Income Inequality and Stock Market Returns*

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July, 2018

Abstract

In this paper, we study the relationship between income inequality and stock market returns. We develop a quantitative general equilibrium model that links shifts in both labour and capital income inequality to the stock market variables. An increase in the share of risky capital in income of capital owners leads to higher equity premium and a rise in the non-risky, labor share reduces it. The negative impact of the higher labour share of income of capital owners dominates and brings the equity premium below the historical value by 0.79 percentage points, in line with the data. If both capital and total income shares of top decile would grow at the same rate as between 1970 and 2014, the equity premium would continue decreasing until 6.11% in 2030, 0.92 percentage point lower than historical equity premium of 7.03%. If instead only capital share of income continues to grow, the equity premium would be higher than the historical average by 0.14 percentage point.

Keywords: *Asset Pricing, Risk Premium Dynamics, Income Inequality, Computational Macroeconomics.*

JEL Classification: D31, E32, E44, H21, O33.

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*For helpful comments and suggestions we thank Bünyamin Erkan, Kevin Lansing, Andreas Pick, Vincent Rebeyrol and participants of the 25th Society of Nonlinear Dynamics and Econometrics meeting in Paris, Fifth International Symposium in Computational Economics and Finance in Paris, Society of Economic Dynamics meeting in Edinburgh and Fifth International Symposium in Computational Economics and Finance in Paris, National Bankof Poland workshop in Warsaw.

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1 Introduction

Equities are concentrated in hands of households at the top of the U.S. income distribution.[1] Changes in their labor and capital incomes would be then expected to affect the movements in asset prices and returns. Both labor and capital shares of income of the U.S. richest households increased during the last four decades.

In this paper, we study the relationship between income inequality and stock market returns. We develop a general equilibrium model that links shifts in both labour and capital income inequality to the stock market variables.

Our framework includes two groups of agents. The top income group (capital owners) owns 100% of the economy's financial wealth—a setup that roughly approximates the highly-skewed distribution of U.S. financial wealth.[2] The rest of economy is populated by workers who consume their labor income and income from risk-free government and corporate bonds. This set-up is similar to Greenwald et al. (2016). The key difference of our model is that, in addition to the capital income, capital owners earn labor income, in line with empirical observation that the top wealth holders of today are also the top earners. In fact, 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.

The model provides a simple intuition on how income inequality shifts, measured by changes in income shares, affect asset pricing variables and in particular equity premium. An increase in the share of risky capital in income and hence in consumption of capital owners leads to higher equity premium. The opposite is true when the share of non-risky, labor income in the total income of capital owners rises. Because empirically capital owners benefited from increase in both incomes over the last four decades, the total quantitative impact of income inequality shifts on the stock market return is unclear.[3]

We build a quantitative model that allows us to assess the impact of the joint increases in capital and labor income shares of top decile on the stock market. The model extends the standard RBC setting used in the production-based (CCAPM) literature allowing for heterogeneity of agents which differ by their ability to hold

[1] Chen and Stafford (2016) argue that even fewer than 20 percent of households own stock directly.

[2] The share of total financial wealth owned by the top 10% of households is around 80% in the sample period (Wolf, 2010).

[3] The total share of income of capital owners or top decile in the U.S. increased from 32% to 46% between 1970 and 2014 as shown in Figure 1. Both labor and capital shares relative to the remaining households increased during this period as shown in Figure 2.

financial assets and having different output elasticities of labor. Two types of agents' set-up allows us to match simultaneously stock market and real economy statistics.

The source of risk in the model is technology shock. The model delivers high mean equity premium and realistic Sharpe ratio via a combination of three factors. First, to generate a high price for risk, following Greenewald et al. (2016), we introduce high and time-varying coefficient of risk-aversion in capital owners' utility function. Second, the capital is subject to adjustment costs in the sprit of Uhlig (2007) and Jermann and Quadrini (2012). Finally, financial leverage of firms increases the quantity of risk borne by capital owners thus helping to generate a realistic Sharpe ratio. Careful calibration of these channels allows for precise matching of the mean and standard deviation of equity premium (and hence the Sharpe ratio), which has proven a challenge in models that use other mechanisms. 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.

We calibrate the model to the U.S. post-war economy where the equity premium on S&P500 reached 7.03%. In order to gauge the quantitative impact of changes in income inequality on the equity premium, we carry out three counterfactual scenarios. We first consider a raise in capital income inequality and change the value of capital share of income, θ, from its baseline value to the value in 2014, 0.34. In line with the initial intuition of the model, this increase leads to the mean equity premium higher by 0.43 percentage points than the historical one.

Second, we rise the value of the labour share of income of top decile in economy-wide labour share α to 13%, its 2014 value. We show that the steady increase of the capital owners' labour share between 1970 and 2014 should have exercised a strong downward pressure on the equity premium. In fact, the model predicts that if there was no increase in capital income inequality, only in labour income, the equity premium would have been lower by 1.64 percentage points.

Finally, considering the two changes together, we show that the net effect on the equity premium is negative, in line with what has been observed in the S&P500 data. The negative impact of the higher labour share of income of capital owners dominates the positive effect of the increased capital share bringing the equity premium below the historical value by 0.79 percentage points.

What will be the equity premium in 15 years if the U.S. income inequality continues to increase? We consider two different scenarios for future trends in income inequality and introduce them into the model to derive the equity premium response.

In line with the empirical predictions, both scenarios extend the upward trend in the U.S. income inequality. The first scenario assumes that both capital and total income shares of top decile will grow until 2030 at the same rate as between 1970 and 2014, namely 0.5% and 0.92%, respectively.

In this case, we find that the equity premium would continue decreasing until 6.11% in 2030, 0.92 percentage point lower than historical equity premium. In the second, more likely scenario, we assume that the labour share of income of capital owners stops growing and only capital share of income continues to increase.[4] If capital share of income continues to grow at the annual rate of 0.5% and the labour share of income of top decile remains unchanged, capital would represent 37% of total income in the U.S. in 2030. Total income of top decile would amount to half of the income in the U.S. economy. In this scenario, the equity premium would be higher than the historical one by 0.14 perecntage point.

Finally, we use the model to perform a reverse engineering exercise, in which, we compute the income inequality required to reach the historical equity premium of 7.03%. We again use simple linear extrapolation rules to make predictions about the behaviour of one of the shares of income and compute a change in the other share required to match historical equity premium. The first experiment assumes a continued growth of labour share of income of top decile of 2% per year until 2030. An increase of capital share of income of 2.04% per year would be needed to replicate the historical equity premium.

Next, we extrapolate the trend in capital share of income so that it keeps growing at an annual 0.5% rate. For the equity premium to increase relative to the currently observed lower equity premium, labour income inequality would need to drop. In fact, it would need to decrease by 3% per year to deliver historical level of equity premium. This scenario seems rather implausible.

