The Importance of Income Uncertainty on the Relationship of Inequality with the Equity Risk Premium

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Abstract

We empirically investigate the relationship between the equity risk premium, income inequality, and income uncertainty in the US economy over the period 1968-2019. Our model involves the examination of dynamic time-varying parameter responses of income inequality to income uncertainty shocks, while controlling for relevant economic and financial indicators. We also allow the relationship between income inequality and the premium to respond asymmetrically to high and low, as well as positive and negative changes in income uncertainty. Our results reveal that income inequality persistently increases the equity premium, regardless of the level of income uncertainty. However, income uncertainty reduces the positive effect of inequality on the premium only for high-income uncertainty, as it does not have any effect for low-income uncertainty.

Keywords: Equity Premium, Income Uncertainty, Inequality

JEL Classifications: C53, G12, D52, E4

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1. Introduction

Inequality, either in income or in wealth, has been rising over time and across the world (Atkinson et al., 2011; Alvaredo et al. 2013; Piketty, 2014; Solt, 2020, Smith et al. 2022). It is a widely recognized issue, as it can exacerbate market inefficiencies and cause social and economic imbalances, hindering economic growth (Berg et al., 2018). Additionally, rising inequality seems to be connected to the financial markets (Claessens and Perotti, 2007; Demirgüç-Kunt and Levine, 2009; Favilukis, 2013), which are charaffcterized by incompleteness.

A strand of finance literature, focusing on incomplete markets, investigates whether introducing an uninsurable income risk - a risk that generates income uncertainty and is also known as background risk - can contribute to the resolution of asset pricing anomalies. A representative asset pricing puzzle, the equity premium puzzle (Mehra and Prescott, 1985), which refers to the excessively high outperformance of stocks over treasury bills, has led several financial economists to examine the connection of inequality with the equity premium when an uninsurable income risk is present. Since individuals with standard preferences are not concerned about others' consumption per se, the introduction of an uninsurable income risk exhibiting systematic variations could lead to aggregate discount rates that fluctuate with inequality (Mankiw, 1986; Constantinides and Duffie, 1996).

Constantinides and Duffie (1996) show that inequality and the equity premium are positively related in an economy with background risk. Ait-Sahalia et al. (2004) show that inequality is correlated with the magnitude of the background risk. Gollier (2001), in his seminal study, examines both a fully insurable economy as well as an economy with a background risk, and shows that the direction of the effect of inequality on the equity risk premium depends on the concavity of the absolute risk tolerance. In more recent studies, Gârleanu and Panageas (2015) find an inverse relationship between inequality and the equity premium, while Toda and Walsh (2020) and Gomez (2022) extend these findings in an incomplete market model with heterogeneous agents in terms of risk aversion and belief. Also, Favilukis (2013) finds that when wage inequality increases, and participation costs fall, the equity premium can decline substantially. Pástor and Veronesi (2016) emphasize on the impact of redistributive taxation on equity premium and inequality and find a positive relationship which becomes negative with the tax rate. Johnson (2012) shows that stock returns that move in the same direction with inequality, tend to attract a negative premium, while Christou et al. (2021) predict that rising income inequality generates a larger equity premium.

Motivated by the findings from the finance literature, we empirically investigate the relationship between the equity premium, income inequality, and income uncertainty as measured by a background risk. Considering the correlation of inequality with the magnitude of the background risk, as well as the ambiguous relationship of the equity premium with inequality, as documented in literature, we examine the impact of income inequality on the equity premium, considering varying levels of background risk. Gollier (2001) examined, from a theoretical perspective, a similar question with wealth inequality, and showed that for a low level of background risk wealth inequality increases the equity risk premium, while for a high level of background risk wealth inequality reduces the equity risk premium. Intuitively, a background risk reduces the degree of risk tolerance because agents with standard preferences, such as with HARA (hyperbolic absolute risk aversion) utility, are risk vulnerable (Gollier and Pratt, 1996). When the background risk is small, the wealthy are less negatively impacted in terms of their risk tolerance compared to the poor, suggesting that risk tolerance exhibits concavity. As a result, wealth inequality raises the premium for a low background risk (Gollier, 2001).

