Supply Shocks and Asset Market Participation*

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Abstract

We examine the transmission of aggregate supply shocks to the consumption and income of U.S. households, documenting substantial redistributive effects between household groups sorted according to their assetholding position. Positive neutral technology shocks redistribute resources in favor of non-assetholders' income and consumption. By contrast, assetholders' consumption and income display a relatively more marked upward adjustment in response to positive investment-specific technology shocks and shifts in the capital share of income. These facts are consistent with the propagation of supply shocks in models with limited asset market participation, where the relative responsiveness of dividend vs. wage income is key to predict how a given shock redistributes resources between different households. Within this class of models, a fundamental disconnect emerges between macroeconomic and asset-pricing drivers. Shocks to the capital share of income are shown to be key in explaining consumption and income inequality, as well as the equity premium, while displaying a modest capacity to explain macroeconomic fluctuations.

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1 Introduction

Supply shocks have traditionally been conceived as driving forces behind business cycles (e.g., Kydland and Prescott, 1982; Prescott, 1986; King and Rebelo, 1999). Concurrently, a vast literature has indicated fluctuations induced by such shocks as playing strong influence on asset prices (e.g., Cochrane, 1991; Jermann, 1998). At least in their early stages of development, both these strands of the macro-financial literature have taken a *representative agent* perspective, which presumes aggregate (average) consumption growth to be an appropriate measure of systematic risk. However, this stands in contradiction with the most basic observation about asset ownership—about a third of U.S. households do not own any form of liquid assets, on average—along with implying a poor performance in explaining key asset-pricing facts (Brunnermeier et al., 2021). In response to such a discrepancy, various contributors have stressed the need to (re)consider *limited asset market participation* as a crucial dimension of consumer heterogeneity. This paper provides a systematic assessment—both from an empirical and a theoretical viewpoint—of the transmission of aggregate supply shocks to the consumption and income of households sorted depending on their assetholding position. Thus, we show how a clear understanding of how household inequality reacts to different supply shocks is key to devise production-based economies that may account for both business-cycle dynamics and asset pricing.

The consumption and income of households sorted according to their assetholding position may differ markedly (see, e.g., Malloy et al., 2009). Moreover, it is widely acknowledged that households' financial position is essential to understand the transmission of demand shocks (see, e.g., Cloyne and Surico, 2017; Cloyne et al., 2019). Yet, little we know about its relevance for the transmission of supply shocks. In fact, these exert a pervasive impact on the main determinants of household income—the wage rate and the rate of return on savings—along with acting as influential business-cycle drivers. In principle, different sensitivities of assetholders' and non-assetholders' consumption and income to different supply shocks may bear major implications not only for the behavior of macroeconomic aggregates, but also for that of asset prices.

Using the U.S. Consumption Expenditure Survey (CEX) and the Survey of Consumer Finances (SCF), we construct the consumption and income series pertaining to two distinct groups of households, based on the Ricardian vs. hand-to-mouth dichotomy embodied by standard models with limited asset market participation. Thus, we retrieve the dynamic responses of both aggregate and household-level variables to neutral technology and investment-specific shocks, as well as to shocks affecting the income share of capital. The identification strategy we adopt follows Fisher (2006) in that we assume that neutral technology shocks do not affect the relative price of investment in the long run. Instead, we identify a shock to the income share of capital by imposing that it does not affect the long-run levels of total factor productivity and the relative price of investment, thus being purely redistributive (as in Santaeulalia-Llopis, 2011).

The empirical analysis indicates three main results: *i*) expansionary shocks of all types produce a significant expansion in the main macroeconomic aggregates (namely, real GDP, investment and consumption), with capital share shocks inducing a particularly delayed and protracted response; *ii*) while neutral technology shocks attenuate households' consumption (income) inequality—as captured by the gap between average assetholders' and non-assetholders' consumption (income)—investment-specific and capital share shocks amplify inequality along these dimensions; *iii*) the consumption-to-income ratio of both household groups contracts in the face of a positive neutral technology shock, while expanding in the face of expansionary investment-specific and capital share shocks.

To rationalize the differential responses of household-specific consumption, we devise a two-period real business cycle (RBC) model featuring limited asset market participation, and embedding the three sources of supply-side perturbation identified in the empirical analysis. This textbook framework returns predictions that are close in line with the empirical analysis, and highlights that differences in household-specific consumption responses are primarily dictated by the composition of household income. Notably, the conditional behavior of the *consumption gap*—the ratio between per-capita assetholders' to non-assetholders' consumption—maps into the response of dividend income vis-á-vis that of labor income: conditional on either shock, the consumption gap comoves positively with the *dividend-to-wage income ratio*. We test and confirm this prediction in the data. This mapping proves to be crucial to devise production-based economies with limited asset ownership that account for sizable equity premia.

To establish this result, we devise a two-agent infinite-horizon RBC model of the U.S. economy that matches the conditional responses of the consumption gap for a set of standard parameter values. We identify a deep disconnect between asset prices and macroeconomic fundamentals. While technology shocks (neutral and, predominantly, investment-specific) emerge as key macroeconomic drivers, they exert little impact on the level and volatility of asset prices, which are instead chiefly driven by capital share shocks. Looking at the conditional behavior of the consumption gap—and, thus, of the dividend-to-wage income ratio—is key to frame this picture. In fact, capital share shocks also account for the lion share of the (short-run and the unconditional) variance of relative consumption, thus indicating that a large fraction of the average equity premium entails a compensation for the risk associated with the stock market paying higher returns in periods where resources are redistributed—at least temporarily—towards asset owners; a property that is consistent with Lettau et al. (2019) and Greenwald et al. (2019).

The final step in the analysis delves into the interplay between household heterogeneity and the joint behavior of macroeconomic aggregates and asset prices, through the lens of our quantitative framework. On one hand, the model shows little departure from its representative-agent benchmark, as far as macroeconomic volatility is concerned. In fact, both the conditional and the unconditional standard deviation of output, consumption and investment are not significantly affected by the introduction of limited asset ownership. On the other hand, the 'irrelevance' of household heterogeneity is confined to the macroeconomic dimension. In fact, the two-agent economy may generate substantially higher average equity premia, compared to the representative agent economy, especially at relatively high levels of limited asset ownership, and even more so in the presence of shocks that generate a large response of dividends over wages. This is the case for investment-specific shocks and—to a larger extent—capital share shocks, which lead assetholders to demand a higher compensation for holding assets when resources are distributed from wage to dividend income. This tendency reinforces as assets are particularly concentrated in the hands of a few, as their income is largely affected by movements in financial income. Conditional on a positive neutral technology shock, instead, resources are more evenly distributed across dividends and wages, so that the equity premium tends to be insulated by changes in the degree of asset market participation. A direct implication of this property is that canonical two-agent production-based models, which typically feature neutral technology shocks alone, can match asset-pricing facts only by implying a procyclical behavior of the dividend-to-wage income ratio and, thus, conditional dynamics in consumption and income inequality along the assetholding dimension that does not square with the empirical evidence we report. All in all, our results emphasize how the study of the structural household-level responses to aggregate shocks represents an essential input for the unified study of business-cycles and asset pricing.

Related literature The last decade has witnessed the genesis of various lines of enquiry on the interplay between incomplete markets and household heterogeneity, as well as on their implications for the aggregate and the distributive outcomes of macroeconomic shocks. A number of works have delved into the role of household heterogeneity for the transmission of aggregate shocks (e.g., Gomes et al., 2012; Kaplan et al., 2018; Bayer et al., 2020) and asset pricing (e.g., Gomes and Michaelides, 2007; Favilukis, 2013; Kogan et al., 2020). Behind this trend is the generalized consensus that representative-agent models with complete markets are inadequate to tackle core (re)distributive issues.

The fact that a substantial fraction of households behave as rule-of-thumb consumers (Campbell and Mankiw, 1989) has motivated several studies that assume the Ricardian vs. hand-to-mouth dichotomy as a standpoint to study the transmission of monetary and fiscal policy (see Mankiw, 2000; Galí et al., 2007; Bilbiie, 2008; Debortoli and Galí, 2017; Broer et al., 2019; Bilbiie, 2020; Cantore and Freund, 2021, among others). In this respect, our empirical evidence complements the work of Cloyne and Surico (2017) and Cloyne et al. (2019), who highlight that the transmission of monetary and fiscal shocks mainly hinges on their impact on the disposable income of consumers who are financially/liquidity constrained. From the perspective of pricing assets, instead, a key implication of limited asset ownership is that only a subset of the households are likely to matter (Vissing-Jørgensen, 2002). In this respect, a relatively large literature has explored the potential of limited asset market participation to tackle a number of puzzles (Danthine and Donaldson, 2002; Guvenen, 2009; De Graeve et al., 2010; Lansing, 2015; Greenwald et al., 2019). Indeed, the influential work of Malloy et al. (2009) has shown that consumption of stockholders and non-stockholders displays substantial differences.[1] We contribute to this strand of the literature by providing novel structural evidence on the cyclical properties of Ricardian and hand-to-mouth households' consumption and income, *conditional* on different aggregate supply shocks.

We consider a general set of aggregate supply shocks and show that, even if they all imply analogous effects in the aggregate, they bear different redistributive properties. We then highlight that these results are relevant for a growing literature that has developed two-agent, production-based asset pricing models. Early contributions in this literature mainly contemplate *neutral technology* shocks as the only source of risk in the economy (see, e.g., Danthine and Donaldson, 2002; Guvenen, 2006, 2009). In this setting, a sizeable equity premium is generated by embedding specific mechanisms, such as operating leverage (Danthine and Donaldson, 2002) or preference heterogeneity (Guvenen, 2009), that entail a stronger sensitivity of assetholders' consumption to aggregate fluctuations relative to non-assetholders' and, as a byproduct, procyclical consumption and income inequality. By contrast, our empirical analysis indicates that, conditional on TFP shocks, the consumption gap is markedly *countercyclical*. On the

[1] In fact, they show that the cross-section of stock returns is better explained by the consumption growth process of stockholders alone, rather than by aggregate consumption growth.

other hand, *investment-specific* shocks (which play a key role in Justiniano and Primiceri, 2008; Papanikolaou, 2011; Kogan and Papanikolaou, 2013; Garlappi and Song, 2017; Kogan et al., 2020), and especially shocks to the *capital share of income* (Lansing, 2015; Lettau et al., 2019), are associated with a marked redistribution of resources between wage and dividend income that generates procyclical consumption and income inequality.

A key finding is that, while investment-specific shocks and—to a lesser extent—technology neutral shocks explain the bulk of macroeconomic volatility, the equity premium and its volatility are chiefly driven by fluctuations in the capital share of income. A closely related work, in this sense, is Greenwald et al. (2014), who stresses that investors are concerned with shocks that have opposite effects on labor and capital. Greenwald et al. (2019) highlights fluctuations in factor shares as key stock market drivers. In fact, we show it is the component of the capital share that is orthogonal to TFP and IST shocks, which gives rise to a sizable risk premium and volatility. Relatedly, Lansing (2015) underscores the importance of redistribution shocks in producing sizable equity premia within production-based, asset-pricing models with limited asset ownership. More generally, we underline the importance of accounting for dynamic interaction between the factor shares and TFP, in line with Ríos-Rull and Santaeulalia-Llopis (2010).

Structure The rest of the paper is organized as follows. In Section 2 we discuss the identification of the shocks of interest, the macroeconomic and the microeconomic data employed, as well as the empirical specification adopted. Section 3 presents the main empirical results about the response of various macroeconomic and household-level variables to aggregate supply shocks. Section 4 frames our empirical results in a two-period, two-agent, business-cycle model. Section 5 examines the quantitative implications of household heterogeneity from both a macroeconomic and an asset-pricing standpoint, within a fully-fledged quantitative setting with concentrated capital ownership. Section 6 concludes.

2 Data and empirical framework

In this section, we present the data and the methodology employed in the empirical analysis. We first describe the macroeconomic and the household-level variables. Thus, we discuss the guidelines for sorting households into assetholders and non-assetholders. We then specify the identification strategy for the shocks of interest. Finally, we report the empirical model adopted for the estimation of the impulse-response functions (IRFs).

2.1 Macroeconomic data

We employ the NIPA quarterly aggregate series on Consumption (non-durable goods and services, as well as durables), Gross Domestic Product (GDP) and Total Investment, in addition to the Consumer Price Index (CPI) for all items, from the Bureau of Labor Statistics (BLS). Real per-capita measures are obtained by dividing their aggregate counterparts by the NIPA U.S. total population and by the CPI. We also investigate the responses of the main sources of household income, namely wage and dividend income, collected by the Bureau of Economic Analysis (BEA). The sample for these macroeconomic data starts in 1982Q4, in line with the availability of household-level data. Full details on the data sources can be found in Appendix A.

2.2 Household survey data

To estimate consumption expenditure at the household level, we rely on the U.S. CEX over the sample 1980-2017. Produced by the BLS, the CEX is a national survey featuring household-level data on consumption expenditure—along with income and other financial and demographic information—on a sample that is designed to represent the non-institutionalized civilian population.

We compute quarterly consumption expenditure based on calendar periods for the representative agent of each category (i.e., assetholders and non-assetholders) as the population-weighted mean expenditure within the group.[2] Spending and income variables are expressed in real and per-capita terms by dividing nominal dollar amounts by family size and the CPI. The consumption definitions follow Cloyne et al. (2019), and are aggregated from the disaggregated expenditure categories reported in the survey. We compute the expenditure on both non-durable goods and services, as well as on durable goods, together with measures of gross and net income, as well as financial income.

Following Cloyne et al. (2019), in every quarter the group-level series of expenditure and income are adjusted by the ratio of the corresponding NIPA national account aggregate to the aggregate expenditure from the CEX. The adjusted series are then smoothed through a backward-looking moving average,[3] so as to deal with seasonal adjustment and the noise that typically characterizes survey data. We apply standard

[2]These are intended as periods (i.e., months, quarters or years) in which spending actually takes place, while collection periods are those in which spending is reported. See the CEX documentation for a detailed discussion.

[3]This includes both the current and the previous three quarters.

restrictions on the household sample. More details on the steps taken to obtain the final consumption and income series from the raw survey data can be found in Appendix B.

2.2.1 Assetholding status definition

We focus on a key dimension of household heterogeneity, defined by consumers' capacity to insure themselves against the adverse consequences of shocks to the economy by holding financial assets. In line with a wide set of macroeconomic two-agent models employed for both normative and positive analyses (Bilbiie, 2008; Lansing, 2015; Debortoli and Galí, 2017, among others) we distinguish between assetholders (also referred to as Ricardian households) and non-assetholders (or hand-to-mouth households). Unlike assetholders, non-assetholders typically hold very little liquid assets, and are therefore unable to smooth consumption intertemporally. To accommodate this sorting criterion, we rely on both the CEX and the SCF.[4]

In line with Mankiw and Zeldes (1991), we define a household to be an assetholder if the dollar value of held assets plus liquid accounts exceeds 1000$. The CEX collects information on whether a household holds "stocks, bonds, mutual funds and other such securities", along with checking and savings accounts. However, the CEX does not contemplate indirect assetholdings, with the likely implication of underestimating households' participation in financial markets. To refine the assetholding status definition, we thus follow an imputation procedure similar to the one employed by Attanasio et al. (2002) and Malloy et al. (2009).

Using SCF data for the period 1989 through 2016, we estimate a probit model for the probability of a household holding assets, directly or indirectly, based on a set of observables that are available also through the CEX. We include age and education (as well as the interaction term between the two), race (white or non-white), year dummies, (log) income, and a dummy variable capturing whether the household earns any financial income (defined as dividend plus interest income). The assetholding status is captured by a dummy taking value 1 if (direct or indirect) holdings of stocks, bonds and liquid accounts exceed the threshold of 1000$.

The estimated coefficients are then used to predict the probability that a household in the CEX holds assets. In the baseline analysis, we employ a "continuous" measure of participation to the asset market. For the representative assetholder, each household's population weight and consumption expenditure is multiplied by the imputed

[4]The SCF is an independent triennial survey run by the Federal Reserve that collects detailed information on income and wealth holdings of U.S. households, but does not include consumption expenditures.

probability of holding assets in amounts that exceed the threshold. Similarly, for the representative non-assetholder, each household's population weight and consumption expenditure is multiplied by the complement to one of the imputed probability of being an assetholder. This imputation is applied only to households who have valid responses to questions connected with all variables used in the regression with CEX data. If this requirement is not fulfilled, the household is imputed an assetholding probability equal to zero. Full details on the imputation procedure are reported in Appendix B.

Following the outlined procedure, we obtain an imputed series for the participation rate that closely tracks the one based on the SCF, especially in the last part of the sample, where the rates are essentially identical.[5] Even in the first half of the sample, where the imputed rate is relatively lower, the difference amounts to few percentage points, and the imputation procedure captures the upward trend observed in the SCF data. The level discrepancy between the two participation rates could be due to differences in the design of the two surveys. As discussed in Lettau et al. (2019), the SCF is designed to measure the wealthiest households, and has high quality financial information. On the other hand, the CEX has some well-known limitations when measuring the top-end of the wealth distribution due to under-reporting, with wealthier households being more likely to hold assets and liquid accounts.

From a quantitative perspective, our procedure classifies between 40% (35%) and 25% (25%) of the households as non-assetholders in the CEX (SCF). These values are very close to the range considered in the existing literature. For example, Kaplan et al. (2018) estimate that around a third of the U.S. population consists of hand-to-mouth households, while Aguiar et al. (2020) estimate such percentage to be around 40%.

Looking at the resulting consumption and income series, we notice that the representative assetholder (non-assetholder) consumes more (less) than average, and earns a higher (lower) than average net income.[6] We also find that the representative assetholder earns about four times the financial income earned by the representative non-assetholder. Interestingly, the quarterly growth rate series for non-assetholders' consumption of non-durables and services is more volatile (with a relative volatility of 1.54 and an absolute standard deviation equals 0.58). There is a stark qualitative difference between this evidence and what is usually reported by contributions using models with concentrated capital ownership, where stockholders' consumption process is relatively less smooth (see Guvenen, 2009, for instance). A rationale for this is

[5]See Figure B.1 in Appendix B, which compares the rates of direct and indirect asset-ownership from the SCF and the one imputed in the CEX for the sample 1982Q4-2017Q4.

[6]The series are depicted in Figure B.2, Appendix B.

that stockholders typically represent the richest end of the wealth distribution, and finance a large part of their consumption expenditure through dividend income, which is more volatile than earnings. In line with this view, when sorting households based on stockholdings rather than assetholdings (see Section 3.3), we find that stockholders have a more volatile consumption growth process (the standard deviation equals 0.53 and 0.43 for stockholders and non-stockholders, respectively).

Some more comments are in order. First, it is well known that, at present, no comprehensive data on consumption, income and wealth at the household level is available for the US. Our imputation procedure allows us to combine wealth information from the SCF with consumption and income data from the CEX. Nevertheless, an implicit assumption is that households with the same demographic and income characteristics are seen as equally likely to have sufficient liquid wealth. In this sense, we see the continuous measure we employ as a way to address this issue. In the robustness analysis, we will also adopt a different method that mostly relies on the financial information available in the CEX, and applies the imputation procedure only residually. Second, it is worth noting that our focus is on households' financial assets rather than on total net wealth, as recently done in Kaplan et al. (2018), Aguiar et al. (2020), and Kehoe et al. (2020). In this respect, our approach allows us to speak to both the macroeconomic and the asset-pricing literature. In the latter, the focus is typically on the dichotomy between stockholders and non-stockholders, which we are able to account for in a way that is symmetric to the baseline analysis. Finally, in Section 3.3 we will test the sensitivity of our results to other relevant aspects of household portfolios, such as housing, so as to proxy the wealthy vs. poor hand-to-mouth distinction, as in Cloyne et al. (2019).

