



Income inequality and stock market returns [☆]

Agnieszka Markiewicz ^{a,*}, Rafal Raciborski ^{b,1}

^a Erasmus University Rotterdam, Tinbergen Institute, the Netherlands

^b European Commission, Belgium



ARTICLE INFO

Article history:

Received 25 March 2019

Received in revised form 14 December 2020

Available online 10 February 2021

JEL classification:

D31

E32

E44

H21

O33

Keywords:

Asset pricing

Risk premium dynamics

Income inequality

Computational macroeconomics

ABSTRACT

We show that the drop in the equity premium since the 1970s can partially be explained by the shifts in the level and composition of U.S. income inequality. To show it, we use a framework that extends the standard production-based Consumption Capital Asset Pricing Model by allowing for heterogeneity of agents, who differ in their ability to hold financial assets and their labor shares of income. The top income group, capital owners, own the firms and provide labor and the rest of the economy is populated by workers who consume their labor income and income from risk-free government and corporate bonds. Intuitively, an increase in the share of capital in income rises the riskiness of consumption and predicts higher equity premium. A rise in the share of capital owners' non-risky labor income leads to lower excess return. Time-series U.S. equity premium regressions and cross-country excess return comparison significantly and robustly validate predictions of the model. The quantitative experiment of shifting capital and labor income shares of capital owners explains one third of the observed reduction in the U.S. equity premium. The reason is that, during the last five decades, capital owners benefited from higher average growth in their non-risky labor income relative to the capital income.

© 2021 Elsevier Inc. All rights reserved.

1. Introduction

Equity premium on the U.S. stock market fell from 10.6% during the 1950s and 1960s to 7.5% since the 1970s. At the same time, the U.S. economy has witnessed an unprecedented increase in income inequality.² Are these two trends related? Since equities are predominantly held by households at the top of the income distribution, changes in their income shares should have an impact on steady state equity prices.³ But is an increase in inequality consistent with a general fall in equity premium?

[☆] For helpful comments and suggestions we thank Lukasz Drozd, Bünyamin Erkan, Jaromir Nosal, Andreas Pick, Vincent Rebeyrol and participants of the 2017 Society of Economic Dynamics meeting in Edinburgh, the 25th Society of Nonlinear Dynamics and Econometrics meeting in Paris, Fifth International Symposium in Computational Economics and Finance in Paris and 2017 National Bank of Poland workshop in Warsaw.

* Corresponding author at: Erasmus University Rotterdam, P.O. Box 1738, 3000 DR Rotterdam, the Netherlands.

E-mail address: markiewicz@ese.eur.nl (A. Markiewicz).

¹ The content of this study does not reflect the official opinion of the European Union. Responsibility for the information and views expressed in the paper lies entirely with the author.

² The total share of income of top decile in the U.S. increased from 32% to 47% between 1970 and 2014 as shown in Fig. 1, top panel.

³ Chen and Stafford (2016) argue that perhaps as few as 20 percent of households own stock directly. Wolff (2017) shows that in 2016, the last wave of the Survey of Consumer Finances (SCF), households in top 10% of the U.S. wealth distribution owned 84% of all stocks.

We argue that the answer to this question does not only depend on the level, but also on the source of income inequality shifts. Over the recent years, two income share trends benefited the wealthier households. First, as is shown in Fig. 2, the labor share of income of top decile in the U.S. increased from 25% to 36%, between 1970 and 2014. Second, as shown in the bottom panel of Fig. 1, the capital share of income, predominantly held by the rich households, increased from 35% to 43%, over the same period. The paper shows that these two shifts have opposite theoretical implications for the equity premium. Intuitively, an increase in the share of income derived from labor constitutes a hedge against stock market fluctuations in terms of consumption risk. As a consequence, an increase in the labor share of income of stock holders should reduce equity premium. On the other hand, higher share of income derived from capital exposes shareholders to additional consumption risk. Therefore, it will typically coincide with higher demanded equity premia. The combined effect is, hence, ambiguous.

To judge the quantitative impact of the observed income level and composition shifts on equity premium we build a stylized general equilibrium model. The model extends the standard RBC setting used in the production-based Consumption Capital Asset Pricing Model (CCAPM) literature by allowing for heterogeneity of agents, who differ in their labor shares of income and their ability to hold financial assets. The top income group (capital owners) owns the economy's financial wealth—a setup that roughly approximates the highly-skewed distribution of U.S. financial wealth. The rest of the economy is populated by workers who consume their labor income and income from risk-free government and corporate bonds. In order to replicate the most salient stock market stylized facts (sizable equity premium, high Sharpe ratio and price–equity ratio), we equip the model with several additional features that increase the sensitivity of capital owners to stock market risk: a high and time-varying coefficient of risk-aversion (similar to Greenwald et al., 2016), capital adjustment costs (e.g. Uhlig, 2007 and Jermann and Quadrini, 2012) and financial leverage (Jermann and Quadrini, 2012). The model is calibrated to match the financial market and real economy statistics and income shares observed over the period of interest.

Based on the empirical evidence on the persistence in income inequality shifts, our main quantitative exercise compares two stationary steady states characterized by different level and composition of capital owners' income shares.⁴ We calibrate the model's baseline steady state to the U.S. post-war economy between 1947 and 1970 with the average equity premium on S&P500 shares of 10.6%. The second steady state is characterized by higher labor and capital income shares in top income decile in line with the shifts that occurred over 1970–2014. We find that this alternative calibration reduces equity premium to 9.7%, implying that the shifts in income distribution and composition over the last five decades can explain about one third of the observed reduction in the U.S. equity premium, over the same period. Clearly, the upward shift in top decile labor income share has dominated the simultaneous increase in capital income share, reducing the overall riskiness of the top decile income and exerting a downward pressure on equity premium. Further experiments show that, absent the capital income share increase, the shift in labor income share alone would have been associated with an even larger fall in excess return of 1.6 percentage points.⁵

The predictions that a higher capital share of income is associated with higher equity premium and that a higher labor share of income of capital owners is negatively correlated with the excess returns can be confronted more directly with the data. We test these predictions using cross-country and U.S. time-series data. Because, as in the model, we are interested in the long-run shifts, we rely on the long-run regressions to estimate the relationship between equity premium and income shares'. We show that U.S. capital income inequality is positively, significantly and robustly associated with the real excess returns while labor share of income of capital owners, defined as top decile or top quintile, is negatively related to the real excess return. An international comparison delivers similar results as, in a panel of 17 OECD countries, 5-year changes in equity premia are positively related with 5-year changes in capital share of income.

Our paper draws on a number of strands in the economic literature. The theoretical model we use for linking shifts in income shares to equity premium builds on the literature embedding risky asset markets into RBC models, similar to the work of Jermann (1998), Boldrin et al. (2001) and Danthine and Donaldson (2002 and 2008), who do not distinguish between workers and capital owners. Guvenen (2009) and Guvenen and Kuruscu (2006) extend the otherwise standard RBC framework by introducing two types of consumers, which differ by their elasticity of intertemporal substitution. In our paper, the elasticity of intertemporal substitution is kept identical for both types of households.

Our modeling framework is also closely related to Lansing (2015), who develops a production-based asset pricing model with two types of households, high concentration of productive capital and “redistributive shocks” to the shares of income. The focus of Lansing's paper is on high post-war level of equity premium and the model is shown to be able to reproduce up to two thirds of it. Our focus, instead, is on the longer-term, structural shifts in income shares and the resulting long-term *downward* trend in the equity premium. Furthermore, in Lansing (2015), the high equity premium is primarily driven by distribution shock raising dividends' volatility. In our model, we obtain a high excess return by incorporating a time-varying risk-aversion in capital owners' utility function in spirit of Greenwald et al. (2016). In contrast to Greenwald et al. (2016), however, our model mirrors the empirical composition of income and therefore, in addition to capital income, capital owners earn wage income.⁶ This modification is essential to quantify the joint impact of shifts in income shares because

⁴ Using administrative micro-level data, DeBacker et al. (2013), Kopczuk et al. (2010) and Guvenen et al. (2014) show that for household income, most of the increase in inequality reflects an increase in the dispersion of the permanent income component.

⁵ This is similar to Walentin (2010) who focusing on the effects of the empirical labor income share increase found that they can explain 44% of the fall in equity premium over a similar period.

⁶ Saez and Zucman (2016) show that in 2012 the top 0.1% of wealth holders earned 31 times the average labor income and their pre-tax income share almost tripled between 1960 and 2012.

they predict the opposite movements in the equity premium. Models ignoring capital owners' income derived from labor will, therefore, tend to overestimate the equity premium and struggle to account for its decades-long downward trend.

Several recent papers study the link between income and wealth inequality and equity premium. Walentin (2010) argues that an increase in stockholders' share of aggregate labor income reduces the covariance between stockholders' total income growth and dividend growth and therefore leads to the lower equity premium, but he ignores the empirical shift in the capital share. In an incomplete markets OLG framework, Favalukis (2013) shows that the observed rise in wage inequality, decrease in participation costs, and loosening of borrowing constraints can jointly explain substantial increases in wealth inequality and stock market participation, a decline in interest rates and the expected equity premium, as well as a prolonged stock market boom. Toda and Walsh (2020) show theoretically and empirically that an increase in the wealth share of stock-holders reduces the equity premium. Gomez (2018) documents that when stock returns are high, inequality increases but higher inequality predicts lower stock returns.

By studying the link between income shares and asset returns, we also contribute to the fast-growing literature emphasizing the importance of wealth dispersion and resulting capital income inequality in the U.S. and other developed economies. Kacperczyk et al. (2019) show that capital income inequality is large and growing fast, accounting for a considerable portion of total income inequality in the U.S. In addition, Saez and Zucman (2016) demonstrate an increased correlation between top labor and top capital incomes in the U.S. data. Our framework is motivated by these recent empirical observations and therefore models capital owners also as high labor income earners.

The paper is organized as follows. In Section 2, we describe a set of stylized facts on changes in income inequality and equity premium. In Section 3, we describe the model and its main intuition. Specifically, we explain the model mechanisms linking shifts in income shares to equity premium. Section 4 describes our empirical strategy including calibration of the model, its quantitative performance and the comparison of two model economies characterized by different level and composition of income inequality. Section 5 further confronts the model predictions with the data via a set of time-series and panel regressions. Section 6 concludes.

2. Income inequality and equity premium in the data

2.1. Capital and labor shares of income

The recent increase of income inequality has been accompanied by rising capital share of income. Karabarounis and Neiman (2014) show that the labor share of income has significantly declined since the early 1980s in the large majority of countries, including the U.S.

Fig. 1 plots increase in the top decile and capital shares of income in the U.S. between 1970 and 2014. There is a clear positive trend in both series. Between 1970 and 2014, capital share of income increased from 35% to 43% and, during the same period, the top decile income share raised from 32% to 47%. Given that the capital stock is concentrated in hands of a relatively small group of wealthy households, the observed increase in capital share of income directly implied an increase in income inequality.

While *total* labor share of income declined in the U.S. in the recent decades, the labor share of the richest households increased as well. Fig. 2 plots the labor share of income of households in the top 10% of the U.S. income distribution between 1947 and 2014.⁷ The share was roughly stable before 1970, started to increase in the 70s and even more rapidly in the 80s, shifting from 25% of total income to 36% in 2014.

2.2. Equity premium

While income inequality has increased during the last five decades, the average equity premium (EP) has declined.

