 \right] I_t. \quad (25)$$

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:

$$\frac{R_{t+1}^B}{R^b} = \left(\frac{R_t^B}{R^b} \right)^{\rho_R} \left(\frac{\pi_t}{\bar{\pi}} \right)^{(1-\rho_R)\theta_\pi} \left(\frac{Y_t}{Y_t^*} \right)^{(1-\rho_R)\theta_Y}. \quad (26)$$

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

$$\frac{B_{t+1}}{B_t} = \left(\frac{B_t}{\bar{B}} \right)^{-\gamma_B} \left(\frac{\pi_t}{\bar{\pi}} \right)^{-\gamma_\pi} \left(\frac{Y_t}{Y_t^*} \right)^{-\gamma_Y}. \quad (27)$$

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

$$\tau \mathcal{B}_t = \mathcal{B}_t - (1 - \tau^L) \mathcal{B}_t^{(1-\tau^P)}. \quad (28)$$

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: $G_t = T_t + B_{t+1} - B_t \frac{R_t^b}{\pi_t}$. 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 (20). The market for liquid assets clears when liquid asset demand, which is given by the households' optimal decisions, $L_t^d = \mathbb{E}[\lambda b_{a,t}^* + (1 - \lambda)b_{n,t}^*]$, equals the supply of liquidity $L_{t+1} = B_{t+1} + q_t^\Pi$ (as L_t^d is the aggregate over positive and *negative* private liquid asset holdings, the supply of liquid assets is bigger than L_{t+1} in gross terms). Similarly, the price of capital q_t , which is determined by (24), 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 $\mathcal{P}_t = \{w_t, w_t^F, \Pi_t^F, \Pi_t^U, r_t, q_t, q_t^\Pi, \pi_t, \pi_t^W, R_t^B, R_t^L, \tau_t, \tau_t^L\}$, 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 (8).
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)²⁸.

²⁸For the implementation of the methods, I make use of and extend the Julia package "BASEforHANK" by Bayer et al. (2022), available on <https://github.com>.

3.6 Definitions and parameter choice

3.6.1 Classification in liquid and illiquid assets

For the classification of assets in the data into the liquid and illiquid categories, I largely follow Kaplan et al. (2014): Illiquid assets, which are assumed to be productive in the model, consist of positive wealth in housing²⁹, 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 analysis³⁰.

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 sectors³¹. Assuming an initial R&D phase of two years on average, in which intangible capital is produced (while physical capital is pledged as collateral), followed by the phase in which goods are produced using the physical capital and the depreciating intangible capital, I arrive at an

²⁹This 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).

³⁰Consumer 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.

³¹Fittingly, Adam and Weber (2023) estimate from product data in the UK the median quarterly turnover rate of consumer products as 13.7%.

Table 1: Calibrations

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

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

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

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

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

Table 2: Estimated parameters (selected)

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

terly dividend growth of the S&P 500 at $\xi^\Pi = 0.05^{32}$. The fractions ω^Π and ι^Π are calibrated to yield a share of liquid assets held in stocks of 39%³³ and a quarterly stock price-dividend ratio of 144³⁴, which implies $\omega^\Pi = 4.7\%$ and $\iota^\Pi = 0.074\%$. I set $\bar{\eta} = 13.5$ and $\bar{\zeta} = 11$, which implies price and wage markups of 8% and 10%, respectively. The real liquid rate is chosen to be 2.5% p.a., while the borrowing penalty \bar{R} is set to 7.5% p.a. in order to roughly match the share of borrowers with the data. The steady state capital rent is $\bar{r} = 3.7\%$ p.a., implying a steady state illiquidity premium of 1.2% p.a. As estimate for the capital rent, I take the series by Gomme et al. (2011) (including housing, without capital gains, after-tax), which has an average yearly return of 5.6% from 1950 to 2016. Since the model abstracts from long-run technological growth, 2% yearly growth should be subtracted from the counterpart 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)

³²The standard deviation is calculated from simulating the model subject to random innovations in capital share-news shocks, and (surprise) markup and TFP shocks; see section 5.

³³From 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%.

³⁴This is the mean of the S&P 500 stock price divided by dividends amassed over the quarter, from 1948 to 2016. Its inverse, the dividend yield, implies an average return on stocks *without* capital gains of 2.9% annualized. Net of stock depreciation, the return becomes 2.5% p.a., as for all liquid assets in the model economy.

and 3-months treasury bills, I compute average yearly returns of 8.3%, 2.5%, and 0.7%, respectively, over the period from 1950 to 2016. The liquid rate in the model should be considered as a weighted average of these rates³⁵.

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 roughly 18%. With respect to the parameters that Bayer et al. (2022) estimated, I choose those estimates where inequality data was included in the estimation (the HANK* specification). Importantly, I deviate with respect to the fiscal rule, where I estimate γ_π and γ_Y so that the ratio of the magnitude of the profits- and the magnitude of the bonds-response in the anticipation phase of the news shock matches the respective ratio in the late 1990s³⁶. Table 2 lists the chosen values for a selection of parameters in the model.

4 A news-induced stock price cycle

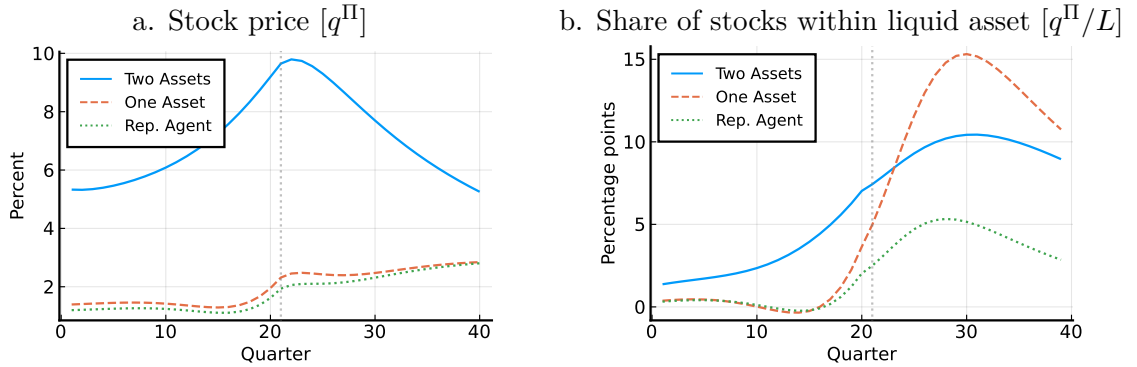
I consider the following experiment: with an anticipation horizon of 5 years ($\ell = 20$)³⁷, households become aware that the capital share will increase (by two times its standard deviation). As outlined in the introduction, one can interpret the capital share increase as a temporary change in the 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.