Finally, in the most likely scenario, we assume that the labour income dispersion stops increasing and we find that the historical equity premium would be reached by 2030 if capital share of income was growing by 1.4% each year, in line with Piketty's (2014) predictions.

The paper is organized as follows. In Section 2, we describe a set of stylized facts

[4] This assumption is motivated by observation that since 2000, the labour income inequality has not been increasing. In contrast, capital share of income started rising since 2000. These trends are in line with the literature on skill-biased technological change which was initially driving income inequality and generated higher dispersion in savings from labour income and higher capital income inequality. See also Saez and Zucman (2016) for empirical support of this hypothesis.

on changes in income inequality and equity premium. In Section 3, we describe the model and its main intuition. Specifically, we explain the mechanisms generating high equity premium and Sharpe ratio and how they respond to shifts in income shares. In this section, we also describe our calibration strategy. Section 4 evaluates the quantitative performance of the model in both macroeconomic and financial dimensions. In Section 5, we carry out a set of counterfactual exercises which allow us to assess the quantitative impact of the recent increase in income inequality on the equity premium. In this section, we also implement a number of scenarios for future behaviour of equity premium based on the income inequality predictions. Section 6 concludes.

2 Income Inequality and Asset Pricing Variables in the Data

2.1 Capital and labor shares of income

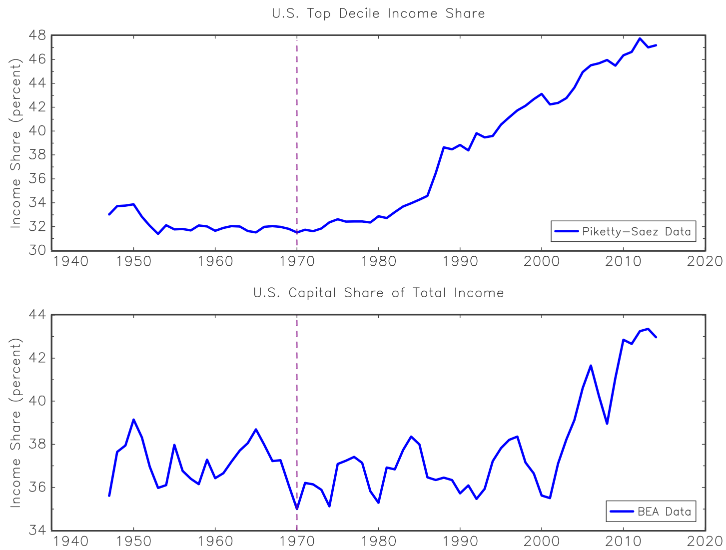
Recent increase of income inequality has been accompanied by rising capital share of income. Karabarbounis and Neiman (2014) show that the labour share of income has significantly declined since the early 1980s in the large majority of countries, including the U.S..

Figure 1 plots increase in the top decile and capital shares of income in the U.S. There is a clear positive trend in both series. Given that the capital stock is concentrated in hands of a relatively small group of people, the observed increase in capital share of income directly implies an increase in income inequality. While total labor share declined in the recent decades, the relative labor share of top incomes increased as well.

Figure 2 plots the composition of the top decile income share in the U.S. between 1947 and 2011. The striped area of the figure corresponds to the labor income and demonstrates that its share increased during the past thirty years from 25 percent to 33 percent. The solid area shows how capital gains, rents, interest rates, dividends, and business income evolved during this period. These components are combined to form one category: capital share of income, which also increased during the last three decades. It represented 8.9 percent of income of the top decile in 1980 and 13 percent in 2011.[5]

[5] The capital share of income of top decile was equal to 16%. Its recent drop was generated by the financial crisis.

Figure 1: Top decile income share and capital share of income in the U.S.



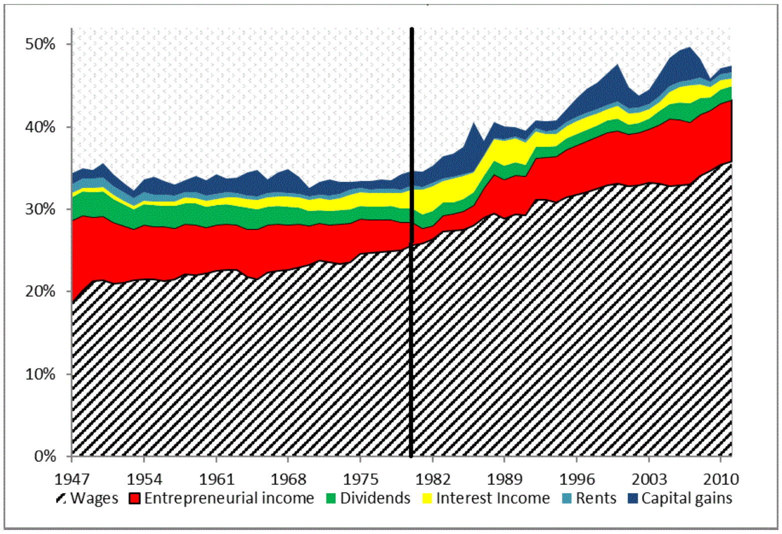
Top decile income share series comes from the World Inequality Database at https://wid.world/. Capital share of income is computed form Bureau of Economic Analysis dabase as 1-compensation of employees.

Top incomes thus experienced an increase from both sources: capital and labor and, there is in fact, a strong positive correlation between top labor and capital incomes. The top wealth holders of today are also the top earners. For instance, 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.

2.2 Equity premium

While income inequality increased during the last four decades the equity premium has decreased. In Table 1, we report the figures for the equity premium computed form the Shiller's website: http://www.econ.yale.edu/~shiller/data.htm. The first column denotes the period over which the statistic was computed. In the second column, we show the values for the equity premium (EP) and in the third column for Sharpe Ratios (SR). The first row shows that the equity premium reached 7% on average during the post-war period while Sharpe ratio was equal to 0.43 during the same period.

Figure 2: Top decile income share and its composition between 1970 and 2011



The solid area shows capital share of income and its composition: capital gains, rents, interest income, dividends and entrepreneurial income. Striped area shows labor share of income which covers wages and salaries, bonuses, exercised stock-options, and pensions. 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 SP 500**

	EP	SR
1947 – 2014	7.03%	0.43
1947 – 1970	9.07%	0.59
1971 – 2014	5.92%	0.34

EP stands for equity premium and SR for Sharpe ratio. Both statistics 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&P 500 and the risk free rate is 6 months rolled commercial paper rate.

