The Equity Premium Puzzle

- Is it still a puzzle?

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Abstract

Using U.S. data from 1989-2024, this study revisits the Mehra–Prescott consumption-based asset-pricing model. The standard calibration leaves almost the entire nine-percentage-point equity premium unexplained. Adding cumulative prospect theory with myopic loss aversion and bootstrapping monthly returns shows that, with textbook parameters, equities and Treasury bills deliver equal utility only at an 11-month evaluation horizon; the implied premium then matches reality but justifies a 25 percent equity share. Re-estimating the prospect-theory parameters narrows model error tenfold and cuts the horizon to seven months, yet still predicts equity weights far below the 40–70 percent held by diversified U.S. investors. Thus, loss-averse monitoring helps explain the premium's level but not investors' heavy equity positions, pointing to the need for additional frictions such as disaster risk or heterogeneity.

Division of Responsibilities

In this section it is described who of the authors of this paper is responsible for each part of the paper.

Jonas Theodor Schmidt (mcp656): Section 1, 3.1, 3.3, 4.3, 5.2, 5.3, 6.1.2, 6.2

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All code was run in Python; see the attachments for the full file. Please note that replicating the bootstrapping process may take up to an hour to complete.

Preface: AI

In this paper, AI has been utilized for code support, proofreading, and suggestions for formulation; however, the primary work and contributions are of the authors.

Summary

1 Introduction

The Equity Premium Puzzle, first introduced by Mehra and Prescott (1985), describes one of the most persistent anomalies in financial economics: the large, unexplained gap between returns on equities and riskless securities. In the United States, from 1889 to 1978, the average real return on equities was 6.98 percent, compared to just 0.8 percent for treasury bills—a gap that standard consumption-based asset pricing models cannot explain without invoking implausibly high levels of risk aversion.

Inspired by the work of Mehra and Prescott (1985), this paper examines the equity premium puzzle through a modern lens, using return data from the past 35 years to assess whether the gap has diminished, persisted, or expanded. Furthermore, it analyzes whether Myopic Loss Aversion (Benartzi and Thaler, 1995) can help resolve the puzzle.

At the heart of the puzzle lies the consumption-based asset pricing model. According to this model, an asset's expected premium depends on two primitives: the investor's coefficient of relative risk aversion and the degree to which the asset's payoff covaries with aggregate consumption. To rationalize the observed gap, numerous modifications to the model have been proposed, with few proving particularly successful on their own. One descriptive model rooted in behavioral economics that has shown considerable promise is Myopic Loss Aversion (Benartzi and Thaler, 1995). It posits that investors disproportionately dislike losses and, crucially, monitor their portfolios too frequently. This frequent evaluation horizon amplifies the pain of short-term drawdowns, thereby increasing the premium investors demand for holding risky assets.

To examine the Equity Premium Puzzle through the lens of Mehra and Prescott (1985) as well as Myopic Loss Aversion, the paper uses monthly observations of the S&P 500 Total Return index, the S&P 0–3-Month T-Bill Total Return index, Real Personal Consumption Expenditures and Price index over the period December 1989 to December 2024. Following Mehra and Prescott (1985), nominal returns and consumption changes are deflated. Furthermore, the assumption of joint log-normality of equity returns and consumption growth is imposed.

To analyze whether Myopic Loss Aversion offers a solution, this paper uses a block-bootstrap procedure that resamples nominal return blocks of one to eighteen months, preserving serial dependence while generating 100,000 synthetic returns for each horizon. For each horizon, the analysis computes Cumulative Prospect Theory (CPT) utilities for stocks and bonds (T-bills) to pinpoint where the two utilities intersect, identifying the evaluation horizon. It then asks whether the CPT utility–maximizing portfolio weights align with historical stock and bond allocations. Next, it examines whether the model-implied equity premium aligns with the historical premium. Finally, it optimizes the fit of the model-implied premium to the historical series using modern CPT parameter bounds. With these optimized parameters the intersection of utilities and the utility-maximizing are revisited. Finally, the graphical fit is commented on.