³⁵The introduction of aggregate risk, that would allow to differentiate among the classes of liquid assets by their model-implied riskiness, would be an advantage for this part of the calibration. For stock holdings, one should account for the capital gains tax rate of 15-25% over the sample for wealthy households, and discount dividends by 2% long-run growth. Additionally, the financial intermediation wedge of 1.5-2% as calculated by Philippon (2015) reduces the effective rate of financial assets for households.

³⁶I define the magnitude of the impulse response as the distance between the maximum and the minimum of the percent deviations in the anticipation phase. I constrain both γ_π and γ_Y to the interval $[-10.0, -0.01]$, and search for a global minimum using a Simulated Annealing-algorithm. The estimated bond supply is much more elastic, i.e. the government stabilizes inflation and the output gap more aggressively, than what was estimated by Bayer et al. (2022) for the whole period since 1960. The reason is that in the late 1990s, the U.S. government strongly reduced their debt.

³⁷I choose an anticipation horizon of five years to be close to the dotcom-boom example: Karnizova (2012) estimates increased “productivity prospects” around 1995, while in 2000, the NASDAQ peaks.

Figure 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).

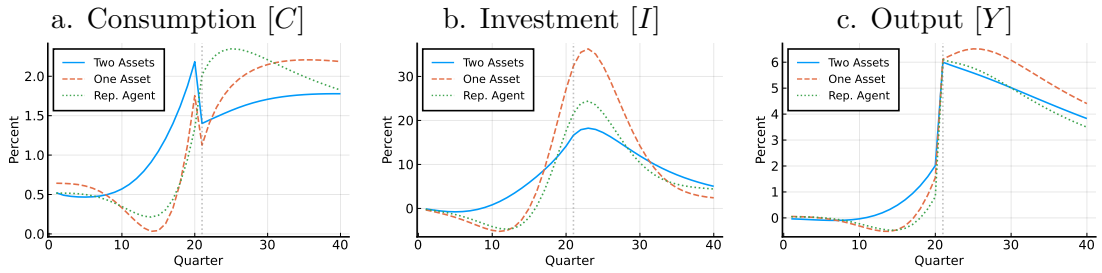
Figures 4 and 5 present the response of the stock price and business cycle variables across three model variants: *Two Assets* denotes the baseline model with heterogeneous agents and portfolio choice between liquid and illiquid assets. *One Asset* retains the market incompleteness, but takes away the portfolio choice: every household holds a representative portfolio, which is determined by the bond supply rule and the ex-ante illiquidity premium being fixed at a steady state level of zero³⁸. This implies that capital becomes liquid in this setting. *Rep. Agent* additionally takes away market incompleteness, and is thus a model of the RANK variety³⁹.

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

³⁸The ex-ante illiquidity premium is defined up to first order as the difference between the expected return on capital and the expected return on liquid assets, $\frac{\mathbb{E}_t(q_{t+1} + r_{t+1})}{q_t} - \frac{R_t^b}{\mathbb{E}_t \pi_{t+1}}$.

³⁹The household's time-preference β is calibrated in the RANK and the One Asset-varieties such that the real rate on the asset in steady state equals that of the baseline Two Asset-model. This implies that also the steady state stock price-dividend ratio is equal across all three varieties.

Figure 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).

a higher real interest rate in equilibrium.

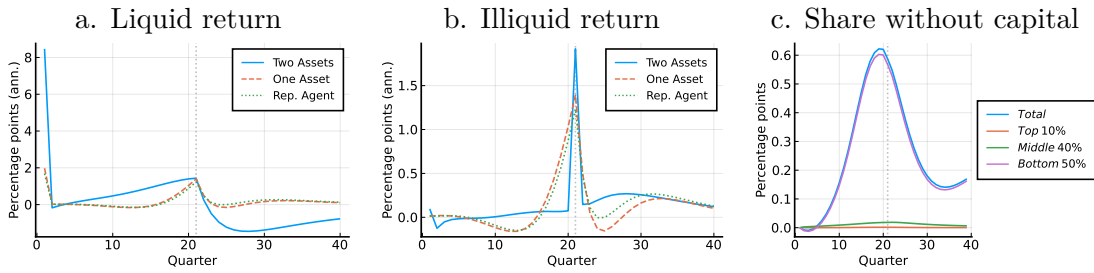
Figure 6 shows the response of the (ex-post) returns to the two asset classes, liquid and illiquid assets, across the model varieties. It is clear that without a time-varying illiquidity premium, the expected returns are the same between asset classes (the liquid asset return jumps up at the onset of the news, as the stock appreciates unexpectedly). In contrast, with illiquid capital, the illiquidity premium declines during the anticipation period (the return on liquid assets increases) and rises after the stock price-peak (the return on liquid assets falls). I also show the change in the share of households without capital. While rich households increase their capital holdings during the boom (intensive margin), poor households are deterred of holding capital by the lower premium (extensive margin). Since the liquidity premium rises after the boom, the demand for capital rises, which increases the capital price.

The increasing real interest rate in the anticipation period does not depress the economy; to the contrary, it stabilizes the income of richer households by increasing their return on liquidity (figure 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

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. Wealth groups in Panel c) are defined in the *cross-section* each quarter.