The following two rows report the statistics for the period between 1970 and after 1970. The equity premium before 1970 was a third higher than after 1970. In case of the Sharpe ratio statistics, this pattern is even stronger as the value before 1970 is almost twice as high as after 1970.

3 Model

As our analytical tool we build on the model by Lansing and Markiewicz (2018). The model extends the standard RBC setting used in the production-based Consumption Capital Asset Pricing Model (CCAPM) literature allowing for two types of agents differing by their ability to hold financial assets and having different output elasticities of labor. This extension to the standard framework lets us trace the impact of the shifts in the capital share and labor-income shares on the stock market price behavior and, in particular, on the mean equity premium.

There are several additional elements of the model worth emphasizing. The high mean equity premium and realistic Sharpe Ratio obtained in our setting are due to a combination of three factors: (i) time-varying coefficient of risk aversion, as in Greenewald et al. (2016), which increases the price for risk in the economy, (ii) capital adjustment costs and (ii) financial leverage, which both increase the quantity of risk borne by the agents investing in stocks. Careful calibration of these channels allows for precise matching of the mean and standard deviation of equity premium (and hence the Sharpe Ratio), which has proven a challenge in models that use other mechanisms to generate high equity premium.[6] 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.[7]

3.1 Workers

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

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

[6] 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).

[7] As is well known, 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. In effect, zero-risk-free saving rate of consumers is usually assumed in these models.

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 the 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.[8] Finally, $n_t^w = n^w$ is the constant supply of labor hours per worker.

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

$$(c_t^w)^{-\gamma^w} = \lambda_t^w$$

$$1 = \beta_t^w E_t \frac{\lambda_{t+1}^w}{\lambda_t^w} R_t^f \tag{3}$$

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

with λ_t^w the 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:

$$R_t^f = \frac{1}{P_t^f}$$

$$R_t^c = \frac{1}{P_t^c}$$

By construction we also have $R_t^c \equiv R_t^f$.

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 - the capital owners' discount factor and γ_t^c - their coefficient of risk aversion. The capital owners' coefficient of risk aversion is time-varying, as in Greenewald et

[8] In contrast, they are assumed to have full access to risk-free saving vehicules such as bank deposits (a_t^f) and corporate bonds (a_t^c). It is possible to assume $a_t^c \equiv 0$ without undermining the results of the paper.

al. (2016). In combination with technology shocks, which are the standard *source* of risk in our economy, shocks to the coefficient of risk aversion increase the *price for risk* that is, the return on the risky asset, net of risk-free return, per unit of risk, as traditionally measured by the excess return's standard deviation. In other words, they increase the Sharpe ratio.

The time-varying coefficient of risk aversion is defined as

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

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 the 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 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 (economic) 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:

$$(c_t^c)^{-\gamma_t^c} = \lambda_t^c$$

$$1 = \beta_t^c E_t \frac{\lambda_{t+1}^c}{\lambda_t^c} R_{t+1}^s \tag{8}$$

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

with λ_t^c the marginal utility of consumption and R_{t+1}^s - 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 standard first order conditions encountered 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 the definition of time-varying discount factors as in Greenewald 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, while at the same time deal with the problem of too volatile risk-free rate, see Greenewald et al (2014), making the risk-free rate in the economy constant:[9]

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

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:

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

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:

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

Above, Y_t is the current output, I_t – 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: $d_t^s = \frac{D_t}{\eta}$.[10]

Output is produced with Cobb-Douglas technology:

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

where θ is the capital income share, $\alpha\left(1-\theta\right)$ 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 N.I.D.

It is assumed that transforming investment I_t into capital K_t is costly, which permits the shadow price of installed capital to diverge from the price of an additional

[9] Another well-established solution to the volatility puzzle is disentangling the risk aversion and intertemporal elasticity of substitution coefficients, which are the reciprocals of each other in our model, 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.

[10] Note that, as is common in the literature, e.g. Lansing (2015), we use the concept of "macroeconomic dividends" in place of financial dividends.

unit of capital. In specifying the capital adjustment cost, we follow Uhlig (2007) and Jermann and Quadrini (2012) and our capital accumulation equation takes the form:

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

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^k, is defined as:

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

which can also be rewritten as

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

The return on capital has an intuitive interpretation, which will be explained 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: $a_t^s = \eta^{-1}$, $a_t^f = 0$, $B_t^{c,w} = (1-\eta)\, a_t^w$, $B_t^{c,c} = \eta a_t^c$ and $B_t^{c,w} + B_t^{c,c} = \mu K_t$

- Dividends: $D_t = d_t$

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, $B_t^{c,c} \equiv 0$. Any alternative assumption, including $B_t^{c,w} \equiv 0$ and $B_t^{c,c} \equiv \mu K_t$, produces results similar to those reported in the paper.

The whole list of equations, after having been stationarized (divided by $exp\,(z_{t-1})$) is shown in Appendix).

3.5 Asset Pricing Variables

We define the equity premium (excess return on stocks):

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

The unconditional Sharpe ratio is then defined as:

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

where E and σ stand for unconditional expectation and standard deviation, respectively.

Finally, it is worth interpreting the Euler equation associated with capital. Comparing arbitrage conditions (8) and (15), we see that they imply

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

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 $G'\left(\frac{I_t}{K_{t-1}}\right)$ translates the value of installed capital into the uninstalled one. Moreover, 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 $\left(1 - G'\left(\frac{I_t}{K_{t-1}}\right)\mu P_t^b\right)$ adjustment term (again, with a suitable adjustment due to the price difference between installed and unistalled capital).

3.6 Intuition of the model

3.6.1 Mechanisms generating high equity premium and Sharpe ratio

Our model is able to easily generate realistic equity premium and Sharpe ratio, while at the same time producing reasonable real-economy statistics. This is remarkable, given the well-known fact that production-based CCAPMs struggle to achieve both objectives at the same time (e.g. Lansing 2015, Guvenen 2009). Several elements of the model contribute to its success.

The source of risk in the model is technology shock. To generate a high price for risk, following Greenewald et al. (2016), we introduce high and time-varying coefficient of risk-aversion in capital owners' utility function. In a standard 1-type of agents model, high and time-varying risk aversion would, via the Euler equation on capital, have a very strong impact on the real side of the economy. However, with two types of agents and a relatively small number of capital owners relative to the total number of consumers, the total consumption is not very strongly affected by shocks to risk aversion. This helps us generate real economy statistics that are similar to those in a baseline RBC model and reasonably close to their real-life counterparts.

While high and volatile coefficient of risk aversion of capital owners makes it possible to produce almost arbitrarily high equity premium, it is not sufficient on its own to generate a realistic Sharpe ratio. Production-based CCAPMs tend to produce too small the quantity of risk, as measured by the unconditional standard deviation of excess returns. We introduce two mechanisms to deal with this problem. First, we assume that capital is subject to adjustment costs. This mechanism makes capital owners' consumption smoothing via adjustment in corporate investment costlier, making them less keen on taking investment risks. Additionally, capital adjustment costs help us match 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.