2.3 Identification of supply shocks

We consider three shocks that have been widely recognized as crucial drivers of both macroeconomic and asset pricing variables, namely neutral and investment-specific technology shocks, as well as redistributive shocks in the form of shifters to the income share of capital. In fact, a long-standing literature (see Gali, 1999; Fisher, 2006, among others) has studied the transmission of technology shocks to the macroeconomy. However, these contributions typically assume that factor shares are constant over time. Recently, several studies (Ríos-Rull and Santaeulalia-Llopis, 2010; Santaeulalia-Llopis, 2011; Choi and Ríos-Rull, 2020) provide evidence that, accounting for the observed time-variation in the factor shares, profoundly modifies the propagation mechanism of technology shocks to aggregate variables. Moreover, (Lettau et al., 2019) demonstrate that fluctuations in factor shares also have the potential to explain the observed risk premia in the stock market.

Our identification strategy follows the procedure outlined by Santaeulalia-Llopis (2011). We specify a trivariate Vector Autoregression (VAR) model with four lags, where the growth rate of the (inverse) relative price of investment to consumption goods ($\Delta \log(\mu_t)$), the growth rate of total factor productivity ($\Delta \log(z_t)$) and the linearly detrended (log) labor share of income ($\log(ls_t)$) are the endogenous variables.[7] Specifically, we define the system

$$\boldsymbol{y}_t = \boldsymbol{c} + \sum_{j=1}^{4} \boldsymbol{\Gamma}_j \boldsymbol{y}_{t-j} + \boldsymbol{\epsilon}_t, \tag{1}$$

where $\boldsymbol{y}_t = [\Delta \log(\mu_t), \Delta \log(z_t), \log(ls_t)]'$, $\boldsymbol{c}$ is a vector of constant terms, $\boldsymbol{\Gamma}_j$ (with $j = 1, ..., 4$) are the matrices of dynamic coefficients and $\boldsymbol{\epsilon}_t \sim N(0, \Sigma)$ is a vector of normally-distributed innovations with mean zero and variance-covariance matrix Σ.

We estimate the reduced-form system (1) over the 1981Q4-2017Q4 sample.[8] Since the innovations $\boldsymbol{\epsilon}_t$ are contemporaneously correlated, to obtain the orthogonal shocks $\boldsymbol{u}_t$ we exploit the relationship $\boldsymbol{\epsilon}_t = \boldsymbol{H}\boldsymbol{u}_t$, where $\boldsymbol{H}$ is 3×3 matrix that we identify through standard long-run restrictions. The identification strategy we adopt imposes that innovations to the factor shares do not affect the long-run levels of the total factor productivity and the relative price of investment, and are therefore purely redistributive. As for the remaining shocks, we follow Fisher (2006) in assuming that neutral technology shocks do not affect the relative price of investment in the long run.[9] Thus, investment-specific technology shocks are the only ones capable of influencing the relative price of investment in the long run.

The associated impulse-response functions are reported in Figure 1. As highlighted by Santaeulalia-Llopis (2011), supply shocks induce some marked interaction among the three variables we consider. A neutral technology (TFP) shock increases the relative price of investment persistently, while the labor share falls on impact, to then

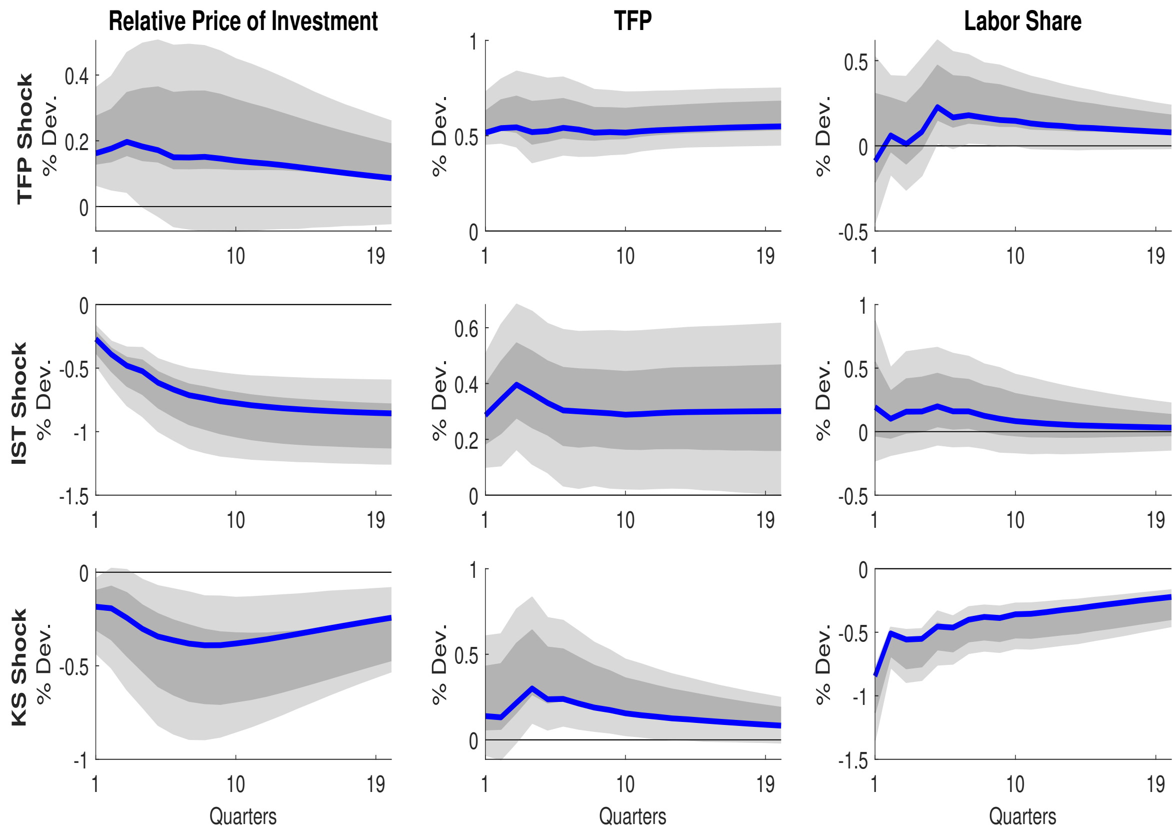
[7] The choice of detrending the labor share follows Choi and Ríos-Rull (2020), and is intended to deal with the secular decline observed over the last few decades. We check that the empirical results reported in Section 3 still hold when not detrending the labor share. Indeed, the resulting series of structural shocks are very similar under the two alternative specifications.

[8] This sample is chosen for three main reasons. First, given that we use a VAR(4) model, the structural shocks will actually be obtained over the sample 1982Q4-2017Q4; i.e., the same time span of household-level data. Second, Fisher (2006) documents the presence of a structural break in the trend of the relative price of investment in 1982. Finally, the sample is consistent with a large literature on the Great Moderation (see, e.g., Stock and Watson, 2002).

[9] The resulting series for the three structural shocks, retrieved over the sample 1982Q4-2017Q4, are displayed by Figure C.1 in Appendix C.

display a temporary increase above the trend (see Ríos-Rull and Santaeulalia-Llopis, 2010; Choi and Ríos-Rull, 2020). An investment-specific (IST) shock is associated with a permanent fall in the relative price of investment and an increase in TFP, while the labor share displays a mild expansion. Finally, a temporary capital share (KS) shock is associated with a decline in the labor share, while contracting the relative price of investment and expanding TFP.

Figure 1: Structural IRFs from the VAR



Notes: The figure displays the structural impulse response functions, estimated from the VAR in equation (1), to the identified TFP (top panel), investment-specific (middle panel) and redistributive (bottom panel) shocks over the sample 1982Q4-2017Q4. Light-grey (dark-grey) shaded areas represent the 90% (68%) confidence intervals. The latter are computed using the moving block bootstrap (Bruggemann et al., 2016), with small-sample bias correction (Kilian, 1998).

2.4 Empirical specification

We estimate the following autoregressive distributed lag model in order to retrieve the impact of supply shocks on macroeconomic and microeconomic variables:

$$x_{i,t} = \alpha_{i,0} + \alpha_{i,1} t + \sum_{r=0}^{R} \beta_{i,r} s_{t-r} + \sum_{p=1}^{P} \delta_{i,p} x_{i,t-p} + u_{i,t}, \tag{2}$$

where t denotes the time trend, while $x_{i,t}$ denotes the (log) aggregate variable (in which case, $i = 0$) or the household-level variable (in which case $i = a$ for assetholders and $i = na$ for non-assetholders) for which we compute the impulse response function to either of the three shocks, as captured by s. We control for R lags of the shock and P lags of the endogenous variable, with both R and P being optimally determined by a corrected-Akaike information criterion, separately for each regression. Finally, heteroskedasticity-consistent standard errors are computed using the wild bootstrap methodology of Goncalves and Kilian (2004).

3 Macro and micro responses to supply shocks

We first provide evidence on the response of macroeconomic variables to neutral and investment-specific technology shocks, as well as to redistributive shocks. Thus, we report the conditional behavior of household-level heterogeneity in consumption and income. Finally, we conduct robustness exercises that show how the results hold when controlling for observable household heterogeneity, when structural supply shocks are identified in a larger VAR setting, and when using a different assetholding status definition.

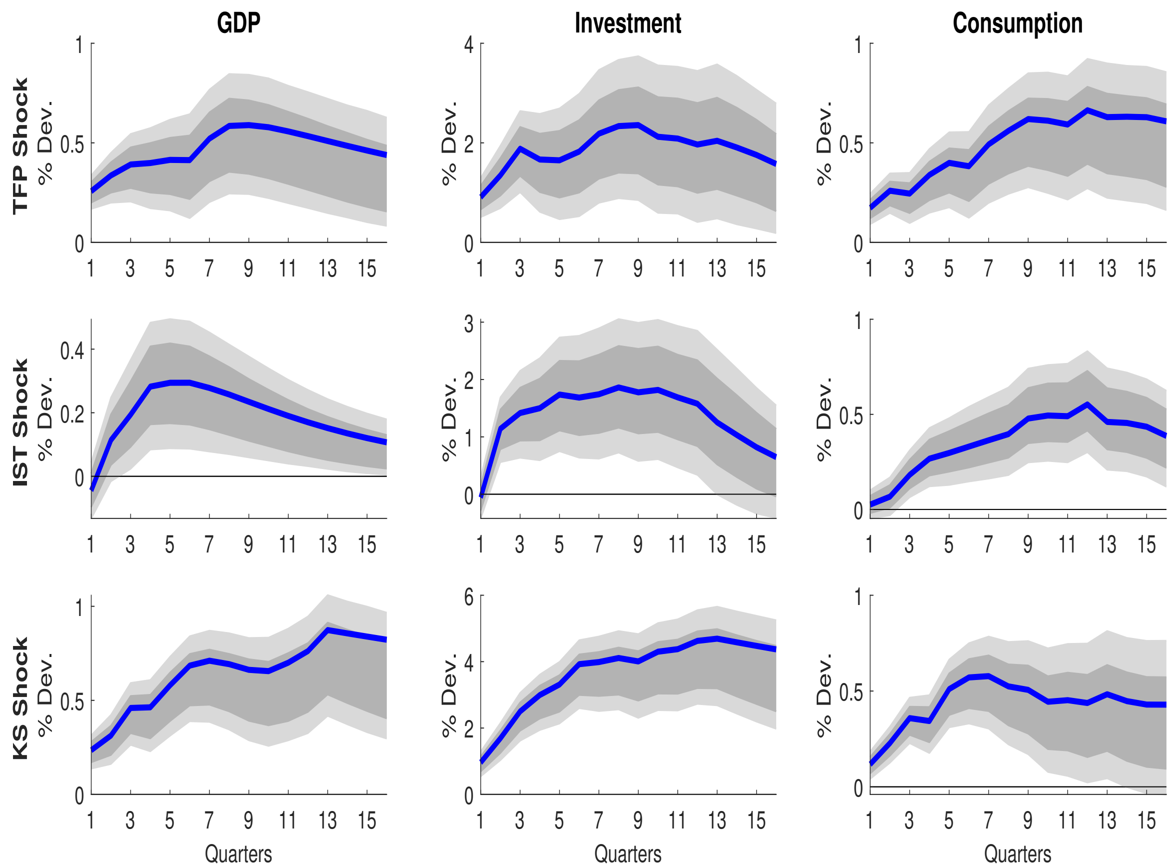
3.1 Macroeconomic responses

Figure 2 reports the responses of output, investment and consumption. The shocks are normalized so that the TFP shock and the KS shock correspond to a 100 basis points increase in TFP and the capital share of income, whereas the IST shock is associated with a 100 basis points drop in the relative price of investment.

All shocks are associated with a strong positive comovement among the three macroeconomic aggregates. A TFP shock generates a simultaneous increase in GDP, consumption and investment, with the full impact of the shock taking roughly two years to be fully reflected into a persistent increase, in all variables. All of these display a more hump shaped response after an IST shock, with the impact on output and investment being somewhat transitory. This supports the view that the expansionary effects of an improvement in investment-specific technology unfold through the formation of new capital (in line with Greenwood et al., 1988).

While the business-cycle implications of IST and TFP shocks have been widely studied by both the theoretical and the empirical literature, we lack empirical evidence on the macroeconomic consequences of exogenous deviations in the capital share of income. The third row of Figure 2 shows that KS shocks are expansionary. The peak

Figure 2: Macroeconomic aggregates



Notes: The figure displays the IRFs of GDP, investment and consumption to an exogenous 100 bp increase in neutral technology (TFP, top row), investment-specific technology (IST, middle row) and capital share of income (KS, bottom row), estimated over the sample 1982Q4-2017Q4. Dark and light-grey shaded areas represent the 68% and 90% confidence intervals, respectively.

response occurs after about two years, in all variables. This shock is also associated with a very large response of investment, with the peak response being almost twice as large as that induced by a TFP shock. Indeed, an increase in the capital share of income renders physical capital more productive, thus exerting a sustained expansionary force on output. On the other hand, the response of consumption is more muted, reaching its peak after about 6 quarters, to then steadily decline.

3.2 Consumption and income responses at the household level

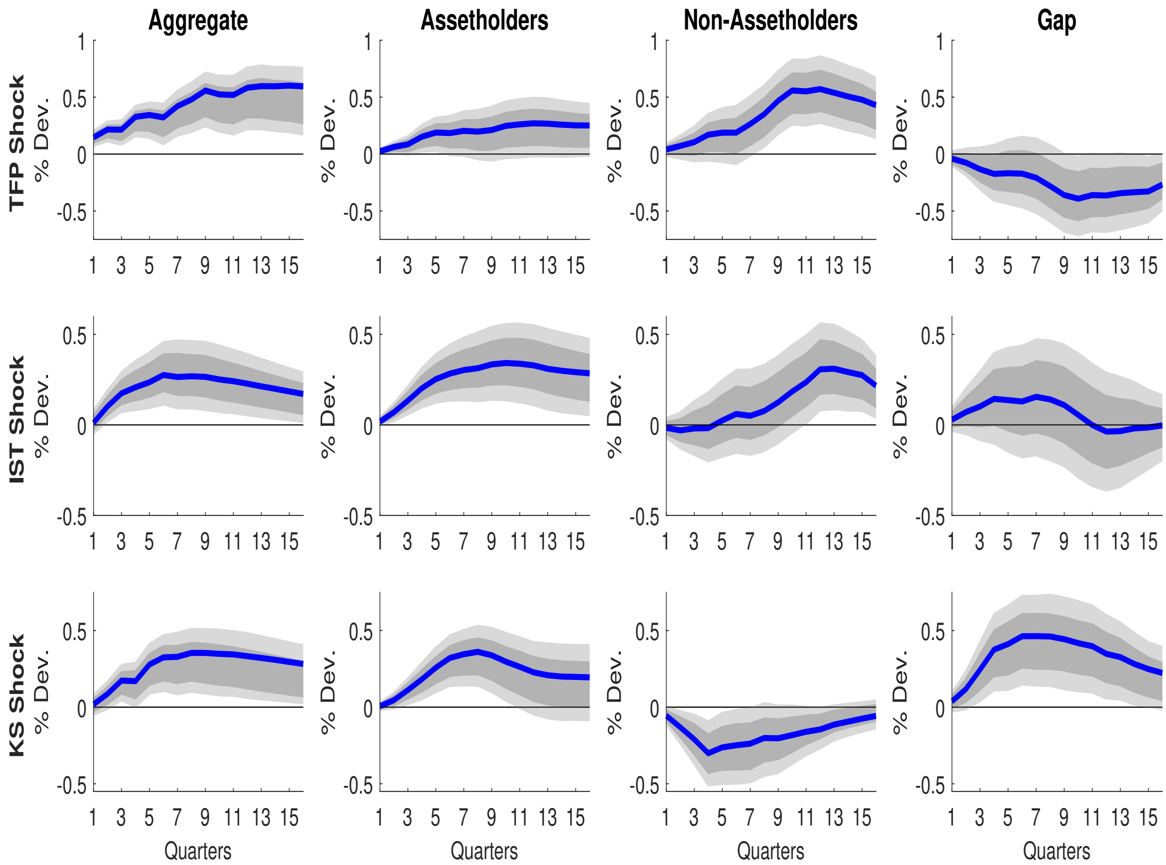
While the responses of main macroeconomic aggregates display a strong positive comovement—conditional on each of the three aggregate supply shocks—we document major differences in the responses of consumption and income of households sorted based on their asset ownership. Figures 3 and 4 report the IRFs of non-durable and services expenditure, as well as of net income, respectively. We focus on: *i*) the estimated responses for the economy-wide representative household (first column), *ii*) the representative assetholder (second column), *iii*) the representative non-assetholder (third column), and *iv*) the ratio between the consumption (or income) of the representative assetholder and that of the non-assetholder (fourth column), which is taken as a metric to account for heterogeneity between the consumption (or income) responses of the two representative households.

Looking at Figure 3, we infer that the responses of different macroeconomic aggregates hide substantial heterogeneity. Both TFP and IST shocks induce positive co-movement between the consumption of the two representative households. However, facing a TFP shock, non-assetholders' consumption rises relatively more than that of the assetholders, thus implying a contraction in the consumption gap. The latter expands, instead, following an expansionary IST shock: on impact, and for the first few quarters, non-assetholders' consumption response is flat and insignificantly different from zero, whereas unconstrained households' consumption IRF displays a strongly significant and positive hump-shaped pattern. As for the KS shock, this implies a strong contraction in non-assetholders' expenditure, as opposed to the expenditure surge displayed by the assetholders. Thus, a positive KS shock inevitably widens the consumption gap.[10]

It is also important to compare the consumption responses considered so far with the dynamic effects of the supply shocks on after-tax income. In fact, heterogeneity in the consumption responses could reflect either different propensities to consume out of disposable income—for given and comparable income responses—or heterogeneous responses of income. Looking at Figure 4, we immediately notice that conditional income dynamics, both at the aggregate and at the household level, closely resembles the behavior of non-durables and services expenditure. This suggests that household-specific consumption responses actually reflect differential responses of in disposable incomes. This should not come as a surprise, given that—at least for TFP and IST shocks—we typically observe substantial permanent-income effects. Therefore, one would expect consumption to closely track income movements, even for the households with a lower marginal propensity to consume. Conditional on a positive TFP shock, the IRF associated with non-assetholders' income peaks at almost 1%, as compared with the 0.4% estimated for assetholders, thus implying a contraction in

[10]By classifying households into assetholders and non-assetholders, we implicitly assume that the transition between groups is reason for no particular concern and that the supply shocks do not trigger significant endogenous changes in assetholding. This condition is required to interpret the consumption responses as actual changes in expenditures, rather than mere compositional effects. Figure D.1 in Appendix D supports this view. Despite the conditional behavior of the share of assetholders is in line with that of the consumption gap—as expected on theoretical grounds—little variation emerges, regardless of the specific shock we consider.