The paper highlights three findings. First, when using Mehra & Prescott's original parameter values applied to modern data, the puzzle has deepened: it shows an equity premium has widened by almost four times more than observed in the original 1889–1978 sample, requiring even higher levels of risk-aversion than originally proposed to match the historical premium. Second, the Cumulative Prospect Theory framework, using parameters from Kahneman & Tversky, selects an evaluation horizon of about 11 to 12 months—roughly the interval at which individual investors file tax returns and receive annual reports—at that horizon, the model's predicted premium of 9.57 percent matches the realized premium of 9.51 percent. Third, the same calibration finds the CPT utility-maximizing portfolio to hold 25 percent equities, well below the 40–70 percent equity share recorded for Investment and Insurance Corporations & Pension Funds.

After optimizing the parameters using modern parameter bounds, the squared error between the model-implied and realized premia falls from 0.0209 to 0.0024. With the optimized parameters, the intersection of stock and bond utilities occurs at 7 months. Furthermore, using the optimized parameters, the 100 percent stock/0 percent bond weights continue to misalign with the observed investment fund and insurance/pension fund stock allocations. Although the graphical fit improves under optimization within reasonable parameter bounds, it still does not flatten out in the same way as the historical premium.

Hence, Myopic Loss Aversion serves as a powerful yet still partial resolution. By combining loss aversion with frequent evaluation, it reproduces the level of the equity premium without resorting to implausible risk aversion. However, it does not fully capture investors' willingness to hold large equity stakes. Bridging the gap further will require additional frictions or the inclusion of other factors to account for historically observed returns.

2 Financial Theory

2.1 Understanding the Equity Premium Puzzle

The Equity Premium Puzzle (EPP) highlights the intriguing contrast between the robust returns on equities − such as U.S. stocks − and the comparatively modest yields on risk-free government bonds. Consumption-based asset pricing typically assumes that investors behave in a fully rational manner, pricing assets based on moderate levels of risk aversion and relatively smooth consumption growth. Nevertheless, historical data reveal a persistent gap between these theoretical predictions and the realized market premium. This disparity raises fundamental questions about how risk is perceived in practice, how investors weigh uncertainty against expected returns, and whether market behaviors can be fully explained by conventional economic assumptions.

The Equity Premium Puzzle has inspired a wide range of potential explanations for why returns on stocks exceed those on risk-free securities by such a noticeable margin. In the more traditional realm, economists have pointed to factors like incomplete markets, which can prevent certain groups of investors from fully participating in equity investments, or the possibility of rare but devastating events that create an elevated need for compensation (Julliard and Ghosh, 2008). Demographic shifts − such as changing birth rates or evolving workforce participation − have also been considered, as they can affect how different generations allocate their assets, and cross-country institutional differences (Ang and Maddaloni, 2005). In 2003, Mehra and Prescott discussed *The Equity Premium Puzzle in Retrospect*. Overall, they argue that the equity premium puzzle stems from mismeasurement, suggesting that once taxes, regulations, and intangible capital are accounted for, the high equity returns align with standard models. However, their explanation still requires implausibly high risk aversion values and negative risk-free returns, leaving key aspects of the puzzle unresolved (Imrohoroglu, 2004).

Therefore, a possible solution lies in behavioral explanations, which emphasize the role of human psychology rather than solely rational calculations. One particularly influential theory is "Myopic

Loss Aversion" Benartzi & Thaler (1995). This perspective suggests that investors tend to monitor their portfolios frequently, becoming especially wary of even minor losses in the short term. Because short-term fluctuations can feel more painful than the pleasure gained from equivalent gains, investors may demand a larger premium on equities to compensate for the possibility of temporary downturns.

2.2 Can Myopic Loss Aversion Explain EPP?

This paper focuses on the possible explanation of Myopic Loss Aversion. This theory was brought to light in 1995 by Benartzi & Thaler, building on insights from Kahneman & Tversky's Prospect Theory (1979). Under Prospect Theory, individuals treat potential gains and losses asymmetrically, placing disproportionate weight on the pain of incurring losses. Benartzi & Thaler argued that when investors evaluate their portfolios frequently − over short intervals, such as monthly or quarterly − they are more likely to witness episodes of loss, even for investments that might be profitable in the long run. As a result, these short-term losses loom larger in the decision-making process than comparable gains, prompting investors to demand higher compensation to hold riskier assets like equities.