3.6.2 Expected responses of equity premium to shifts in income shares

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

A shift in the labor income share of capital owners in total income, $\tilde{\alpha} = \alpha(1-\theta)$, has a less direct effect. Combining the capital owners' budget constraint (7) with the definition of dividends (10) lets us write capital owners' consumption as:

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

The first term on the RHS of (18) represents the total labour 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. As a result, the volatility of the associated stochastic discount factor , $M_t^c = \beta_t^c \frac{\lambda_{t+1}^c}{\lambda_t^c}$, will fall, and the mean stock excess return will fall.

From the above analysis, 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. This effect reinforces the direct effect of a shift in θ discussed earlier. Since empirically both shares of incomes increased, we use a set of simulations of the model calibrated to the US economy to quantify the net effect of these two simultaneous shifts.[11]

3.7 Computation

For solving the model, we use a non-linear solution method based on Coleman (1991) and following Davig (2004) and Lendvai and Raciborski, mimeo.[12] See Appendix C1 for details. In order to compute the statistical moments of macro and financial variables, for every model parametrization of interest we simulated the economy for 1.020.000 periods. The moments reported are based on time series consisting of the last 1.000.000 observations.[13]

[11] An additional trend that could have been observed through the last decades was a steady increase in stock ownership among households. A seminal result in the literature is that limited stock market participation helps explain high excess returns observed on stock markets (Vissing-Jorgensen, 2002). By this token, the steady increase of stock ownership should have contributed to the falling equity premium. Our model, in its baseline version presented above, is not able to capture this insight.

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

[13] The first 20 000 observations are burn-in.

3.8 Calibration

Our calibration strategy is as follows. We calibrate most real economy parameters to reflect certain empirical properties of the economy in the post-war period, see Table 2. Parameter β is calibrated to match the mean annual risk-free rate $E\left({R_t}^f\right) = 2\%$. The share η of capital owners in the population is equal to top income decile. The remaining three real economy parameters (capital income share, θ, capital owners labor income share in total labor income, α and the ratio of capital owners to workers employment) are calibrated so that to match certain economy wide characteristics in 1970, see Table 2. Finally, the financial leverage parameter (μ) and risk aversion shock parameters ($\gamma^c, \mu^x, \rho^x, \sigma^x$) are chosen to match a set of stock market statistics.

Table 2: **Calibration of the main parameter values**

Table 2: Baseline Parameter Values

Parameter	Value	Description/Target
η	0.10	Capital owners = top income decile.
θ_{1970}	0.28	Capital's share of income in 1970.
α_{1970}	0.05	Top decile income share = 3.5% in 1970.
N^c_{1970}/N^w_{1970}	0.19	Mean relative wage $W^c_0/W^w_0 = 2$ in 1970.
μ^z	0.00	
σ^z	$7.7160e^{-4}$	Output volatility of 2% in the post-war period.
ρ^z	0	*RW*
δ	0.08	Annual depreciation rate of 8%
ξ	0.33	Ratio of volatility of investment to volatility of output $\frac{\sigma^{\Delta I}}{\sigma^{\Delta y}} \simeq 2.84$.
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	$R_t^f = 1.02$

Starting from the real economy statistics, the value of σ^z, is chosen such that the volatility of output in our economy matches its empirical counterpart of 2% annually. The value of capital adjustment cost parameter, ξ, is chosen to match the ratio of volatility of investment to volatility of output equal to 2.84. The remaining parameters in the capital adjustment cost function 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). The value of depreciation rate, δ, is set to 8%, annually.

The following parameter values are set to their 1970 empirical counterparts. The capital share of income, θ_{1970}, was 28% in 1970. The value of parameter α_{1970} is set such that the top decile income share, $\alpha_{1970}(1-\theta_{1970}) = 3.5\%$. Further, without a loss of generality, we set the demand for skilled labor in the model equal to 1. Following Lansing (2015), we then choose the value of demand for unskilled labor such that the relative wage of skilled to unskilled labor, $W_0^c/W_0^w = 2$, its value in 1970.

Table 3: **Baseline parameter values for stock market**

Parameter	Value
μ	0.21
γ^c	100
$\min\left(\gamma_t^c\right)$	1
μ^x	-1.1
σ^x	0.4
ρ^x	0.95

Table includes calibrated values of the coefficient of risk aversion, γ_t^c, and its AR(1) shock. Risk aversion coefficient is defined as: $\gamma_t^c = \frac{\gamma^c}{1+\exp(x_t)}$ with γ^c being maximum degree of risk aversion and x_t an AR(1) process with mean μ^x: $x_t - \mu^x = \rho^x\left(x_{t-1}-\mu^x\right) + \varepsilon_t^x$ and ε_t^x an iid shock with variance $(\sigma^x)^2$.

Table 3 reports baseline parameter values for stock market. The financial leverage, μ, and maximum risk aversion parameter, γ^c, are calibrated to reproduce as closely as possible two fundamental stock market statistics, the mean equity premium, $ER_{t+1}^e = 7.03\%$ and the Sharpe ratio, $SR = 0.43$ in the post-war S&P 500. We need a much lower maximum degree of capital owners' risk aversion than Greenewald et al. (2016), $\gamma^c = 100$. This also translates into a much lower mean degree of capital owners' risk aversion, which in our baseline calibration is $E\left(\gamma_t^c\right) = 26$. The main reason for this difference is the assumption of a moderate degree of financial leverage, absent in Greenewald et al. (2016). The value of financial leverage, $\mu = 21\%$, is close to the value of 15% assumed by Guvenen's (2009) and is conservative in comparison to values used in the literature (e.g. Boldrin et al., 2001, assume leverage of 50%). The mean of the shock process to the coefficient of risk aversion $\mu^x = -1.1$ is set to match log price-dividend ratio and its variance, $\sigma^x = 0.4$, to generate dividends' growth volatility. Finally, we set the AR(1) coefficient of the risk aversion shock, ρ^x, to match the well documented long-horizon predictability of equity premium.

4 Quantitative Performance of the Model

We proceed as follows. We first simulate our model for the parameter calibration given in Tables 2 and 3, and in particular, for the capital share of income $\theta = 0.28$ and the share of capital owners' labor income in total labor income $\alpha = 0.05$. The model is simulated over 1.000.000 periods. We assess its performance by comparing a set of model-based statistics with the data.