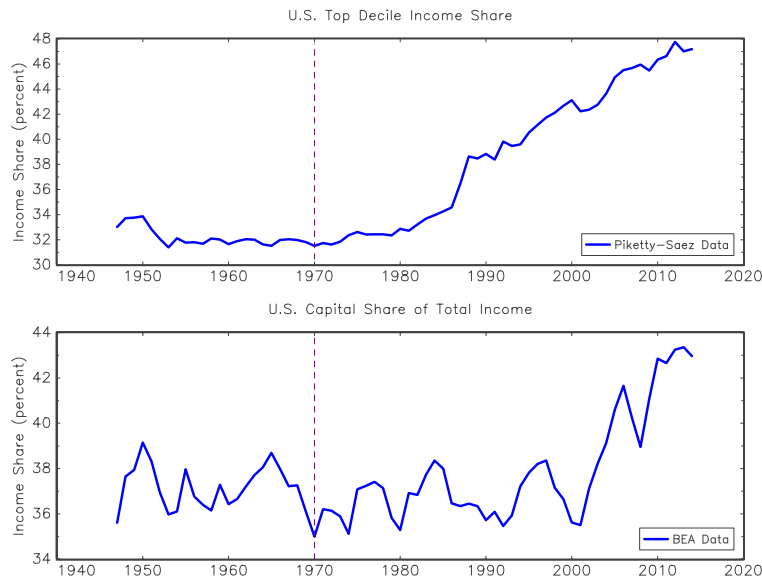
Many studies including Blanchard (1993), Claus and Thomas (2001), Jagannathan et al. (2001), Fama and French (2002), Pastor and Stambaugh (2001) and more recently Kacperczyk et al. (2019) document a reduction of the empirical equity premium towards the end of the 20th century. In Fig. 3 we plot 10-year rolling EP and shaded NBER U.S. recessions between 1947 and 2015. Although the EP is procyclical and displays a significant correlation coefficient with U.S. GDP growth of 0.3, its mean is visibly lower in the second part of the sample.⁸ As there appears to be a structural shift in the mean in the beginning of the seventies, we cut our sample in two in 1970 and report the corresponding subsample equity premia and Sharpe ratios in Table 1. A similar picture emerges if we split the sample at different dates between 1960 and 1975.

The first column of Table 1 reports the period over which the statistic was computed. In the second column, we show the values for the EP and in the third column for Sharpe ratios (SR). The first row shows that the equity premium equals, on average, 8.5% during the entire post-war period while Sharpe ratio was equal to 0.49 during the same period.

The following two rows report the statistics for the period before 1970 and after 1970. The equity premium before 1970 was a third higher than after 1970. A similar pattern is displayed when excess return is corrected for risk. The Sharpe ratio statistic, reported in the last column of the table is 25% lower after 1970.

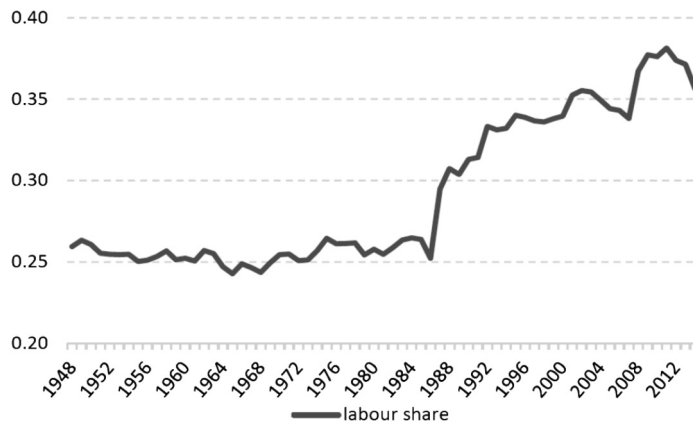
⁷ Further decomposition of labour income share dynamics, over the last five decades, is presented in Appendix D.

⁸ Lustig and Verdelhan (2012) and Gómez-Cram (2020), among others, study the dynamics of the equity premium over the business cycle.



Top decile income share series comes from the World Inequality Database at <https://wid.world/>. Capital share of income is computed from Bureau of Economic Analysis database as 1-compensation of employees.

Fig. 1. Top decile income share and capital share of income in the U.S. between 1970 and 2014.



The figure plots labor share of income of top decile which includes wages and salaries, bonuses, exercised stock-options, and pensions. The series are computed as shares of total U.S. income.

Fig. 2. Top decile labor share of income 1970 and 2014. (Income share data is described in Atkinson et al. (2011) and can be found at <https://wid.world/>.)

Table 1
Equity premium and Sharpe ratio for S& P500.

| | EP | SR |
|-------------|-------|------|
| 1947 – 2014 | 8.5% | 0.49 |
| 1947 – 1970 | 10.6% | 0.59 |
| 1971 – 2014 | 7.5% | 0.44 |

EP stands for equity premium and SR for Sharpe ratio. Both statistics are computed using the annual data from Goyal’s website. Stock returns are the continuously compounded returns on the S&P 500 index, including dividends. EP is computed as the difference between the return including dividends on S&P 500 and the risk free rate measured as 6 months rolled commercial paper rate.

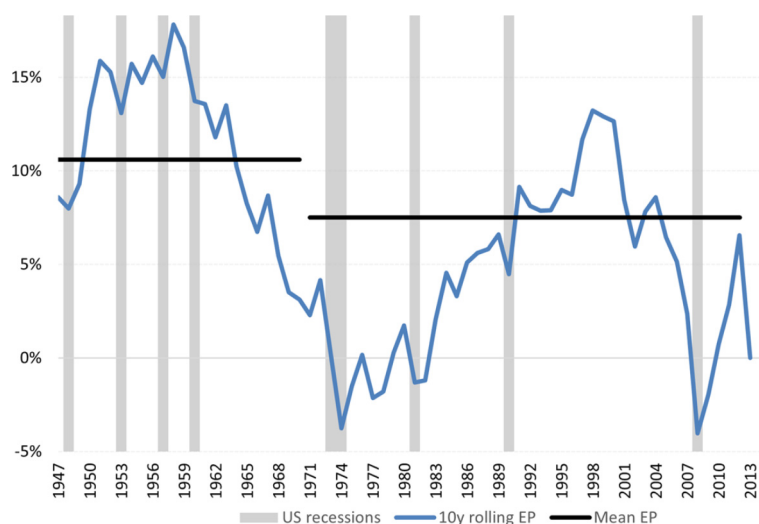


Figure plots 10-year rolling equity premium computed from Goyal's website: <http://www.hec.unil.ch/agoyal/> accompanying Welch and Goyal (2008, updated). The grey areas correspond to the NBER dated U.S. recessions and the black horizontal lines to the mean EP before 1970 and after 1970.

Fig. 3. 10-year rolling equity premium and U.S. recessions.

3. Model

Our analytical framework takes inspiration from Lansing (2015) and Lansing and Markiewicz (2018). We build a model, which extends the standard RBC setting used in the production-based Consumption Capital Asset Pricing Model (CCAPM) literature allowing for two types of agents, capital owners and workers, differing by their ability to hold financial assets and facing different output elasticities of labor. We assume that capital owners own the firms, an assumption mirroring the data patterns. Wolff (2017) shows that in 2016, the last wave of the Survey of Consumer Finances (SCF), households in top 10% of the U.S. wealth distribution owned 84% of all stocks.

Empirical stock market statistics are known to be very hard to match in the RBC settings. We equip our model with three features that combined let us reproduce the high empirical mean equity premium and realistic Sharpe ratio. First, fitting the latter statistic has been known to require large fluctuations in the aggregate risk aversion produced in the model (e.g., Campbell and Cochrane, 1999). Based on this intuition, we follow Greenwald et al. (2016) and introduce a time-varying coefficient of risk aversion into our framework. This feature of the model finds support in a recent study by Guiso et al. (2018), who provide direct evidence that both qualitative and quantitative measures of risk aversion exhibited large increases following the financial crisis of 2008.

Having achieved a high price for risk in the model due to varying risk aversion, two additional mechanisms: (i) capital adjustment costs and (ii) financial leverage, are introduced to help the model increase the quantity of risk borne by the agents investing in stocks. Careful calibration of these three mechanisms allows for precise matching of the Sharpe ratio, equity premium and variance of dividend growth. In particular, generating a sizable Sharpe ratio has been recognized a serious challenge in models that use other mechanisms to generate high equity premium.⁹ Additionally, introducing financial leverage pins down the non-zero rate of risk-free savings on the side of consumers, which increases the realism of the model.¹⁰

3.1. Workers

Workers, of mass $1 - \eta$, maximize a discounted sum of utility over consumption, c_t^w :

$$\max_{c^w, a^f, a^c} E_0 \sum_{t=0}^{\infty} \beta_t^w \frac{(c_t^w)^{1-\gamma^w}}{1-\gamma^w}, \quad (1)$$

⁹ This literature is too broad to be discussed here. For an early account of the puzzle in a framework with fully-fledged production see, e.g., Jermann (1998). It is worth emphasizing that there is typically a trade-off between fitting the asset market and real-economy statistics and that it is not possible to fit exactly both sets of statistics in our model. This observation is of general nature, however, and holds for many modern production-based CCAPMs (e.g. Guvenen, 2009).

¹⁰ In this class of models, due to the Euler equation that does not contain quantities, the prevailing risk-free rate of return is consistent with an arbitrary asset portfolio composition. A zero-risk-free saving rate is, therefore, usually assumed in these models, which stands at a stark contradiction with the data.

where β_t^w is an individual worker's discount factor and γ^w is her coefficient of risk aversion. The maximization is subject to a budget constraint:

$$c_t^w + a_t^f P_t^f + a_t^{c,w} P_t^c = W_t^w n_t^w + a_{t-1}^f + a_{t-1}^{c,w}, \tag{2}$$

with W_t^w the wage rate received by workers, P_t^f and P_t^c the prices of zero-supply risk-free bonds and (risk-free) corporate bonds, respectively, and a_t^f and $a_t^{c,w}$ the respective positions taken by workers in these assets. Workers are assumed to incur a transaction cost for trading stocks which prohibits their participation in stock exchange.¹¹ Finally, $n_t^w = n^w$ is the constant supply of labor hours per worker.

Assuming transversality condition, first order conditions for the worker's problem are standard:

$$\begin{aligned} (c_t^w)^{-\gamma^w} &= \lambda_t^w \\ 1 &= \beta_t^w E_t \frac{\lambda_{t+1}^w}{\lambda_t^w} R_t^f \end{aligned} \tag{3}$$

$$1 = \beta_t^w E_t \frac{\lambda_{t+1}^w}{\lambda_t^w} R_t^c \tag{4}$$

with λ_t^w a worker's marginal utility of consumption and E_t representing the mathematical expectation operator conditional on information at the end of period t . By definition, the returns on risk-free assets satisfy:

$$\begin{aligned} R_t^f &= \frac{1}{P_t^f} \\ R_t^c &= \frac{1}{P_t^c} \end{aligned}$$

By construction, we also have $R_t^c \equiv R_t^f$. Note that we implicitly assumed that firms do not default on their debt.

3.2. Capital owners

Capital owners, of mass η , represent the top decile of income distribution. Similarly to workers, they maximize a discounted sum of utility over consumption, c_t^c :

$$\max_{c^c, a^{c,c}, a^s} E_0 \sum_{t=0}^{\infty} \beta_t^c \frac{(c_t^c)^{1-\gamma_t^c}}{1-\gamma_t^c}, \tag{5}$$

where β_t^c is the capital owners' discount factor and γ_t^c is their coefficient of risk aversion. The capital owners' coefficient of risk aversion is time-varying. In combination with technology shocks, shocks to the coefficient of risk aversion increase the price of risk.