Figure 3: Non-durables and services expenditure

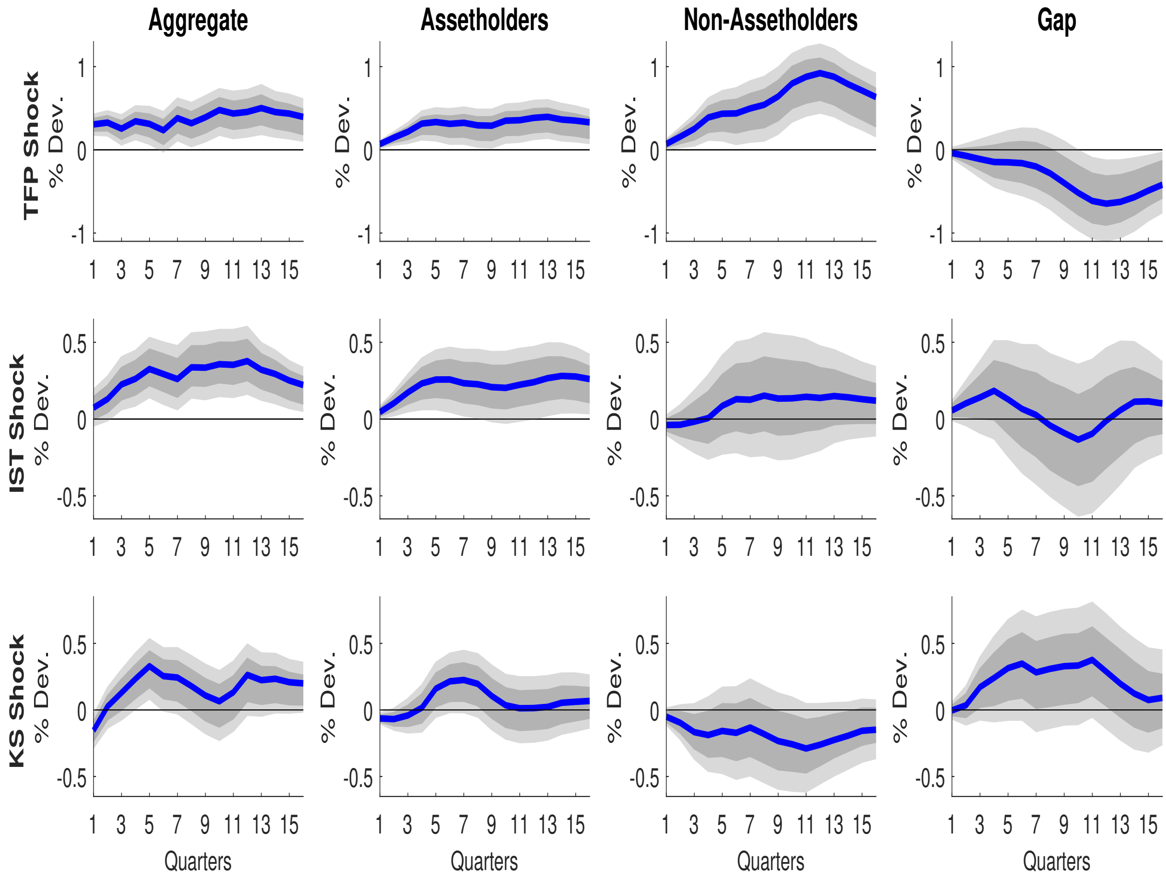


Notes: The figure displays the IRFs of non-durables and services expenditures for the representative agent (first column), the representative assetholder (second column), the representative non-assetholder (third column), and the ratio between assetholder's and non-assetholder's expenditure (fourth column) to an exogenous 100 bp increase in neutral technology (TFP, top row), investment-specific technology (IST, middle row) and capital share of income (KS, bottom row), estimated over the sample 1982Q4-2017Q4. Dark and light-grey shaded areas represent the 68% and 90% confidence intervals, respectively.

the income gap. Conversely, IST shocks induce a significant and positive response in assetholders' income, while leaving that of non-assetholders almost unaffected. Moreover, we document a negative comovement in the two agents' income, thus implying an expansionary income gap, in response to KS shocks.

To summarize our findings so far, while accounting for the entire time profile of the IRFs, Table 1 reports the cumulative response of different measures of household-level consumption and income over 16 quarters, following the shock of interest. According to Panel A, following a positive neutral technology shock non-assetholders increase their spending in non-durables and services, as well as total consumption expenditure, by a statistically significant 5.35% and 6.59%, respectively, as compared to the 3.05% and 3.36% increase in spending by the assetholders. Thus, consistent with the IRF analysis on the consumption gap, we find that TFP shocks exert long-lasting and

Figure 4: Net income



Notes: The figure displays the IRFs of net income for the representative agent (first column), the representative assetholder (second column), the representative non-assetholder (third column), and the ratio between assetholder's and non-assetholder's expenditure (fourth column) to an exogenous 100 bp increase in neutral technology (TFP, top row), investment-specific technology (IST, middle row) and capital share of income (KS, bottom row), estimated over the sample 1982Q4-2017Q4. Dark and light-grey shaded areas represent the 68% and 90% confidence intervals, respectively.

large effects that favor, in relative terms, non-assetholders. Non-assetholders also denote a more marked rise in net income (8.82%, compared to 4.73% for assetholders). However, total consumption adjusts relatively less compared to net income, suggesting that part of the increase in the disposable income is saved by both types of agents. As for the IST shock (Panel B), this triggers a rise in assetholders' total consumption (4.34%), which exceeds, albeit marginally, the overall upward adjustment in net income (3.42%). At the same time, the cumulative response of non-assetholders' income is statistically indistinguishable from zero, while their consumption rises by 3.84%, implying a widening of both the consumption and the income gap. Similar conclusions apply when considering a KS shock (Panel C): here, however, the cumulative response of non-assetholders' consumption and income is negative and economically meaningful.

As assetholders and non-assetholders display different average consumption and income levels, heterogeneous relative responses of these household-specific variables do not necessarily map into an actual redistribution of (monetary) resources of the same sign. In this respect, given that assetholders are on average richer than non-assetholders, our estimates indicate the potential emergence of such a discrepancy only in the case of TFP shocks, which imply positive comovement between the two households' expenditure (and income) responses, along with a drop in their 'gap' counterparts.To check whether this is the case, Table D.1 in Appendix D reports the cumulative responses expressed in dollar values (adjusted for the group-specific means). According to this, we confirm an actual redistribution of resources, from assetholders to non-assetholders, when looking at the dollar responses of their net incomes to a positive TFP shock. On the other hand, assetholders' gross (i.e., before-tax) income increases *more* compared to non-assetholders' (respectively by a statistically significant 2012.78$ and 1600.66$). This suggests that, although expansionary TFP shocks tend to redistribute gross income in favor of the assetholders, in the presence of progressive taxation the after-tax income of non-assetholders ultimately experiences a larger expansion. As for the remaining supply shocks, we appreciate a clear correspondence between the dollar responses of gross and net income.

3.3 Robustness

Prior to framing our results from a theoretical viewpoint, we conduct a number of exercises aimed at ensuring that the findings highlighted so far about the dynamics of the consumption and income gap are robust features of the data. In this section we summarize the main results of our robustness checks, while more details are reported in Appendix D.

Controlling for observable heterogeneity Our first robustness exercise aims at controlling for households' observable heterogeneity. Most heterogeneous-agent models assume that households are ex-ante identical, and therefore do not differ by other dimensions than their income history, or the ability to access financial markets. Nevertheless, it is well known that the composition of households' portfolios is strongly correlated with demographic characteristics such as age, education and gender (Guiso and Sodini, 2013). Moreover, recent works have shown that housing tenure is a key determinant of the responsiveness of households' consumption and income to demand shocks (see Cloyne and Surico, 2017; Cloyne et al., 2019, among the others). To control for such potentially relevant dimensions of heterogeneity, we follow Kehoe et al.

Table 1: Cumulative responses over 16 quarters

	Non-Durables and Services	Total Consumption	Net Income
	Panel A: TFP Shock		
Assetholders	3.05	3.36	4.73
	[0.99,4.25]	[1.19,4.69]	[2.73,5.72]
Non-Assetholders	5.35	6.59	8.82
	[3.07,6.82]	[3.95,8.42]	[5.28,10.69]
	Panel B: IST Shock		
Assetholders	4.02	4.34	3.42
	[2.55,5.32]	[2.46,5.87]	[1.9,4.75]
Non-Assetholders	2.01	3.84	1.46
	[0.67,3.52]	[2.28,5.76]	[-0.96,3.81]
	Panel C: KS Shock		
Assetholders	3.49	6.2	0.99
	[1.5,4.6]	[3.64,7.75]	[-0.75,2.23]
Non-Assetholders	-2.64	-2.87	-2.85
	[-3.71,-1.29]	[-4.33,-1.23]	[-4.68,-0.3]

Notes: Cumulative responses over 16 quarters to an exogenous 100 bp increase in neutral technology (Panel A), investment-specific technology (Panel B) and capital share of income (Panel C), estimated over the sample 1982Q4-2017Q4. Bootstrapped 68% confidence intervals reported in brackets. The cumulative responses are computed as the present discounted value (given an average annual real interest rate equal to 1%) of the relative change in expenditure or income over the 16 quarters following the shock.

(2020) in that we group households into 24 categories based on age, education, gender and housing-tenure status. We therefore compute the consumption and income series for a representative assetholder and a non-assetholder that, by construction, are identical along the dimensions we control for. Figures D.2 and D.3 show that the relative responses of household-level consumption and income are essentially invariant, with respect to the original specification. Table D.2 also reassures us that the size and significance of the cumulative responses remain essentially unchanged.

Sorting based on stockholdings So far, the study has focused on a assetholders–non-assetholders dychotomy. However, the distinction between stockholders and non-stockholders has traditionally received wider consideration in the asset-pricing literature (Malloy et al., 2009). We verify that the conditional cyclical properties of the consumption and income gaps also apply to this type of household groups, as demonstrated in Figures D.4 and D.5. In particular, over a 16-quarters horizon the cumulative response of both agents' non-durables and services consumption is very similar, in the face of both TFP and IST shocks (see Table D.3). Furthermore, non-stockholders' cumulative consumption response to a positive KS shock is still negative, yet not statistically indistinguishable from zero.

An alternative sorting strategy The representative household-specific series are constructed using a 'continuous' measure of participation to the asset market. While we deem this method appropriate to deal with the uncertainty entailed by the imputation procedure, it involves two unappealing features. First, it ignores the information on assetholdings provided in the CEX (as the probability of being an assetholder is computed based on SCF data). Second, it implies that the same household's consumption (or income) simultaneously contributes to the representative assetholder's and non-assetholder's consumption, according to the imputed probability. Therefore, as a robustness check we employ a method whereby: *i*) the imputation from the SCF is applied only to those households who cannot be defined as assetholders according to the financial information in the CEX; *ii*) a household is univocally classified as an assetholder or a non-assetholder. Figures D.6 and D.7 and Table D.4 show that, based on this sorting procedure, the results are even more clearcut, compared to the baseline. For example, the IRFs of the consumption and the income gaps to the IST shock are now statistically significant, and the negative comovement between the two agents' consumption responses is further exacerbated, conditional on a KS shock.

Extended VAR Finally, we repeat the empirical analysis by extending the VAR system in Equation (1) to include (log) per-capita hours as a fourth variable. The inclusion of this variable allows us to control for the potential impact of demand shocks on the TFP, the relative price of investment, and the labor share. The identified shocks are largely unaffected by the addition of per-capita hours. Figures D.8 and D.9, show that the responses of household-level consumption and income—as well as those of their respective gaps— maintain the same dynamic properties as in the baseline analysis. Also, Table D.5 reports cumulative responses that are very close to the baseline estimates.

4 Framing the empirical analysis

In this section, we introduce a stylized model that can transparently rationalize the main insight from the empirical analysis on household-level consumption and income: while positive TFP shocks redistribute resources in favor of the representative non-assetholder's income and consumption, expansionary IST and KS shocks induce a relatively stronger upward adjustment in the consumption and income of the representative assetholder. According to our framework, the explanation of these facts crucially rests on the relative responsiveness of wage vs. dividend income to different aggregate supply shocks. The section concludes with further empirical evidence in support of this mechanism.

4.1 A two-period model

We consider a two-period economy populated by a representative firm and a continuum of households of unit size. We restrict the analysis to a perfect-foresight scenario, without loss of generality.

Households are either non-assetholders (denoted by *na*), whose share in the total population of households equals γ, or assetholders (*a*), whose population share amounts to $1-\gamma$. The two types of households have the same utility function, $U^i = \log(c_1^i)+\beta\log(c_2^i)$, where $\beta \in (0,1)$ is a common discount factor and c_t^i denotes household-specific consumption of a generic perishable good, for $i=a,na$ and $t=1,2$.

Non-assetholders cannot access financial markets. Being unable to smooth consumption intertemporally, the representative non-assetholder consumes her labor income hand-to-mouth, $c_t^{na}=w_t$, where w_t is the wage rate and where we have implicitly assumed that non-assetholders supply their entire time-endowment, which is normalized to one, in both periods of life. Assetholders, instead, purchase stocks of the representative firm in period one, and inelastically supply their labor to the firm in both periods. The resulting period budget constraint is $c_t^a = w_t + d_t s_1$, where d_t denotes firm profits and s_1 is the number of shares purchased in period one, to be held over the entire lifetime. We assume stocks to be in unit net supply, so that $(1-\gamma)s_1 = 1$.

Production of the non-durable consumption good is carried out by the representative firm through the constant return-to-scale technology $y_t = z_t k_{t-1}^{\alpha_t} n_t^{1-\alpha_t}$, (with $\alpha_t \in (0,1)$), where k_{t-1} denotes the existing capital stock, n_t is the total labor input, z_t is TFP, and α_t is the income share of capital. Firm profits in periods 1 and 2 read as $d_1 = y_1 - w_1 - i_1/\mu_1$ and $d_2 = y_2 - w_2$, respectively. Following Greenwood et al. (1997), we interpret μ_1 as capturing investment-specific technological change. Finally, we assume full capital depreciation, so that the effective investment taking place in period one equals the capital stock.

4.2 Heterogeneity in the transmission of supply shocks

After determining the solution for capital investment and agent-specific period consumption choices, as detailed in Appendix E.1, we examine the response of the consumption gap, conditional on each of the three shocks we consider. Unlike the quantitative model devised in the next section, the two-period framework mainly serves as a device to frame the propagation of different supply shocks in a setting featuring household heterogeneity in the access to a saving technology. Nevertheless, to maintain adherence to our identification strategy, we consider TFP as featuring a permanent shift over the two periods of life, while KS shocks will be temporary, and take place in the first period only. As for investment-specific technological change, this can only occur in period one, by construction.

4.2.1 Consumption-gap responses

The consumption gap assumes a central role in examining the responsiveness of different household types' consumption in the face of the shocks we study in Section 3.2. In line with the empirical analysis, we consider c^a/c^{na} as the gap between the representative assetholder's and the non-assetholder's total discounted consumption (i.e., $c^i = c_1^i + \beta c_2^i$, for $i = a, na$). After substituting each agent's consumption by their period budget constraints, it can be shown that

$$\frac{c^a}{c^{na}} = 1 + \frac{1}{1-\gamma}\frac{d_1 + \beta d_2}{w_1 + \beta w_2}, \tag{3}$$

implying that asymmetries in household-specific per-capita consumption depend on the income distribution between labor and capital. Thus, the consumption gap will move in either direction depending on the capacity of each shock to stimulate the responsiveness of dividend income relative to wage income. Such implication is central to our analysis, as it allows us to explain how different shocks propagate to agent-specific consumption and, thus, in the aggregate.

We compute the derivative of c^a/c^{na} with respect to each shock the model contemplates.[11] Starting with the TFP shock, we report the next proposition.

Proposition 1. *An expansionary TFP shock induces a contraction in the consumption gap:*

$$\frac{d(c^a/c^{na})}{dz} < 0, \tag{4}$$

where $z_t = z$, for $t = 1, 2$. ***Proof.*** *See Appendix E.2.*

As in the data, an expansionary TFP shock redistributes resources from assetholders to non-assetholders, thus contracting the consumption gap. To see why this is the case, we can express Equation (3) in terms of primitives, switching off KS and IST shocks for expositional convenience:

$$\frac{c^a}{c^{na}} = \frac{1}{(1-\gamma)(1-\alpha)} \frac{z\left(k_0^\alpha + \beta k_1^\alpha\right) - i_1}{z\left(k_0^\alpha + \beta k_1^\alpha\right)} - \frac{\gamma}{1-\gamma} \tag{5}$$

This relationship indicates that the negative wealth effect induced by investment acts as a drag on the increase in assetholders' income, potentially restricting it below that of non-assetholders. In turn, such tendency maps into agents' consumption choices. This mechanism also helps us to understand the behavior of relative consumption with respect to IST shocks, as detailed by the next proposition:

Proposition 2. *An expansionary IST shock determines an expansion in the consumption gap:*

$$\frac{d(c^a/c^{na})}{d\mu_1} > 0. \tag{6}$$

Proof. *See Appendix E.2.*

Ameliorating the efficiency with which the final good can be transformed into physical capital limits the negative wealth effect borne by assetholders' through capital investment, while expanding period-1 capital in equilibrium (taking Equation (5) into

[11] In each exercise of comparative statics, we set the shocks that are not being investigated to their steady-state values.

consideration, we can simply replace i_1 with i_1/μ_1, while switching off TFP shocks, all else equal). Thus, the consumption gap ultimately expands.

The next proposition delves into the relative consumption effects of a KS shock that redistributes resources from labor to the capital, thus favoring dividend income over wage income, and ultimately expanding the consumption gap.

Proposition 3. *An expansionary KS shock determines an expansion in the consumption gap, i.e.*

$$\frac{d(c^a/c^{na})}{d\alpha_1} > 0 \tag{7}$$

as long as the following sufficient condition is met: $1 \leq k_0/y_1 < \exp(1/\beta\alpha)$.[12] ***Proof.*** *See Appendix E.2.*

4.3 Dividend and wage income responses to the supply shocks

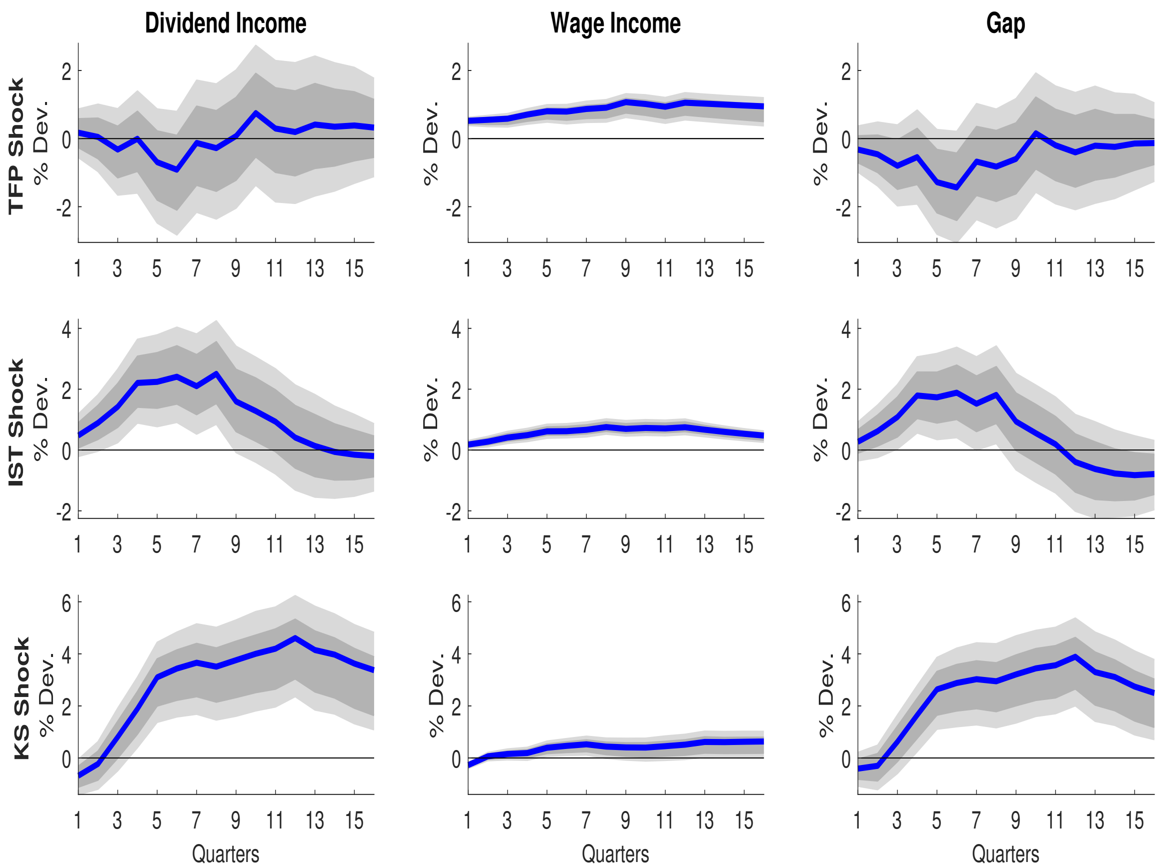
The behavior of relative (per-capita) consumption in response to different supply shocks emphasizes the tension between dividend and wage income, and how a given shock redistributes resources between them (see Equation (3)). While expansionary IST and KS shocks disproportionately benefit the productivity of capital investment and, thus, dividend income, a TFP shock produces a more balanced impact on labor and capital income, with the former displaying higher reactiveness.