In order to study the impact of changes in income inequality on the equity premium, we run 3 additional simulations. We first consider a rise in capital income inequality. We change the value of θ from its baseline value to 0.34 and study the impact of this increase on the mean equity premium. Second, we increase the value of α to 13%, its 2014 value and analyze the effect of this change. Finally, similar to the trends in the data, we consider the joint shifts in the capital and labour shares of income. To isolate the impact of income shares shifts on the equity premium, we keep all the other parameters of the model unchanged.

4.1 Baseline scenario

We first discuss the performance of the baseline version of the model calibrated to the post-war U.S. real economy and S&P 500 index. In the top panel of Table 4, we report stock market statistics and in the lower panel real economy statistics. Both panels include the moments observed in the U.S. data and in the model. All the asset pricing statistics are based on the annual S&P 500 series coming from Robert Shiller's website and covering post-war period between 1947 and 2014. 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 first two rows of Table 4 report the average equity premium and Sharpe ratio. Our baseline model specification reproduces the historical equity premium on the U.S. stock market and produces sizeable Sharpe ratio. The third and fourth rows of the same table display log price-dividend ratio, $\ln\left(\frac{P_t^s}{D_t}\right)$. While the model is able to match the volatility of the ratio, $\sigma^{\ln\left(\frac{P}{D}\right)}$, it somewhat underpredicts its log-level. Finally, the volatility of dividend growth of 7% is well matched by the model.

On the real side of the economy, the model replicates the volatility of output growth, $\sigma^{\Delta y}$, by construction and very closely the investment-output volatility ratio, $\frac{\sigma^{\Delta I}}{\sigma^{\Delta y}}$. The model slightly overpredicts the consumption-output volatility ratio, $\frac{\sigma^{\Delta c}}{\sigma^{\Delta y}}$. The reason is that, in the model, relatively high volatility of capital owners' consumption is required to match the high equity premium and Sharpe ratio observed in the data. Since workers consume less on average, capital owners' consumption constitutes an important part of total consumption, despite the much lower number of them in the total population.

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

Variable	Moment	Data	Model
	Stock market		
R^e_{t+1}	Equity premium	7.03	7.04
$\frac{E[R^e_t]}{\sigma[R^e_t]}$	Sharpe ratio	0.43	0.38
$\ln\left(\frac{P^s_t}{D_t}\right)$	Log Price-Dividend ratio	3.41	2.71
$\sigma^{\ln\left(\frac{P}{D}\right)}$	Volatility of Log Price-Dividend ratio	0.45	0.59
$\sigma^{\Delta D}$	Volatility of dividend growth	0.07	0.07
	Real economy		
$\sigma^{\Delta y}$	Volatility of Output Growth	2%	2%
$\frac{\sigma^{\Delta I}}{\sigma^{\Delta y}}$	Ratio vol investment growth-vol output growth	2.84	2.10
$\frac{\sigma^{\Delta c}}{\sigma^{\Delta y}}$	Ratio vol consumption growth-vol output growth	0.76	1.15

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&P 500 and the risk free rate. Risk free rate is 6 months rolled commercial paper rate. Price-dividend ratio is calculated for S&P 500. 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 2009 Dollars and we compute their annual growth rates.

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

$$\sum_{j=0}^{h} R^e_{t+j+1} = \beta \frac{P^s_t}{D_t} + \varepsilon_{t+1,t+h} \tag{19}$$

where $\sum_{j=0}^{h} R^e_{t+j+1}$ is a cumulative excess return over $h+1$ years with $h = 0, 1, 2$, $\frac{P^s_t}{D_t}$ 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&P 500 series are reported in the top panel of Table 5 while their model-based counterparts are displayed in the lower panel of the same table. In line with previous findings, we see that 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.

Table 5: **Long Run Return Predictability Regressions**

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

Table reports results of estimation of the regression $\sum_{j=0}^{h} R^e_{t+j+1} = \beta \frac{P^s_t}{D_t} + \varepsilon_{t+1,t+h}$ where $\sum_{j=0}^{h} R^e_{t+j+1}$ is a cumulative excess return over h+1 years with h=0,1,2. $\frac{P^s_t}{D_t}$ 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.

5 Increase in Income Inequality and Equity Premium

How did the trends in inequality affect stock market and, in particular, equity premium? Between 1970 and 2016 the capital income share increased by 6 percentage points (from 28% to 34%), while the top decile labor income share increased by about

9.5 percentage points (from 3.5% to 13%). In order to gauge the impact of these shifts on equity premium, we simulate the model economy with higher income inequaility observed in 2016. Specifically, we set the income share parameters to their 2016 steady state values.

Table 6: **Income shares shifts and mean equity premium**

Scenario	Parameter values	Equity premium	Change vs baseline
Baseline	$\theta = 0.28; \alpha = 0.05$	7.04%	-
$\theta \Uparrow$	$\theta = 0.34; \alpha = 0.05$	7.43%	$+0.43pp$
$\alpha \Uparrow$	$\theta = 0.28; \alpha = 0.20$	5.76%	$-1.64pp$
θ and $\alpha \Uparrow$	$\theta = 0.34; \alpha = 0.20$	6.25%	$-0.79pp$

$\theta \Uparrow$ denotes an increase in capital share of income and $\alpha \Uparrow$ an increase in the labour share of income of capital owners. The equity premium in the model is computed over 1.000.000 simulated periods. All the paramaters of the model except for the ones included in the table are set to their baseline calibration values reported in Tables 2 and 3.

As suggested by the intuition of the model (section 3.6.2), shifts in the capital income and top decile labor income shares have opposite effects on equity premium. In order to confirm the initial intuition, we introduce each income shift at the time. First, we keep α at its 1970 value but increase θ to match the 2014 value of the capital income share. Next, we do the opposite: we keep θ at its 1970 value, but increase α to its 2014 level. Finally, to assess the total, quantitative impact of the simultaneous trends in income shares observed in the data, we introduce both shifts together. The results of these exercises are reported in Table 6.

The first row shows the baseline model simulation outcomes where the equity premium equals 7.04%. The second row displays the results of the simulation with an increase in capital income inequality as measured by increase in θ. In line with the intuition, increase in the share of income derived from the risky source, requires a higher return on the risky asset and translates into a higher equity premium. An increase in the capital share of income of 6 percentage points generates an increase in equity premium of 0.43 percentage points.

The third row reports the results of the counterfactual with θ kept unchanged at its 1970 value, and α set to its 2016 level. A 15 percentage points increase in α translates into a large drop in equity premium of 1.64 precentage points. Unsurprisingly, considered simultaneously the shifts generate a drop in equity premium. An economy with higher shares of income, as observed in the U.S. data, displays equity premium of 6.25%, similar to the one found in the S&P500 between 1971 and 2014 equal to 5.92%.