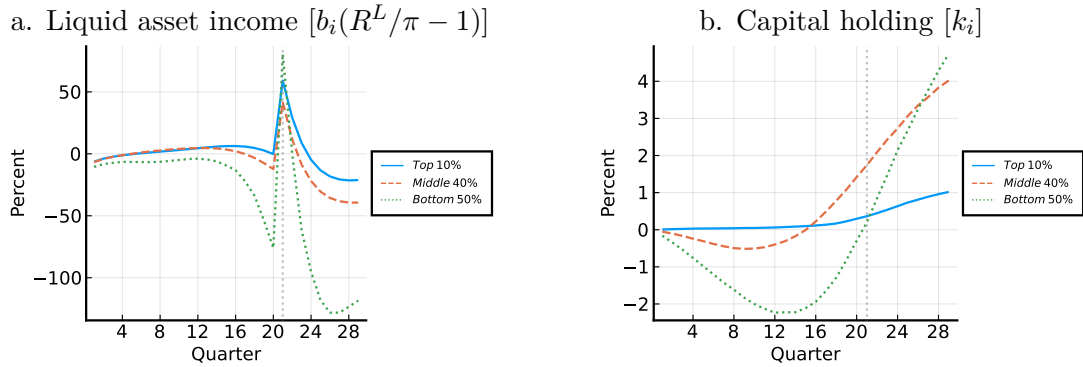
aggregate observations from 1995 to 2000⁴⁰. In terms of real business cycle variables, the model exactly replicates the 6% rise in output and the 15% increase in investment, while it only accounts for one third to one half of the observed increase in consumption. As noted above, I calibrate the fiscal rule so that the model responses match the ratio of the decline in U.S. government debt to the decline in corporate profits during the late 1990s. In absolute size, the model explains about 75% of the observed declines in government bonds and profits (notably, federal debt held by the public declined by 20% during that time).

The shortcoming with respect to aggregate consumption may be due to the fixed debt limit in the model, while in reality, financial innovation related to collateral borrowing might have allowed households to consume more. Considering only unsecured borrowing, I find that the model accounts for half of the 30% increase in consumer credit. In the model, the increase in borrowing, mostly by the bottom 50% of households, contributes to the overall increase in wealth inequality during the anticipation period. From the World Inequality Database, the Gini index of wealth increased by 1.25% in that time span; the model explains about half of this increase⁴¹. 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

⁴⁰I 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].

⁴¹This is remarkable, since the model does not feature heterogeneous stock shares; in the data, rich households gain disproportionately from stock price booms, see Kuhn et al. (2020).

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



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

around a 25% of this increase⁴².

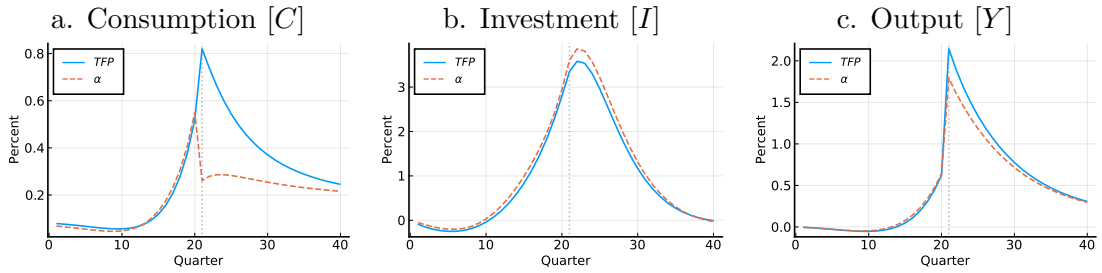
4.2 Alternative news shock

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 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

⁴²A more detailed model of stocks and their difference compared to other liquid assets, namely the different aggregate risk they carry, could help explaining this gap. Institutional changes, or agents that learn about the fundamentals over time, receiving observed prices as signals, would be other possible explanations.

Figure 8: Response of business cycle to alternative news shock



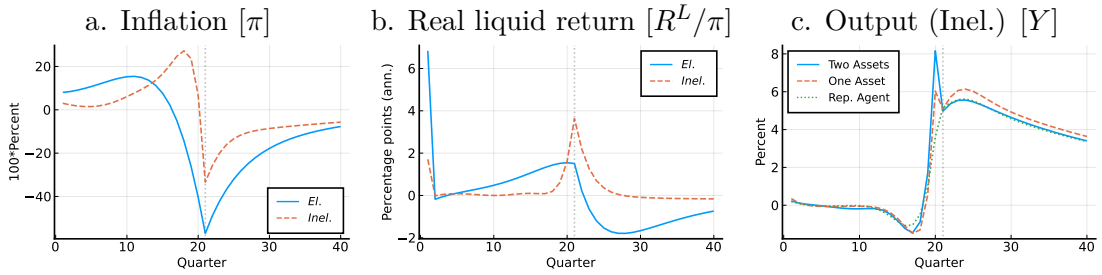
Notes: Model impulse responses are to news about a temporary TFP-increase in 5 years, and to news about a temporary capital share-increase in 5 years (both quarter 21). The size of the capital share-impulse is scaled to fit to the TFP news shock (given by two times σ_A). For comparability, the persistence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

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 rule that allows for a prolonged rise of inflation during the anticipation phase, middle class households do not invest enough to start the business cycle (and stock price) boom. The reason is that inflation depresses asset returns and magnifies the increase in the marginal costs of firms (affecting the entrepreneurs) and of unions (affecting the workers) late in the anticipation phase. The expectation of being exposed to these income losses discourages the households' capital investment earlier in the cycle. As a result, even in the model with portfolio choice, government expenditure is crowded out too late to drive the boom, and therefore all three model variants exhibit roughly the same output-response (as well

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

as consumption-response) to the news shock.

4.4 Wealthy hand-to-mouth households

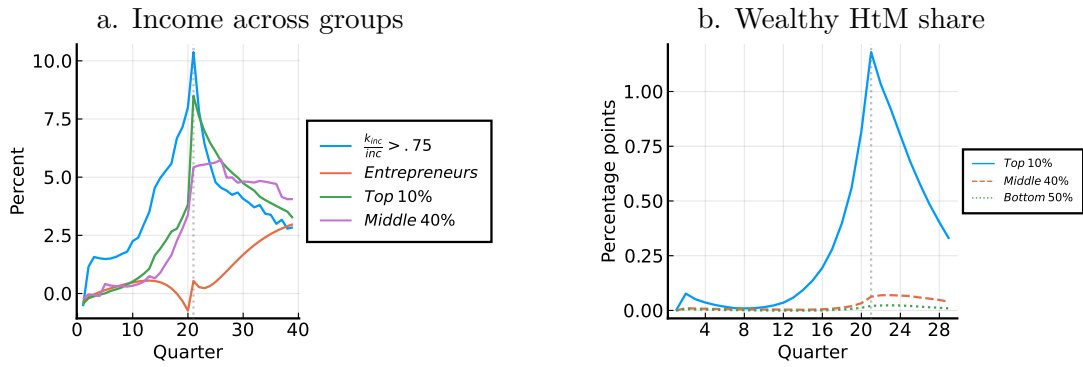
Following Kaplan et al. (2014), wealthy hand-to-mouth households are households that have non-zero wealth in the illiquid asset ($k_i > 0$), while being at a kink in the budget set: either at zero liquid savings ($b_i = 0$), or at the borrowing limit ($b_i = \underline{B}$). Motivated by my numerical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

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

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

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

Figure 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*.