We utilize data from the US economy, over the time-period 1968-2019. Our methodology involves the examination of dynamic time-varying parameter responses of income inequality to income uncertainty shocks. We also control for relevant financial and economic indicators to account for possible omitted variable bias and allow the relationship between income inequality and the premium to respond asymmetrically to high and low, as well as positive and negative changes in income uncertainty. Due to data limitations, we focus on income inequality, instead of wealth inequality. Black et al. (2020) suggest that labor income seems to be the primary determinant of wealth for the majority of the population. Hence, there may exist cases in which predictions using income inequality can be similar to predictions of wealth inequality. In these scenarios, we might be able to verify empirically, although to a limited extent, Gollier's (2001) equivalent findings.

Our findings indicate that inequality consistently leads to a rise in the equity premium, regardless of the level or change in income uncertainty. Income uncertainty diminishes the positive impact of inequality on the premium for high-income uncertainty. However, in the scenario of low-income uncertainty, a decrease in income uncertainty will not have any effect on the positive impact of inequality on the premium. The empirical findings that we obtain confirm the theoretical findings of Gollier (2001) that demonstrate a positive relationship between inequality and the equity premium when background risk is low.

The remainder of the paper is organized in the following sections: Section 2 discusses the data and variables; Section 3 discusses the model and methodology; Section 4 analyzes the results and Section 5 concludes.

2. Data and Variables

The data utilized in the paper include the equity risk premium (EP), income inequality ($INEQ$) and income uncertainty (IU), as well as indices of economic (EAI) and financial activity (FAI). All data correspond to the US economy during the period 1968-2019. The dependent variable, EP (Figure 1a), is defined as the total rate of return on the stock market minus the prevailing short-term interest rate (risk-free rate). We use monthly S&P 500 index returns from the Center for Research in Security Press (CRSP) to construct stock returns (continuously compounded S&P 500 index returns, including dividends). The treasury-bill rates proxy risk-free rate values.

To measure $INEQ$ (Figure 1b), we use the Gini index of income. US data is available annually through the National Income and Product Accounts (NIPA) from the Bureau of Economic Analysis (BEA). We utilize the Boot et al. (1967) linear temporal disaggregation of the annual Gini index of income to change its frequency to monthly observations while maintaining its average.

We also construct financial (FAI) and economic activity (EAI) indices (Figures 1c. and 1d., respectively) from Welch and Goyal's (2008) equity premium (EP) predictors and macroeconomic variables proposed by McCracken and Ng (2016). FAI and EAI are defined as first principal components. Neely et al. (2014) and Buncic and Tischhauser (2017) employed the same EP modeling dataset for a different period. Moreover, the McCracken and Ng (2016) and Stock and Watson (2002a, b) datasets share predictive content.

Labor income (LI) is defined as the natural log of the real personal income minus transfers. Data in monthly frequency is available from the Federal Reserve Economic Database. To remove random variations, we report the series with its 12-month moving average ($LIMA$). To estimate the IU, we first construct a 7-year series of rolling standard deviations of $LIMA$ ($LIMA\_SD$), as shown in Figure 1e. Then IU is measured as the conditional $GARCH$ (2,2) variance of $LIMA\_SD$ as illustrated by Figure 1f. The main advantage of using $GARCH$ modelling over the rolling standard deviations of the labor income moving average, is that $GARCH$ models tend to be more flexible and can take advantage of the whole data set when estimating income uncertainty, capturing long-term volatility patterns. $GARCH$ models have also been used in literature to assess conditional volatility of idiosyncratic risk (Fu, 2009).

It is typical to use maximum likelihood method (ML) to estimate $GARCH$ models, with the most popular technique being the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm. We select a $GARCH(2,2)$ variant based on its ability to generate the highest log likelihood value, among other specifications, such as $GARCH(1,1)$, $GARCH(1,2)$, $GARCH(2,1)$, $E-GARCH(2,2)$, and $GJR\ GARCH(1,1)$ that produce similar results. The specification of our preferred $GARCH\ (2,2)$ is as follows: $LIMA\_SD_t = \kappa_0 + \varepsilon_t$ (1)

$$IU_t = \lambda_0 + \sum_{i=1}^{2} \mu_i \, \varepsilon_{t-i}^2 + \sum_{i=1}^{2} \nu_i IU_{t-i} \quad (2)$$