In addition to the equity premium, we look at the impact of changes in income shares on other asset pricing variables. Table 7 shows the figures for Sharpe ratio, log price-dividend ratio, volatility of log-price-dividend ratio and volatility of dividend growth.

Table 7: **Asset pricing moments in different scenarios**

Scenario	Parameter values	SR	log P/D	sd log P/D	sd. div. gr.
Baseline	$\theta = 0.28; \alpha = 0.05$	0.38	2.71	0.59	0.07
$\theta \Uparrow$	$\theta = 0.34; \alpha = 0.05$	0.38	2.71	0.62	0.07
$\alpha \Uparrow$	$\theta = 0.28; \alpha = 0.20$	0.35	2.81	0.56	0.07
θ and $\alpha \Uparrow$	$\theta = 0.34; \alpha = 0.20$	0.35	2.80	0.59	0.07

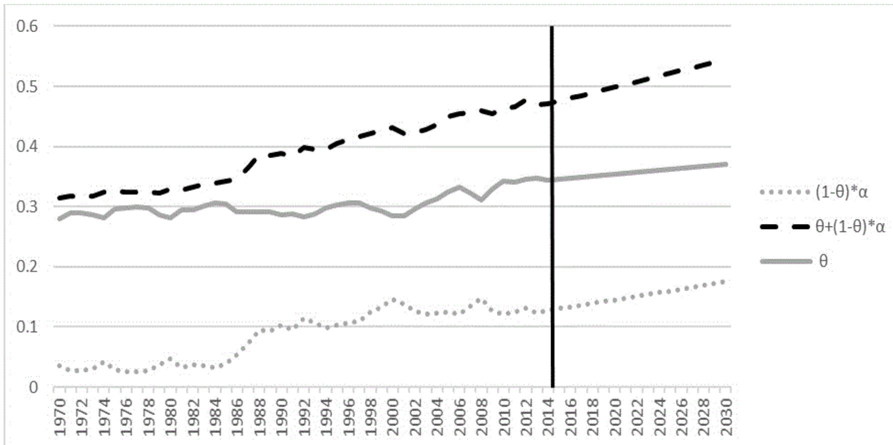
$\theta \Uparrow$ denotes an increase in capital share of income and $\alpha \Uparrow$, an increase in the labour share of income of capital owners. The equity premium in the model is computed over 1.000.000 simulated periods. All the paramaters of the model except for the indicated ones are set to the baseline calibration values reported in Tables 2 and 3.

The second row shows the statistics under counterfactual with only θ shifting by 6 percentage points. We see that there is no impact on Sharpe ratio because increase in capital share of income raises both the return and the volatility of return on capital. Because changes in labour income share of capital owners have an impact only on the stock return, we find that an increase in α generates and drop in Sharpe ratio.

5.1 Alternative scenarios and predictions

What will be the equity premium in 15 years if the U.S. income inequality continues to increase? While it is utterly difficult to predict income inequality changes, most research suggests that, at least to some extent, the current trend will persist. Schwabish and Topoleski (2013) argue that the historical pattern of rising earnings inequality will continue for the next two decades. Piketty (2014) makes a strong claim that the capital income share will continue to grow as well. In line with these predictions, we extrapolate current inequality trends into the future, until 2030, and using our model, we compute the resulting equity premia. Specifically, we assume that capital share of income, θ, continues growing at a yearly 0.5%, as observed between 1970 and 2014, on average. We also assume that the total top decile income share, $(1 - \theta)\,\alpha + \theta$, will grow at the same rate as on average between 1970 and 2014, namely 0.92% per year. We then compute the resulting labour share of income of top decile, $(1-\theta)\,\alpha$, and its implied growth rate of 2% per year.

Figure 3: Top decile income shares in the U.S. data and predictions (scenario 1)



Dotted grey line plots the labour share of income of capital owners: $(1-\theta)\,\alpha$. Grey solid line plots capital share of income: θ, and the dashed black line plots the sum of the two: $(1-\theta)\,\alpha+\theta$ which corresponds to top decile income share. The black vertical line indicates 2014 when the available data sample stops. Figures beyond 2014 correspond to the forecasted values. It is assumed that capital share of income, θ, continues to grow at an annual 0.5% and the labour share of income of capital owners at an annual rate 2%.

The evolution of income shares under this scenario is plotted in Figure 3. The figure plots the labour share of income of capital owners: $(1-\theta)\,\alpha$ (grey dotted line), capital share of income: θ (grey solid line) and total share of income of top decile: $(1-\theta)\,\alpha+\theta$ (black dashed line). Beyond 2014, we plot linear forecasts in income share trends. If both labour and capital shares of income of top decile would continue growing until 2030, the capital share of income, θ, would reach 0.37, its labour share of income, $(1-\theta)\alpha$, 0.18, and total top decile income share 0.55. Note that if this trend would persist, top decile income share would double between 1970 and 2046.

Table 8 reports the parameter values of the two baseline and two alternative inequality scenarios and resulting equity premia. The first baseline scenario corresponds to the initial calibration described in Table 2 where we match the stock market and real economy statistics in the post-war U.S. data. The second baseline scenario corresponds to the simulation with higher income inequality as observed in the data in 2014, and described in Tables 6 and 7.

The last three columns of Table 8 report the mean equity premium, the difference

Table 8: **Mean equity premium in different scenarios**

	Average growth rates		Parameter values				EP	EP vs B1	EP vs B2
	$\Delta\theta$	$\Delta\alpha$	θ	α	$(1-\theta)\alpha$	$\theta+(1-\theta)\alpha$			
Baseline 1	-	-	0.28	0.05	0.04	0.32	7.04	-	-
Baseline 2	0.5%	2%	0.34	0.20	0.13	0.47	6.25	$-0.79pp$	-
Scenario 1	0.5%	2%	0.37	0.28	0.18	0.55	6.11	$-0.92pp$	-0.14
Scenario 2	0.5%	0	0.37	0.20	0.13	0.49	7.61	$+0.57pp$	$+1.36$