We test these predictions in the data. Figure 5 graphs the empirical response of dividend and wage income, as well as the response of (the log of) the ratio between the two. TFP shocks disproportionately affect wages, with a peak response of almost 1% after 5 quarters, while the IRF of dividends is not significant at any horizon. This, in turn, reflects into their ratio declining below trend over the first 6 quarters. By contrast, both IST and KS shocks tend to favor dividend income more than wage income, implying a significant expansion in their ratio. In particular, KS shocks produce very sizeable and lingering effects on dividends, which rise by more than 4% after 12 quarters. Conversely, the response of wages is almost muted for the first two years after the shock, to then reach a peak of roughly 1%.

All in all, conditional movements in the dividend-to-wage income ratio are in line with those of the consumption gap—as shown in Figure 3—as well as with the theoretical insights of our stylized economy. Importantly, these results also echo the evidence reported in Table 1, where heterogeneity in the response of households' consumption reflects that of their income responses. In fact, assetholders' net income expands relatively less (more), as compared with non-assetholders, in the face of an expansionary

[12] For standard parameterizations of α and β, we observe that the upper bound to the capital-to-output ratio is rather loose, and includes a very large set of empirically relevant values.

Figure 5: Aggregate dividend and wage income



Notes: The figure displays the IRFs of dividend income, wage income and the ratio between the two to an exogenous 100 bp increase in neutral technology (TFP, top row), investment-specific technology (IST, middle row) and capital share of income (KS, bottom row), estimated over the sample 1982Q4-2017Q4. Dark and light-grey shaded areas represent the 68% and 90% confidence intervals, respectively.

TFP (IST or KS) shock. This fact will prove to be key to understand how asset-pricing moments are affected by the interplay between different shocks and limited asset ownership.

5 Macroeconomic and asset-pricing implications

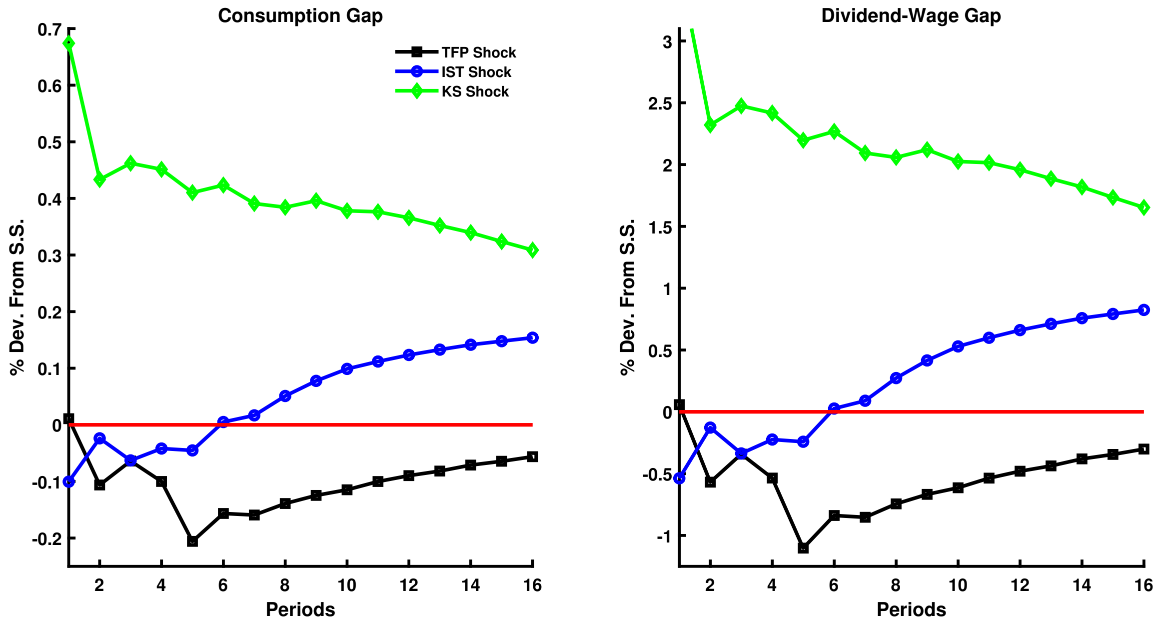
We extend the two-period model to an infinite-horizon setting including standard propagators, such as habits in consumption and convex investment-adjustment costs. This framework is used to highlight how heterogeneity in the response of different types of income remains central to understand the consumption response of different household types. Different shocks entail varying degrees of redistribution between household types and between different income sources. This is key to understand how fluctuations in macroeconomic aggregates and asset prices are shaped in limited asset ownership economies.

The framework builds on the production-based asset-pricing model with limited asset ownership of Lansing (2015). We introduce three aggregate supply shocks, in line with the analysis so far. Conditional on these, we allow for dynamic interaction among TFP, the relative price of investment and the labor share, as documented in Section 2.3. This stands in contrast with the traditional approach of assuming independent autoregressive processes for the supply shocks, which are calibrated to match the dynamics of macroeconomic data. The main benefit from taking this route is that we avoid the implicit assumption that supply shocks are the only source of perturbation in the economy. Furthermore, inspired by Ríos-Rull and Santaeulalia-Llopis (2010) we see our VAR specification as a flexible tool to capture (potentially) endogenous dynamic interactions between TFP and the labor share.[13]

Calibration The parameters of the model are set in line with standard values in the literature, without explicitly aiming at matching any statistical moments of macroeconomic or asset-pricing data. Appendix F details the model and its calibration. The framework does a fairly good job at replicating the volatility of investment, dividends and—most importantly, in consideration of the role it assumes in our narrative—the consumption gap. The volatility of output and aggregate consumption are, instead, clearly overshooted. This is largely foreseen, though, and for different reasons. In fact, the calibration strategy we adopt for the exogenous state variables leaves no degrees of freedom, as for the aim of matching the standard deviation of output. As for σ_{g_c}, instead, Guvenen (2009) and Chen (2017) have extensively discussed how selecting the parameters characterizing household utility and the capital adjustment costs typically entails some distinctive trade-offs when trying to match the volatility of investment, dividends and consumption. In our case, the good performance along the first two dimensions evidently comes at the expense of the last one, in the absence of mechanisms that typically smooth consumption dynamics. As for asset pricing, it is worth mentioning that the model produces plausible excess stock returns, both in their level and volatility (the equity premium is 3.94 in the model vs. 4.39 in the data, while its volatility is 19.14 in the model vs. 15.67 in the data). As compared with traditional representative agent production-based models, restricting access to financial investment to a limited number of assetholders raises the equity premium they demand, through the connection between their consumption growth and financial income, which is intrinsecally more volatile. A criticality, in this case, is represented by the risk-free rate,

[13] For instance, Choi and Ríos-Rull (2020) show that a combination of putty-clay technology, time-bias—whereby shocks may affect newer firms in a stronger way than older firms—and competitive wage-setting, can rationalize the overshooting property of the labor share, following a TFP shock.

Figure 6: Consumption and dividend-wage gaps: IRFs



Notes: Consumption and dividend-to-wage gap responses to one-standard deviation expansionary TFP, IST and KS shocks.

which is not as low as in the data, along with displaying some excess volatility. As in Jermann (1998) and Lansing (2015), consumption habits and capital adjustment costs generating sufficiently volatile stock returns concurrently induce strong fluctuations in investors' marginal utility, which reflects into the standard deviation of the risk-free rate.

Conditional dynamics After reporting the *unconditional* properties of the model, in Figure 6 we evaluate its capacity to reproduce the cyclical properties of consumption and income redistribution between the two representative households, *conditional* on each shock being considered. Expansionary KS shocks are associated with a positive response of the consumption gap, as well as a stronger response of dividends with respect to wages. This is also the case for IST shocks, after a weak initial response. Conversely, expansionary TFP shocks induce a countercyclical change in the consumption gap, which reflects higher sensitivity of labor income with respect to dividend income. Notably, the model-implied IRFs—for both the consumption gap and different income sources—are quantitatively consistent with their empirical counterparts, if one abstracts from the absence of a delayed response. For instance, the peak response (which is reached on impact, in the model) of the consumption gap to the KS (TFP) shock is about 0.7% (-0.2%), which is comparable with the IRFs displayed in Figure 3. In addition, the responses of both the consumption gap and the dividend-to-wage ratio to the IST shock are relatively more muted, in line with the empirical evidence of Section 3. From a quantitative viewpoint, allowing for dynamic interactions among the exogenous shocks turns out to be important to reproduce results in line with the empirical findings. Without such interactions, in our setting dividends would otherwise increase persistently after an increase in TFP. By contrast, in Section 2.3 we have documented that a TFP increase is associated with a rise in the relative price of investment and a fall in the capital share of income (after the first period), with both effects exerting a negative force on dividends, in line with Figure 5. Coherently, the model produces a relatively muted response of dividends to a TFP shock.

5.1 Macroeconomic and asset-pricing drivers

The quantitative setting allows us to ask which shock acts as the main driver of macroeconomic and asset-pricing variables. In this respect, Table 2 reports the relative contribution of each shock to the macroeconomic (top panel) and asset-pricing (bottom panel) moments of interest. As for the macroeconomic variables, the variance decomposition is performed both over the short run (up to 16 quarters), and for their unconditional moments, with the short-run variance decomposition being computed as in den Haan (2000). As for the asset-pricing variables, we decompose only their unconditional moments, following Jensen et al. (2018).[14]

Table 2 highlights a clear disconnect between the macroeconomic and the asset-pricing drivers. Technology shocks (both investment-specific and neutral) are responsible for large part of business fluctuations, jointly accounting for roughly 80% of the (unconditional) volatility of output, investment and consumption. In fact, both the short-run and the long-run decompositions consistently identify IST shocks as the main drivers of macroeconomic fluctuations, in line with the contribution of Justiniano and Primiceri (2008). Turning our focus on the equity premium, IST shocks account for a negligible fraction of its volatility, consistent with the fact that such shocks emerge as being rather neutral, in terms of consumption redistribution between the two agents, as indicated by the empirical analysis of Section 3. Though to a lesser extent, this is also the case for TFP shocks, which have traditionally been considered as a key source of risk in production-based asset-pricing models. Therefore, TFP and IST shocks play a very marginal role when it comes to reproduce fluctuations in asset prices, where the dynamics of (the first and second moment of) the equity premium and, to a lesser extent, the risk-free rate, can almost entirely be attributed to KS shocks.

[14]Specifically, for the generic detrended variable $\tilde{x}$ and the corresponding moment $\mathcal{M}(\tilde{x})$, the relative contribution of shock ξ to the unconditional moment is defined as $\mathcal{M}(\tilde{x})_\xi = \frac{\mathcal{M}(\tilde{x})-\mathcal{M}(\tilde{x})_{-\xi}}{\sum_\xi[\mathcal{M}(\tilde{x})-\mathcal{M}(\tilde{x})_{-\xi}]}$ for $\xi = u^\mu, u^z, u^\alpha$, where $\mathcal{M}(x)_{-\xi}$ is the unconditional moment of $\tilde{x}$ when shock ξ is turned off.

Table 2: Shock contribution

Moment		TFP	IST	KS
Macro aggregates				
$\sigma_{\log(\tilde{y})}$	unc.	16.1	64.9	19
	0-4ys	16	54.6	29.4
$\sigma_{\log(\tilde{c})}$	unc.	18.2	61.2	20.6
	0-4ys	20.6	56	23.4
$\sigma_{\log(\tilde{inv})}$	unc.	14	68.3	17.7
	0-4ys	10.8	50.8	38.4
$\sigma_{\log(\tilde{c}^a/\tilde{c}^{na})}$	unc.	9.5	46.5	44
	0-4ys	6.6	4.8	88.6
Asset prices				
$E(r^b)$		17.4	-2	84.6
$E(r^s - r^b)$		9.9	-1.3	91.4
σ_{r^b}		20.7	7.8	71.5
$\sigma_{(r^s - r^b)}$		3	1.6	95.4

Notes: Each entry indicates the (percentage) contribution of the corresponding shock to a specific macroeconomic or asset-pricing moment. Along each row, the sum of the three shock contributions amounts to 100. For the macroeconomic variables, the decomposition is presented over both the short run (16 quarters) and the long run (unconditional). For the asset-pricing variables, the decomposition is only presented in terms of unconditional moments.

Looking at the consumption gap and its drivers is key to understand the source of such disconnect between financial volatility and macroeconomic fundamentals. KS and IST shocks account for the lion share of the unconditional variance of the consumption gap, with the former explaining almost the totality of its short-run volatility. This sheds light on the intimate connection between the consumption of assetholders relative to that of non-assetholders, and how assets are priced in this economy. A large fraction of the average equity premium reflects a compensation for the risk associated with the stock market paying higher returns in periods when resources are redistributed (at least temporarily) to asset owners, who therefore need a stronger incentive to hold risky assets. In this respect, KS shocks of a given sign are particularly effective, as compared with IST shocks, at generating large swings in assetholders' consumption in the same direction. This is due to the strong sensitivity of dividends, as compared to wages, to such shocks. By contrast, TFP shocks mainly affect wages, as compared with dividends, thus implying a relatively muted response of assetholders' consumption, and a lower equity premium.

Table 3: Effects of household heterogeneity

	Macro aggregates				Asset prices		
		Baseline	High			Baseline	High
		$\gamma = 0.33$	$\gamma = 0.8$			$\gamma = 0.33$	$\gamma = 0.8$
$\sigma_{\log(\tilde{y})}$	unc.	0.46	0.66	$E(r^b)$	unc.	-9.9	-38.9
	TFP	0.95	2.2		TFP	0.47	1.4
	IST	-0.97	5.1		IST	0.22	0.61
	KS	4.6	16.4		KS	-9.8	-37.6
$\sigma_{\log(\tilde{c})}$	unc.	-0.33	-0.52	$E(r^s - r^b)$	unc.	19.4	74.3
	TFP	-0.27	-0.66		TFP	0.8	3.3
	IST	-0.13	-0.42		IST	9	64.5
	KS	-0.89	-0.64		KS	21.7	83.4
$\sigma_{\log(\tilde{inv})}$	unc.	0.91	2.1	σ_{r^b}	unc.	9.3	31.3
	TFP	1.6	3.6		TFP	10	33.9
	IST	-2.1	-10.9		IST	8.3	28.9
	KS	12.2	44.2		KS	9.2	30.8
				$\sigma_{(r^s - r^b)}$	unc.	9.4	32.7
					TFP	0.38	0.25
					IST	17.6	55.8
					KS	9.8	33.9

Notes: Each entry indicates the percent variation in the macroeconomic or asset pricing moment obtained in the TA economy relative to the RA economy. Results are shown for both the baseline value of the fraction of non-assetholders ($\gamma = 0.33$) and for $\gamma = 0.80$. Both unconditional and conditional percentage variations are reported.

5.2 On the role of household heterogeneity

Armed with these insights on the determinants of macroeconomic and asset-pricing moments, we are now ready to examine the role of limited stock ownership in driving the aggregate results. To this end, we perform a simple comparative-statics exercise, whereby we compare a RA benchmark to two alternative TA economies that only differ in the degree of access to the asset market participation.

In the existing literature, the calibration of the share of hand-to-mouth households, γ, crucially depends on how this is interpreted. On one hand, most contributions in the macroeconomic literature see γ as capturing the share of the population with limited access to financial markets *lato sensu* and, as such, they set it within the $[0.2 - 0.4]$ interval (see, e.g., Bilbiie, 2008; Debortoli and Galí, 2017; Aguiar et al., 2020). This view is compatible with the share of U.S. households holding very few liquid assets. On the other hand, some look at γ as the share of the population with a direct exposure to the stock market, hence holding the ultimate ownership of the productive assets in the economy (see, e.g., Lansing, 2015; Lansing and Markiewicz, 2017). In this case γ is calibrated to higher values—typically between 0.75 and 0.9—a choice that allows matching the striking heterogeneity between wealthy households and the rest of the population.

In light of this, Table 3 contrasts a set of macroeconomic and asset-pricing moments for two different levels of asset ownership: our baseline value ($\gamma = 0.33$), and a relatively high value of 0.8. In both cases, we report the percentage deviation from the corresponding moment in the RA economy (i.e., at $\gamma = 0$). Moreover, we report both unconditional statistics and their counterparts conditional on each shock at the time. It is striking how the degree of limited asset ownership has little impact on the volatility of the three macroeconomic aggregates, regardless of considering conditional vs. unconditional moments. In fact, moving from the RA benchmark to $\gamma = 0.33$ and $\gamma = 0.8$ only implies a sizable increase in the volatility of both investment and—to a lesser extent—output, conditional on KS shocks.

On the asset-pricing front, instead, increasing limited asset ownership allows the model to jointly reduce the average risk free rate and increase the average equity premium, while increasing the volatility of both moments. Quantitatively, the impact of γ becomes pronounced only at relatively high values: at $\gamma = 0.8$, the average equity premium (the risk-free rate) is higher (lower) by 74.3% (38.9%) relative to the RA case, with the conditional analysis showing that such tendency is chiefly driven by IST and KS shocks. It is worth noticing how the marked curvature of the dilution factor, $1/(1-\gamma)$, explains why the equity premium only expands at relatively high levels of limited asset ownership. Moreover, this factor dominates the impact of γ on total dividends, thus shaping the unconditional volatility of per-capita dividends, which expands as γ increases.

To gauge the importance of γ for movements of the consumption gap and, thus, the equity premium, we need to account for two key facts. First, increasing γ necessarily leads to a more concentrated distribution of stocks: thus, the smaller the share of assetholders, the larger the contribution of the dividend component (relative to the wage component) to their income. Second, as we suggest in Section 5.1, the equity premium mainly reflects assetholders' exposure to risk associated with changes in consumption and income that are induced by KS shocks. In fact, this type of disturbances are particularly effective at generating large *procyclical* swings in the consumption gap and, therefore, the ratio between dividend and wage income. Combining these two facts implies that, as asset ownership progressively becomes less diluted through an increase in γ—so that dividends account for a larger share of assetholders' income—the equity premium factors in higher risk emanating from KS shocks. Conditional on TFP shocks, which typically affect dividends less than wages, the equity premium barely changes, instead, as the fraction of non-assetholders increases. This suggests that the first generation of production-based asset pricing models featuring limited participation and neutral technology shocks as the only driver of business cycles (Danthine and Donaldson, 2002; Guvenen, 2006, 2009) may only deliver plausible asset returns at the cost of generating conditionally procyclical consumption inequality, which is at odds with what we observe in the data.

6 Concluding remarks

Aggregate supply shocks induce markedly different responses of the consumption and income of assetholders and non-assetholders. While neutral technology shocks attenuate households' consumption and income inequality, investment-specific and capital share shocks amplify consumer inequality. A model with limited asset ownership comes close to capture these facts, with the propagation of each type of shock resting on its capacity to stimulate dividend *vis-à-vis* wage income, a prediction that is robustly confirmed by the data. Thus, through the lens of the model, we show that household inequality is quantitatively irrelevant to macroeconomic volatility, but not to asset pricing: the shocks that account for the bulk of the volatility in consumption inequality are also the key source of priced risk behind the equity premium.