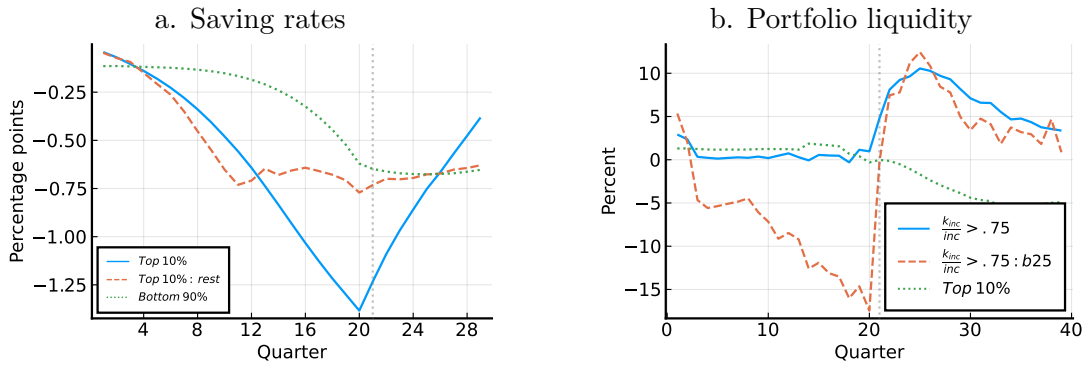
the anticipation period, so that more households will refrain from doing so (as discussed above, higher real rates *earlier* in the cycle instead are beneficial for investment).

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). Entrepreneurs, who receive the profit income, experience an income rise at the onset of the capital share increase, but lose in the anticipation period. Therefore, entrepreneurs are less likely to become wealthy hand-to-mouth households in the anticipation phase⁴³. 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). In steady state, only 0.2% of households are wealthy hand-to-mouth (at the borrowing limit). 73% of those households are in the top 10% of the wealth distribution. I find that during the stock price boom, the share of wealthy hand-to-mouth households among the wealthiest decile grows by 10%. Hence, by far the largest inflow into the group of wealthy hand-to-mouth households comes from capital-wealthy households, who optimally choose to get at or near the borrowing constraint so that they can hold on to the capital a little longer.

⁴³What is more, entrepreneurs on average 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-distribution for these households. All groups are defined in the *cross-section* each quarter.

4.5 Marginal traders

How can it be known whether the mechanism highlighted in section 2 is at work in the full HANK model? To show this, I split up households into those that were wealthy hand-to-mouth at some period s after the news shock, and became unconstrained at the subsequent period $s + 1$, and the *rest*. The idea is that it should be the saving behavior of the first group, and not of the *rest* of households, that explains the time-varying returns on liquid assets during the cycle. Figure 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 return on liquid assets⁴⁴. Note that, since the aggregate supply of liquid assets is down,

⁴⁴One may be worried that, since aggregate consumption also decreases after the temporary shock to the capital share, the lower rates are due to a general decline in consumption. However, the results are robust for a news shock about a very persistent TFP increase ($\rho_A = 0.992$). In that scenario, almost

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

Figure 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 state⁴⁵. Therefore, I also show the mean response of the lowest quartile in the portfolio liquidity distribution of these households. The marginal traders will be in this region of the distribution during the anticipation phase. I find that households with high capital income in that region of the distribution lower their portfolio liquidity during the anticipation phase. After the boom, the “rentiers” increase their liquid saving - their portfolio liquidity rises - as they are exposed to high consumption risk at that point. This depresses the real rate on liquid assets in equilibrium.

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

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

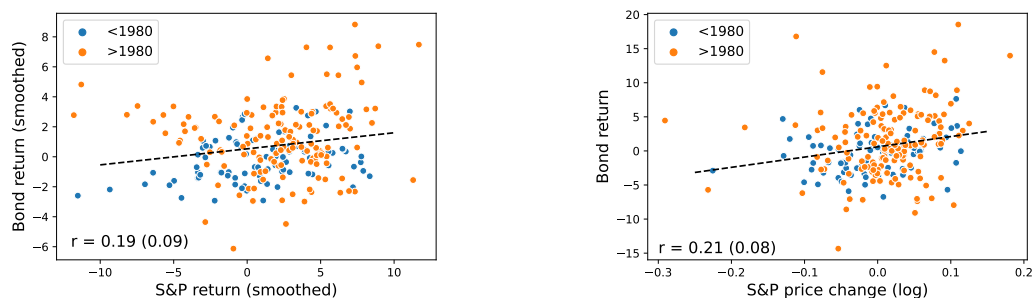
The theory implies that the expected return on liquid assets, like government bonds,

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.

⁴⁵In the data, this composition effect rather goes in the opposite direction: since empirically, capital rents increase less in stock price booms than real bond rates, there is some evidence that the overall share of households with dominant capital income decreases in stock price booms. However, this does not drive the overall reduction in portfolio liquidity: see section 5.