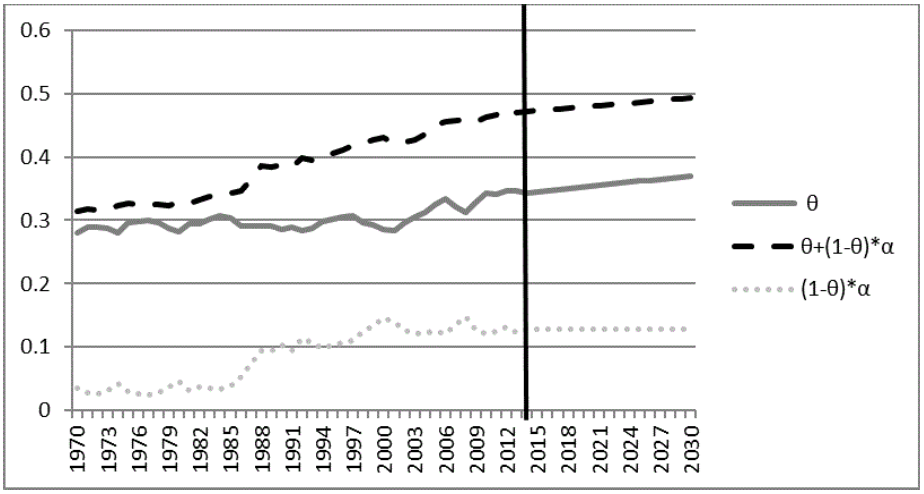
Δx stands for growth rate in variable x. θ is capital share of income. $(1-\theta)\alpha$ is labour share of income of top decile and $\theta+(1-\theta)\alpha$ is their total income share. EP stands for equity premium. EP vs B1 stands for equity premium versus baseline 1 and EP vs B1 verus baseline 2. Statistics are computed using model simulations of 1.000.000 periods. All the parameters except for the ones indicated in the table are set to the baseline calibration values reported in Table2.

relative to the first baseline and the difference relative to the second baseline scenario. Unsurprisingly, under scenario 1, the equity premium would continue decreasing up to 6.11% in 2030, 0.92 percentage point lower than historical equity premium and 0.14 percentage point lower than in 2014. The mechanism driving this result is exactly the same as previously. An increasing share of risky assets in the portfolio of top decile requires higher return while a growing share of non-risky assets (labour income) implies lower return. Because the labour share of income grew faster than capital share of income between 1970 and 2014 (2% versus 0.5%), the growth in the labour income share dominates the one in the capital income share and generates lower equity premium.

We also consider an alternative, more likely scenario, in which, the labour share of income of capital owners stops growing and only capital share of income continues to increase. In fact, until 2000s, the ICT (Informatioon and Comunication Technology) diffusion driven skill-premium and resulting earnings dispersion was mainly driving the increase in income inequality. Grey dotted line in Figure 4 shows that the major increase in labour share of income of top decile occured between 1980 and 2000. In contrast, capital share of income, has been fairly stable until 2000s as shown in lower panel of Figure 1 but started to increase afterwards. In fact, Saez and Zucman (2016) show that an initial increase in the earnings of top incomes largely contributed to the accumulation of wealth and generated in turn an increase in capital income inequality. We assume that these two recent trends persist until 2030. As in the first scenario, we compute the average yearly growth rate in the capital share of income between

1970 and 2014 and extrapolate it into the future. The labour share of income of top decile remains unchanged at 2014 value.

Figure 4: Top decile income shares in the U.S. data and predictions (scenario 2)



Dotted grey line plots the labour share of income of capital owners: $(1-\theta)\,\alpha$. Grey solid line plots capital share of income: θ, and the dashed black line plots the sum of the two: $(1-\theta)\,\alpha+\theta$ which corresponds to top decile income share. The black vertical line indicates 2014 when the available data sample stops. Figures beyond 2014 correspond to the forecasted values. It is assumed that capital share of income, θ, continues to grow at the annual 0.5% while the labour share of income of capital owners does not grow at all.

Figure 4 shows the income inequality trends under this scenario. Again, beyond 2014, we plot forecasted values of income shares. If capital share of income continues to grow at the annual rate of 0.5% and the labour share of income of top decile remains unchanged, capital share of income would reach 37% and total income share of capital owners would be equal to 49%.

The sixth row of Table 8 reports the equity premium value if this scenario would take place. Because we assumed that only capital share of income would keep on increasing, the equity premium would be higher than the historical (baseline 1) equity premium by 0.14 and higher by 1.36 relative to the equity premium between 1970 and 2014.

Finally, we perform a reverse engineering exercise, in which, using our model, we compute the income inequality required to reach the historical equity premium of 7.04%. Because there are two sources of income inequality, we need to make some assumptions about the future behavior of one of them. We use simple linear extrapolation rules from scenarios 1 and 2 to make predictions about one of the shares of income and compute a change in the other share required to match historical equity premium.

More specifically, in scenario 3, we assume that labour share of income of top decile continues growing at an annual 2% and we compute the level and implied growth of capital share of income, θ, necessary to generate the historical equity premium. In scenario 4, we assume the reverse, namely, that the capital share of income continues growing at yearly 0.5% and we calculate the growth in the labour share of income, $(1-\theta)\alpha$, required to replicate the equity premium. Finally, we create a fifth scenario, parallel to scenario 2, where we assume that the labour share of income of top decile stops growing and we compute the change in capital share of income needed to produce the equity premium of 7.03%. Results of these experiments are reported in Table 9.

Table 9: **Income inequality required to match historical equity premium**

	Inputs into the model	Parameters to match EP	Δ to match EP
Scenario 3	$\alpha = 0.28; \Delta\alpha = 2\%$	$\theta = 0.475$	$\Delta\theta = 2.04\%$
Scenario 4	$\theta = 0.37; \Delta\theta = 0.5\%$	$\alpha = 0.120$	$\Delta\alpha = 3.00\%$
Scenario 5	$\alpha = 0.20; \Delta\alpha = 0$	$\theta = 0.430$	$\Delta\theta = 1.40\%$

Δx stands for growth rate in variable x. θ is capital share of income. $(1-\theta)\alpha$ is labour share of income of top decile and $\theta + (1-\theta)\alpha$ is their total income share. 'Δ to match EP' indicates the annual growth rate in one of the shares needed to match the EP. EP Statistics are computed using model simulations of 1.000.000 periods. All the parameters except for the ones indicated in the table are set to the baseline calibration values reported in Table2.

Results of these counterfactuals are reported in Table 9. The first row displays the third scenario where we assumed a continued growth of labour income of 2% per year until 2030. The historical equity premium would be reached if the labour income inequality was accompanied by increase in capital income inequality. Specifically, simulations of our model suggest that an increase of capital share of income of 2.04% per year would be needed to mitigate the negative impact of labour income inequality increase on the equity premium. In this scenario, the capital share of income, θ, would reach 0.475 in 2030.

In the fourth scenario, reported in the second row of Table 9, we assume that capital share of income keeps on growing at the annual 0.5% rate. According to our model, for the equity premium to increase relative to the currently observed lower equity premium, labour income inequality would need to drop. In fact, it would need to decrease by 3% per year to generate the historical level of equity premium. This scenario seems rather implausible.

Finally, the most likely, fifth scenario is described in the third row of Table 9. In this scenario, we assume that the labour income disperison stops increasing and we find that the historical equity premium would be reached by 2030 if capital share of income was growing by 1.4% each year, in line with Piketty's (2014) predictions.