The time-varying coefficient of risk aversion is defined as:

$$\gamma_t^c = \frac{\gamma^c}{1 + \exp(x_{t-1})} \tag{6}$$

with γ^c being the maximum degree of risk aversion and x_t an autoregressive process of order 1 with mean μ^x : $x_t - \mu^x = \rho^x (x_{t-1} - \mu^x) + \varepsilon_t^x$ and ε_t^x an iid shock.

The maximization is subject to a budget constraint:

$$c_t^c + a_t^s P_t^s + a_t^{c,c} P_t^c = W_t^c n_t^c + a_{t-1}^s (P_t^s + d_t^s) + a_{t-1}^{c,c}, \tag{7}$$

with W_t^c being the wage rate received by capital owners, a_t^s and $a_t^{c,c}$ the number of stocks and corporate bonds held by capital owners, respectively, P_t^s the stock price and d_t^s the (macroeconomic) dividend received by capital owners from holding stocks. $n_t^c = n^c$ is their constant supply of labor.

Assuming the usual transversality condition, first order conditions for the capitalist's problem are:

$$\begin{aligned} (c_t^c)^{-\gamma_t^c} &= \lambda_t^c \\ 1 &= \beta_t^c E_t \frac{\lambda_{t+1}^c}{\lambda_t^c} R_{t+1}^s \end{aligned} \tag{8}$$

¹¹ In contrast, they are assumed to have full access to risk-free saving vehicles such as bank deposits (a_t^f) and corporate bonds ($a_t^{c,w}$).

$$1 = \beta_t^c E_t \frac{\lambda_{t+1}^c}{\lambda_t^c} R_t^c \tag{9}$$

with λ_t^c the marginal utility of consumption and R_{t+1}^s the next period return on stocks:

$$R_{t+1}^s = \frac{P_{t+1}^s + d_{t+1}^s}{P_t^s}$$

The form of the above first order conditions is very similar to the standard first order conditions derived in the CCAPM literature. However, since risk-free assets are now held by two types of agents, whose consumption is allowed to display different dynamics, Euler equations of capital owners and workers associated with these assets are, in most general case, inconsistent with each other. To deal with this problem, we apply a definition of time-varying discount factors borrowed from Greenwald et al. (2016):

$$\beta_t^c \equiv \beta \left[E_t \frac{\lambda_{t+1}^c}{\lambda_t^c} \right]^{-1}$$

$$\beta_t^w \equiv \beta \left[E_t \frac{\lambda_{t+1}^w}{\lambda_t^w} \right]^{-1}$$

where $0 < \beta < 1$. These definitions guarantee consistency of both sets of Euler equations. The additional advantage of this approach is that we obtain a constant risk-free rate, which is a good approximation of its empirical counterpart (measured, e.g. by the T-bill rate):

$$R_t^c \equiv R^c \equiv \frac{1}{\beta}$$

In contrast, many asset pricing models with production sector generate risk-free rate that is too volatile.¹²

3.3. Firms

Identical competitive firms, of mass 1 maximize the present value of their future profits, D_t , discounted at the marginal rate of substitution, $\beta^t \frac{\lambda_{t+1}^c}{\lambda_0^c}$, of the firms' owners:

$$\max_{K, N^c, N^w} \sum_{t=0}^{\infty} \beta^t E_t \frac{\lambda_{t+1}^c}{\lambda_0^c} D_t (K_{t-1}, K_t, N_t^c, N_t^w)$$

where K_t is the end of period capital stock and N_t^c and N_t^w indicate demand for the capital owners' and workers' labor, respectively. Profits are defined as:

$$D_t (K_{t-1}, K_t, N_t^c, N_t^w) \equiv D_t = Y_t - W_t^c N_t^c - W_t^w N_t^w - I_t + P_t^c \mu K_t - \mu K_{t-1} \tag{10}$$

Above, Y_t is the current output, I_t is total investment and μ measures the degree of financial leverage of firms. When $\mu = 0$, the new capital of a firm is fully financed through retained earnings. It will be assumed that profits are redistributed via dividends to capital owners: $d_t^s = D_t$.¹³

Output is produced with Cobb-Douglas technology:

$$Y_t = AK_{t-1}^\theta \left(\exp(z_t) (N_t^c)^\alpha (N_t^w)^{1-\alpha} \right)^{1-\theta} \tag{11}$$

where θ is the capital income share, $\alpha(1-\theta)$ is the capital owners' share of labor income and $z_t = z_{t-1} + \mu^z + \varepsilon_t^z$ is a TFP shock with possibly non-zero growth rate, μ^z , and ε_t^z is zero-mean *nid*.

It is assumed that transforming investment I_t into capital K_t is costly, which allows the shadow price of installed capital to diverge from the price of an additional unit of capital. In specifying the capital adjustment cost, we follow Uhlig (2007) and Jermann and Quadrini (2012) so that the capital accumulation equation takes the form:

$$K_t = (1 - \delta) K_{t-1} + G \left(\frac{I_t}{K_{t-1}} \right) K_{t-1} \tag{12}$$

¹² Another well-established solution to the volatility puzzle is disentangling the risk aversion and intertemporal elasticity of substitution coefficients by using the Epstein-Zin-Weil utility function (Epstein and Zin, 1989 and 1991; Weil, 1990). While this would solve the risk-free rate volatility problem, it would not, on its own, assure consistency between the arbitrage conditions.

¹³ Note that, as is common in the literature, e.g. Lansing (2015), we use the concept of “macroeconomic dividends” in place of financial dividends.

with function $G(\bullet)$ such that

$$G\left(\frac{I_t}{K_{t-1}}\right) = \frac{a_1}{1 - \frac{1}{\xi}} \left(\frac{I_t}{K_{t-1}}\right)^{1 - \frac{1}{\xi}} + a_2$$

where a_1, a_2 are two positive constants. For $\xi < \infty$, adjustment costs become strictly positive.

Assuming transversality condition, first order conditions are as follows:

$$W_t^w = (1 - \theta)(1 - \alpha) \frac{Y_t}{N_t^w} \tag{13}$$

$$W_t^c = (1 - \theta)\alpha \frac{Y_t}{N_t^c} \tag{14}$$

$$1 = \beta_t^c E_t \frac{\lambda_{t+1}^c}{\lambda_t^c} R_{t+1}^k \tag{15}$$

where return on capital, R_{t+1}^k , is defined as:

$$R_{t+1}^k = \frac{G'(\frac{I_t}{K_{t-1}})}{1 - G'(\frac{I_t}{K_{t-1}})\mu P_t^b} \left(\theta \frac{Y_{t+1}}{K_t} - \mu + \frac{1 - \delta + G(\frac{I_{t+1}}{K_t})}{G'(\frac{I_{t+1}}{K_t})} - \frac{I_{t+1}}{K_t} \right) \tag{16}$$

which can also be rewritten as

$$R_{t+1}^k = \frac{D_{t+1} + \frac{(1 - G'(\frac{I_{t+1}}{K_t})\mu P_{t+1}^c)}{G'(\frac{I_{t+1}}{K_t})} K_{t+1}}{\frac{(1 - G'(\frac{I_t}{K_{t-1}})\mu P_t^c)}{G'(\frac{I_t}{K_{t-1}})} K_t} \tag{17}$$

The interpretation of the expression for the return on capital is given below.

3.4. Equilibrium market clearing conditions

In the equilibrium, all markets clear:

- Consumption goods market: $C_t^w = (1 - \eta)c_t^w$, $C_t^c = \eta c_t^c$ and $C_t^w + C_t^c = C_t$
- Goods market: $C_t + I_t = Y_t$
- Labor market: $N^w = (1 - \eta)n^w$, $N^c = \eta n^c$ and $N^w + N^c = N$
- Asset markets: $a_t^s = \eta^{-1}$, $a_t^f = 0$, $B_t^{c,w} = (1 - \eta)a_t^{c,w}$, $B_t^{c,c} = \eta a_t^{c,c}$ and $B_t^{c,w} + B_t^{c,c} = \mu K_t$.

In the above, large-case-letters refer to aggregate (per capita) variables. Since the share of corporate bonds held by capital owners (and workers) is not pinned down by the Euler equations, we make an additional assumption that $B_t^{c,w} \equiv \mu K_t$ or, alternatively, $B_t^{c,c} \equiv 0$. Alternative assumptions, including $B_t^{c,w} \equiv 0$ and $B_t^{c,c} \equiv \mu K_t$, produce results similar to those reported in the paper.

The whole list of equations, after having been stationarized is shown in Appendix A.

3.5. Asset pricing variables

We compute a set of model-based financial variables and use their moments as targets in our calibration.

We define the equity premium as follows:

$$R_{t+1}^e = R_{t+1}^s - R_t^f$$

The unconditional Sharpe ratio is then defined as:

$$SR = \frac{E[R_t^e]}{\sigma[R_t^e]}$$

where E and σ stand for unconditional expectation and standard deviation, respectively. For the sake of completeness, we also define price-dividend ratio pd_t :

$$pd_t = \frac{P_t^s}{d_t^s}$$

Finally, it is worth providing an interpretation of the Euler equation associated with capital ownership. Comparing arbitrage conditions (8) and (15), we see that the market value of a firm is:

$$P_t^s = \frac{(1 - G'(K_{t-1}^{I_t})\mu P_t^c)}{G'(K_{t-1}^{I_t})} K_t$$

In a model without frictions, stock price, P_t^s , would be simply equal to capital stock per capita, K_t . However, in our model, the price of installed and uninstalled capital differ. The adjustment term $G'(K_{t-1}^{I_t})$ translates the value of installed capital into the uninstalled one. Since the second derivative of $G(\bullet)$ is negative, when the ratio of investment to installed capital is high, stock prices are high and the value of return on additional investment - low. Furthermore, stock owners own only a fraction $1 - \mu$ of capital stock, as they have to borrow from workers the funds to cover the remaining part of capital. This is reflected in the $(1 - G'(K_{t-1}^{I_t})\mu P_t^c)$ adjustment term, again, with a suitable modification due to the price difference between the installed and uninstalled capital.

3.6. Expected responses of equity premium to shifts in income shares

Using the model, we can make predictions on the impact of shifts in income shares on the stock market variables and in particular on the equity premium. An increase in the capital income ratio, as governed by the production function parameter θ , will lead to an increase in the mean equity premium. The reason is that, all else equal, higher θ directly increases the marginal return on capital, via (16), as well as the volatility of return on capital, which raises the riskiness of investment in stocks and hence increases the required premium.

Combining the capital owners' budget constraint (7) with the producers' optimality condition for capital owners' wages (14) and using equilibrium conditions for stock holdings, capital owners' corporate bond holdings and the aggregate supply of capital owners' labor, we can write capital owners' consumption as:

$$c_t^c = \tilde{\alpha} \frac{Y_t}{\eta} + \frac{D_t}{\eta}, \tag{18}$$

where $\tilde{\alpha} = \alpha(1 - \theta)$. The first term on the RHS of (18) represents the total labor income of capital owners. This is a part of capital owners' income that is relatively less risky. The second term is simply capital income, equal to total dividends income. This is the relatively more risky part of their income. From the above, it is clear that an upward shift in $\tilde{\alpha}$ will decrease consumption risk faced by capital owners, by increasing the weight of the less risky component of capital owners' income. Capital owners' consumption volatility should, as a result, drop and reduce the covariance between the stochastic discount factor, $M_t^c = \beta_t^c \frac{\lambda_{t+1}^c}{\lambda_t^c}$ and the mean stock excess return.