Figure 12: Correlations among liquid asset returns

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

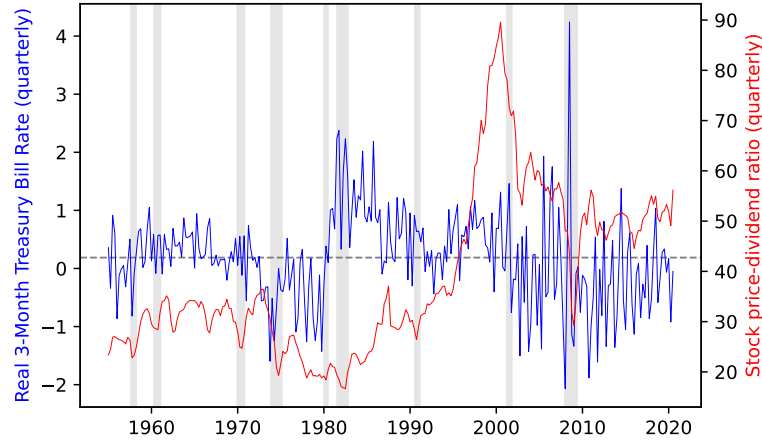


Notes: Data by Robert Shiller (S&P and 10 year treasury bond). All returns are ex-post (realized) quarterly observations from 1955.Q4 to 2016.Q4. Smoothed series were computed by taking a moving average with a 4-quarter window. Lower maturity-bonds have a similar positive correlation with stock prices: the respective correlation coefficients for the (smoothed) real 3-months treasury bill rate are 0.22 (left panel) and 0.12 (right panel, without outlier 2008.Q3). Newey-West standard errors (1 lag) in parentheses.

is positively correlated with the expected stock return / the expected stock price growth. 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. Plotting the real 3-months treasury bill rate together with the stock price-dividend ratio along the time-dimension gives an impression of the relevance of this correlation as evidence for my theory (Figure 13). It shows that the larger swings in stock prices in the last decades, namely the downturns in the 1970s and 2000s, and the booms in the 1980s and 1990s, all occur in times of lower than average, respectively higher than average, real interest rates. The time after the Great Recession seems an abnormality, which may be due to the effect of quantitative easing on asset prices during that time.

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 return on liquid assets, and thus also stock returns, when capital returns fall. Figure 14a 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 B.1), I check that the positive correlations are

Figure 13: Real 3-months treasury bill rate and the stock market



Notes: Stock market data from S&P500 (Robert Shiller), recession years (grey areas) by NBER. The real 3-months treasury bill rate is computed with realized inflation. The dotted line marks the average quarterly real 3-months treasury bill rate over the sample (0.19 pp).

unaffected by the inclusion of dividends and other business cycle variables. In sum, the data is consistent with a theory of investment-driven stock price-booms, where a fall in capital rents depresses stock returns after the boom.

5.1 Evidence from survey data

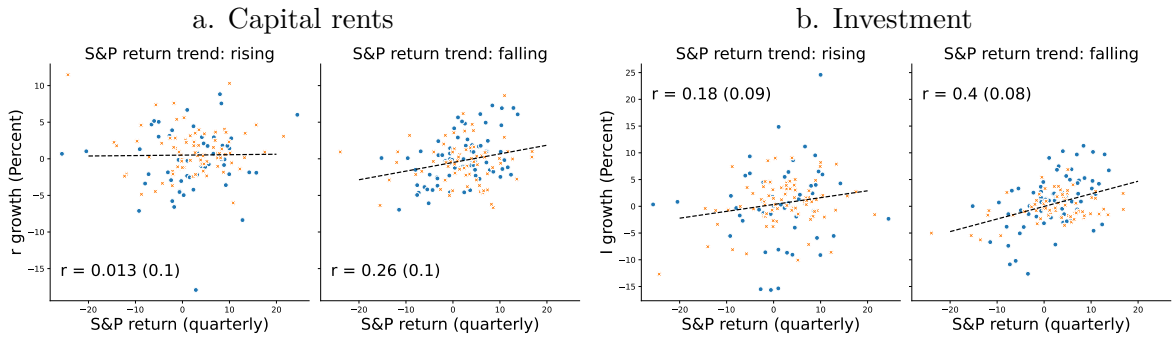
Turning to heterogeneous portfolio choice, which is a crucial part of the proposed theory, I use the SCF+ by Kuhn et al. (2020) to isolate the group of households for whom capital income (excluding capital gains) is the main share (at least 75% in the baseline) of their overall income⁴⁶. On average over all sampled years, 2.3% of households are in that category (2.7% in the model). The theory implies that their portfolio choice is decisive in affecting the illiquidity premium, and thus stock prices, over the cycle. In order to abstract from secular trends in the portfolio liquidity of the different wealth groups, I 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 data⁴⁷.

While in the model, households with high capital incomes are all in the top decile of the wealth distribution, in the data, only 41% are in that wealth group, while 39% have

⁴⁶In the older waves of the Survey of Consumer Finances before 1983, capital income is only available as a measure that lumps together income from illiquid and liquid investments (like dividend income), while only the former counts as capital income in the model. Therefore, I treat separately the time periods before and after 1983. See appendix B.2.

⁴⁷I 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 B.2.

Figure 14: Capital rents and investment over the stock price-cycle



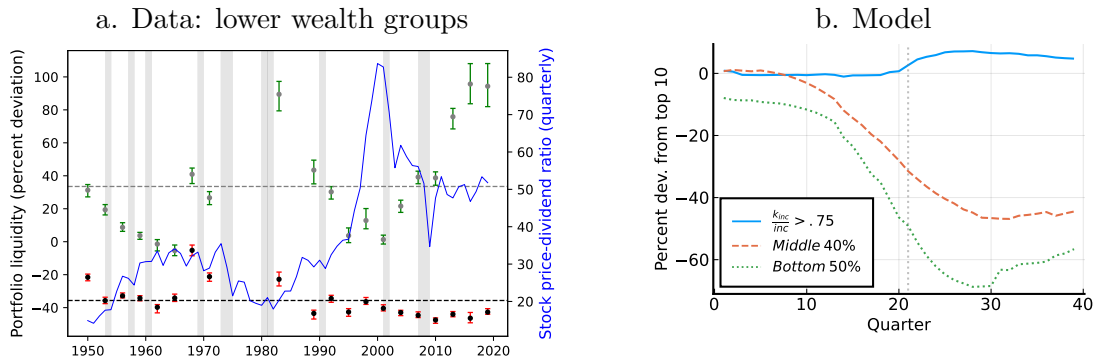
Notes: Data by Robert Shiller (S&P 500) and Gomme et al. (2011) (capital rents). Quarterly observations (1948.Q2 - 2016.Q4). S&P return trend computed using HP-filter ($\lambda = 1600$). Blue dots: before 1980. Orange crosses: after 1979. Newey-West standard errors (1 lag) in parentheses.