The estimated parameters of our model can be found in Table 1 and indicate, through the large log likelihood value, that the model can explain income uncertainty with high accuracy. Figure 1 shows historical observations from our data series. There is evidence of a declining equity premium (Figure 1a) and rising income inequality (Figure 1b), while financial activity (Figure 1c) shows diminishing fluctuations and economic activity (Figure 1d) is increasing. From the late 1960s to the 1980s, we observe a significant and growing level of income uncertainty (Figure 1f). After the mid 1980s, income uncertainty decreases and remains consistently low till the early 2010s. This pattern seems to be associated with the declining inflation of the 1980s and an anchored inflation rate of 2% since the 1990s. It is possible that the Great Recession might be the primary driver for the observed rise in income uncertainty in the early 2010s.

Table 1. $GARCH(2,2)$ Estimates

	Coefficients
κ_0	0.109*** (0.00006)
λ_0	0.000000019 (0.000000021)
μ_1	1.476*** (0.1291)
μ_2	-0.463 (0.1891)
ν_1	-0.304 (0.1891)
ν_2	0.290*** (0.0961)
Time Period	1968:02 - 2019:12
Log Likelihood	1441

Note: ML estimation, using the BFGS algorithm. Standard errors in parentheses. *p<10%; **p<5%; ***p<1%.