By the same token, using definition $\tilde{\alpha} = \alpha(1 - \theta)$, it is also clear that an increase in the capital share of income, θ , will have an additional indirect effect on the mean equity premium, by raising the relative weight of the riskier component in capital owners' consumption.

A simplified model

We further illustrate these mechanisms by considering a simplified version of our framework that lets us work with lognormal approximations of Euler equations (9) and (15). For the sake of simplicity, assume a constant coefficient of risk aversion $\gamma_{t+1}^c = \gamma_t^c \equiv \bar{\gamma}^c$ and normal distribution of shocks. Taking unconditional expectations and log-linearizing equations (8) and (9), we find the usual approximated expression for the expected equity premium, $E(r^e)$:

$$E(r^e) = E(r^s) - E(r^f) = \bar{\gamma}^c cov[\Delta c^c, r^s] - \frac{\sigma_{r^s}^2}{2} \tag{19}$$

where $E(r^s)$ and $E(r^f)$ are expected log returns on equity and risk-free assets, respectively and σ_{r^s} denotes equity returns' volatility. This above equation shows how an increase in the capital share of income, θ , leads to higher equity premium. Through higher volatility of equity returns, $\sigma_{r^s}^2$, θ increases their covariance with consumption growth, Δc^c . While higher volatility of returns on equity has also a direct negative effect on equity premium via negative $\frac{\sigma_{r^s}^2}{2}$, this effect is small for sufficiently high coefficients of risk aversion, $\bar{\gamma}^c$ (see also below). As a result, higher capital share of income will coincide with higher equity premium.

To study the effect of a change in the capital owners' labor share of income, $\tilde{\alpha}$, in the simplified setting, assume a joint process for consumption and dividend growth that is *i.i.d.* over time. In this case, Abel (2008) shows that $r^s = \Delta D$. Note that, in equilibrium $d_t^s = D_t$, and therefore the approximated expected equity premium is as follows:

$$E(r^e) = \bar{\gamma}^c cov[\Delta c^c, \Delta D] - \frac{\sigma_{\Delta D}^2}{2} \tag{20}$$

Using the expression for capital owners' consumption (18) to approximate Δ^c and plugging into the above equation, the expected equity premium can be finally written as:

$$E(r^e) = \bar{\gamma}^c \Omega \frac{\tilde{\alpha} Y}{\tilde{\alpha} Y + D} + \left(\bar{\gamma}^c - \frac{1}{2} \right) \sigma_{\Delta D}^2 \tag{21}$$

where $\Omega = cov[\Delta \tilde{\alpha} Y, \Delta D] - \sigma_{\Delta D}^2$. Note that $\frac{\tilde{\alpha} Y}{\tilde{\alpha} Y + D}$ is increasing in $\tilde{\alpha}$ and therefore leads to a reduction in equity premium as long as Ω is negative. This, in turn, will be the case when the covariance between capital owners' labor income growth and dividends' growth is lower than the variance of dividends growth. Furthermore, since $\tilde{\alpha} = \alpha(1 - \theta)$, an increase in top decile capital share θ will increase equity premium. This effect is further reinforced due to higher θ also increasing the volatility of dividend growth, $\sigma_{\Delta D}^2$, whenever $\bar{\gamma}^c > \frac{1}{2}$.

Time-varying risk aversion coefficient γ_t^c adds some complexity to the model, but the intuition developed above holds. Higher θ and lower $\tilde{\alpha}$ will generate an increase in equity premium in the model because they will rise the riskiness of capital owners' consumption, as measured by covariance between their consumption and dividends' growth. Since in the data we observe an increase in both shares of income simultaneously, the effect of their combined shifts on the average equity premium cannot be determined a priori. In the remainder of the paper, we resort to simulations to establish plausible quantitative effect of this shift.

4. Quantitative exercise

Our key experiment is to compare two different economies (two steady states) which differ by level and composition of income shares. This strategy is more suitable in our context than a study of the transition dynamics because the recent increase in inequality appears to be mostly permanent. Using administrative micro-level data, DeBacker et al. (2013), Kopczuk et al. (2010) and Guvenen et al. (2014) show that for household income, most of the increase in inequality reflects an increase in the dispersion of the permanent income component. We first calibrate the baseline scenario in which the steady state shares of incomes are equal to the average values observed between 1947 and 1970, a period of relative stability of income shares (see Figs. 1 and 2). We then consider the second steady state where the top decile income share is higher and its composition is different.

Changes in income shares have not been the only factor that have affected the average equity premium.¹⁴ In this paper, we abstract from studying these additional factors and, instead, we entirely focus on isolating the impact of higher inequality on the stock market outcomes.

4.1. Calibration

Our calibration strategy is as follows. We compute financial and real economy statistics for the period between 1947 and 1970 and calibrate the model to match the behavior of the U.S. economy in this initial steady state. Table 2 reports all the parameter values in the calibration where some of them are set to match empirical moments and others are taken from existing literature. A time period in the model represents a year. The share η of capital owners in the population is equal to the top income decile. The main reason for modelling the top decile as capital owners is that, from the Survey of Consumer Finances described by Wolff (2017), we know that 10% the richest households in the U.S. owns 84% of all stocks held by household in 2016 and 80% between 1947 and 1970, on average.

To compute α , we proceed as follows. For each year $t = 1947, \dots, 1970$, we compute $\alpha_t = (s_t^{10} - 0.8 \times \theta_t) / (1 - 0.8 \times \theta_t)$ where s_t^{10} is the total top decile income share and θ_t is the total capital share of income in the economy in year t . Because top decile owned 80% of it over this period, we multiply θ_t by 0.8. We then compute the average $\alpha = \frac{1}{T} \sum_{t=47}^T \alpha_t = 0.06$, $T = 70$. Following Lansing (2015), we choose the value of demand for workers' labor such that the relative wage of capital owners to workers, $W_0^c / W_0^w = 2$, its value between 1947 and 1970.

We choose the value of the standard deviation of the TFP shock, σ^z , such that the volatility of output growth in our economy matches its empirical counterpart between 1947 and 1970, of 2.6% annually. The value of depreciation rate, δ , is set to a standard 8%, annually. The value of capital adjustment cost parameter, ξ , is selected to match the ratio of volatility of investment growth to volatility of output growth equal to 2.5. The remaining parameters in the capital adjustment cost function, α_1 and α_2 , are specified so that the steady state investment to capital ratio equals the depreciation rate and the first derivative of this function in investment-capital ratio is equal to 1, as in Uhlig (2007) and Jermann and Quadrini (2012). Parameter β is calibrated to match the mean annual risk-free rate $E(R_t^f) = 2\%$. Further, without a loss of generality, we set the demand for capital owners' labor in the model equal to 1.

The financial leverage, μ , is set to 0.43. Masulis (1988) reports that the leverage ratio of U.S. firms has varied between 13% and 44% from 1929 to 1986, Guvenen (2009) sets it to 0.15, Jermann (1998) between 0.4 and 0.6, and Boldrin et al.

¹⁴ For instance, an important trend observed over the last several decades has been a steady increase in stock ownership among households. In a seminal paper, Vissing-Jorgensen (2002) established that limited stock market participation helps explain high excess returns observed on equities. By this token, an increase of stock ownership over the last decades should have contributed to the falling equity premium.

Table 2
Calibration of the main parameter values.

| Baseline Parameter Values | | |
|---------------------------|----------------|---|
| Parameter | Value | Description/Target |
| η | 0.10 | Capital owners = top income decile. |
| θ | 0.27 | Capital's share of income of top decile for 1947-1970 = 0.8×0.34 |
| α | 0.06 | Computed from the top decile income share for 1947-1970 = 0.06 |
| N_1^c/N_{19}^w | 0.19 | Mean relative wage = $W_0^c/W_0^w=2$ |
| μ^z | 0.00 | RW |
| σ^z | $23.80e^{-5}$ | Output volatility for 1947-1970 = 2.6% |
| ρ^z | 0.00 | RW |
| δ | 0.08 | Annual depreciation rate = 8% |
| ξ | 0.67 | Ratio of volatility of investment to volatility of output $\frac{\sigma^{\Delta I}}{\sigma^{\Delta Y}} = 2.5$ |
| a_1 | $2.2000e^{-4}$ | Steady state investment to capital ratio equal to depreciation rate. |
| a_2 | 0.11 | $G'(\frac{I_t}{K_{t-1}})=1$ |
| β | 0.98 | $R_t^f=1.02$ |
| μ | 0.43 | Masulis (1988), Guvenen (2009), Jermann (1998) |
| γ^c | 187.90 | Equity premium for 1947-1970 = 10.6% |
| $\min(\gamma_t^c)$ | 1 | Greenwald et al. (2016) |
| μ^x | -0.17 | Sharpe ratio for 1947-1970 = 0.6 |
| σ^x | 0.35 | Standard deviation of Δd for 1947-1970 = 7% |
| ρ^x | 0.95 | Long-horizon return regression coefficients = (-0.32; -0.62; -0.87) |

(2001) to 0.5. Because the values assumed in the literature and empirical values of μ vary, we simply take an average of these numbers. We study the importance of financial leverage for the level of equity premium and other moments in Section 4.3. We set $\gamma^c = 187.9$, the parameter of capital owners' risk aversion to match the equity premium between 1947 and 1970, equal to 10.6%. The mean of the shock process to the coefficient of risk aversion $\mu^x = -0.17$ is set to match Sharpe ratio and its variance, $\sigma^x = 0.35$, to replicate the empirical dividends' growth volatility. Finally, we set the AR(1) coefficient of the risk aversion shock, ρ^x , to 0.95 to match the well documented long-horizon predictability of equity premium, reported in Appendix C.¹⁵

For solving the model, we use a non-linear solution method based on Coleman and Fenyes (1992) implemented by Davig (2004) and Lendvai and Raciborski (2014).¹⁶ The details of this procedure are described in Appendix A. In order to compute the statistical moments of macro and financial variables, for every model parametrization of interest we simulate the economy for 1.020.000 in-model years. The moments reported are based on time series consisting of the last 1.000.000 observations.¹⁷

4.2. Baseline scenario

We first simulate our model for the parameter calibration given in Table 2 (baseline scenario). We assess its quantitative performance by comparing a set of non-targeted model-based statistics with the data between 1947 and 1970. To capture the regime shift that occurred in the data, we consider a joint rise in the capital and the labor shares of income. To understand better the impact of different sources of income inequality shifts on equity premium, we then analyze model economies with either higher labor or higher capital share of income of the top decile.

In Table 3, we contrast model-generated asset pricing and macro moments non-targeted by the baseline calibration with the data. All the asset pricing statistics are based on the annual S&P500 index coming from Shiller's website and covering post-war period between 1947 and 1970. The real economy statistics are based on the series computed by U.S. Bureau of Economic Analysis and retrieved from the FRED at St Louis Fed.

The top panel of Table 3 reports financial statistics generated by the baseline model simulations. The model slightly undershoots log price-dividend ratio, $\ln\left(\frac{P_t^s}{D_t}\right)$, but replicates reasonably well its volatility, $\sigma^{\ln\left(\frac{P}{D}\right)}$, and volatility of stock price return, $\sigma^{\Delta P^s}$. It also generates a sufficient amount of persistence as the first-order autocorrelation of price-dividend ratio, $\rho^{\ln\frac{P_t^s}{D_t}}$, and of stock price change, $\rho^{\Delta P^s}$, are well replicated. This is primarily achieved by introducing persistent risk aversion shock. These results come on top of the equity premium and the Sharpe ratio statistics, which we matched exactly in the calibration phase.