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

Figure 1 shows the relative portfolio liquidity of “rentiers” over time, and in comparison to the stock price-dividend ratio of the S&P 500. Figure 15 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 (as much) in the years after the boom, especially so for the middle class.

To put this prediction to the test, I conduct the following exercise: let $\{y_i\}_i$ denote the sequence of two sets of subsequently sampled years, respectively, contained in the SCF+: years between 1950 and 1971, and years between 1983 and 2019. For each sequence of the relative portfolio liquidities of households in group g , computed from the survey data, denoted by $\{\text{pflq}^g(y_i)\}_i$, I compute the difference between subsequent years: $\Delta_i \text{pflq}^g = \text{pflq}^g(y_i) - \text{pflq}^g(y_{i-1})$. I also collect the stock price-dividend ratios for the years where survey data is available, and compute the same differenced

Figure 15: Relative portfolio liquidity in model and data



Notes: Survey evidence from SCF+ (Kuhn et al., 2020), stock market data from S&P500 (Robert Shiller), recession years (grey areas) by NBER. Portfolio liquidity is defined as the ratio of liquid assets by total wealth.

Left panel: Left axis shows the relative deviation of portfolio liquidity of households 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.

sequence, $\Delta_i \frac{q_{\Pi^F}^{\Pi}}{\Pi^F} = \frac{q_{\Pi^F}^{\Pi}}{\Pi^F}(y_i) - \frac{q_{\Pi^F}^{\Pi}}{\Pi^F}(y_{i-1})$. Then, I combine the differenced variables of both sets of years into one pooled sample. Column (I) in table 3 shows the results of regressing $\Delta_i \frac{q_{\Pi^F}^{\Pi}}{\Pi^F}$ on the change in relative portfolio liquidity $\Delta_i \text{pflq}^g$ of the groups $g \in \{\text{high capital income, middle 40\%, bottom 50\%}\}$. As predicted by the model, the relative portfolio liquidity of households with high capital income comoves negatively with stock price-dividend growth, with a correlation of -0.37 (standardized), when controlling for the portfolios of the other two wealth groups. Notably, the relative portfolio liquidity of the poor half of the wealth distribution also correlates negatively with the stock market. There is a zig-zag pattern of the portfolio liquidity between the bottom 50% and the top 10% over the sample: it falls in the 1950s, rises thereafter, falls from the 1980s to 2000, 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. I find that the portfolio liquidity of the “rentiers” and the bottom 50% explain mostly different parts of the variation, as leaving the latter out of the regression yields largely the same result for the “rentiers”.

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 13.4% of their total wealth in stocks, while households whose income is dominated by capital income hold 10% of

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

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

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

their wealth in stocks⁴⁸. Since stocks are liquid, the higher valuation of stock wealth during stock price-booms mechanically increases the liquid wealth and, ceteris paribus, also the portfolio liquidity of the top 10% relative to the households with high capital incomes. To check if this mechanism drives the results, I add the relative stock share of the “rentiers” compared to the top 10% as an additional regressor, where the stock share is defined as the ratio of the wealth held in equity and other managed assets by total wealth of the household. Columns (III) and (V) in table 3 show the results. When controlling for the stock share, the evidence for a negative relation between the relative portfolio liquidity of the high capital income-households and the stock market becomes stronger. The reason is that, during stock price booms, the share of stock wealth in total wealth of the “rentiers” *increases* compared to that of the top 10%, even though the top 10% own more stocks on average. This effect — which cannot arise in the model, since it abstracts from aggregate risk — attenuates the negative relation between the relative portfolio liquidity and the stock market in the baseline specification.

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

⁴⁸The share of wealth that the top 50% of the wealth distribution holds in stocks decreases markedly from the first to the second half of the sample, see appendix B.2.

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 incomes⁴⁹. In the columns (IV) and (V), I consider this possibility, by including the change in the share of households with dominant capital income within the top 10% as an additional regressor. I find that, while there is evidence that the share of “rentiers” among the wealthiest households is indeed countercyclical, the negative correlation between relative portfolio liquidity and the stock market remains virtually unchanged. To summarize, the predicted fall in the liquidity of the portfolios of households with high capital incomes and households in the bottom half of the wealth distribution during stock price booms is supported by the evidence from the Survey of Consumer Finances.

5.1.1 Who are the marginal traders?

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

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

⁴⁹Note that, in the household survey, capital gains from equity do not count as income. I use the same accounting in the model. Therefore, stock price booms do not mechanically raise liquid incomes.

Table 4: Unconditional moments in data and simulated model

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

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

5.2 Simulation

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

Table 4 shows the simulation results for various model variants and shock combinations, and compares them to the unconditional moments of the data. The main result is that the baseline variant, column (I), explains around 75% of the fluctuation in the price-dividend ratio of the S&P 500. The comparison with columns (II) and (III) shows that news shocks and portfolio choice between liquid and illiquid assets are both important for explaining stock price fluctuations. Only the two-asset model allows for a time-varying

Table 5: Campbell-Shiller decomposition in data and model

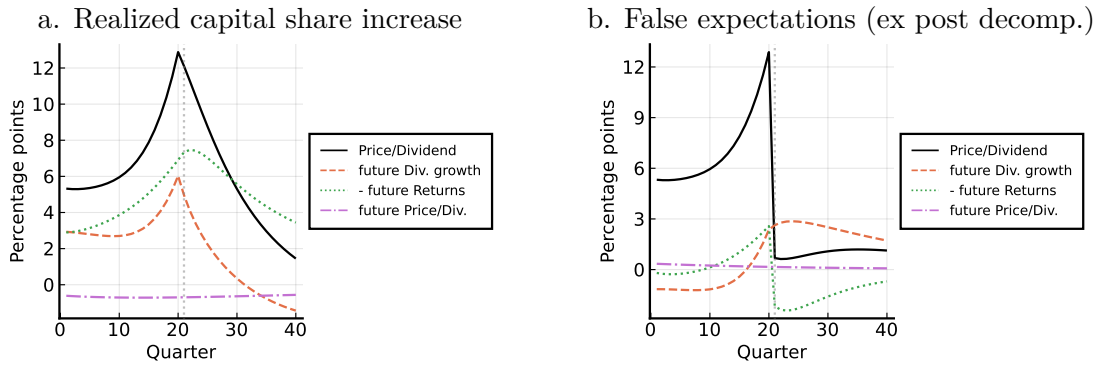
Source / Variant	Dividends	Discount rate	PD-ratio
Cochrane (2011)	0.11	1.01	0.11
Kuvshinov (2022)	0.55	0.45	-
Baseline	0.39	0.52	0.08
One-Asset	0.97	-0.04	0.07
No News	0.29	0.44	0.28
Only Noise	0.25	0.57	0.18