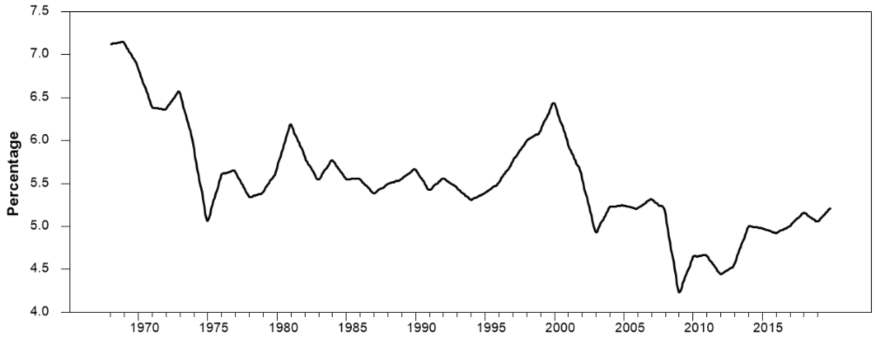

Figure 1. Historical data plots, 1968:01–2019:12. Figure 1a. Equity Risk Premium

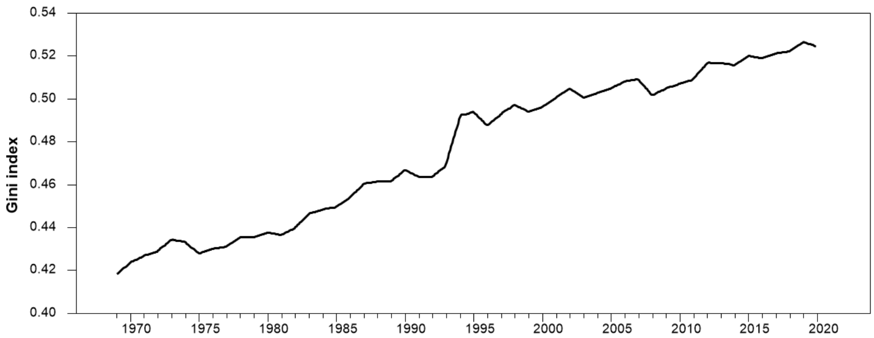

Figure 1b. Income Inequality

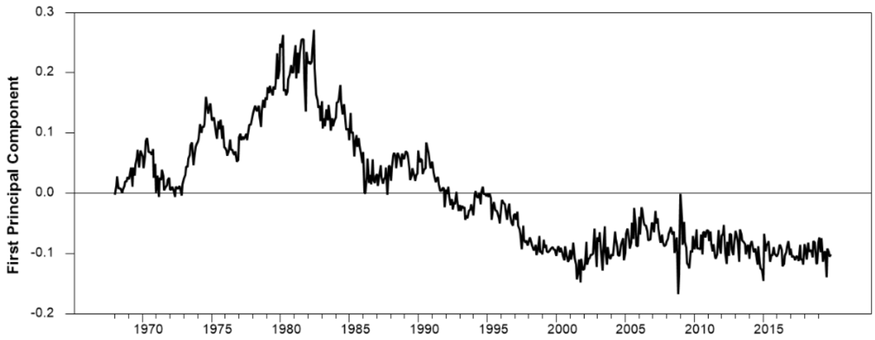

Figure 1c. Financial Activity Index

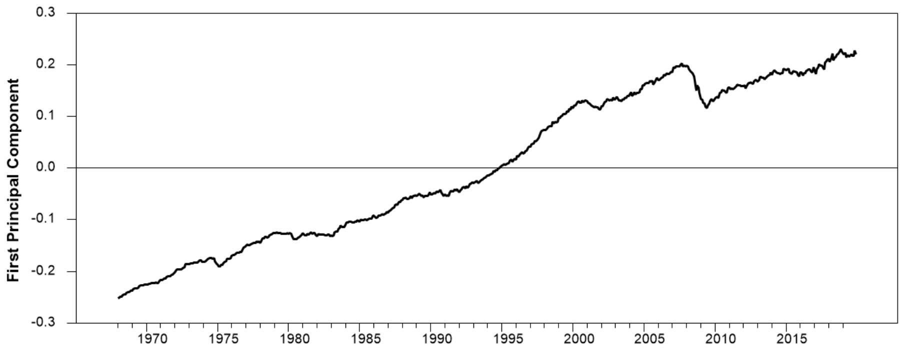

Figure 1d. Economic Activity Index

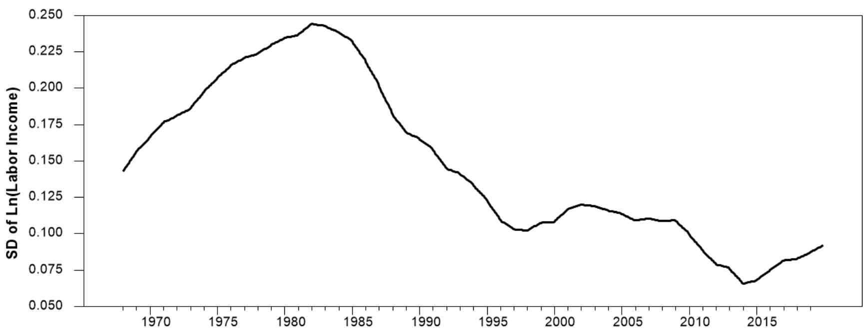

Figure 1e. Rolling Standard Deviations of Labor Income ($LIMA\_SD$)

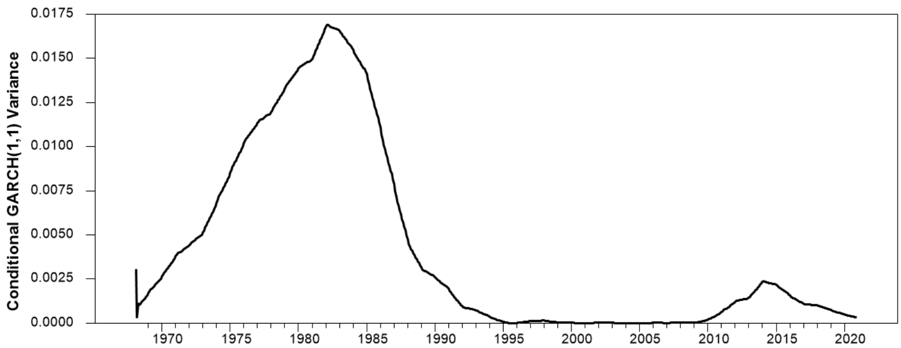

Figure 1f. Income Uncertainty (IU)

3. Model and Methodology

The conventional framework for the EP predictability analysis is the linear regression model of the following form:

$$EP_t = \beta_0 + \boldsymbol{X}_{t-1}\boldsymbol{\beta} + e_t, \quad (3)$$

where EP_t is the equity risk premium at time t, β_0 is an intercept term, $\boldsymbol{\beta}$ is an p × 1-dimensional vector of p slope parameters, $\boldsymbol{X}$ is an $n \times p$-dimensional vector of p predictor variables observed at time $t-1$, and e_t is the disturbance term with a zero mean.

To examine IU effects on the relationship between $INEQ$ and EP, we conduct a two-step estimation. In the first step, we model EP as a function of the first lag of EP, $INEQ$, EAI, and FAI. As illustrated by Equation (3), the conventional framework for the equation does not account for the structure and behavior changes between EP and its determinants, as it forces the estimated coefficients to remain constant for the whole regression period.