The model, despite its very stylized real economy part does also well in matching the statistics on output, consumption and investment. While the model is calibrated to match output volatility, $\sigma^{\Delta y}$, and the ratio of investment to output

¹⁵ Note that our coefficients, reported in Appendix C, do not exactly match their empirical counterparts because we have one parameter and 3 values to match.

¹⁶ Our codes are based on sample codes for the solution of a bare-bone RBC model provided by Troy Davig.

¹⁷ The first 20 000 observations are a burn-in.

Table 3
Unconditional asset pricing and real economy moments in the model and the U.S. data.

| Variable | Moment | Data | Model |
|---|--|-------|-------|
| Asset pricing moments | | | |
| $\ln\left(\frac{P_t^s}{D_t}\right)$ | Log Price-Dividend ratio | 3.41 | 2.34 |
| $\sigma^{\ln\left(\frac{P_t^s}{D_t}\right)}$ | Volatility of Log Price-Dividend ratio | 0.45 | 0.58 |
| $\sigma^{\Delta P^s}$ | Volatility of Stock Price growth | 0.19 | 0.17 |
| $\rho^{\ln\left(\frac{P_t^s}{D_t}\right)}$ | Autocorrelation of Price-Dividend ratio | 0.95 | 0.93 |
| $\rho^{\Delta P^s}$ | Autocorrelation Stock Price growth | −0.01 | −0.05 |
| Macro moments | | | |
| $\rho^{\Delta c, \Delta y}$ | Correlation consumption growth-output growth | 0.82 | 0.92 |
| $\rho^{\Delta i, \Delta y}$ | Correlation investment growth-output growth | 0.64 | 0.38 |
| $\frac{\sigma^{\Delta c}}{\sigma^{\Delta y}}$ | Ratio vol consumption growth-vol output growth | 0.77 | 1.10 |
| $\frac{\sigma^{\Delta cc}}{\sigma^{\Delta cw}}$ | Ratio vol consumption cap owners-workers | 1.63 | 1.96 |
| I/Y | Ratio business investment-output | 0.19 | 0.15 |

This table reports unconditional sample moments generated from the simulated data of our benchmark model with parameter values documented in Table 2. Equity premium, Sharpe ratio and price-dividend ratio are computed using the annual data from Shiller's website: <http://www.econ.yale.edu/~shiller/data.htm>. Equity premium is computed as the difference between the return including dividends on S&P500 and the risk free rate. Risk free rate is 6 months rolled commercial paper rate. Price-dividend ratio is calculated for S&P500. Volatility is measured by standard deviation. Δx stands for growth rate in variable x . The real economy data is from FRED. Real output is proxied by real GDP, real investment by private non-residential fixed investment and consumption by real personal consumption expenditures. All the real economy variables are originally expressed in Billions of Chained 2012 Dollars and, except for I/Y , we compute their annual growth rates. The empirical value for relative volatility of consumption, $\frac{\sigma^{\Delta c}}{\sigma^{\Delta cw}}$, has been taken from Lansing (2015).

volatilities, $\frac{\sigma^{\Delta i}}{\sigma^{\Delta y}}$, Table 3 shows that it is also able to replicate many other qualitative features of the data. The first row of the lower panel of the table shows that correlation between consumption growth and output, $\rho^{\Delta c, \Delta y}$, equals to 0.92 in the model compared to 0.82 in the U.S. data. Our model economy only slightly overpredicts the aggregate consumption volatility relative to output, $\frac{\sigma^{\Delta c}}{\sigma^{\Delta y}}$, and it delivers realistic empirical ratio of consumption volatility of capital owners to that of workers, $\frac{\sigma^{\Delta cc}}{\sigma^{\Delta cw}}$.

4.3. Mechanisms generating high equity premium and Sharpe ratio

The empirical equity premium and the Sharpe ratio are notoriously difficult to reproduce, particularly in production-based general equilibrium models. To successfully match these statistics, we have equipped our model with several mechanisms that generate high risk and high sensitivity to risk in our economy. We now take a closer look at the role these mechanisms play in the model.

It is useful to think about the equity premium as a product of two factors: the quantity of risk and the stock holders' sensitivity to risk, given its quantity. Two mechanisms, that predominantly aim at producing a high quantity of risk in the economy have been introduced in the model. First, we assume that capital is subject to adjustment costs. By increasing the cost of investment adjustment in face of unanticipated negative productivity shock, this mechanism impedes capital owners' consumption smoothing, which makes their consumption both more volatile and more procyclical. An additional advantage of the capital adjustment costs is that they are helpful in matching the volatility of investment relative to output. Second, we also introduce a limited amount of financial leverage of firms in the form of risk-free corporate debt. This multiplies the risk taken up by capital owners per each stock held.

Calibrating both mechanisms to realistic values (the empirical volatility of investment relative to output in the case of the former and a moderate degree of financial leverage for the latter) shows that they substantially increase the quantity of risk in the economy, but are not sufficient to produce a high equity premium (the Sharpe ratio remains low). Therefore, following Greenwald et al. (2016), we introduce a third mechanism, a high and time-varying coefficient of risk-aversion in capital owners' utility function. The high risk-aversion helps us generate a realistic Sharpe ratio while its volatility over time further helps to increase the volatility of equity returns.

We carry out a set of counterfactual simulations to assess the importance of these model features for generating high equity premium and Sharpe ratio (results reported in Table 4). The first row of the table reports the figures for the targeted asset pricing moments in the data and the subsequent rows document corresponding statistics in various model specifications. The baseline refers to statistics generated by simulating the model calibrated to the initial steady state, with

Table 4
Unconditional asset pricing and real economy moments in different model specifications and the U.S. data.

| Model/Moment | EP | SR | $\sigma^{\Delta d}$ | $\frac{\sigma^{\Delta I}}{\sigma^{\Delta y}}$ |
|--|-------|-----|---------------------|---|
| Data | 10.6% | 0.6 | 7.0% | 2.5 |
| Baseline | 10.6% | 0.6 | 7.0% | 2.5 |
| $\mu = 0$ | 3.5% | 0.5 | 8.0% | 1.9 |
| $\sigma^x = 0$ | 9.0% | 1.9 | 3.3% | 1.0 |
| $\gamma^c = 8, \sigma^x = 0$ | 1.3% | 0.3 | 5.8% | 1.0 |
| $\mu = 0, \gamma^c = 4, \sigma^x = 0$ | 0.2% | 0.2 | 3.0% | 1.0 |
| $\mu = 0, \gamma^c = 4,$ $\sigma^x = 0, \xi = 10$ | 0.1% | 0.2 | 17% | 2.9 |

EP stands for equity premium, SR for Sharpe Ratio, $\sigma^{\Delta d}$ volatility of dividend growth, and $\frac{\sigma^{\Delta I}}{\sigma^{\Delta y}}$ for ratio of investment volatility to output volatility.

parameters described in Table 2. Alternative model specifications differ from the baseline only by the parameter values reported in the first column of the table.

We start studying the counterfactuals by considering statistics produced by the model with no financial leverage, $\mu = 0$, see the third row of the table. Higher leverage increases the quantity of risk in the economy, but leaves the price for risk roughly intact. Its elimination reduces equity premium by 7 pp and only slightly decreases the Sharpe ratio. In an economy with the variance of the risk aversion shock set to zero, $\sigma^x = 0$, displayed in the fourth row, the risk premium falls, while the Sharpe ratio increases sharply. As expected, time-varying risk aversion adds to the quantity of risk in the economy by affecting the volatility of risky returns. At the same time, it also affects the price for risk through its impact on the stock holders' mean risk-aversion.¹⁸

In order to isolate the impact of reduced mean risk aversion on equity premium, we consider a specification with lower γ , $\gamma = 8$. In row 5, we show that lower γ decreases mean equity premium by making stock holders insensitive to risk and both Sharpe ratio and equity premium fall substantially. Additionally, the model specification in row 6 shows that financial leverage and high and time-varying risk aversion are crucial in reproducing a realistic equity premium and Sharpe ratio. When both channels are removed, the equity premium in the model is shown to undershoot its empirical counterpart by an order of magnitude. Finally, the last row of Table 4 reports the results of a model simulation with a calibration which additionally lowers capital adjustment costs (implying a higher ξ , which is set to 10). This specification further reduces the quantity of risk (still lower risk premium volatility) but, additionally, can be shown to produce too high variances of dividends and investment growth. This is because lower capital adjustment costs make it very easy for capital owners to adjust investment.

4.4. Income inequality and equity premium

We have shown that our relatively simple set-up with two types of agents is sufficient to broadly match both, stock market and real economy statistics. We now use it to study the impact of shifts in income distribution on the equity premium and we simulate the model economy with higher income inequality observed in 2014. Similarly to the initial steady state values for income shares, we compute $\alpha_{2014} = (s_{2014}^{10} - 0.8 \times \theta_{2014}) / (1 - 0.8 \times \theta_{2014})$ where $s_{2014}^{10} = 0.47$ is the total top decile income share in 2014, and $\theta_{2014} = 0.43$ is the total capital share of income in the U.S. economy in 2014. We expect shifts in capital income and labor income shares of capital owners to have opposite effects on equity premium because of their different impact on the riskiness of capital owners' consumption.

Table 5 shows quantitative impact of inequality shifts on a set of model outcomes. Each of the simulated models represents a steady state with different level and the composition of income inequality. The first column of the table indicates which model scenario is considered and what parameter values it implies (second column). The third column shows the simulated equity premium and the fourth column computes the resulting difference relative to the baseline simulation. The last column in Table 5 displays covariance between dividends' growth and capital owners' consumption growth, $cov[\Delta c^c, \Delta D]$, which is a measure of consumption risk, as derived in section 3.6.

A model economy with shares of income calibrated to 2014 data (second row) displays equity premium of 9.7%. The recent shifts in the income distribution and decomposition can therefore explain one third of the observed reduction in the U.S. equity premium, which fell from 10.6% post-war to 7.5% over 1971-2014. However, the accompanied fall in covariance between capital owners' consumption and log-dividend growth, $cov[\Delta c^c, \Delta D]$, from 0.35 to 0.31, is relatively small. This result likely reflects the opposite impact of the shifts in the two simultaneous sources of income inequality. To demonstrate that this intuition is correct, we now vary each source of inequality individually.¹⁹

¹⁸ The risk-aversion shock is defined in eq. (6) and shows that the higher volatility of the shock decreases the mean risk-aversion of capital owners.

¹⁹ While we focus on the consumption risk as the main driver, note that equity premium in the toy model of section 3.6 also depends directly on the volatility of dividends (with a negative sign, see eq. (20)), which increases in θ , but is less sensitive to α . Furthermore, in the full model, which is more

Table 5
Income shares shifts and mean equity premium.

| Scenario | Parameter values | EP | Δ vs baseline | $cov[\Delta c^c, \Delta D]$ |
|--------------------------------|--------------------------------|-------|----------------------|-----------------------------|
| Baseline | $\theta = 0.27; \alpha = 0.06$ | 10.6% | - | 0.35 |
| θ and $\alpha \uparrow$ | $\theta = 0.34; \alpha = 0.20$ | 9.7% | -0.9pp | 0.31 |
| $\theta \uparrow$ | $\theta = 0.34; \alpha = 0.06$ | 11.2% | +0.6pp | 0.43 |
| $\alpha \uparrow$ | $\theta = 0.27; \alpha = 0.20$ | 9.0% | -1.6pp | 0.24 |

$\theta \uparrow$ denotes an increase in capital share of income and $\alpha \uparrow$ an increase in the labor share of income of capital owners. The equity premium (EP) in the model is computed over 1,000,000 simulated periods. All the parameters of the model except for the ones included in the table are set to their baseline calibration values reported in Table 2. Δ vs baseline reports by how much the EP changed relative to the baseline simulation. $cov[\Delta c^c, \Delta D]$ denotes the covariance between consumption growth of capital owners and dividends' growth.