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

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

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

Figure 16: Campbell-Shiller decomposition with countercyclical dividends (model)



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

In b), the news is offset by a negative capital share surprise shock in quarter 21.

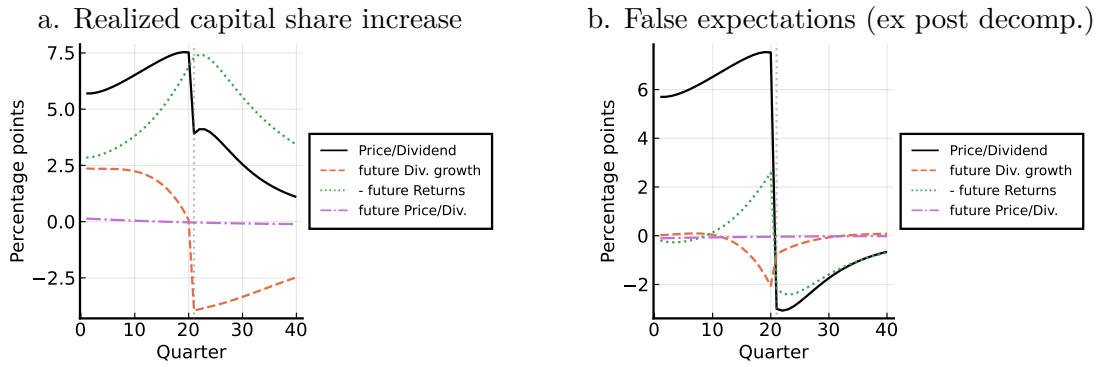
around its (proposed) stationary value, and is given by

$$\log(q_t^\Pi / \Pi_t^F) = c + \mathbb{E}_t \sum_{j=0}^{\infty} \rho^j \left[\underbrace{\hat{\Pi}_{t+1+j}^F}_{\text{dividend growth news}} \quad \underbrace{-r_{t+1+j}^L}_{\text{discount rate news}} \right], \quad (29)$$

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

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

Figure 17: Campbell-Shiller decomposition with procyclical dividends



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

In b), the news is offset by a negative capital share surprise shock in quarter 21.

The hypothetical asset yields dividends $\omega^{\Pi}Y$.

Why is such a large share of stock price fluctuations in the model explained by expected future dividend growth? In panel a) of figure 16, I plot the Campbell-Shiller decomposition as an impulse response to a capital share news shock. One can see that the price-dividend ratio correlates with future dividend growth. The reason is that dividends are countercyclical in the model (although profit smoothing mitigates this), so that a stock price boom that coincides with a business cycle boom automatically implies positive dividend growth news. In panel b), I plot the impulse response to a noise shock. Specifically, the contemporaneous price-dividend ratio, which up to the 21st quarter is driven by the wrong expectation of a capital share increase, is plotted together with the true future components that are known ex-post. Now, of course, the Campbell-Shiller decomposition does not hold in the anticipation period, as the price is based on a wrong expectation. Indeed, as the real rate also falls after the news-disappointment in the model, the future returns-component can “rationalize” some of the excess price-dividend ratio relative to future dividend growth. Due to profit smoothing, future dividend growth fails to ex-post rationalize the variation of the price-dividend ratio over the cycle.

In order to illustrate the impact of the cyclicity of dividends for the results, I also compute the Campbell-Shiller decomposition for an alternative asset, where the dividend is simply given by a fraction of output (see figure 17). For this type of stock, the future returns-component explains the smooth increase of the price-dividend ratio in the anticipation phase, and its smooth decline in the subsequent bust-phase. Future dividends instead explain the jumps in the price-dividend-ratio, one at the onset of the news, and one at the onset of the productivity change. With constant returns (or discount rates), a

forward-looking price would already incorporate the future expected decline in dividends at the onset of the news, and thus be mostly declining in the anticipation phase. But since the future dividends will also be discounted less as the demand for liquidity will rise, the price-dividend ratio rises in the anticipation phase. In figure 17b, I show that if the capital share-expectation is disappointed, the future returns (which increase quickly after the news-disappointment, as the price level shoots up and then declines slowly) explain most of the subsequent lower stock price, while the future dividend-component converges back to its steady state-level.

6 Conclusion

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

Why are households more risk-loving during a stock price boom? I propose that they anticipate higher future returns on illiquid assets. This induces wealthy household to optimally shift their portfolio towards more illiquid assets, which puts them at a higher idiosyncratic risk. Instead of a time-varying aggregate risk premium, I show that a time-varying illiquidity premium, which reflects the idiosyncratic risk-return calculus of the marginal traders, can account for stock price booms and subsequent busts. This accommodates recent evidence (Kuvshinov, 2022) that the risk factors of assets with different liquidities do not comove in the data.

The empirical evidence is in line with the proposed mechanism: first, returns on liquid and illiquid assets correlate with the stock market as expected. Second, I show using survey data that households who earn mostly capital income shift their wealth towards illiquid assets in stock price booms, and increase the liquidity of their portfolio in the subsequent stock price bust, as predicted by the model. Matching a heterogeneous agent

model to micro-level data, I ascribe a large part of stock price fluctuations to the stock-trading of owners of private businesses who are in the top 10% of the income and wealth distribution. I leave the further investigation of this hypothesis — ideally using data on consumption and investment — for future research. On the model side, solving the model nonlinearly, thereby accounting for heterogeneous stock shares, appears to be a promising next step.