Thus, we utilize Markov chain Monte Carlo (MCMC) to estimate the time-varying parameters (TVP) in the equity premium equation. MCMC combines the Monte Carlo technique for random sampling and approximating probability distributions and the Markov Chain for defining the transition from one state to another, based on a specific probabilistic rule. The main challenge that motivates the usage of the MCMC algorithm is the evaluation of the posterior distribution of $\boldsymbol{\beta}$ in the following Bayesian setting:

$$\mathbb{P}(\boldsymbol{\beta}|D) = \frac{\mathbb{P}(D|\boldsymbol{\beta})\ \mathbb{P}(\boldsymbol{\beta})}{\sum_{j=1}^{N}\mathbb{P}(D|\boldsymbol{\beta})\ \mathbb{P}(\boldsymbol{\beta})} = \frac{\mathbb{P}(D|\boldsymbol{\beta})\ \mathbb{P}(\boldsymbol{\beta})}{\mathbb{P}(\mathrm{D})}, \quad (4)$$

where $\boldsymbol{\beta}$ is the parameter vector, D is the available data, $\mathbb{P}(\boldsymbol{\beta})$ is the prior probability of $\boldsymbol{\beta}$, $\mathbb{P}(\boldsymbol{\beta}|D)$, is the posterior probability of β given D, $\mathbb{P}(D|\boldsymbol{\beta})$, is the probability of D given $\boldsymbol{\beta}$, and $P(D)$ is the marginal probability of D. As the size of the sample space increases exponentially with each additional parameter, evaluating the marginal density imposes serious challenges, either empirically or analytically. MCMC resolves the problem of recovering the posterior distribution, by directly drawing a large number of samples of $\boldsymbol{\beta}s$ from $\mathbb{P}(\boldsymbol{\beta}|D)$. Then, MCMC forms sample averages to approximate the posterior probability (Monte Carlo approximation). Next, MCMC utilizes the Gibbs sampling algorithm to construct the Markov chain where the probability of the next sample (β_t) is calculated as the conditional probability, given the prior sample (β_{t-1}). For instance, let's assume that we start with n chains for $\boldsymbol{\beta}$, of length i 0 to T, $(\beta_{1,i}, \beta_{2,i}, \beta_{3,i}, \ \dots, \beta_{n,i})$. The sequence of $\boldsymbol{\beta}$s will evolve according to the following scheme:

$$\beta_{1,1} \sim f\left(\beta_{1,1}\middle|\beta_{2,0}, \beta_{3,0}, \dots, \beta_{n,0}, D^1\right)$$

$$\beta_{2,1} \sim f\left(\beta_{2,1}\middle|\beta_{1,1}, \beta_{3,0}, \dots, \beta_{n,0}, D^1\right)$$

$$\beta_{3,1} \sim f\left(\beta_{3,1}\middle|\beta_{1,1}, \beta_{2,1}, \dots, \beta_{n,0}, D^1\right)$$

$\beta_{n,1} \sim f(\beta_{n,1}|\beta_{1,1},\beta_{2,1},\dots,\beta_{n-1,1},D^1)$

$\beta_{1,2} \sim f(\beta_{1,2}|\beta_{2,1},\beta_{3,1},\dots,\beta_{n,1}, D^2)$

$$\beta_{n,T} \sim f(\beta_{n,T}|\beta_{1,T},\beta_{2,T},\dots,\beta_{n-1,T},D^T) \quad (5)$$

Our empirical model allows the unobservable state parameter to follow independent random walks. Thus, the empirical work is based on the following state-space representation of unobservable state variables:

$\beta_t = \beta_{t-1} + w_t$

$$w_t \sim N(0,Q) \quad (6)$$

where w_t is a shock to the state equation that is assumed to have a zero mean and normal distribution. Q is defined as the variance of the shock to the state equation.