Our empirical results emphasize the importance of accounting for household heterogeneity, even when considering aggregate shocks that stem from the supply side of the economy. In particular, different sensitivities of wage and dividend income to these shocks imply substantial reallocation of resources over the business cycle, allowing us to orientate in the design of production-based economies that aim at generating sizable macroeconomic fluctuations, along with reproducing realistic features of asset prices.

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Appendices

A Data sources

Below is reported the list of sources for the macroeconomic data employed in the empirical analysis. Unless otherwise noted, the data are provided by the Bureau of Economic Analysis (NIPA) and retrieved from the FRED website. Real per-capita measures are obtained by dividing nominal values by the U.S. population and the end-of-the-quarter monthly Consumer Price Index for all items computed by the Bureau of Labor Statistics.

- GDP: Gross Domestic Product, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. Code: GDP.
- Investment: Gross Private Domestic Investment, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. Code: GPDI.
- Non-durables: Personal Consumption Expenditures: Nondurable Goods, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. Code: PCEND.
- Services: Personal Consumption Expenditures: Services, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. Code: PCES.
- Durables: Personal Consumption Expenditures: Durable Goods, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. Code: PCEDG.
- Total Consumption: Non-durables + Services + Durables.
- CPI: Consumer Price Index for All Urban Consumers: All Items in U.S. City Average, Index 1982-1984=100, Monthly, Seasonally Adjusted. Code: CPIAUCSL. Aggregated to quarterly frequency by taking the end-of-quarter value. CPI Inflation is computed as the first log-difference in the quarterly series.
- Gross Income: Personal Income, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. NIPA, Table 2.1, Line 1.
- Net Income: Disposable Personal Income, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. NIPA, Table 2.1, Line 27.
- Wages: Compensation of Employees, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. NIPA, Table 2.1, Line 2.

- Financial Income: Personal Income Receipts on Assets, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. NIPA, Table 2.1, Line 13.
- Interest Income: Personal Interest Income, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. NIPA, Table 2.1, Line 14.
- Dividend Income: Personal Dividend Income, Billions of Dollars, Quarterly, Seasonally Adjusted at Annual Rate. NIPA, Table 2.1, Line 15.
- Population: Population, Thousands, Quarterly, Not Seasonally Adjusted. Code: B230RC0Q173SBEA.
- (Inverse) Relative Price of Investment: Relative price of "consumption" to price of "equipment", Quarterly, Annualized Growth Rates ($400\times$log-difference), from Fernald (2014).
- TFP: Business Sector (not utilization adjusted) Total Factor Productivity, Quarterly, Annualized Growth Rates ($400\times$log-difference), from Fernald (2014).
- Labor Share of Income: Nonfarm Business Sector: Labor Share, Index 2012=100, Quarterly, Seasonally Adjusted. Code: PRS85006173.
- Aggregate Hours: Index/Level and Office of Productivity And Technology and Work Hours: Hours Worked, Nonfarm Business. BLS. Code: PRS85006033. The per-capita measure is obtained by dividing over Population 16+.
- Population 16+: Civilian noninstitutional population, Level (in thousands), 16 years and over. BLS. Code: LNU00000000.
- Quarterly financial data are sourced from Amit Goyal's website (as discussed in Welch and Goyal, 2008), and the equity premium is computed from the average dividend yield and dividend growth following Fama and French (2002).

B Construction of household-level series from the CEX

In this appendix we describe the dataset and preliminaries used to construct quarterly time series of consumption and income at the household level over the period 1982-2017 from the U.S. CEX.

Description of the dataset

The CEX is a national survey collecting household-level data on detailed consumption expenditures together with income, financial and demographic information on a sample that is designed to represent the non-institutionalized civilian population of the US. The survey is divided in two parts: the Interview Survey and the Diary Survey. The analysis developed in this paper focuses on the first one. Data from the CEX are available from the start of 1980 to the end of 2017. The survey is a rotating panel containing interviews of about 4,500 households per quarter before 1999, increasing to about 7,500 thereafter. About 20% of the sample is replaced each quarter. In each interview, households report detailed expenditures made in the previous three months. Households are interviewed every 3 months, for a maximum of 5 interviews. The first interview is for practice and is not publicly available, while financial information is collected only in the last interview.

Sample choice, consumption definition and assetholding status

Consumption and income definition

Our analysis employs data available for the whole sample (1980Q1-2018Q1). We compute consumption of non-durable goods and services and durable goods aggregated from the disaggregated expenditure categories reported in the monthly expenditure files (MTAB and MTBI files) of the CEX. Non-durables and services consist of food, alcoholic beverages, apparel and services, gasoline and motor oil, household operations, utilities, tobacco, public transportation, fees and admissions, personal care products, reading, other vehicle expenses and other entertainment supplies, equipment, and services. Durable goods include purchases of vehicles, house furnishings and tv and audio equipment. Finally, gross and net income are defined as before and after tax income, respectively, while financial income is computed as the sum of dividend and interest income. Wage income is given by the sum of wages and salaries.

Exclusions

Standard restrictions are applied to the sample. Only households who completed the survey, i.e. for which four interviews are available in the FMLY/FMLI files, are included in the sample. Indeed, financial information is collected only in the fifth (i.e. the last) interview. Matching households across quarters is not possible around changes in sample design, which happened at the beginning of 1986, 1996, 2005 and

2015.[15] Such changes imply new household ID numbers. Therefore, all the households who did not finish their interviews before their ID changed are dropped.

Households with negative net income or incomplete income responses are excluded from the sample. Regarding the latter restriction, for the period 1980-2013 the variable RESPSTAT is used, which indicates whether the household is a complete or an incomplete income reporter. From 2014 such variable is no longer available. Hence, we use the variable ERANKH, which measures the weighted cumulative percent expenditure outlay ranking of the household to total population is left blank for incomplete income reporters. Moreover, all consumption observations for households interviewed in the years 1980 and 1981 are dropped as the food question was changed in 1982 leading to a drop in reported food expenditures.[16] Finally, we exclude all households who report a change in the household head's age different, from 0 or 1, between any two interviews.

Assetholding status from the CEX

The FMLY/FMLI files report household-level financial information on holdings of "stocks, bonds, mutual funds and other such securities" and of liquid accounts such as savings and checking accounts.

For the period 1980-2012, we use the following variables: SECESTX, which reports the amount the household holdings in the aforementioned asset categories (at the last day of the month preceding the interview); CKBKACTX, which reports the amounts (at the last day of the month preceding the interview) "in checking accounts, brokerage accounts and other similar accounts"; SAVACCTX, which asks "On the last day of (last month), what was the total amount your CU had in savings accounts in banks, savings and loans, credit unions, and similar accounts?". From 2013, these three variables were removed from the survey. However, at the same time a new variable STOCKX was added, which asks "As of today, what is the total value of all directly-held stocks, bonds, and mutual funds?". Similarly the new variable LIQUIDX was introduced, which measures the amounts invested in "checking, savings, money market accounts, and certificates of deposit or CDs".

Given these variables, we define a household as assetholder if the sum of SECESTX, CKBKACTX and SAVACCTX or STOCKX and LIQUIDX exceeds the threshold of 1000$. To keep comparability with the SCF variables, dollar amounts in year t

[15] The year-specific documentation files report this type of information. These files can be found at: http://www.nber.org/ces

[16] As noted by Malloy et al. (2009), the 'food' question was changed back to the initial one in 1988, but there is no sensible way to solve this issue without losing a substantial number of observations.

are multiplied by the absolute variation between year $t-1$ and year t in the (yearly average of the monthly) current-methods version of the CPI for all urban consumers (CPI-U-RS).[17]

However, indirect holdings cannot be retrieved from the CEX, as also noted by Malloy et al. (2009). In fact, we find that the participation rate in the stock market from the CEX is somewhat upward trending until the early 2000s. Nevertheless, the same rate substantially drops from those years until 2017, when only about 10% of the sample is classified as stockholders. Indeed, in 2013 the 'financial assets' question was changed to consider only direct holdings. Also, Lettau et al. (2019) argue that the CEX provides inferior measures for financial holdings, as compared with other surveys, such as SCF, which can potentially explain the lower estimated rates.

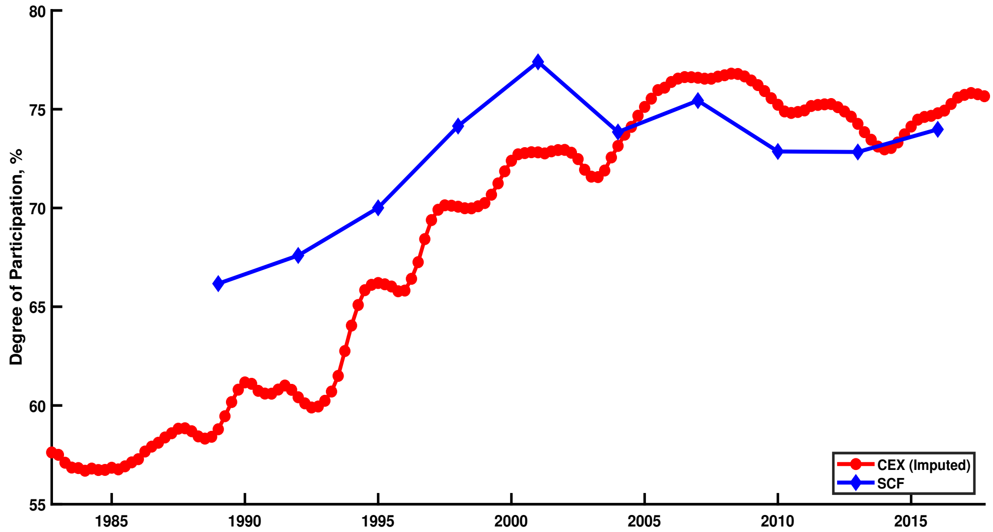
Imputation procedure from the SCF

To refine the assetholding status definition to account for indirect holdings, we follow the imputation procedure proposed by Attanasio et al. (2002) and Malloy et al. (2009). Specifically, we perform a probit analysis based on the SCF. This dataset contains wealth information on both direct and indirect stock or assetholdings that can be used to predict the probability that a household holds assets, directly or indirectly, in the CEX. We use the SCF, from 1989 through 2016 (i.e., the last available year). For the asset definition we generate a dummy variable equal to 1 if the sum of (direct and indirect) holdings in equity, bonds, savings accounts and checking accounts exceeds the threshold of 1000$.

Following Malloy et al. (2009), we then estimate a probit model where the dependent variable is the assetholding dummy and the regressors are the observable characteristics that are also available in the CEX: age, age squared, an indicator for the household head with education of > 12 but < 16 years (highschool), one for education > 16 years (college), an indicator for race not being white/caucasian, year dummies, (log) real total household income before taxes, an indicator for positive interest+dividend income, and a constant. We also include interaction terms between age and highschool (agehs) and between age and college (ageco). SCF weights are employed in the probit model to have population estimates. Here are the estimated coefficients (with t-statistics in parentheses) from the probit regression for assetholdings:

[17] Available at: https://www.bls.gov/cpi/research-series/home.htm

Figure B.1: Direct and indirect asset-ownership rates



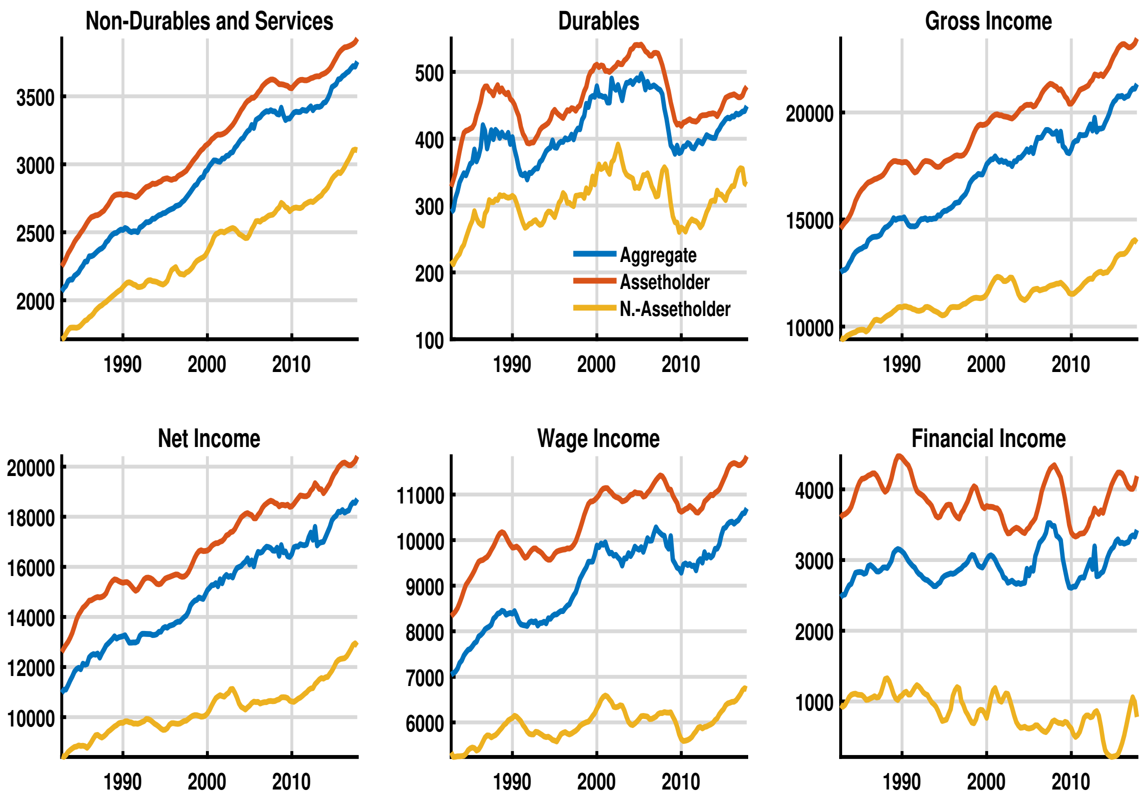
Notes: The figure compares the rates of direct and indirect asset-ownership, as measured from the SCF (blue line) and the CEX (red line).

$$
\begin{aligned}
x'_{SCF}b_{asst} = & \underset{(-56.72)}{-5.07} + \underset{(13.72)}{.022}\, age + \underset{(-5.96)}{-.00008} age^2 + \underset{(14.75)}{.51}\; highschool + \underset{(35.86)}{1.22}\, college \\
& + \underset{(-2.92)}{-.002} agehs + \underset{(-13.07)}{-.008} ageco + \underset{(-45.76)}{-.38}\; nonwhite + \underset{(1.57)}{.03}\, Y_{1992} + \underset{(9.27)}{.20}\, Y_{1995} \\
& + \underset{(15.93)}{.35}\, Y_{1998} + \underset{(20.19)}{.43}\, Y_{2001} + \underset{(14.65)}{.31}\, Y_{2004} + \underset{(17.50)}{.37}\, Y_{2007} + \underset{(16.67)}{.33}\, Y_{2010} + \underset{(16.30)}{.32}\, Y_{2013} \\
& + \underset{(18.42)}{.37}\, Y_{2016} + \underset{(44.36)}{.37}\, log(income) + \underset{(73.13)}{.95}\, (int + div > 0).
\end{aligned}
$$

We then use these coefficients to predict the probability that a household in the CEX holds assets as $\Phi(x'_{CEX}b_{asst})$, where Φ is the CDF of the standard normal distribution and x_{CEX} is the vector of the same regressors as in the SCF. When predicting the assetholding probability for a household in the CEX, we use the dummy *1992* coefficient for the years 1990-1993, the dummy *1995* coefficient for the years 1994-1996, the dummy *1998* coefficient for the years 1997-1999, and so on.

We employ a 'continuous' measure of participation, whereby every household contributes to the population weight and consumption or income of the representative assetholder according to their predicted probability. Specifically, we use the probability predicted for the last month of observation for the household, since financial information is reported only in the last interview. Notice that this imputation proce-

Figure B.2: Household-level consumption and income



Notes: Selected consumption and income variables for the representative household (blue line) from the NIPA, together with the representative assetholder (orange line) and the representative non-assetholder (yellow line), as estimated from the CEX, based on the probability-weighted assetholding status imputed from the SCF.

dure is applied only to those households who have non-missing responses to all the questions involved in the imputation procedure. Otherwise, the household receives a probability 0 of being an assetholder. Figure B.1 compares the resulting participation rate compared to the one from the SCF. As for the resulting consumption series, the participation rates in the CEX are smoothed through a backward-looking 4-quarters moving average filter.

Quarterly consumption and income estimates

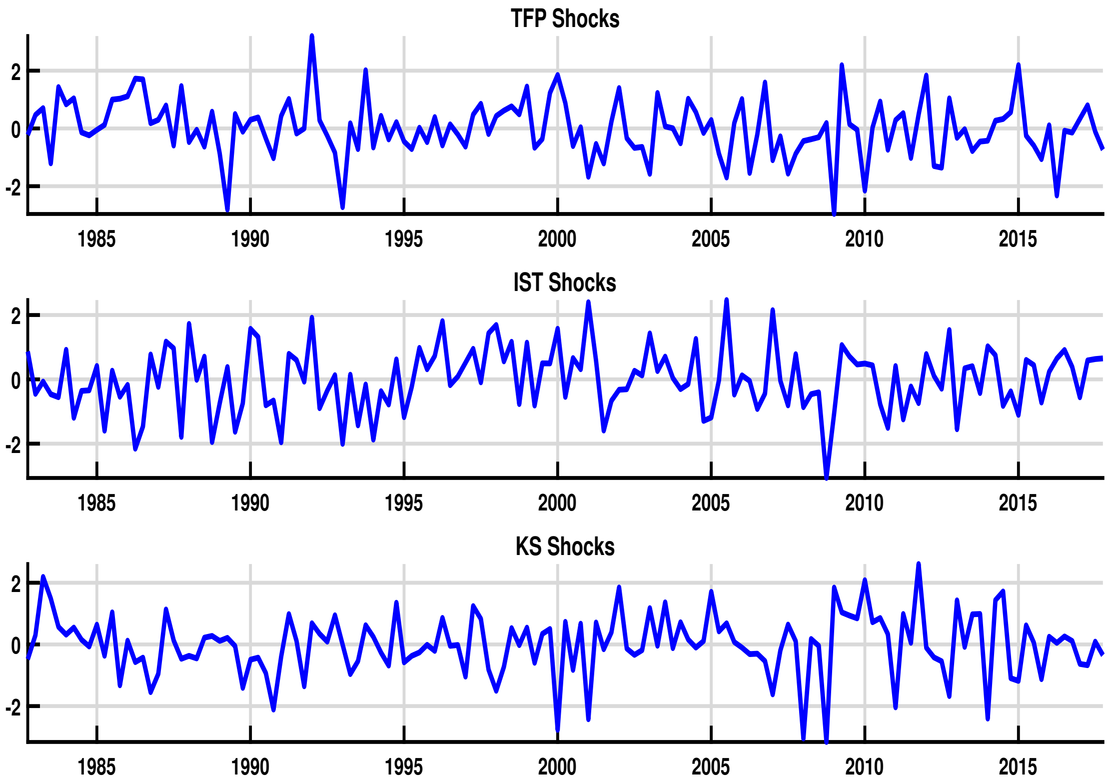
The ultimate aim of the analysis is to obtain a time series of consumption and income for a representative asset and non-assetholder, by employing the assetholding status definition obtained from the imputation procedure described above. To do so, we compute population (weighted) quarterly mean expenditure estimates aggregated from monthly expenditures, following the formulae provided in the CEX documentation.[18]. Nominal expenditure values are deflated by the end-of-the-quarter CPI for all items, and divided by family size in order to obtain per-capita expenditures.