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A Challe-Ragot model

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

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

B Empirical evidence

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

This section presents regressions of quarterly 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:	03:37:32	Log-Likelihood:	-180.15					
No. Observations:	135	AIC:	374.3					
Df Residuals:	128	BIC:	394.6					
Df Model:	7							
Covariance Type:	HAC							
	coef	std err	t	P > t	[0.025	0.975]		
Cap.rent growth	-0.0945	0.114	-0.829	0.409	-0.320	0.131		
Consumpt. growth	0.2247	0.106	2.127	0.035	0.016	0.434	Omnibus:	6.483
Investm. growth	0.1410	0.104	1.350	0.179	-0.066	0.348	Prob(Omnibus):	0.039
Before 1980	0.0513	0.090	0.573	0.568	-0.126	0.228	Skew:	-0.330
Rising Infl.	-0.1436	0.086	-1.673	0.097	-0.313	0.026	Kurtosis:	3.922
GDP deviation	-0.1788	0.103	-1.736	0.085	-0.383	0.025	Cond. No.	1.77
Dividend growth	-0.0034	0.092	-0.037	0.971	-0.186	0.180		

Notes:

[1] R² 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:	03:37:32	Log-Likelihood:	-178.93
No. Observations:	140	AIC:	371.9
Df Residuals:	133	BIC:	392.4
Df Model:	7		
Covariance Type:	HAC		

	coef	std err	t	P > t	[0.025	0.975]			
Cap.rent growth	-0.0299	0.124	-0.241	0.810	-0.275	0.215			
Consumpt. growth	0.1405	0.095	1.484	0.140	-0.047	0.328	Omnibus:	13.595	Durbin-Watson: 2.285
Investm. growth	0.3318	0.097	3.422	0.001	0.140	0.524	Prob(Omnibus):	0.001	Jarque-Bera (JB): 23.130
Before 1980	-0.0507	0.072	-0.700	0.485	-0.194	0.093	Skew:	-0.455	Prob(JB): 9.49e-06
Rising Infl.	-0.0892	0.069	-1.285	0.201	-0.227	0.048	Kurtosis:	4.771	Cond. No. 2.40
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			

Notes:

[1] R² 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:	03:37:32	Log-Likelihood:	-185.04
No. Observations:	140	AIC:	382.1
Df Residuals:	134	BIC:	399.7
Df Model:	6		
Covariance Type:	HAC		

	coef	std err	t	P > t	[0.025	0.975]			
Cap.rent growth	0.1267	0.124	1.021	0.309	-0.119	0.372	Omnibus:	24.887	Durbin-Watson: 2.230
Consumpt. growth	0.1624	0.095	1.714	0.089	-0.025	0.350	Prob(Omnibus):	0.000	Jarque-Bera (JB): 50.473
Before 1980	-0.0217	0.080	-0.273	0.785	-0.179	0.136	Skew:	-0.767	Prob(JB): 1.10e-11
Rising Infl.	-0.0554	0.071	-0.776	0.439	-0.197	0.086	Kurtosis:	5.510	Cond. No. 2.00
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			

Notes:

[1] R² 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.2 Survey evidence

B.2.1 Data selection and definitions

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

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

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

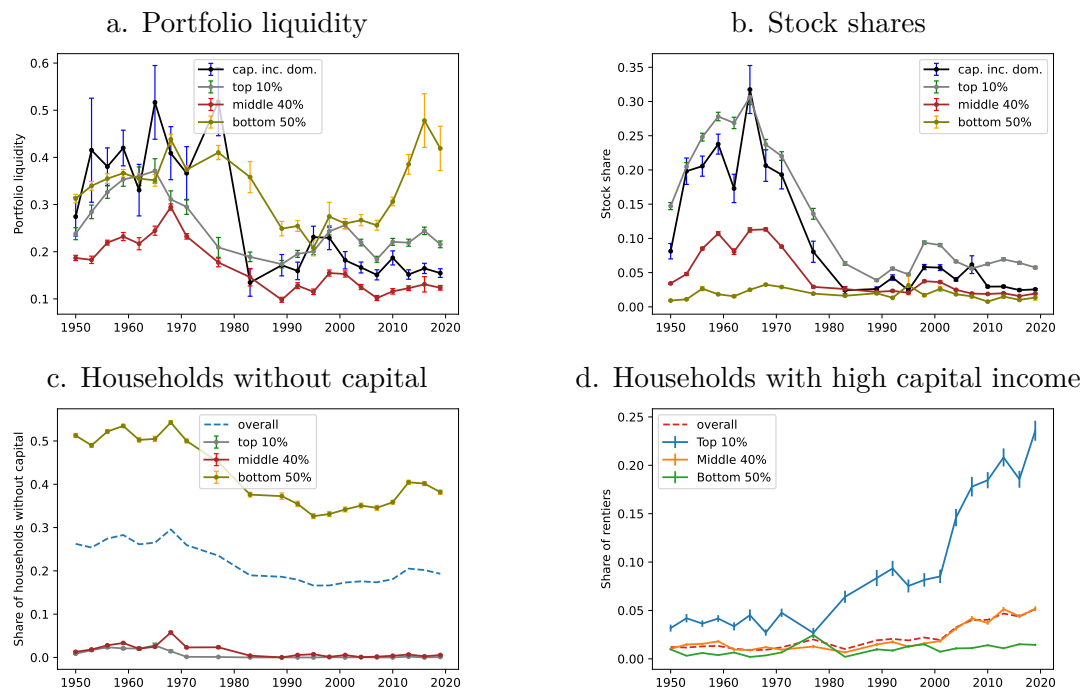
Since asset incomes number 2 and 3 likely stem from more liquid sources, namely treasury bonds and stocks, this definition of capital income does not fit to the dichotomy between liquid and illiquid assets suggested by the analysis in the main text. Therefore, starting from year 1983 (the modern waves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

In line with the quantitative model, I define as high capital income those households where capital income is at least 75% of their total income. In order to make this definition comparable across the old and modern waves of the SCF, where only the modern

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

B.2.2 Portfolio choice over time

Figure B.1: Heterogeneous portfolio choice over time



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

Several secular trends are noticeable:

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

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

B.3 Business cycle data

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

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

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

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