The third row displays the results of the simulation with a higher capital income inequality as measured by increased θ and counterfactually unchanged labor income inequality. An increase in the capital share of income of 7 pp increases equity premium by 0.6 pp. As expected, a higher share of capital income multiplies consumption risk associated with stock market exposure, as measured by the covariance between consumption and dividend growth, $cov[\Delta c^c, \Delta D]$, which increases sharply, from 0.35 to 0.43. In contrast, as the last row of Table 5 demonstrates, in a counterfactual scenario in which θ is kept unchanged at its initial value, a 14 pp increase in the top decile labor income share, α , generates a large drop in equity premium of 1.6 pp and a corresponding sizable reduction in $cov[\Delta c^c, \Delta D]$ from 0.35 to 0.24.

To sum up, an upwards shift in capital share and labor share of top decile income exert opposite pressures on capital owners' consumption risk. Due to these opposite forces at work, the large historical increase in inequality resulted in only a modest fall of equity premium. In fact, according to our model, the historical increase in the labor income share of capital owners may have had a strong downward effect on equity premium. It may have reduced the latter by as much as 1.6 pp. However, the upward shift in capital income share attenuated this effect by about 0.7 pp, resulting in overall reduction of equity premium, which amounted to one third of the observed decline.

5. Model predictions in the data

In what follows, we further confront the model predictions with the data. The model predicts that higher capital share of income should be associated with higher equity premium while higher labor share of income of capital owners is expected to be negatively correlated with the excess return. We test these hypotheses both over time and in cross section.

5.1. Shares of income and equity premium in the U.S.

In the U.S. data, we have information on the decomposition of income of the richest households between capital and labor. Since, as in the model, we want to relate the long-run shifts in equity premium to the shares of income, we compute 5-year moving differences for all the variables, where $\Delta 5yx$ denotes $x_t - x_{t-5}$ for any variable. We then regress a 5-year change in capital share of income and in labor share of income of capital owners on the real excess equity return. The sample covers post-war period between 1945 and 2014 with the exception of top quintile, for which the U.S. Census Bureau provides the labor and total income shares since 1970. Table 6 below shows the results of the regressions.

The second column of Table 6 reports the slope coefficient, β , obtained from the regression and the corresponding standard errors in brackets. The results show that capital income inequality is positively related to the real excess returns. In contrast, labor share of income of capital owners, defined as top decile or top quintile in the data, is negatively related to the real excess return. The estimates are significant and in line with the theoretical predictions of the model. To check if the income shares do not proxy for some other variables that are known to drive real equity excess return, we include in the regressions a set of standard controls: price dividend ratio, price earnings ratio and the Lettau-Ludvigson consumption-wealth ratio, commonly referred to as CAY. Table 7 reports these extended regressions and shows that our results are robust to the inclusion of additional controls. No matter the specification, the coefficients on the capital and labor shares of income remain significant and display the expected signs. We additionally include regressions with lagged dependent and independent variables and report results in Tables 10 and 11 of Appendix E. They largely confirm findings displayed in Tables 6 and 7. We conclude that the predictions of our theoretical model are consistent with the U.S. time series dynamics.

complex than the toy model, equity premium is subject to additional effects. For these reasons we do not have a 1-to-1 relation between the equity premium and $cov[\Delta c^c, \Delta D]$ in the simulations.

Table 6
Slope coefficients in regressions of excess returns on inequality measures.

$$\Delta 5yEP_t = \beta \Delta 5yS_t + \varepsilon_t$$

| Inequality Measure | |
|---------------------------------|--------------------|
| U.S. capital share of income | 3.83*** (1.36) |
| Labor share of income of top 20 | -3.61*** (1.25) |
| Labor share of income of top 10 | -2.27*** (0.75) |

$\Delta 5yEP_t$ stands for 5-year difference in Equity premium and $\Delta 5yS_t$ for 5-year change in share of income. All the regressions are performed on the data between 1945 and 2014, using Newey-West estimator with correction for heteroscedasticity and autocorrelation in the error term. Standard errors are reported in brackets. *** denotes significance at 1% level.

Table 7
Additional regressions of excess returns on inequality measures.

| Slope Coefficients in Equity Premium Regressions with Capital Income Inequality Proxy | | | | | |
|---|--------------------|--------------------|-------------------|-------------------|-------------------|
| Regressors | (1) | (2) | (3) | (4) | (5) |
| Capital Share of Income | 3.83*** (1.36) | 7.78*** (1.86) | 2.89* (1.55) | 5.21*** (1.23) | 5.77** (2.49) |
| p/d | | 0.34*** (0.11) | | | 0.46*** (0.12) |
| p/e | | | -0.06 (0.08) | | -0.23 (0.13*) |
| CAY | | | | -0.95 (1.04) | 1.76* (0.94) |
| Sample | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 |
| Slope Coefficients in Equity Premium Regressions with Labor Income Inequality Proxy | | | | | |
| Top 20 Labor Share of Income | -3.61*** (1.25) | -5.72*** (1.27) | -2.29* (1.21) | -3.64* (1.35) | -4.80** (1.97) |
| p/d | | 0.44*** (0.12) | | | 0.55*** (0.11) |
| p/e | | | -0.09 (0.10) | | -0.21 (0.13) |
| CAY | | | | -0.21 (2.05) | 2.74** (1.09) |
| Sample | 1970-2014 | 1970-2014 | 1970-2014 | 1970-2014 | 1970-2014 |
| Slope Coefficients in Equity Premium Regressions with Labor Income Inequality Proxy | | | | | |
| Top 10 Labor Share of Income | -3.81*** (1.28) | -6.66** (2.91) | -1.81** (0.71) | -3.46* (1.80) | -4.55 (3.00) |
| p/d | | 0.38*** (0.08) | | | 0.50*** (0.11) |
| p/e | | | -0.07 (0.07) | | -0.27** (0.11) |
| CAY | | | | -0.19 (0.91) | 1.00 (1.28) |
| Sample | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 |

All the variables are computed as 5-year moving changes. The data is retrieved from the website of Amit Goyal and Welch and Goyal (2008, updated) The regressions are performed on the data between 1945(1970) and 2014, using Newey-West estimator with correction for heteroscedasticity and autocorrelation in the error term. Standard errors are reported in brackets. * denotes significance at 10% level, ** at 5% level and *** at 1% level.

Table 8
Capital share of income and equity premium.

| $\Delta 5yEP_{i,t} = \varphi \Delta 5y\theta_{i,t-j} + \delta_t + \eta_i + \varepsilon_{i,t}$ | | |
|---|---------|---------|
| | $j = 0$ | $j = 1$ |
| α | 5.38*** | 1.85** |
| | (0.89) | (0.93) |
| <i>N. obs</i> | 435 | 435 |

Table reports results of estimation of the regression $\Delta 5yEP_{i,t} = \varphi \Delta 5y\theta_{i,t-j} + \delta_t + \eta_i + \varepsilon_{i,t}$ is the 5-year change in equity premium in country i and year t , computed as a difference between total equity return and government bill rate. $\Delta 5y\theta_{i,t-j}$ is a 5-year change in the capital share of income in country i and year $t - j$, where $j = 0, 1$. δ_t are yearly dummies, η_i are country fixed effects and $\varepsilon_{i,t}$ is the error term. All the regressions are performed on the data between 1945 and 2014, using Huber/White/sandwich variance estimator. Standard errors are reported in brackets. *** denotes significance at 1% level and ** at 5% level.

5.2. Capital share of income and equity premium across countries

We do not have information about the decomposition of income of the richest households for countries other than the U.S. but we do have international data on the evolution of capital shares of income. This allows us to assess if the long-run shifts in capital shares of income are correlated with changes in equity premium in cross-section. To do it, we construct a dataset that draws on the long-run database on equity returns used in Jordà et al. (2017 and 2019) and on the data from Karabarbounis and Neiman (2014) on capital shares of income for 17 OECD countries. The sample period differs across countries but, for most of them, it covers the period of growth in income inequality between 1980 and 2014. The equity premium is computed as a difference between total equity return and government bill rate. Again, we compute 5-year moving changes for all the variables.

We then regress the 5-year change in equity premium, $\Delta 5yEP_{i,t}$, on the 5-year change in the capital share of income, $\Delta 5y\theta_{i,t-j}$. Because we do not have information on other equity premium factors, we control for unobservable variables by including country specific dummies, η_i and we account for common trend through yearly dummies, δ_t . Results of this exercise are reported in Table 8 where the middle column reports contemporaneous correlation coefficients and the right column coefficient on one period lagged change in the capital share of income. In both cases the coefficients are positive and significant. They confirm the intuition derived from the model that an increase in capital share of income is associated with higher equity premium.

6. Conclusion

In this paper, we study the relationship between income inequality and stock market returns. We develop a framework that extends the standard production-based Consumption Capital Asset Pricing Model by allowing for heterogeneity of agents. The top income group, capital owners, own the firms and provide labor. The rest of the economy is populated by workers who consume their labor income and income from risk-free government and corporate bonds. Motivated by recent empirical observation on the high correlation between capital and labor top incomes, capital owners in our model earn high labor income. Since they are the ones who price the risky assets, changes in their both income sources affect the stock market variables.

In the model, higher capital share of income increases the riskiness of capital owners' consumption, as measured by covariance between dividends and capital owners' consumption growth, and predicts a higher equity premium. A rise in the share of non-risky labor income in their total income leads, in contrast, to lower excess return.

We calibrate the model to the post-war U.S. economy and simulate it with increased income inequality, as observed in 2014. We find that the impact of the labor share of income was quantitatively larger and therefore we observe a decrease in the equity premium both in the model and in the data. Quantitatively, a model economy with higher shares of income of capital owners displays equity premium of 9.7%. The recent shifts in the income distribution and decomposition can therefore explain one third of the observed reduction in the U.S. equity premium, which fell from 10.6% post-war to 7.5% in 1971–2014.

We then confront the model predictions with the data. We show that, in the U.S., capital income inequality is positively, significantly and robustly associated with the real excess returns while labor share of income of capital owners, defined

as top decile or top quintile, is negatively related to the real excess return. An international comparison delivers similar results. In a panel of 17 OECD countries, changes in equity premia are positively related with changes in capital share of income.

Appendix A. Theoretical predictions

This appendix provides the derivations of the results in Section 3.6.

Start from capital owners' budget constraint (22):

$$c_t^c + a_t^s P_t^s + a_t^{c,c} P_t^c = W_t^c n_t^c + a_{t-1}^s (P_t^s + d_t^s) + a_{t-1}^{c,c} \tag{22}$$

Taking into account market clearing conditions from section 3.4: $a_t^s = a_{t-1}^s = \eta^{-1}$, $a_t^{c,c} = a_{t-1}^{c,c} = 0$, $n_t^c = \eta^{-1} N^c$ and $d_t^s = D_t$, we have:

$$c_t^c = W_t^c \frac{N^c}{\eta} + \frac{D_t}{\eta} \tag{23}$$

Now from capital owners' wage equation we obtain:

$$c_t^c = \tilde{\alpha} \frac{Y_t}{\eta} + \frac{D_t}{\eta} \tag{24}$$

where we defined $\tilde{\alpha} = \alpha (1 - \theta)$.