In line with Cloyne et al. (2019), the group-specific expenditures and income series are adjusted every quarter by the ratio between the corresponding aggregate NIPA series and the estimated CEX aggregate. Finally, to eliminate some of the noise inherent to survey data and to seasonally-adjust the series, the consumption series are smoothed with a backward looking (current and three previous quarters) moving average. Figure B.2 displays the results based on the chosen sorting criterion. Mean estimates are also calculated for the representative household, i.e. over the whole sample and for all households, so as to obtain an aggregate consumption estimate from the CEX. The final quarterly consumption and income series cover the sample 1982Q4-2017Q4.

C Identified shocks

[18] In particular, we employ the example codes provided at the link: https://www.bls.gov/cex/pumd-getting-started-guide.htm#section5. These codes allow one to compute calendar period estimates.

Figure C.1: Structurally-identified supply shocks



Notes: The figure displays the time series of the identified neutral technology (top panel), investment-specific technology (middle panel) and capital share (bottom panel) shocks over the sample 1982Q4-2017Q4.

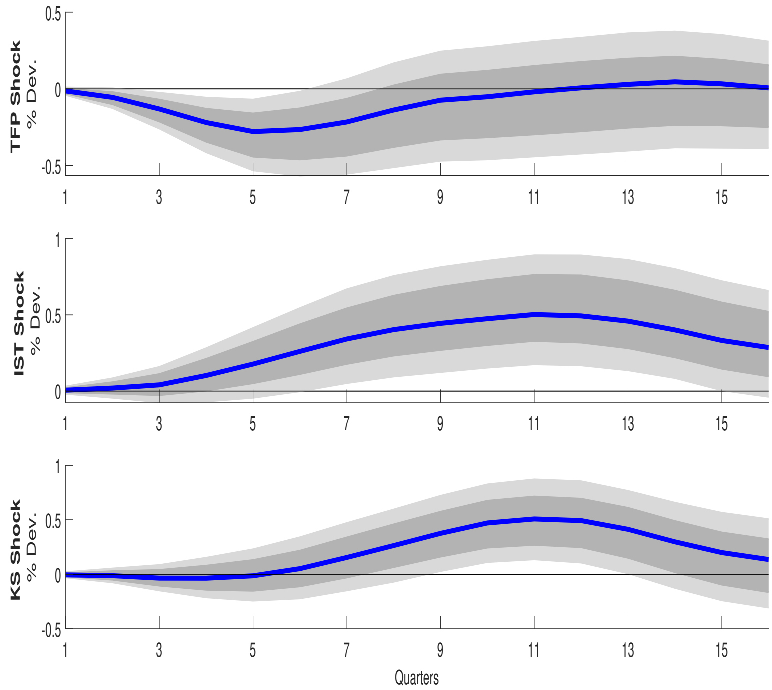
D Additional results and robustness

In this appendix, we report additional results on the compositional change and estimated cumulative responses discussed in Section 3.2, together with all the details—including figures and tables—about the robustness exercises discussed in Section 3.3.

D.1 Compositional change

As discussed in the main text, the interpetation of changes in consumption and income by assetholders and non-assetholders as a causal effect of exogenous supply shocks requires that the same shocks do not cause a sizeable transition of households from one group to the other. To address this point, Figure D.1 reports the responses of the assetholders' population share to TFP, IST and KS shocks. All the three shocks generate statistically significant responses, with a peak response to TFP (IST and KS) shocks of about -0.4% (0.5%). Nevertheless, we argue that their economic significance is negligible. To see this, recall that assetholders constitute on average 67% of the population over the sample. Therefore, the IRF to a TFP (IST and KS) shock implies that the assetholding rate decreases (increases) from 67% to about 66.7% (67.3%) at the peak. Clearly, these fluctuations are extremely small, which allows us to interpret our estimated household level consumption and income responses as the causal effect of exogenous supply shocks.

Figure D.1: Assetholders' population share



Notes: The figure displays the IRF of the assetholders' population share to an exogenous 100 bp increase in neutral technology (TFP, top row), investment-specific technology (IST, middle row) and capital share of income (KS, bottom row), estimated over the sample 1982Q4-2017Q4. Dark and light-grey shaded areas represent the 68% and 90% confidence intervals, respectively.

D.2 Cumulative responses: dollar values

To provide an idea of the magnitudes entailed by the cumulative responses reported in Table 1, we report the corresponding dollar-value responses in Table D.1. According to Panel A, following a positive neutral technology shock non-assetholders increase their spending in non-durables and services, as well as total consumption expenditure, by a statistically significant dollar amount of 787\$ and 1085\$, respectively, as compared to the 598\$ and 755\$ expenditure increase by the assetholders. Consistent with the IRF analysis, the larger consumption adjustment by non-assetholders

Table D.1: Cumulative responses over 16 quarters: dollar values

	Non-Durables and Services	Total Consumption	Net Income
	Panel A: TFP Shock		
Assetholders	597.85	755.4	1236.39
	[195.38,815.98]	[268.17,1075.58]	[724.76,1493.01]
Non-Assetholders	787.17	1085.9	1410.72
	[448.73,1005.65]	[657.95,1400.41]	[842.27,1719.76]
	Panel B: IST Shock		
Assetholders	787.31	977.64	892.22
	[518.8,1054.1]	[561.48,1308.57]	[495.17,1251.88]
Non-Assetholders	296.49	632.46	233.68
	[101.61,526.37]	[359.87,932.27]	[-170.24,625.87]
	Panel C: KS Shock		
Assetholders	683.32	1394.85	258.4
	[303.32,918.93]	[808.03,1726.97]	[-188.78,591.49]
Non-Assetholders	-388.18	-472.89	-456.09
	[-560.03,-206.21]	[-722.14,-204.71]	[-779.82,-68.57]

Notes: Cumulative responses over 16 quarters to an exogenous 100 bp increase in neutral technology (Panel A), investment-specific technology (Panel B) and capital share of income (Panel C), estimated over the sample 1982Q4-2017Q4. Bootstrapped 68% confidence intervals reported in brackets. The cumulative responses are computed as the present discounted value (given an average annual real interest rate equal to 1%) of the relative change in expenditure or income over the 16 quarters following the shock. To obtain a total expenditure/income effect at the household level in 2017 dollars, the magnitude is multiplied by an average household size of 2.5 and by a price-adjustment factor equal to 2.48 (recall that the CPI for all items is expressed in 1982-1984 basis.)

reflects a more marked rise in net income (1411\$, compared to 1236\$). By contrast, an investment-specific technology shock (Panel B) triggers a remarkable cumulative rise in assetholders' total consumption (977\$), which is in the ballpark of the dollar-amount upward adjustment in net income (892\$). At the same time, the cumulative response of non-assetholders' consumption and income are relatively smaller. Finally, similar conclusions apply for the capital share shock (Panel C), although the cumulative responses of the hand-to-mouth consumers' consumption and income are now significantly negative.

D.3 Robustness

Controlling for observable heterogeneity For this robustness check, we follow Kehoe et al. (2020). Based on CEX data, we partition the population into twenty-four groups for all possible combinations of the following classifications: gender (male and female), age (young-up to 40 years, and old-above 40 years), education (college and no college) and housing tenure status (renter, mortgagor and outright owner). We then compute the average consumption and income series for assetholders and non-assetholders (based on the baseline sorting criterion) within each group. We then reweigh each group by the respective population share, and compute the consumption and income series for the representative assetholder or non-assetholder. As a consequence, after the reweighting the two groups are equally balanced in terms of age, gender, education or housing tenure status. More specifically, for the variable x (e.g., consumption) we compute:

$$\bar{x}^{a}_{t} = \sum_{k} x^{a}_{k,t} \times \omega_{k,t} \quad \text{and} \quad \bar{x}^{na}_{t} = \sum_{k} x^{na}_{k,t} \times \omega_{k,t},$$

for the representative assetholder and non-assetholder, respectively, where k indicates the group (for example, male-no college-renter or female-college-outright owner), $x^{a,na}_{k,t}$ denotes the within-group k average assetholder or non-assetholder variable, and $\omega_{k,t}$ represents the population share of group k at time t.

Sorting based on stockholdings The sorting procedure is exactly symmetric to the baseline presented in the main text. The only difference lies in the types of assets we consider. Specifically, in this case we sort households only based on their (direct or indirect) holdings of stocks. Specifically, we re-estimate a probit regression where the dependent variable is a dummy taking value one if the variable EQUITY in the SCF is positive. The variable equity summarizes the value of stocks held directly, in mutual funds or pension schemes, by the household. Therefore, this sorting criterion is much more in line with most of the asset pricing literature. Consistently, we estimate that only about 20% of the households participated in the stock market at the beginning of the sample. At the end of the sample, instead, the participation rate is estimated around 50%.

Different sorting method In the main body of the paper we define a household as an assetholder if, based on the CEX information on "stocks, bonds, mutual funds and other such securities", her asset holdings, including checking and savings accounts, exceed 1000\$. To address potential measurement errors, we then refine the definition as follows. We predict the probability of a household being anassetholder only for those households who are not defined as such based on the CEX variables, using the same probit coefficients as for the baseline analysis. Next, to uniquely partition households between the two groups, we apply a threshold method. In particular, households are classified as assetholders for sure (hence, with probability 1) if the predicted probability exceeds 70%. By contrast, households are defined as non-assetholders for sure (thus receiving a probability 0 of being assetholders) if the predicted probability is below 70%. In other words, according to this method a household is defined as an assetholder either if it fulfills the requirement in the CEX data, or if the imputed probability exceeds 70%. The fraction of hand-to-mouth households estimated according to this sorting criterion is essentially unchanged, compared to the baseline case.

Extended VAR We re-estimate the VAR system in Equation (1) by including (log) per-capita hours worked as a fourth endogenous variable. The identification assumptions on the purely redistributive effects of KS shocks remain intact also in this quadrivariate version of the VAR. We then use the structurally identified IST, TFP and KS shocks to compute household-level consumption and income responses.

Table D.2: Cumulative responses over 16 quarters - Observable heterogeneity

	Non-Durables and Services	Total Consumption	Net Income
	Panel A: TFP Shock		
Assetholders	2.86	3.6	3.75
	[1.01,3.97]	[1.3,5.32]	[2.02,4.8]
Non-Assetholders	5.7	6.89	5.86
	[3.17,6.83]	[3.77,8.21]	[2.89,7.61]
	Panel B: IST Shock		
Assetholders	3.88	4.43	3.39
	[2.64,5.11]	[2.87,6.1]	[1.79,4.74]
Non-Assetholders	2.91	3.79	2.64
	[1.58,4.39]	[2.34,5.47]	[0.71,4.31]
	Panel C: KS Shock		
Assetholders	4.66	6.73	1.7
	[2.83,5.65]	[4.29,8.05]	[-0.05,2.87]
Non-Assetholders	-0.26	1.88	-2.16
	[-2.19,1.25]	[-0.68,3.81]	[-4.15,-0.23]

Notes: Cumulative responses over 16 quarters, controlling for observable heterogeneity.

Table D.3: Cumulative responses over 16 quarters - Sorting based on stockholdings

	Non-Durables and Services	Total Consumption	Net Income
	Panel A: TFP Shock		
Stockholders	5.99	4.15	5.63
	[3.03,6.71]	[1.77,5.86]	[3.75,6.99]]
Non-Stockholders	5.88	7.04	8.77
	[4.14,6.83]	[5.45,8.16]	[6.24,10.02]
	Panel B: IST Shock		
Stockholders	2.48	4.14	2.03
	[1,3.7]	[2.17,5.89]	[0.18,3.75]
Non-Stockholders	1.26	2.64	1.27
	[0.21,2.53]	[1.52,3.97]	[-1.01,3.29]
	Panel C: KS Shock		
Stockholders	2.52	4.76	-0.18
	[0.65,3.67]	[1.99,6.15]	[-2.04,1.57]
Non-Stockholders	-0.99	-0.46	-2.18
	[-2.29,0.26]	[-2.42,1.12]	[-3.75,-0.16]

Notes: Cumulative responses over 16 quarters for households sorted based on stockholdings.

Table D.4: Cumulative responses over 16 quarters - Different sorting method

	Non-Durables and Services	Total Consumption	Net Income
Panel A: TFP Shock			
Assetholders	2.83	4.47	3
	[0.69,3.72]	[1.82,5.81]	[1.33,3.83]
Non-Assetholders	4.53	4.62	9.27
	[2.02,6.54]	[1.22,7.05]	[4.15,11.94]
Panel B: IST Shock			
Assetholders	3.9	3.64	2.37
	[2.54,5]	[2.04,5.11]	[1.41,3.41]
Non-Assetholders	-0.57	3.6	-0.82
	[-2.27,1.45]	[1.13,6.48]	[-3.76,2.48]
Panel C: KS Shock			
Assetholders	2.62	4.55	-0.14
	[0.76,3.67]	[1.95,5.28]	[-1.38,0.95]
Non-Assetholders	-4.36	-6.94	-3.66
	[-6.09,-2.88]	[-9.03,-4.54]	[-6.78,-0.47]

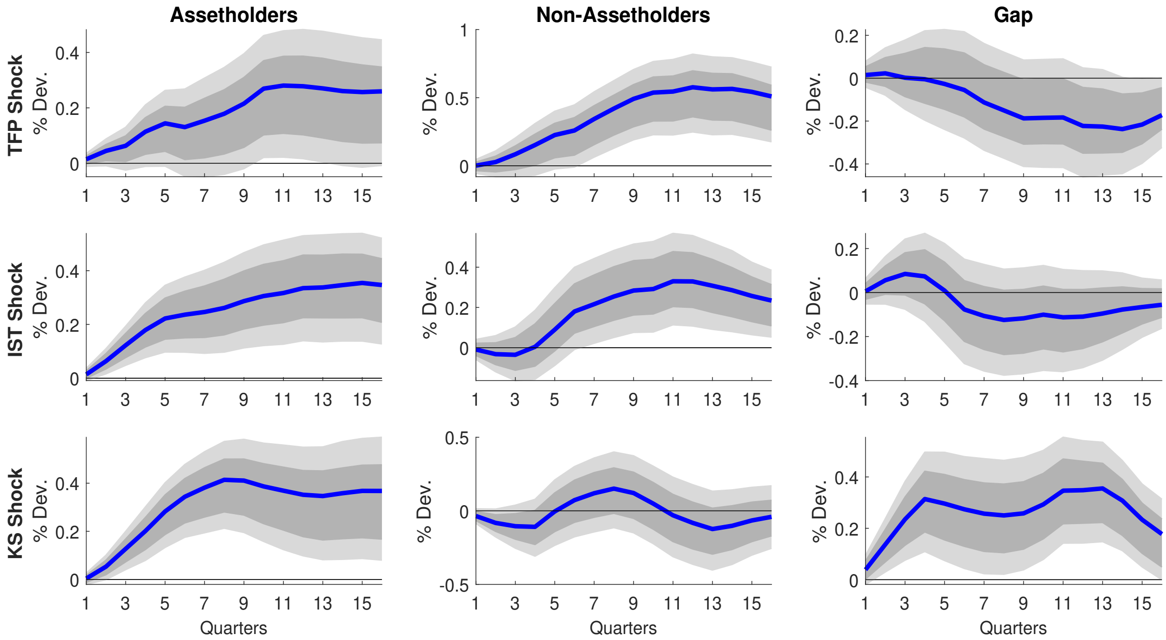
Notes: Cumulative responses over 16 quarters for households sorted according to the probability-threshold method.

Table D.5: Cumulative responses over 16 quarters - Extended VAR

	Non-Durables and Services	Total Consumption	Net Income
Panel A: TFP Shock			
Assetholders	3.16	3.27	4.32
	[1.24,4.25]	[1.26,4.67]	[2.5,5.28]
Non-Assetholders	4.66	5.81	8.02
	[2.48,6.2]	[3.26,7.73]	[4.45,9.96]
Panel B: IST Shock			
Assetholders	4.37	4.88	2.95
	[2.8,5.59]	[2.93,6.27]	[1.24,4.24]
Non-Assetholders	2.19	2.38	1.31
	[0.69,3.59]	[0.28,3.86]	[-1.08,3.43]
Panel C: KS Shock			
Assetholders	2.31	3.65	2.191
	[0.11,3.74]	[1.15,4.93]	[0.11,3.63]
Non-Assetholders	-1.81	-2.86	-1.96
	[-3.67,-0.21]	[-5.4,-0.34]	[-4.36,0.49]

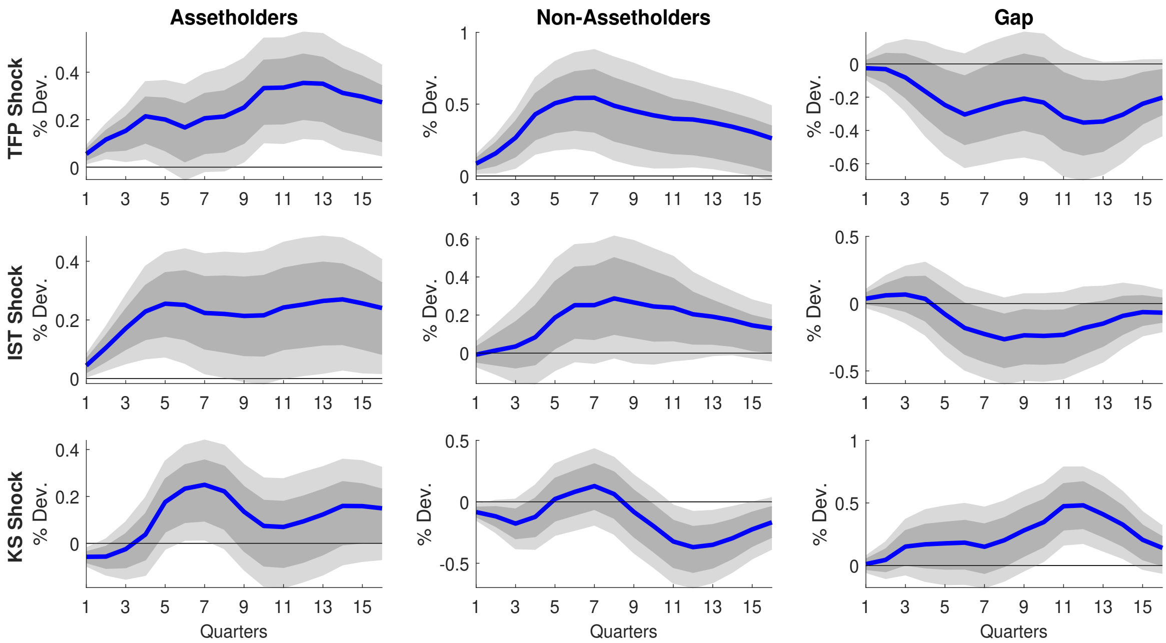
Notes: Cumulative responses over 16 quarters to the shocks identified in the extended VAR.

Figure D.2: Non-durables and services expenditure - Observable heterogeneity



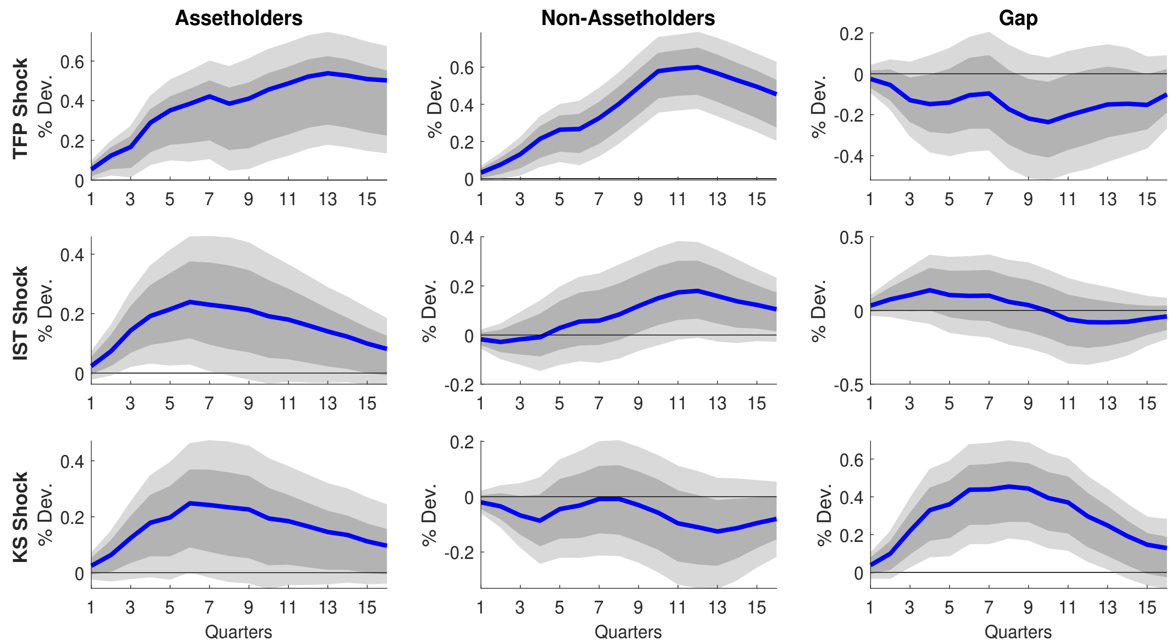
Notes: The figure displays the IRFs of non-durables and services expenditures, controlling for observable heterogeneity.