The measurement equation is as follows:

$\Delta EP_t = \beta_{0t} + \beta_{1t}EP_{t-1} + \beta_{2t}\mathrm{INEQ}_{t-1} + \beta_{3t}\mathrm{FAI}_{t-1} + \beta_{4t}\mathrm{EAI}_{t-1} + e_t,$

$t = 1,\dots,T$

$$e_t \sim N(0,\sigma_e^2), \quad (7)$$

where the time-varying parameters (TVPs) are estimated with a Markov switching variances of e_t. Thus, Equation (7) generates a time series for β_{2t} that account for the potential response of ΔEP to the changes in $INEQ$ over time. Unlike Equation (3), MCMC generates a time series that captures the varying responses of ΔEP to $INEQ$ while accounting for the lagged effect of FAI, EAI, and EP itself.

In the second step, we examine the relationship between the TVP of $INEQ$ and IU. We do so by examining two different specifications for β_{2t} as a function of IU:

Specification (I):

$\beta_{2t} = \delta_1 + \delta_2\, IU_{t-1} + \delta_3\, FAI_{t-1} + \delta_4 EAI_{t-1} + \delta_5\, \beta_{2t-1} + \omega_{1t}$

Specification (II):

$\beta_{2t} = \alpha_1 + \alpha_2\, IU_{H,t-1} + \alpha_3\, IU_{L,t-1} + \alpha_4\, FAI_{t-1} + \alpha_5\, EAI_{t-1} + \alpha_6\, \beta_{2t-1} + \omega_{2t}$

with

$$\omega_{it} \sim N(0,\sigma_{i\omega}^2). \quad (8)$$

We define the different cases of IU as follows:

$IU_{H,t} = IU_t \ if \ IU_t > \overline{IU}$, $and \ IU_{L,t} = IU_t \ if \ IU_t < \overline{IU}$, i.e. income uncertainty is high (resp. low) if it is above (resp. below) the average level of IU. Specification (II) considers high ($IU_{H,t-1}$) and low ($IU_{L,t-1}$) levels of income uncertainty, when estimating the TVP of $INEQ$.

4. Results and Discussion

In this section we present and discuss our findings. For starters, we provide estimation results from the first step of our methodology, corresponding to measurement equation (7). Given that the parameters are time-varying, Table 2 summarizes the estimated means of the TVPs from the measurement equation (7). It also provides information on standard deviations and other descriptive statistics (min, median and max). It is evident that all but the TVP of EAI are statistically significant and the model is well fitted in the data, as indicated from the large R^2. The evolution of each time-varying parameter is depicted in Figure 2. We also verify that the ΔEP (first difference of the equity premium) and its in-sample forecasts are an almost perfect fit, as depicted in Figure 3. We are specifically interested in the TVP of $INEQ$ (β_{2t}) for our next step. The positive TVP of $INEQ$ implies that inequality positively affects the equity premium.

Table 2. Measurement equation estimations

	Mean	**Std. Dev.**	**Min.**	**Median**	**Max.**
Estimates					
β_{1t}	0.9949***	0.000074	0.9947	0.9949	0.9950
β_{2t}	0.0785***	0.0282	0.0395	0.0876	0.1133
β_{3t}	0.0022***	0.0001	0.0020	0.0022	0.0024
β_{4t}	0.0024	0.0011	0.0005	0.0019	0.0045
R^2	0.9200				

Notes: Table 2 reports the estimated mean and std. deviation of the TVPs of the measurement equation (5), along with other descriptive statistics (min, median, max) and the R-squared. *p<10%; **p<5%; ***p<1%.