A simplified model

Assume a constant coefficient of risk aversion $\gamma_{t+1}^c = \gamma_t^c \equiv \bar{\gamma}$ and discount rate $\beta_t^c = \beta^c$ and normal distribution of shocks. Define $\hat{x} = \log(X)$. Equations (8) and (9) in the main text can now be written as:

$$1 = \beta^c E e^{-\bar{\gamma} \Delta \hat{c} + \hat{r}^s} \tag{25}$$

$$1 = \beta^c e^{\hat{r}^f} E e^{-\bar{\gamma} \Delta \hat{c}} \tag{26}$$

where we note that $\lambda_t^c = (c_t^c)^{-\bar{\gamma}}$. Imposing logs on both sides and using the well-known property of log-normally distributed variables:

$$\log(E(x)) = E(\log(x)) + \frac{1}{2} \text{var}(\log(x)) \tag{27}$$

we obtain:

$$0 = \log(\beta^c) + E(-\bar{\gamma} \Delta \hat{c}_{t+1}^c + \hat{r}_{t+1}^s) + \frac{1}{2} \text{var}(-\bar{\gamma} \Delta \hat{c}_{t+1}^c + \hat{r}_{t+1}^s) \tag{28}$$

$$0 = \log(\beta^c) + E(-\bar{\gamma} \Delta \hat{c}_{t+1}^c) + \hat{r}_t^f + \frac{1}{2} \text{var}(-\bar{\gamma} \Delta \hat{c}_{t+1}^c) \tag{29}$$

Noting that

$$\text{var}(-\bar{\gamma} \Delta \hat{c}_{t+1}^c + \hat{r}_{t+1}^s) = \text{var}(-\bar{\gamma} \Delta \hat{c}_{t+1}^c) + \text{var}(\hat{r}_{t+1}^s) - 2\bar{\gamma} \text{cov}(\hat{r}_{t+1}^s, \Delta \hat{c}_{t+1}^c) \tag{30}$$

we obtain equation (19):

$$E(\hat{r}_{t+1}^e) = E(\hat{r}_{t+1}^s) - \hat{r}_t^f = \bar{\gamma} \text{cov}(\hat{r}_{t+1}^s, \Delta \hat{c}_{t+1}^c) - \frac{1}{2} \text{var}(\hat{r}_{t+1}^s) \tag{31}$$

Since

$$\hat{r}_{t+1}^s = \Delta \hat{d}_{t+1} \tag{32}$$

Hence, dropping time indices:

$$E(\hat{r}^e) = \bar{\gamma} \text{cov}(\Delta \hat{d}, \Delta \hat{c}^c) - \frac{1}{2} \text{var}(\Delta \hat{d}) \tag{33}$$

which gives equation (20). Now, loglinearize equation (18) of the main text to obtain:

$$\hat{c}^c = \frac{\tilde{\alpha} Y}{\tilde{\alpha} Y + D} \hat{y} + \frac{D}{\tilde{\alpha} Y + D} \hat{d} \tag{34}$$

Plugging for \widehat{c}^c in equation (20) and rearranging terms results in equation (21):

$$E(\widehat{r}^e) = \overline{\gamma} \Omega \frac{D}{\overline{\alpha} Y + D} + (\overline{\gamma} - \frac{1}{2}) \text{var}(\Delta \widehat{d}) \tag{35}$$

where

$$\Omega = \text{cov}(\Delta \widehat{d}, \widehat{\Delta c}^c) - \text{var}(\Delta \widehat{d}). \tag{36}$$

Appendix B. Numerical simulation procedure and calibration

The complete model consists of households' and firms' first order optimization conditions, the budget constraints, the production function, the capital accumulation equation, the transversality conditions and the definitions of returns. The solution method follows Davig (2004) and is based on Coleman and Fenyes (1992). It conjectures candidate decision and pricing rules which allow to reduce the system to a set of expectational first-order difference equations. In our case, due to consecutive substitutions, we are able to reduce the system to only one conjectured decision rule, that for total (per capita) investment, denoted $I_t = I_t(K_{t-1}, \Delta z_t, \gamma_t^c)$. Dividing all equations by $\exp(z_{t-1})$ and denoting the so transformed variables with a tilde: $X_t \rightarrow \tilde{X}_t$, the system of equations is as follows:

$$\begin{aligned} \tilde{C}_t^w &= (1 - \alpha)(1 - \theta) \tilde{Y}_t + \tilde{B}_{t-1}^{c,w} - (\tilde{B}_t^{c,w} / R_t^f) \exp(\Delta z_t) \\ \tilde{C}_t^c &= \alpha(1 - \theta) \tilde{Y}_t + D_t + \tilde{B}_{t-1}^{c,c} - (\tilde{B}_t^{c,c} / R_t^f) \exp(\Delta z_t) \\ \tilde{C}_t &= \tilde{Y}_t - \tilde{I}_t(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c) \\ \tilde{D}_t &= \theta \tilde{Y}_t - \tilde{I}_t(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c) - \mu \tilde{K}_{t-1} + \mu (\tilde{K}_t / R_t^f) \exp(\Delta z_t) \\ \tilde{Y}_t &= A \left((N^w)^{1-\alpha} (N^c)^\alpha \right)^{1-\theta} \tilde{K}_{t-1}^\theta \exp((1 - \theta) \Delta z_t) \\ \tilde{K}_t &= \left(1 - \delta + G \left(\frac{\tilde{I}_t(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c)}{\tilde{K}_{t-1}} \right) \right) \tilde{K}_{t-1} \exp(-\Delta z_t) \\ 1 &= \beta E_t \left(\frac{(\tilde{c}_{t+1}^c / \tilde{c}_t^c)^{-\gamma_t^c}}{E_t(\tilde{c}_{t+1}^c / \tilde{c}_t^c)^{-\gamma_t^c}} R_{t+1}^k \right) \\ R_{t+1}^k &= \frac{\tilde{D}_{t+1} + \frac{(1 - G'(\tilde{I}_{t+1} / \tilde{K}_{t+1})) \mu / R_{t+1}^f}{G'(\tilde{I}_{t+1} / \tilde{K}_{t+1})} \tilde{K}_{t+1}}{\frac{(1 - G'(\tilde{I}_t / \tilde{K}_{t-1})) \mu / R_t^f}{G'(\tilde{I}_t / \tilde{K}_{t-1})} \tilde{K}_t} \\ \tilde{P}_t^s &= \frac{(1 - G'(\tilde{I}_t / \tilde{K}_{t-1})) \mu / R_t^f}{G'(\tilde{I}_t / \tilde{K}_{t-1})} \tilde{K}_t \\ R_{t+1}^s &= \frac{\tilde{P}_{t+1}^s \exp(\Delta z_t) + \tilde{D}_{t+1}}{\tilde{P}_t^s} \\ R_t^f &= \beta^{-1} \\ R_{t+1}^e &= R_{t+1}^s - R_t^f \\ \tilde{B}_t^{c,w} + \tilde{B}_t^{c,c} &= \mu \tilde{K}_t \\ \tilde{B}_t^{c,c} &= 0 \\ G \left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} \right) &= \frac{a_1}{1 - 1/\xi} \left(\frac{\tilde{I}_t(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c)}{\tilde{K}_{t-1}} \right)^{1 - \frac{1}{\xi}} + a_2 \\ G' \left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}} \right) &= a_1 \left(\frac{\tilde{I}_t(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c)}{\tilde{K}_{t-1}} \right)^{-\frac{1}{\xi}} \end{aligned} \tag{37}$$

Table 9
Long Run Return Predictability Regressions.

| Long Horizon Return Regressions | $\sum_{j=0}^h R_{t+j+1}^e = \beta \frac{P_t^s}{D_t} + \varepsilon_{t+1,t+h}$ | |
|---------------------------------|--|-------|
| Data | | |
| $X_t:$ | $\frac{P_t^s}{D_t}$ | R^2 |
| h | | |
| 0 | −0.23** (0.11) | 0.05 |
| 1 | −0.48** (0.18) | 0.11 |
| 2 | −0.67** (0.22) | 0.16 |
| Model | | |
| h | | |
| 0 | −0.21*** (0.002) | 0.01 |
| 1 | −0.41*** (0.002) | 0.02 |
| 2 | −0.58*** (0.003) | 0.03 |

Table reports results of estimation of the regression $\sum_{j=0}^h R_{t+j+1}^e = \beta \frac{P_t^s}{D_t} + \varepsilon_{t+1,t+h}$ where $\sum_{j=0}^h R_{t+j+1}^e$ is a cumulative excess return over $h+1$ years with $h=0,1,2$. $\frac{P_t^s}{D_t}$ is price-dividend ratio at time t and $\varepsilon_{t+1,t+h}$ is the error term. The specification is estimated by OLS with Newey-West correction of the standard errors. Standard errors are reported in brackets.

This system is solved for every possible set of state variables over a discrete partition of the state space. The solution consists of a set of decision rules and pricing functions satisfying the above system. The solution method treats the state variables, the initially conjectured decision rules and pricing functions as given. Based on this, it is possible to compute the values of the remaining endogenous variables in any given state and for any realization of the shock. The expectations are computed by numerical quadrature. Given these, $\tilde{I}_t(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c) = \tilde{I}_t$ is treated as an unknown. The solution is then found by solving equation (37) in 1 unknown using Chris Sims' non-linear equation solver code `csolve`.²⁰ The iteration procedure is repeated until the iteration improves the current decision rule at any given state vector by less than the tolerance level set to 10^{-9} .

Appendix C. Long-horizon predictability of equity premium

In addition to the unconditional moments we compute the long-horizon predictability of equity premium based on the price-dividend ratio. We estimate a specification of the following form:

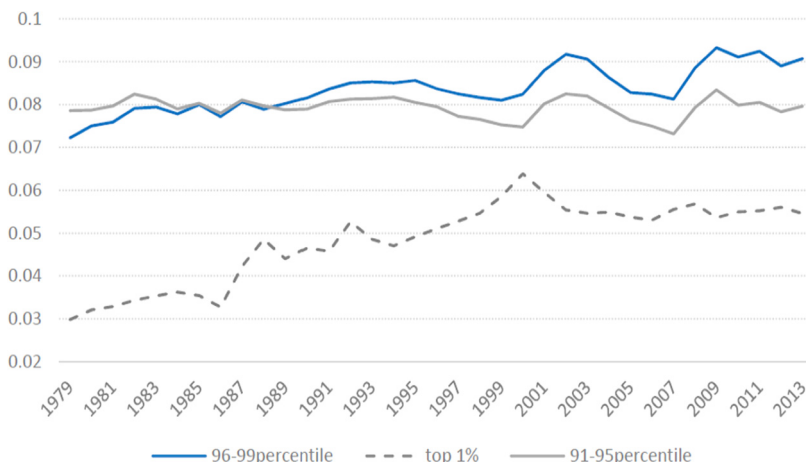
$$\sum_{j=0}^h R_{t+j+1}^e = \beta \frac{P_t^s}{D_t} + \varepsilon_{t+1,t+h} \tag{38}$$

where $\sum_{j=0}^h R_{t+j+1}^e$ is a cumulative excess return over $h + 1$ years with $h = 0, 1, 2$, $\frac{P_t^s}{D_t}$ is price-dividend ratio at time t , and $\varepsilon_{t+1,t+h}$ is the error term. The results of the estimation of this specification for S&P500 series are reported in the top panel of Table 9 while their model-based counterparts are displayed in the lower panel of the same table. We find that, in line with existing evidence, a drop in current price-dividend ratio predicts increase in the future cumulative excess returns, both in the data and in the model. The absolute value of estimated coefficient β as well as R^2 increase in the horizon h .