Figure D.3: Net Income - Observable heterogeneity



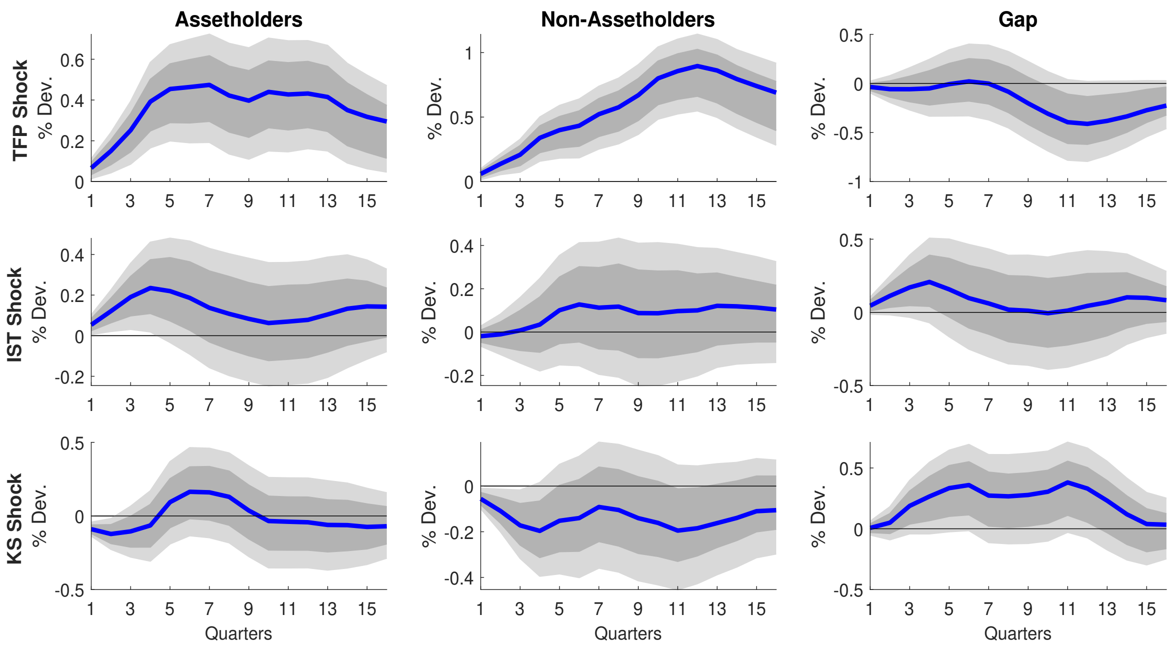
Notes: The figure displays the IRFs of net income, controlling for observable heterogeneity.

Figure D.4: Non-durables and services expenditure - Sorting based on stockholdings



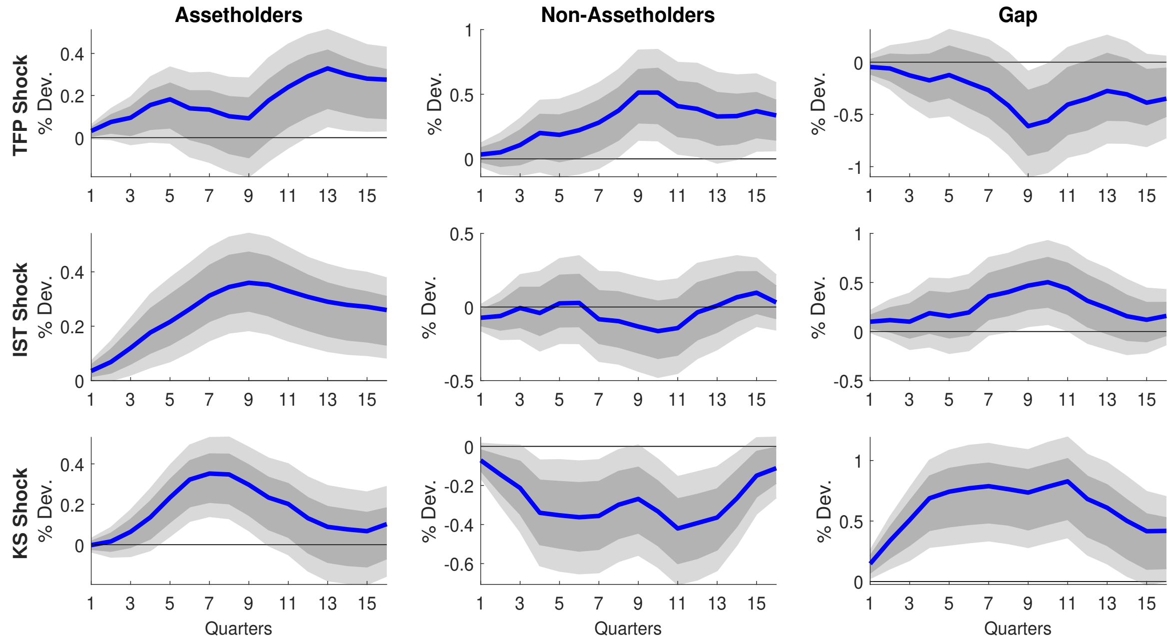
Notes: The figure displays the IRFs of non-durables and services expenditures for households sorted based on stockholdings.

Figure D.5: Net Income - Sorting based on stockholdings



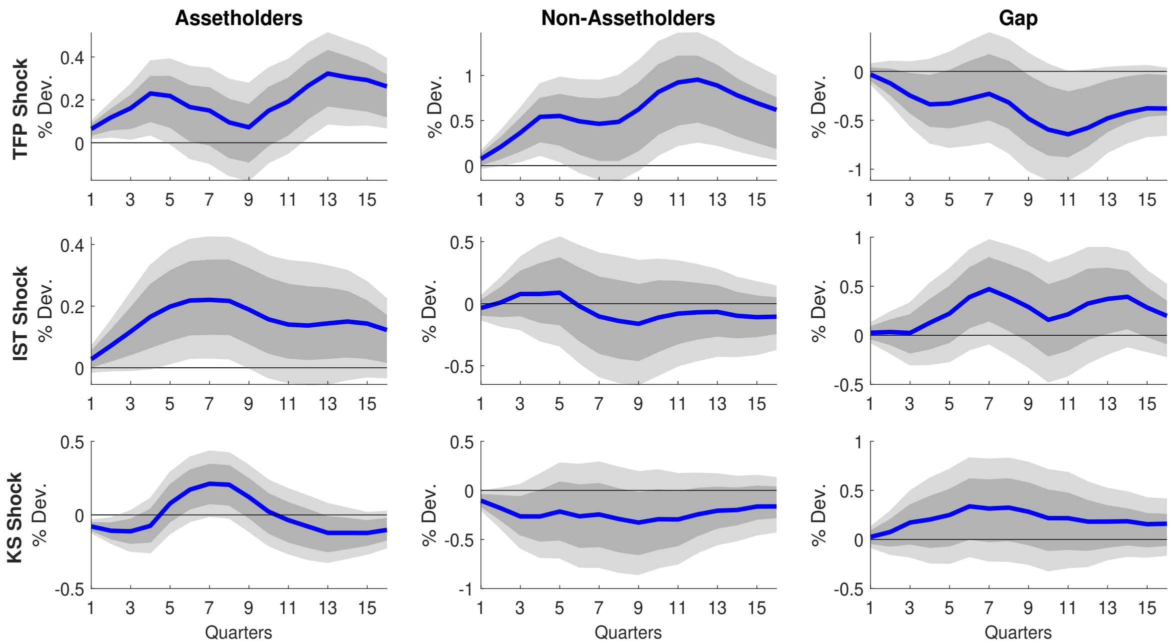
Notes: The figure displays the IRFs of net income for households sorted based on stockholdings.

Figure D.6: Non-durables and services expenditure - Different sorting method



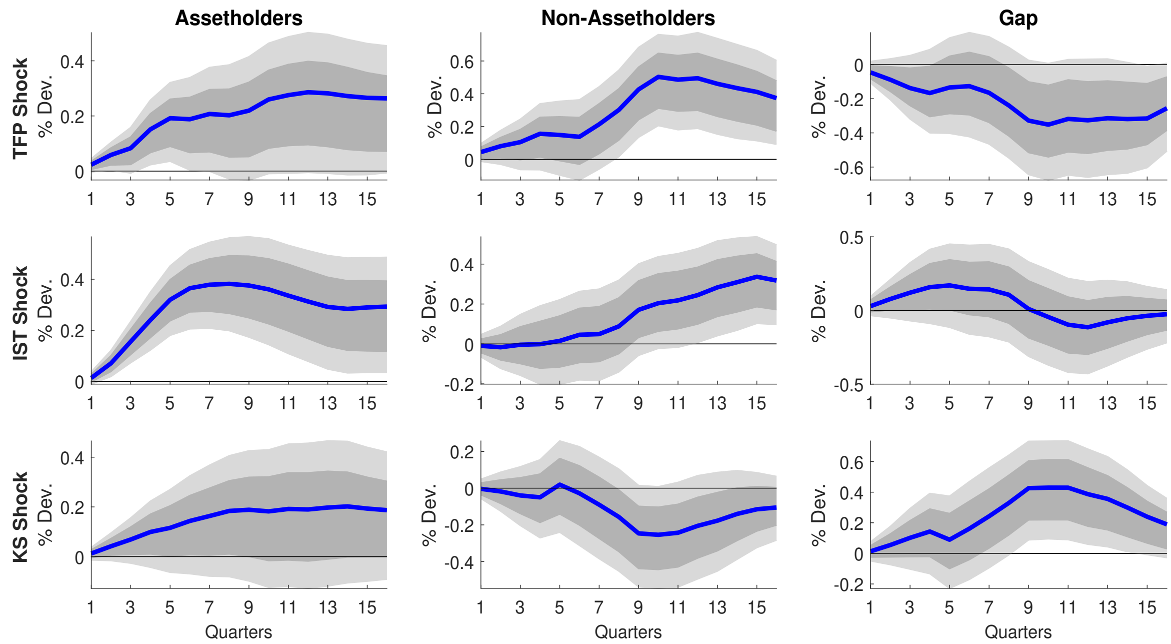
Notes: The figure displays the IRFs of non-durables and services expenditures for households sorted according to the probability-threshold method.

Figure D.7: Net Income - Different sorting method



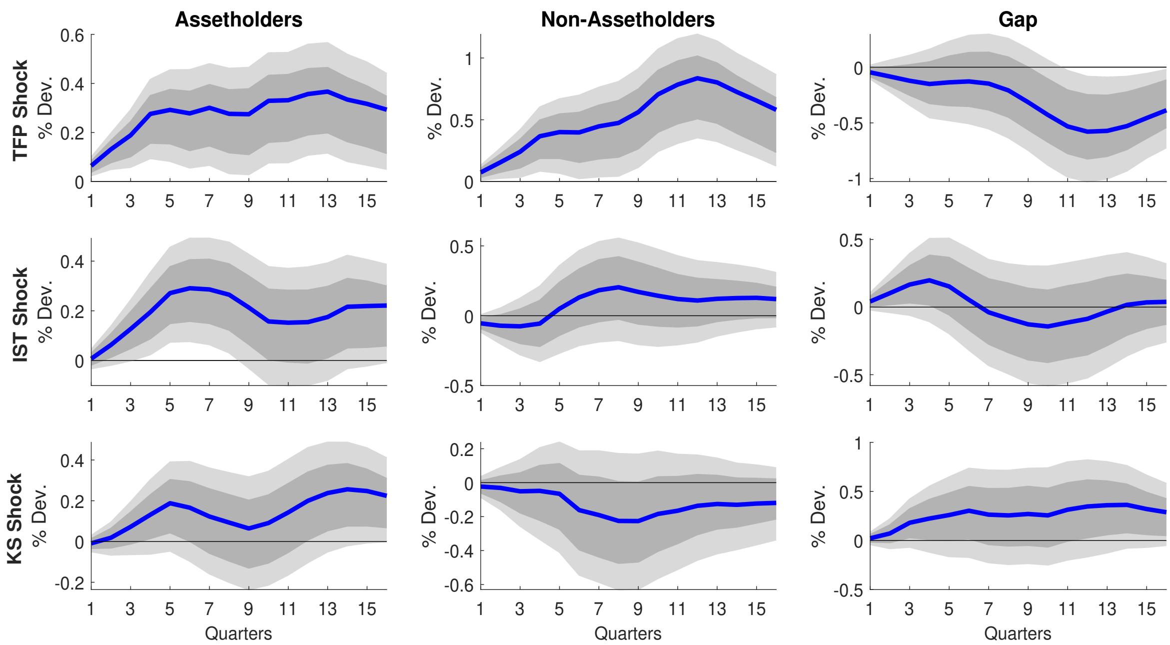
Notes: The figure displays the IRFs of net income for households sorted according to the probability-threshold method.

Figure D.8: Non-durables and services expenditure - Extended VAR



Notes: The figure displays the IRFs of non-durables and services expenditures to the shocks identified in the extended VAR.

Figure D.9: Net Income - Extended VAR



Notes: The figure displays the IRFs of net income to the shocks identified in the extended VAR.

E Further details on the two-period model

E.1 Solution

The firm maximizes the discounted flow of profits choosing labor input and the capital input:

$$\max_{k_1,n_1,n_2} \left[d_1 + \beta \frac{\lambda_2}{\lambda_1} d_2 \right], \tag{E.1}$$

where λ_t denotes assetholders' period marginal utility, for $t = 1, 2$.

The first-order conditions from firm optimization read as

$$r_2^k = \frac{1}{\beta} \frac{\lambda_1}{\mu_1 \lambda_2}, \tag{E.2}$$

$$w_1 = (1 - \alpha_1) z k_0^{\alpha_1}, \tag{E.3}$$

$$w_2 = (1 - \alpha_2) z k_1^{\alpha_2}, \tag{E.4}$$

where $r_2^k \equiv \frac{dy_2}{dk_1}$.

By plugging the assetholder's period budget constraints into (E.2), we obtain (E.5); thus, we plug the latter into the expressions for the wage rate in each of the two periods, (E.3) and (E.4), to obtain (E.6), (E.8), (E.7), and (E.9):

$$k_1 = \frac{\beta \alpha_2 [1 - \gamma(1 - \alpha_1)]}{1 - \gamma(1 - \alpha_2) + \beta \alpha_2} \mu_1 z k_0^{\alpha_1}, \tag{E.5}$$

$$c_1^{na} = (1 - \alpha_1) z k_0^{\alpha_1}, \tag{E.6}$$

$$c_2^{na} = (1 - \alpha_2) z k_1^{\alpha_2}, \tag{E.7}$$

$$c_1^a = \frac{1 - \gamma(1 - \alpha_2)}{1 - \gamma} \frac{1 - \gamma(1 - \alpha_1)}{1 - \gamma(1 - \alpha_2) + \beta \alpha_2} z k_0^{\alpha_1}, \tag{E.8}$$

$$c_2^a = \frac{1 - \gamma(1 - \alpha_2)}{1 - \gamma} z k_1^{\alpha_2}. \tag{E.9}$$

Thus, after aggregating over the two household types:

$$c_1 + i_1 = y_1, \tag{E.10}$$

$$c_2 = y_2. \tag{E.11}$$

E.2 Proofs

Proof of Proposition 1. We take (3) and set $\mu_1 = 1$ and $\alpha_t = \alpha$, for $t = 1, 2$. Taking $\frac{d(c^a/c^{na})}{dz}$ and imposing it to be negative amounts to prove the following inequality:

$$\frac{c^c}{c^w} < \frac{1-\gamma(1-\alpha)}{(1-\gamma)(1-\alpha)},$$

which can be reduced to $\beta\alpha > 0$, the latter always holding true, under the restrictions imposed to β and α.

Proof of Proposition 2. We take (3) and set $\alpha_t = \alpha$ and $z_t = 1$, for $t = 1, 2$. Thus, we compute:

$$\frac{d(c^a/c^{na})}{d\mu_1} = \beta\frac{1-\alpha}{1-\gamma}r_2^k\frac{dk_1}{d\mu_1}\frac{k_1}{\mu_1},$$

and check when this is positive, which is always the case.

Proof of Proposition 3. We take (3) and set $\mu_1 = 1$, as well as $\alpha_2 = \alpha$ and $z_t = 1$, for $t = 1, 2$. Thus, we compute:

$$\left.\frac{d(c^a/c^{na})}{d\alpha_1}\right|_{\alpha_1=\alpha} = \left[y_1\log(k_0) - \frac{dk_1}{d\alpha_1} + \beta r_2^k\frac{dk_1}{d\alpha_1}\right]\left[(1-\alpha)y_1 + \beta(1-\alpha)y_2\right] - \left[(1-\alpha)y_1\log(k_0) - y_1 + \beta(1-\alpha)r_2^k\frac{dk_1}{d\alpha_1}\right]\left[y_1 - k_1 + \beta y_2\right],$$

which can be simplified into

$$\frac{d(c^a/c^{na})}{d\alpha_1}|_{\alpha_1=\alpha} = \Psi y_1 + \beta y_2 + (1-\alpha)\log(k_0)$$

where

$$\Psi \equiv \frac{1-\gamma(1-\alpha)}{[1-\gamma(1-\alpha)+\beta\alpha]} - (1-\alpha)\log(k_0)\frac{[1-\gamma(1-\alpha)]\,\beta\alpha}{[1-\gamma(1-\alpha)+\beta\alpha]}.$$

We note that y_1 and y_2 are always positive, and that $log(k_0)$ is non-negative as long $k_0 \geq 1$. Therefore, $\left.\frac{d(c^a/c^{na})}{d\alpha_1}\right|_{\alpha_1=\alpha} > 0$ as long as $\Psi > 0$. This is verified for

$$k_0 < \exp\left(\frac{1}{1-\alpha}\frac{1}{\beta\alpha}\right),$$

Therefore, we conclude that $\left.\frac{d(c^a/c^{na})}{d\alpha_1}\right|_{\alpha_1=\alpha} > 0$ if the following sufficient condition holds:

$$1 \leq k_0 \leq \exp\left(\frac{1}{1-\alpha}\frac{1}{\beta\alpha}\right).$$

Equivalently, for $\kappa_0 \equiv \frac{k_0}{y_1} = k_0^{1-\alpha}$:

$$1 \leq \kappa_0 \leq \exp\left(\frac{1}{\beta\alpha}\right)$$

needs to be met.

We check numerically that, for standard calibrations of α and β, this sufficient condition identifies a rather large set of plausible values of the capital-to-output ratio.

F A RBC model with limited asset ownership

This appendix details the model employed in Section 5, as well as its calibration and ability to match macroeconomic and asset-pricing moments.

Households Assetholders own firms through equity shares, and smooth consumption intertemporally by trading one-period bonds. Non-assetholders are assumed to be excluded from the bond and the stock markets. Both agents are assumed to inelastically supply their entire time-endowment to the firms. Households are equally productive and, therefore, all earn the same wage, regardless of their type. The fraction of assetholders in the total population of consumers equals $1-\gamma$.