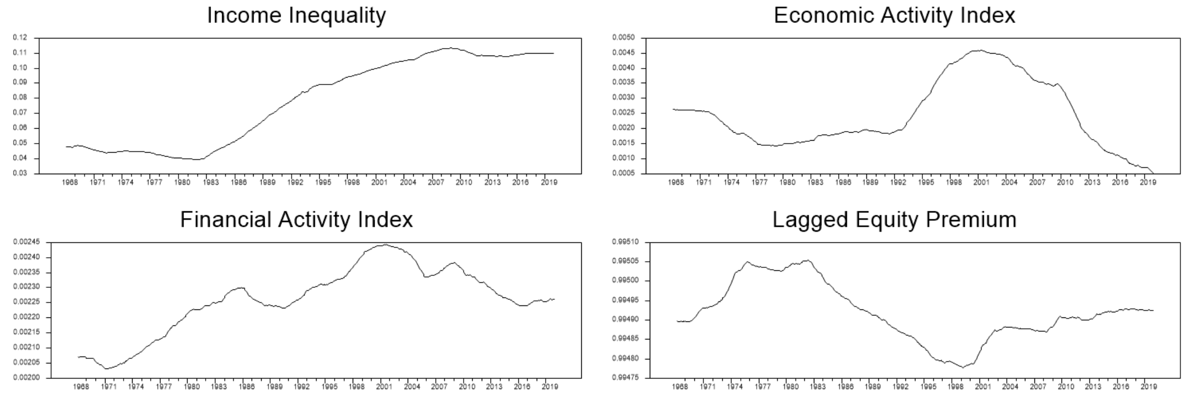

Figure 2. Time-varying parameters estimated through measurement equation (7).

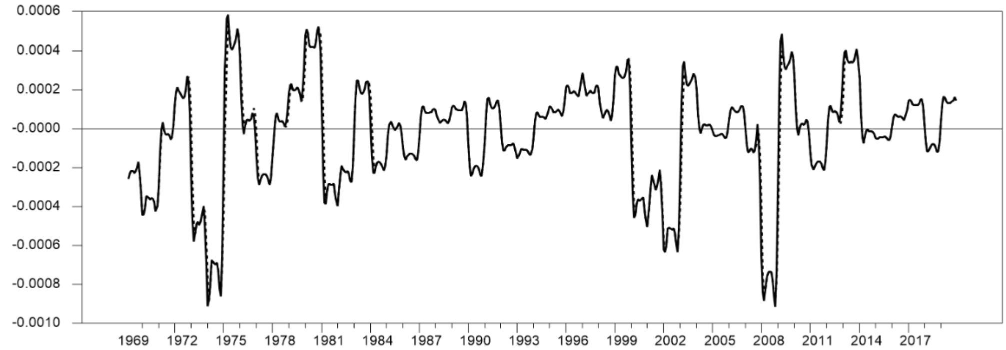

Figure 3. The First Difference Equity Premium (___) and its in-Sample Forecasts (---), calculated by MCMC.

Now we proceed to the second step of our methodology, by quantifying the relationship of the TVP of $INEQ$ with IU (Equations (8)). We focus on estimating the positive effect of inequality on the premium (β_{2t}) as function of income uncertainty (IU), examining two different specifications through OLS regressions. We need to note that β_{2t} will always be positive, as suggested from Table 2 results, so the question now is transferred to whether IU will enhance or weaken this effect.

Table 3 reports the OLS estimates of the Specifications (I) and (II) from Equations (8), with a consistent covariance matrix that allows for heteroscedasticity and serial correlation. According to Specification (I), there is a negative relationship between income uncertainty and the time varying parameter of income inequality (β_{2t}), implying that a rise in income uncertainty weakens the positive effect of inequality on the equity premium.

Specification (II) allows β_{2t} to respond asymmetrically to high and low levels of income uncertainty (IU). We observe that when IU is high, there is a negative and statistically significant relationship between IU and β_{2t}, implying that the positive effect of income inequality on the premium significantly decreases at a high level of income uncertainty (IU_H). On the other hand, when IU is low (IU_L), the negative relationship between IU and β_{2t} is statistically insignificant, suggesting that at a low level of income uncertainty, we do not expect the positive effect of inequality on the premium to decrease.

The closest we can examine Gollier's (2001) theoretical results from an empirical perspective is Specification (II). Specifically, Gollier (2001) shows that for low background risk, inequality increases the premium, while for large background risk, inequality decreases the premium. Our empirical results partially support Gollier's (2001) theoretical results, as we find positive relationship of inequality with the equity premium for a low level of background risk.

Table 3. Time-Varying Parameter of Inequality Estimates

	(I)	(II)
Constant	-0.004*** (0.0003)	-0.004*** (0.0004)
IU_{t-1}	-0.040*** (0.0061)	
$IU_{H,t-1}$		-0.0374*** (0.0069)
$IU_{L,t-1}$		-0.0233 (0.0174)
FAI_{t-1}	2.488*** (0.2402)	2.455*** (0.2505)
EAI_{t-1}	-0.112*** (0.0183)	-0.104*** (0.0207)
$TVP\ on\ INEQ_t$	0.988*** (0.0014)	0.988*** (0.0015)
$Log\ Likelihood$	4566.091	4561.830
$\bar{R}^2$	0.9999	0.9999

Notes: OLS Regressions. Dependent variable is the TVP on $INEQ$. Standard errors in parentheses. *p<10%; **p<5%; ***p<1%.