6 Conclusion

In this paper, we study the relationship between income inequality and stock market returns. We develop a general equilibrium model with capital owners who own 100% of the economy's financial wealth and workers who consume their labor income and income from risk-free government and corporate bonds. In addition, capital owners in our model earn labor income, in line with empirical observation on the high correlation between capital and labour top incomes. Since the capital owners 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 share of capital owners' consumption derived from risky source as well as the riskiness of investment. Both mechanisms generate higher equity premium. When the share of capital onwers' income derived from the less risky source (labour) increases, the required risk premium drops and so that equity premium. We use the genral equilibrium model to assess the total quantitative impact of changes in capital owners' income shares on equity premium.

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 labour share of income was quantitatively larger hence we observe a decrease in the equity premium consistent with the data.

We also use our set-up to carry out a number of counterfactual exercises. First we extrapolate current inequality trends into the future and, using the model, predict the potential equity premium. Second, we compute the level and growth in income inequality needed for the equity premium to go back to its historical mean.

If both capital and total income shares of top decile will grow until 2030 at the same rate as between 1970 and 2014, namely 0.5% and 0.92%, respectively, the equity premium would continue decreasing until 6.11% in 2030, 0.92 percentage point lower than historical equity premium of 7.03%. If capital share of income continues to grow at the annual rate of 0.5% and the labour share of income of top decile remains unchanged, the equity premium would be higher than the historical one by 0.14 percentage point.

If we assume that of labour share of income of top decile keeps growing at an annual 2% per year until 2030, an increase of capital share of income of 2.04% per year would be needed to replicate the historical equity premium. If instead capital share of income continues growing at the past rate of annual 0.5%, labour income inequality would need to drop for the equity premium to increase relative to the currently observed one. In fact, it would need to decrease by 3% per year to deliver historical level of equity premium. This scenario seems rather implausible. In the most likely scenario where the labour income dispersion stops increasing and we find that the historical equity premium would be reached by 2030 if capital share of income was growing by 1.4% each year, in line with Piketty's (2014) predictions.

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7 Appendix A: Numerical Simulation Procedure and Calibration

7.1 Baseline Simulation

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 (1991). 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 $I_t = I_t\left(K_{t-1}, \Delta z_t, \gamma_t^c\right)$. Dividing all equations by $\exp\left(z_{t-1}\right)$ and denoting the so transformed variables with atilde: $X_t \rightarrow \tilde{X}_t$, the system of equations is as follows:

$$\tilde{C}_t^w = (1-\alpha)(1-\theta)\tilde{Y}_t + \tilde{B}_{t-1}^{c,w} - \left(\tilde{B}_t^{c,w}/R_t^f\right)\exp\left(\Delta z_t\right)$$

$$\tilde{C}_t^c = \alpha(1-\theta)\tilde{Y}_t + D_t + \tilde{B}_{t-1}^{c,c} - \left(\tilde{B}_t^{c,c}/R_t^f\right)\exp\left(\Delta z_t\right)$$

$$\tilde{C}_t = \tilde{Y}_t - \tilde{I}_t\left(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c\right)$$

$$\tilde{D}_t = \theta\tilde{Y}_t - \tilde{I}_t\left(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c\right) - \mu\tilde{K}_{t-1} + \mu\left(\tilde{K}_t/R_t^f\right)\exp\left(\Delta z_t\right)$$

$$\tilde{Y}_t = A\left(\left(N^w\right)^{1-\alpha}\left(N^c\right)^{\alpha}\right)^{1-\theta}\tilde{K}_{t-1}^{\theta}\exp\left((1-\theta)\Delta z_t\right)$$

$$\tilde{K}_t = \left(1-\delta+G\left(\frac{\tilde{I}_t\left(\tilde{K}_{t-1}, \Delta z_t, \gamma_t^c\right)}{\tilde{K}_{t-1}}\right)\right)\tilde{K}_{t-1}\exp\left(-\Delta z_t\right)$$

$$1 = \beta E_t\left(\frac{\left(\tilde{C}_{t+1}^c\tilde{C}_t^c\right)^{-\gamma_t^c}}{E_t\left(\tilde{C}_{t+1}^c\tilde{C}_t^c\right)^{-\gamma_t^c}}R_{t+1}^k\right) \tag{20}$$

$$R_{t+1}^k = \frac{\tilde{D}_{t+1} + \frac{\left(1-G'\left(\tilde{I}_{t+1}\tilde{K}_t\right)\mu/R_{t+1}^f\right)}{G'\left(\tilde{I}_{t+1}\tilde{K}_t\right)}\tilde{K}_{t+1}}{\frac{\left(1-G'\left(\tilde{I}_t\tilde{K}_{t-1}\right)\mu/R_t^f\right)}{G'\left(\tilde{I}_t\tilde{K}_{t-1}\right)}\tilde{K}_t}$$

$$\tilde{P}_t^s = \frac{\left(1-G'\left(\tilde{I}_t\tilde{K}_{t-1}\right)\mu/R_t^f\right)}{G'\left(\tilde{I}_t\tilde{K}_{t-1}\right)}\tilde{K}_t$$

$$R^s_{t+1} = \frac{\tilde{P}^s_{t+1} \exp\left(\Delta z_t\right) + \tilde{D}_{t+1}}{\tilde{P}^s_t}$$

$$R^f_t = \beta^{-1}$$

$$R^e_{t+1} = R^s_{t+1} - R^f_t$$

$$\tilde{B}^{c,w}_t + \tilde{B}^{c,c}_t = \mu \tilde{K}_t$$

$$\tilde{B}^{c,c}_t = 0$$

$$G\left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}}\right) = \frac{a_1}{1-1\xi}\left(\frac{\tilde{I}_t\left(\tilde{K}_{t-1}, \Delta z_t, \gamma^c_t\right)}{\tilde{K}_{t-1}}\right)^{1-1\xi} + a_2$$

$$G'\left(\frac{\tilde{I}_t}{\tilde{K}_{t-1}}\right) = a_1\left(\frac{\tilde{I}_t\left(\tilde{K}_{t-1}, \Delta z_t, \gamma^c_t\right)}{\tilde{K}_{t-1}}\right)^{-1\xi}$$

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 and 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, $\tilde{I}_t\left(\tilde{K}_{t-1}, \Delta z_t, \gamma^c_t\right) = \tilde{I}_t$ is treated as an unknown. The solution is then found by solving this equation[14] in 1 unknown using Chris Sims' non-linear equation solver code csolve.[15] The iteration procedure is repeated until the iteration improves the current decision rule at any given state vector by less than some tolerance level, which we set to 10^{-12}.

[14] Specifically, this equation is the capital Euler equation (20).
[15] Available at http://sims.princeton.edu/yftp/optimize.