The utility of the representative assetholder reads as

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{(c_t^a - \chi_c h_t)^{1-\sigma} - 1}{1-\sigma}, \tag{F.1}$$

where we assume assetholders to exhibit external habits in utility, with the habit stock, h_t, weighing on per-period utility by the parameter χ_c, and evolving according to the following law of motion (Jaccard, 2014):

$$h_t = m h_{t-1} + (1-m) c_{t-1}^a, \tag{F.2}$$

where c_{t-1}^a denotes assetholders' per-capita consumption at time $t-1$. The parameter m allows us to introduce a slow-moving component in habit formation. Similar to Campbell and Cochrane (1999), $1-m$ captures how sensitive the reference level is to changes in assetholders' per-capita consumption.

Consumption and saving decisions are limited by the following budget constraint

$$c_t^a + p_t^s q_{t+1}^s + p_t^b q_{t+1}^b = (p_t^s + d_t) q_t^s + q_t^b + w_t n_t^a. \tag{F.3}$$

which states that consumption and the purchase of equity shares (in quantity q^s_{t+1} at the price p^s_t) as well as of one-period bonds (in quantity q^b_{t+1} at the price p^b_t) must be financed by labor income, $w_t n^a_t$ (where $n^a_t = 1$), and the returns on the financial investments. Shares purchased in the previous period yield a dividend d_t, while one-period bonds yield a single consumption unit per-bond in the following period.

The two agents differ only for their ability to access financial markets.[19] Being unable to smooth consumption intertemporally, non-assetholders consume their labor income hand-to-mouth, so that

$$c^{na}_t = w_t n^{na}_t, \tag{F.4}$$

where w_t is the wage and $n^{na}_t = 1$.

Asset prices The first-order conditions for assetholders' optimization problem with respect to c^a_t, q^s_{t+1}, and q^b_{t+1} are:

$$\lambda_t = (c^a_t - \chi_c h_t)^{-\sigma}, \tag{F.5}$$

$$p^s_t = E_t m_{t,t+1}(p^s_{t+1} + d_{t+1}), \tag{F.6}$$

$$p^b_t = E_t m_{t,t+1}, \tag{F.7}$$

where λ_t denotes the Lagrangean multiplier on the budget constraint and $m_{t,t+1} \equiv \beta E_t(\lambda_{t+1}/\lambda_t)$ is the assetholder's stochastic discount factor. The first-order conditions (F.6) and (F.7) govern asset-pricing dynamics. In particular, the risk-free rate is given by $r^b_{t+1} = 1/p^b_t = 1/E_t m_{t,t+1}$, while the stock return is $r^s_{t+1} = \frac{p^s_{t+1}+d^s_{t+1}}{p^s_t}$. Asset prices depend on the preferences of the marginal investor: the assetholder, in our case.

Firms Firms operate under perfect competition and produce according to a standard Cobb-Douglas technology:

$$y_t = A z_t n_t^{1-\alpha_t} k_t^{\alpha_t},\ \alpha_t \in (0,1), \tag{F.8}$$

where n_t is aggregate employment, k_t is aggregate capital, z_t is total factor productivity and A is a scaling factor (to be discussed in Section F.1). The labor share of income, $ls_t \equiv 1 - \alpha_t$, is allowed to fluctuate over time.

Following Jermann (1998), capital accumulation follows a law of motion featuring

[19] Since non-assetholders do not price securities, they can in principle have exactly the same preferences as assetholders, without affecting the equilibrium conditions.

capital adjustment costs:

$$k_{t+1} = (1-\delta)k_t + \phi\left(\frac{i_t}{k_t}\right)k_t, \tag{F.9}$$

where δ is the depreciation rate and

$$\phi\left(\frac{i_t}{k_t}\right) = \left[\frac{a_1}{1-1/\chi_k}\left(\frac{i_t}{k_t}\right)^{1-1/\chi_k} + a_2\right] \tag{F.10}$$

is a concave adjustment-cost function. In particular, $\chi_k \to 0\ (\infty)$ implies higher (lower) adjustment costs.

The firm's problem consists of choosing labor, capital, and investment to maximize

$$\underset{i_t,n_t,k_{t+1}}{max}\ E_0 \sum_{t=0}^{\infty} m_{t,t+1}\left\{d_t - q_t[k_{t+1} - (1-\delta)k_t - \phi(i_t/k_t)k_t],\right\} \tag{F.11}$$

subject to the constraints (F.8), (F.9), and (F.10), where q_t is the shadow price of capital.

Dividends are defined as

$$d_t = y_t - w_t n_t - \frac{i_t}{\mu_t}, \tag{F.12}$$

where, following Greenwood et al. (1988) and Liu et al. (2013), μ_t accounts for investment-specific technological change. Profit maximization leads to:

$$w_t = (1-\alpha_t)y_t/n_t, \tag{F.13}$$

implying that dividends can be rewritten as

$$d_t = \alpha_t y_t - \frac{i_t}{\mu_t}, \tag{F.14}$$

whereas the first-order condition with respect to capital investment is

$$\phi'\left(\frac{i_t}{k_t}\right) = \frac{1}{\mu_t q_t}, \tag{F.15}$$

with

$$\phi'\left(\frac{i_t}{k_t}\right) = a_1\left(\frac{i_t}{k_t}\right)^{-1/\chi_k}. \tag{F.16}$$

Finally, the firm's optimal decision regarding capital yields

$$q_t = E_t\left\{m_{t,t+1}\left[\alpha_{t+1}\frac{y_{t+1}}{k_{t+1}} + q_{t+1}\left((1-\delta) + \phi\left(\frac{i_{t+1}}{k_{t+1}}\right) - \phi'\left(\frac{i_{t+1}}{k_{t+1}}\right)\frac{i_{t+1}}{k_{t+1}}\right)\right]\right\}. \tag{F.17}$$

Equilibrium All agents take prices as given. The competitive equilibrium in this economy is defined by a sequence of prices and quantities such that the optimality conditions (F.4), (F.5), (F.6), (F.7), (F.13), (F.15) and (F.17) hold, all constraints are satisfied, and all markets clear. More specifically, labor-market clearing requires that

$$n_t = \gamma n_t^{na} + (1-\gamma) n_t^a = 1, \tag{F.18}$$

while equilibrium in the good market implies

$$y_t = c_t + i_t, \tag{F.19}$$

where

$$c_t = \gamma c_t^{na} + (1-\gamma) c_t^a \tag{F.20}$$

defines aggregate per-capita consumption. Assuming that the bond market is in zero net supply entails that, in equilibrium, $q_t^b = 0$, $\forall t$. Moreover, assuming that the stock market is in unit supply yields the stock market clearing condition

$$(1-\gamma) q_t^s = 1, \tag{F.21}$$

where the left side of the equality represents the aggregate demand of stocks, since only a fraction $(1-\gamma)$ of the population participates in the stock market. Therefore, in equilibrium the budget constraint (F.3) for the representative assetholder reads as

$$c_t^a = w_t n_t^a + \frac{d_t}{1-\gamma}. \tag{F.22}$$

Finally, plugging (F.4) and (F.22) into equation (F.20) yields

$$c_t = \gamma w_t n_t^{na} + (1-\gamma) \left(w_t n_t^a + \frac{d_t}{1-\gamma} \right), \tag{F.23}$$

which, given the assumption that both non-assetholders and assetholders supply all their time-endowment to firms ($n_t^{na} = n_t^a = 1$), becomes $c_t = w_t + d_t$; that is, aggregate consumption consists of labor income plus dividends.

Exogenous state variables The dynamics of the three exogenous state variables in the model, namely investment-specific technology μ_t, total factor productivity z_t and the labor share ls_t, are governed by the trivariate VAR estimated as in equation (1). Given the permanent nature of IST and TFP shocks, the model exhibits non-stationary dynamics. Thus, in Appendix F.2 we rewrite it in stationary form. In the remainder,

Table F.1: Baseline parameter values

Description	Parameter	Value
Fraction of non-assetholders	γ	0.33
Depreciation rate	δ	0.0271
Capital share of income	α	0.35
Discount rate	β	0.9893
Capital adjustment cost	χ_k	0.28
Local utility curvature	σ	3.3
Habit weight	χ_c	0.6
Habit stock persistence	m	0.9

Notes: The model is calibrated at a quarterly frequency.

'$\sim$' will be used to denote variables in log-deviation from their trend.

Unlike most of the extant literature (Justiniano and Primiceri, 2008; Papanikolaou, 2011; Lansing, 2015, among the others), we do not assume that exogenous processes to be independent. In fact, imposing the estimated VAR system allows the model to exactly reproduce the impulse-response functions to IST, TFP and KS shocks as depicted in Figure 1, thus accounting for the cross-correlations among the three variables. Relatedly, Ríos-Rull and Santaeulalia-Llopis (2010), Santaeulalia-Llopis (2011) and Choi and Ríos-Rull (2020) emphasize the dynamic effects of technology shocks on the labor share, and how this bears important implications for the propagation of supply shocks to aggregate variables.

F.1 Calibration

The calibration of some parameters is designed to match targeted long-run relationships. A time period in the model is taken to be one quarter. The fraction of workers, γ, is set to 0.33, which represents a mid-value for the fraction of non-assetholders, over the sample 1982Q4-2017Q4. The calibration strategy for the depreciation rate (δ), the discount rate (β), and the unit parameter in the production function (A) follows Ríos-Rull and Santaeulalia-Llopis (2010). We target the capital-output ratio in yearly terms $k/y = 2.31$, and the investment-output ratio $i/y = 0.25$. Given these targets, from the relationship $i/y = \delta k/y$, we retrieve $\delta = 0.0271$. After evaluating equation (F.17) at the steady state and setting the capital share $\alpha = 0.35$—as in Choi and Ríos-Rull (2020)—we obtain $1 = \beta\,(1 - \delta + \alpha y/k)$, which yields $\beta = 0.9893$. Without loss of generality, we normalize steady-state output to one, thus solving equation (F.8) for $A = 1/n(k/n)^{-\alpha}$.

As for the remaining parameters, we choose a set of values that are in line with

Table F.2: Macroeconomic moments

Variable	Empirical	Simulated
σ_{g_y}	0.71 [0.58,0.80]	1.66
σ_{g_c}	0.52 [0.42,0.60]	1.25
σ_{g_i}	3.16 [2.46,3.81]	3.07
σ_{g_d}	4.98 [3.13,7]	4.64
$\sigma_{g_{c^a/c^{na}}}$	0.68 [0.56,0.79]	0.76
$corr_{g_c,g_y}$	0.74 [0.64,0.81]	0.99
$corr_{g_i,g_y}$	0.69 [0.6,0.75]	0.98
$corr_{g_d,g_y}$	0.25 [0.1,0.44]	0.95
$corr_{g_{c^a/c^{na}},g_y}$	0.15 [−0.03,0.26]	0.90
$corr_{g_z,g_y}$	0.49 [0.33,0.6]	0.55
$corr_{g_\mu,g_y}$	-0.06 [−0−16,0.1]	0.24
$corr_{\log(ls),g_y}$	-0.08 [−0.27,0.07]	-0.25

Notes: Bootstrapped 90% confidence intervals in brackets. All moments refer to quarterly variables. g_x denotes the first-differenced logarithm of a generic variable x.

Table F.3: Asset pricing moments

Variable	Empirical	Simulated
$E(r^b)$	1.07 [0.59,1.57]	2.48
$E(r^s - r^b)$	4.39 [3.24,5.78]	3.94
σ_{r^b}	1.50 [1.16,1.65]	10.52
$\sigma_{r^s-r^b}$	15.67 [15.12,17.32]	19.14

Notes: Bootstrapped 68% confidence intervals in brackets. All moments refer to annualized variables.

the existing literature. Parameters a_1 and a_2 in equation (F.10) are constructed so that capital adjustment costs do not affect the steady state of the economy. Thus, we set $a_1 = \delta^{1/\chi_k}$ and $a_2 = \delta - \frac{\delta}{1-1/\chi_k}$, which implies that $\phi\left(\frac{i}{k}\right) = \delta$, $\frac{i}{k} = \delta$ and $\phi'\left(\frac{i}{k}\right) = 1$ in the steady state. Similar to Jermann (1998), Guvenen (2009) and Chen (2017), we set the capital adjustment cost parameter $\chi_k = 0.28$. The local utility curvature parameter $\sigma = 3.3$ is taken from Lansing (2015), while the weight of the habit stock in the utility function $\chi_c = 0.6$ can be considered as a standard choice in the production-based asset-pricing literature, lying within the range of values adopted in Lansing (2015) ($\chi_c = 0.2$) and Jermann (1998) ($\chi_c = 0.82$). Notice that the combination of σ and χ_c implies an average risk-aversion of 8. Finally, the persistence of the habit stock $m = 0.9$ follows Cochrane (2017), close to the persistence of the surplus-consumption ratio considered in Campbell and Cochrane (1999).

Model-implied moments The theoretical business-cycle statistics, together with their data counterparts, are reported in Table F.2. On one hand, the limited participation economy entails excessively volatile output and consumption growth. The volatility of output growth, in particular, is to be mostly attributed to the exogenous state variables, whose dynamics are kept in line with the empirical analysis of Section 2.3. In fact, the calibration strategy leaves no degree of freedom, as for controlling the standard deviation of output. On the other hand, the utility function and the capital adjustment cost parameters have a simultaneous impact on the second moments of consumption, investment and dividends growth. As thoroughly discussed by Guvenen (2009) and Chen (2017), the choice of such parameters involves several trade-offs in matching the volatility of these three variables.[20] Therefore, the strikingly good match for the empirical standard deviation of investment, dividends and—most importantly for our analysis—the consumption gap, comes at the expense of a relatively high volatility of aggregate consumption. Moreover, the model shares a typical feature of RBC frameworks, namely a rather high correlation of all macroeconomic aggregates with output. On the other hand, the output correlations of the exogenous drivers (TFP, IST and the labor share) compare fairly well with the point estimates.

As shown in Table F.3, the two-agent economy is able to account for plausible stock excess returns, both in terms of mean and standard deviation. The close mapping between the consumption gap and the dividend-to-wage income ratio is of key impor-

[20]For example, lower adjustment costs would make investment more volatile, while reducing the volatility of consumption and dividends. Analogously, a higher average risk-aversion (determined by a higher σ or χ_c, or a combination of the two), would imply a lower elasticity of intertemporal substitution, thus making consumption and dividends smoother, at the expense of higher investment volatility.

tance, in this respect. Restricting access to financial investment to a limited number of assetholders raises the equity premium they demand, through the connection between their consumption growth and financial income, which is intrinsecally more volatile. While the model produces a sizable equity premium, the risk-free rate is not as low as in the data, and also appears rather volatile. As in Jermann (1998) and Lansing (2015), the combination of habit utility and (high) capital adjustment costs that generates sufficiently volatile stock returns induces, at the same time, strong fluctuations in investors' marginal utility, which reflects into the standard deviation of the risk-free rate.

F.2 Stationary equilibrium

Given the permanent nature of TFP and IST shocks, the model exhibits non-stationary dynamics. As such, it needs to be rewritten in stationary form by appropriately transforming the growing variables. Define $\Gamma_t \equiv (z_t \mu_t^\alpha)^{\frac{1}{1-\alpha}}$, and the associated growth rate $g_{\Gamma,t} \equiv \Delta \log(\Gamma_t) = \frac{1}{1-\alpha}[g_{z,t} + \alpha g_{\mu,t}]$, where $g_{z,t} \equiv \Delta \log(z_t)$ and $g_{\mu,t} \equiv \Delta \log(\mu_t)$ denote the growth rates of TFP and IST, respectively. We apply the following transformations:

$$\tilde{y}_t \equiv \frac{y_t}{\Gamma_t}, \quad \tilde{k}_t \equiv \frac{k_t}{\Gamma_{t-1}\mu_{t-1}}, \quad \tilde{i}_t \equiv \frac{i_t}{\Gamma_t \mu_t}, \quad \tilde{q}_t \equiv q_t \mu_t, \quad \tilde{d}_t \equiv \frac{d_t}{\Gamma_t}, \quad \tilde{w}_t \equiv \frac{w_t}{\Gamma_t}, \quad \tilde{c}_t \equiv \frac{c_t}{\Gamma_t},$$
$$\tilde{c}_t^{na} \equiv \frac{c_t^{na}}{\Gamma_t}, \quad \tilde{c}_t^a \equiv \frac{c_t^a}{\Gamma_t}, \quad \tilde{h}_t \equiv \frac{h_t}{\Gamma_t}, \quad \tilde{\lambda}_t \equiv \lambda_t \Gamma_t^\sigma.$$

Then, the stationary equilibrium is the solution to the following system of equations:

$$\tilde{c}_t^{na} = \tilde{w}_t, \tag{F.24}$$

$$\tilde{c}_t^a = \tilde{w}_t + \frac{\tilde{d}_t}{1-\gamma}, \tag{F.25}$$

$$\tilde{c}_t = \tilde{w}_t + \tilde{d}_t, \tag{F.26}$$

$$\tilde{h}_t = \exp(-g_{\Gamma,t})[m\tilde{h}_{t-1} + (1-m)\tilde{c}_{t-1}^a], \tag{F.27}$$

$$\tilde{\lambda}_t = (\tilde{c}_t^a - \chi_c \tilde{h}_t)^{-\sigma}, \tag{F.28}$$

$$m_{t,t+1} = \beta E_t \left(\frac{\tilde{\lambda}_{t+1}}{\tilde{\lambda}_t} \right) \exp(-\sigma g_{\Gamma,t+1}), \tag{F.29}$$

$$p_t^s = E_t m_{t,t+1}(p_{t+1}^s + \tilde{d}_{t+1}), \tag{F.30}$$

$$p_t^b = E_t m_{t,t+1}, \tag{F.31}$$

$$\tilde{y}_t = \exp\left[-\frac{\alpha}{1-\alpha}(g_{z,t} + g_{\mu,t})\right] A n^{1-\alpha_t} \tilde{k}_t^{\alpha_t}, \tag{F.32}$$

$$\tilde{k}_{t+1} = \exp\left(-g_{\Gamma,t} - g_{\mu,t}\right)\left[(1-\delta)\tilde{k}_t + \phi\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right)\tilde{k}_t\right], \tag{F.33}$$

$$\phi\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right) = \frac{a_1}{1-1/\chi_k}\left[\frac{\tilde{i}_t}{\tilde{k}_t}\exp\left(g_{\Gamma,t} + g_{\mu,t}\right)\right]^{1-1/\chi_k} + a_2, \tag{F.34}$$

$$\tilde{d}_t = \tilde{y}_t - \tilde{w}_t n_t - \tilde{i}_t, \tag{F.35}$$

$$\tilde{w}_t = (1-\alpha_t)\frac{\tilde{y}_t}{n_t}, \tag{F.36}$$

$$\phi^{'}\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right) = a_1\left[\frac{\tilde{i}_t}{\tilde{k}_t}\exp\left(g_{\Gamma,t} + g_{\mu,t}\right)\right]^{-1/\chi_k}, \tag{F.37}$$

$$\phi^{'}\left(\frac{\tilde{i}_t}{\tilde{k}_t}\right) = \frac{1}{\tilde{q}_t}, \tag{F.38}$$

$$\tilde{q}_t = E_t m_{t,t+1}\Bigg\{\alpha_{t+1}\frac{\tilde{y}_{t+1}}{\tilde{k}_{t+1}}\exp\left(g_{\Gamma,t+1}\right) + \tilde{q}_{t+1}$$
$$\left[(1-\delta)\exp\left(-g_{\mu,t+1}\right) + \phi\left(\frac{\tilde{i}_{t+1}}{\tilde{k}_{t+1}}\right)\exp\left(-g_{\mu,t+1}\right) - \phi^{'}\left(\frac{\tilde{i}_{t+1}}{\tilde{k}_{t+1}}\right)\frac{\tilde{i}_{t+1}}{\tilde{k}_{t+1}}\exp\left(g_{\Gamma,t+1}\right)\right]\Bigg\}. \tag{F.39}$$