5. Conclusion

Several asset pricing studies have examined the impact of inequality on the equity risk premium. However, the findings are mixed, both in terms of the direction and the magnitude of the effect. We contribute to the finance literature by empirically investigating the relationship of income inequality and the equity premium, considering varying levels of income uncertainty. In order to achieve this objective, we utilize data from the US economy from 1968 to 2019, specifically focusing on the time-varying parameter responses of income inequality to shocks on income uncertainty. We also incorporate relevant financial and economic indicators to mitigate the possible problem of omitted variable bias. Our results indicate that inequality increases the equity premium, however income uncertainty can significantly weaken this effect. Specifically, when income uncertainty is high, there is a negative and statistically significant relationship between income uncertainty and the positive impact of inequality on the premium. On the other hand, when income uncertainty is low, the positive impact of inequality on the premium does not decrease.

As a future endeavor, it would be worthwhile to expand this research topic by examining, both theoretically and empirically, asymmetric changes (positive or negative) in income uncertainty and how they affect the positive relationship of income inequality with the equity premium. Furthermore, this methodology could be applied to a panel of developed and emerging nations, examining whether and how the dynamics of income inequality, income uncertainty and equity premium vary. Lastly, given data availability, it would be interesting to examine how wealth inequality might influence these dynamics.

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Appendix

The set of equity premium predictors of Welch and Goyal (2008) that we utilize to construct our Financial Activity Index (FAI) is the following:

1. Dividend-price ratio (log), DP: log of dividends paid on the S&P 500 index minus the log of stock prices (S&P 500 index).

2. Dividend yield (log), DY: log of dividends minus the log of lagged stock prices.

3. Earnings-price ratio (log), EP: log of earnings on the S&P 500 index minus the log of stock prices.

4. Dividend-payout ratio (log), DE: log of dividends minus the log of earnings.

5. Equity risk premium volatility, RVOL: is based on the moving standard deviation estimator

6. Book-to-market ratio, BM: book-to-market value ratio for the Dow Jones Industrial Average.

7. Net equity expansion, NTIS: ratio of net equity issues by NYSE-listed stocks to the total end-of-year market capitalization of NYSE stocks.

8. Long-term yield, LTY: long-term government bond yield.

9. Long-term return, LTR: return on long-term government bonds.

10. Term spread, TMS: long-term yield minus the Treasury bill rate.

11. Default yield spread, DFY: difference between Moody's BAA- and AAA-rated corporate bond yields.

12. Default return spread, DFR: long-term corporate bond return minus the long-term government bond return.

13. Inflation, INFL: calculated from the Consumer Price Index (CPI) for all urban consumers

The set of McCracken and Ng (2016) macroeconomic variables that we use to construct our Economic Activity Index (EAI) is the following:

INDPRO: IP (Industrial Production) Total Index

IPFPNSS: IP Final Products and Nonindustrial Supplies

IPFINAL: IP Final Products (Market Group)

IPCONGD: IP Consumer Goods

IPDCONGD: IP Durable Consumer Goods

IPNCONGD: IP Nondurable Consumer Goods

IPBUSEQ: IP Business Equipment

IPMAT: IP Materials

IPDMAT: IP Durable Materials

IPNMAT: IP Nondurable Materials

IPMANSICS: IP Manufacturing (SIC)

IPB51222S: IP Residential Utilities

IPFUELS: IP Fuels

CUMFNS: Capacity Utilization Manufacturing

CONSPI: Nonrevolving consumer credit to Personal Income

M1SL: M1 Money Stock

M2SL: M2 Money Stock

M2REAL: Real M2 Money Stock

BOGMBASE: Monetary Base

TOTRESNS: Total Reserves of Depository Institutions

NONBORRES: Reserves of Depository Institutions

BUSLOANS: Commercial and Industrial Loans

REALLN: Real Estate Loans at All Commercial Banks

NONREVSL: Total Nonrevolving Credit

For the series (1) - (14) the transformation implemented is $\Delta \log (x_t)$, for (15) it is Δx_t and for variables (16) – (24) it is $\Delta^2 \log (x_t)$, where x_t is the corresponding variable in each case.

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