²⁰ Available at <http://sims.princeton.edu/yftp/optimize>.

Appendix D. Decomposition of top decile labor income share dynamics

Appendix consists of Fig. 4.



The blue solid line plots the labor share of 96th to 99th percentile in the total U.S. income. The solid grey line plots the labor share of 91th to 95th percentile in the total U.S. income and the dashed grey line plots the labor share of top 1%. The data comes from supplement information provided in CBO’s report: The Distribution of Household Income and Federal Taxes (2013) and can be found at <https://www.cbo.gov/publication/51361>.

Fig. 4. Decomposition of the labor income of the top decile income share between 1979 and 2013. (For interpretation of the colors in the figure(s), the reader is referred to the web version of this article.)

Appendix E. Additional equity premium regressions with income inequality proxies

Table 10
Slope coefficients in regressions of returns on inequality measures.

$$\Delta 5yEP_t = \Delta 5yEP_{t-1} + \beta \Delta 5ys_{t-1} + \varepsilon_t$$

| Inequality Measure | Coefficient | Standard Error |
|---------------------------------|-------------|----------------|
| U.S. capital share of income | 2.84** | (1.37) |
| Labor share of income of top 20 | -3.73** | (1.34) |
| Labor share of income of top 10 | -1.81** | (0.78) |

$\Delta 5yEP_t$ stands for 5-year difference in Equity premium and $\Delta 5ys_{t-1}$ for 5-year change in share of income lagged one period. All the regressions are performed on the data between 1945 and 2014, using Newey-West estimator with correction for heteroscedasticity and autocorrelation in the error term. Standard errors are reported in brackets. ** denotes significance at 5% level.

References

Abel, A., 2008. Equity premia with benchmark levels of consumption: closed form results. In: Mehra, R. (Ed.), Handbook of the Equity Risk Premium, pp. 117–157.

Atkinson, A.B., Piketty, T., Saez, E., 2011. Top incomes in the long run of history. Journal of Economic Literature 49, 3–71.

Blanchard, O., 1993. Movements in the equity premium. Brookings Papers on Economic Activity, 75–138.

Boldrin, M., Christiano, L.J., Fisher, J.D.M., 2001. Habit persistence, asset returns, and the business cycle. The American Economic Review 91, 149–166.

Campbell, J., Cochrane, J., 1999. By force of habit: a consumption-based explanation of aggregate stock market behavior. Journal of Political Economy 107, 205–251.

Chen, B., Stafford, F.P., 2016. Stock market participation: family responses to housing consumption commitments. Journal of Money, Credit, and Banking 48, 635–659.

Claus, J., Thomas, J., 2001. Equity premia as low as three percent? Evidence from analysts’ earnings forecasts for domestic and international stock markets. The Journal of Finance 56, 1629–1666.

Coleman, T., Fenyves, P., 1992. Partitioned quasi Newton methods for nonlinear equality constrained optimization. Mathematical Programming 53, 17–44.

Table 11
Additional regressions of excess returns on inequality measures.

| Slope Coefficients in Equity Premium Regressions with Capital Income Inequality Proxy | | | | | |
|---|-------------------|-------------------|--------------------|--------------------|-------------------|
| Regressors | (1) | (2) | (3) | (4) | (5) |
| Lagged Capital Share of Income | 2.84** (1.37) | 6.82** (2.15) | 2.42* (1.43) | 4.75** (1.67) | 8.72*** (2.50) |
| $\Delta 5yEP_{t-1}$ | -0.08 (0.12) | -0.30** (0.14) | -0.07 (0.13) | -0.28*** (0.07) | -0.28** (0.09) |
| $(p/d)_{t-1}$ | | -0.08 (0.09) | | | -0.06 (0.08) |
| $(p/e)_{t-1}$ | | | -0.07 (0.07) | | -0.11 (0.13) |
| CAY_{t-1} | | | | 1.48** (1.25) | 3.81** (1.88) |
| Sample | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 |
| Slope Coefficients in Equity Premium Regressions with Labor Income Inequality Proxy | | | | | |
| Top 20 Labor Share of Income | -1.81** (0.78) | -2.99** (1.27) | -3.98*** (0.97) | -4.31** (1.24) | -4.55 (3.00) |
| $\Delta 5yEP_{t-1}$ | 0.07 (0.11) | -0.19 (0.16) | -0.22** (0.09) | -0.26*** (0.07) | 0.46*** (0.12) |
| $(p/d)_{t-1}$ | | 0.09 (0.12) | | | 0.46*** (0.12) |
| $(p/e)_{t-1}$ | | | 0.02 (0.10) | | -0.23 (0.13*) |
| CAY_{t-1} | | | | 3.77** (1.81) | 1.76* (0.94) |
| Sample | 1970-2014 | 1970-2014 | 1970-2014 | 1970-2014 | 1970-2014 |
| Slope Coefficients in Equity Premium Regressions with Labor Income Inequality Proxy | | | | | |
| Top 10 Labor Share of Income | -3.73** (1.34) | -3.71 (2.25) | -1.50* (0.75) | -3.46* (1.83) | -4.37 (2.71) |
| $\Delta 5yEP_{t-1}$ | 0.07 (0.11) | -0.15 (0.17) | -0.07 (0.13) | -0.21** (0.07) | -0.11 (0.14) |
| $(p/d)_{t-1}$ | | -0.13 (0.12) | | | -0.13 (0.14) |
| $(p/e)_{t-1}$ | | | 0.08 (0.07) | | 0.07 (0.11) |
| CAY_{t-1} | | | | 2.30** (1.13) | 2.34 (1.99) |
| Sample | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 | 1945-2014 |

All the variables are computed as 5-year moving changes. The data is retrieved from the website of Amit Goyal and Welch and Goyal (2008, updated) The regressions are performed on the data between 1945/1970 and 2014, using Newey-West estimator with correction for heteroscedasticity and autocorrelation in the error term. Standard errors are reported in brackets. ** denotes significance at 5% level and *** at 1% level.

- Danthine, J.-P., Donaldson, J.B., 2002. Labour relations and asset returns. *The Review of Economic Studies* 69, 41–64.
- Danthine, J.-P., Donaldson, J.B., 2008. Distribution Risk and Equity Returns. *Handbook of the Equity Risk Premium* 69, 414–462.
- Davig, T., 2004. Regime-switching debt and taxation. *Journal of Monetary Economics* 51, 837–859.
- DeBacker, J., Heim, B., Panousi, V., Ramnath, S., Vidangos, I., 2013. Rising inequality: transitory or persistent? *New evidence from a panel of US tax returns*. *Brookings Papers on Economic Activity*, 67–122.
- Epstein, L., Zin, S., 1989. Substitution, risk aversion, and the temporal behavior of consumption and asset returns: a theoretical framework. *Econometrica* 57, 937–969.
- Epstein, L., Zin, S., 1991. Substitution, risk aversion, and the temporal behavior of consumption and asset returns: an empirical analysis. *Journal of Political Economy* 99, 263–286.
- Fama, E.F., French, K.R., 2002. The equity premium. *The Journal of Finance* 57, 637–659.
- Favilukis, J., 2013. Inequality, stock market participation, and the equity premium. *Journal of Financial Economics* 107, 740–759.
- Gomez, M., 2018. Asset prices and wealth inequality. Working Paper.
- Gómez-Cram, R., 2020. Late to Recessions: Stocks and the Business Cycle. LSE working paper.
- Greenwald, D.L., Lettau, M., Ludvigson, S.C., 2016. The Origins of Stock Market Fluctuations. NBER Working Paper No. 19818.
- Guiso, L., Sapienza, P., Zingales, L., 2018. Time varying risk aversion. *Journal of Financial Economics* 128, 403–421.
- Güvenen, F., 2009. A parsimonious macroeconomic model for asset pricing. *Econometrica* 77, 1711–1750.
- Güvenen, F., Kuruscu, B., 2006. Does market incompleteness matter for asset prices? *Journal of the European Economic Association* 4, 484–492.
- Güvenen, F., Ozkan, S., Song, J., 2014. The nature of countercyclical income risk. *Journal of Political Economy* 122, 621–660.
- Jagannathan, R., McGratten, E., Scherbina, A., 2001. The Declining U.S. Equity Premium. NBER WP8172.
- Jermann, U.J., 1998. Asset pricing in production economies. *Journal of Monetary Economics* 41, 257–275.
- Jermann, U.J., Quadrini, V., 2012. Macroeconomic effects of financial shocks. *The American Economic Review* 102, 238–271.
- Jordà, Ò., Schularick, M., Taylor, A., 2017. Macrofinancial history and the new business cycle facts. In: Eichenbaum, Martin, Parker, Jonathan A. (Eds.), *NBER Macroeconomics Annual 2016*, vol. 31. University of Chicago Press, Chicago.
- Jordà, Ò., Knoll, K., Kuvshinov, D., Schularick, M., Taylor, A., 2019. The rate of return on everything, 1870–2015. *The Quarterly Journal of Economics* 134, 1225–1298.

- Kacperczyk, M., Nosal, J., Stevens, L., 2019. Investor sophistication and capital income inequality. *Journal of Monetary Economics* 107, 18–31.
- Karabarbounis, L., Neiman, B., 2014. The global decline of the labor share. *The Quarterly Journal of Economics* 129, 61–103.
- Kopczuk, W., Saez, E., Song, J., 2010. Earnings inequality and mobility in the United States: evidence from social security data since 1937. *The Quarterly Journal of Economics* 125, 91–128.
- Lansing, K.J., 2015. Asset pricing with concentrated ownership of capital and distribution shocks. *American Economic Journal: Macroeconomics* 7, 67–103.
- Lansing, K.J., Markiewicz, A., 2018. Top incomes, inequality and welfare. *The Economic Journal* 128 (608), 262–297.
- Lendvai, J., Raciborski, R., 2014. Pricing Financial Assets in an RBC Framework with Loss-Averse Agents. Mimeo.
- Lustig, H., Verdelhan, A., 2012. Business cycle variation in the risk-return trade-off. *Journal of Monetary Economics* 59, 35–49.
- Masulis, R.W., 1988. The Debt–Equity Choice. *Institutional Investor Series in Finance*. Ballinger Press, Cambridge, MA.
- Pastor, L., Stambaugh, R.F., 2001. The equity premium and structural breaks. *The Journal of Finance* 56, 1207–1239.
- Saez, E., Zucman, G., 2016. Wealth inequality in the United States since 1913: evidence from capitalized income tax data. *The Quarterly Journal of Economics* 131 (2), 519–578.
- Toda, A.A., Walsh, K.J., 2020. The equity premium and the one percent. *The Review of Financial Studies* 33, 3583–3623.
- Uhlig, H., 2007. Explaining asset prices with external habits and wage rigidities in a DSGE model. *The American Economic Review: Papers and Proceedings* 97, 239–243.
- Vissing-Jorgensen, A., 2002. Limited asset market participation and intertemporal substitution. *Journal of Political Economy* 110, 825–853.
- Walentin, K., 2010. Earnings inequality and the equity premium. *The B.E. Journal of Macroeconomics (Contributions)* 10, 23.
- Weil, P., 1990. Non-expected utility in macroeconomics. *The Quarterly Journal of Economics* 1, 29–42.
- Welch, I., Goyal, A., 2008. A comprehensive look at the empirical performance of equity premium prediction. *The Review of Financial Studies* 21, 1455–1508.
- Wolff, E.N., 2017. *A Century of Wealth in America*. Harvard University Press, Cambridge, MA.