Essentially, Myopic Loss Aversion combines two concepts: a pronounced aversion to losses (loss aversion) and a tendency to evaluate outcomes on a myopic, or short-term, basis. This heightened sensitivity to dips in portfolio value can amplify the perceived risk of holding stocks, given their inherent volatility. Even if an equity investment offers a favorable trajectory over multiple years, momentary downturns may be magnified in investors' minds when viewed through frequent updates and news cycles. Consequently, the required rate of return, i.e., the Equity Premium, rises to account for this behavioral bias.

3 Model Theory

3.1 Why is it a Puzzle?

The model of Mehra & Prescott (1985) is based on a representative agent economy consisting of a discrete time model, $t = 0, 1, 2, \dots T$, as well as assuming that consumption growth is stochastic. That is, the growth rate of consumption, g_t, follows a Markov Process, i.e., a memory-less process. The representative agent has time-separable utility preferences with constant relative risk aversion (CRRA):

$$U = E_0\left[\sum_{t=0}^{\infty} \beta^t U(C_t)\right], \qquad U(C_t) = \frac{C_t^{1-\gamma} - 1}{1-\gamma}, \tag{3.1.1}$$

hence $U(C_t)$ is the CRRA utility function of consumption at time t, C_t, and γ being the coefficient of risk aversion with $0 < \gamma < \infty$ where $\gamma = 0$ is considered risk-neutral as $U(C_t)$ is linear in C_t and $\gamma \to \infty$ posists infinite risk aversion. In the case of $\gamma = 1$, the limit of the utility function is $\ln(C_t)$ as by l'Hôpital's rule.[1]

β is the subjective discount factor with $0 < \beta < 1$, hence for $\beta \to 1$, the agent becomes more 'patient', attaching nearly the same importance to future consumption as to current consumption. In this setting, β directly influences asset prices and returns, because a more patient representative agent is generally willing to defer consumption, which affects how they price risky and risk-free assets over time. Therefore, β differs from the original setting as in CAPM where an asset's β_{CAPM}

[1] $\lim_{\gamma \to 1} \frac{C^{1-\gamma}-1}{1-\gamma} = \ln(C)$

measures how its return move relative to the overall market portfolio. In other words, it is a purely market-based notion of risk. Here, β follows the distinctions of a Consumption-CAPM (CCAPM) where asset's payoffs co-vary with aggregate consumption growth, rather than with the market portfolio's fluctuations.
The puzzle arises as the CCAPM typically implies a much lower compensation for risk than what has historically been observed due to real-world consumption growth being relatively stable with few outliers due to economic shifts. Therefore, with moderate risk aversion and a plausible β, Mehra & Prescott lights the struggle to generate the high annual premiums that equities have commanded over risk-free assets.
To match the high equity premium in the CCAPM setting, the risk aversion parameter, γ needs to be pushed to unrealistically large values (typically > 30) or adjust β beyond economically reasonable parameter values.

3.2 Analysis of the Mehra & Prescott Model

To analyze the Equity Premium in today's time, we use the utility function in equation (3.1.1) and assume that the agent faces the budget constraint:

$$C_t + P_t a_{t+1} = Y_t + (P_t + D_t)\, a_t$$

where P_t is the price of the asset at time t, a_t is the quantity of shares held in the asset at time t, Y_t is the income at time t, and D_t is the dividend paid by the asset at time t.
Moreover, we use that the consumption growth:

$$g_{t+1} = \frac{C_{t+1}}{C_t},$$

is i.i.d and lognormal [2]. Therefore, by defining the Marginal Rate of Consumption and inserting the consumption growth yields:

$$\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \Rightarrow g_{t+1}^{-\gamma}$$

Now we turn to Asset Returns, R_t, and consider the economy with two assets in our setting:

- R_f being the real known return of the risk-free bond.
- R_e being the stochastic real total return of the risky asset.

By constructing the Lagrange w.r.t the Budget Constraint and considering the F.O.Cs of C_t and a_{t+1}:

$$\mathcal{L} = E_0\left[\sum_{t=0}^{\infty} \beta^t U(C_t) + \lambda_t \left(Y_t + (P_t + D_t)\, a_t - C_t - P_t a_{t+1}\right)\right],$$

we derive the Euler Equation given in the Mehra & Prescott model for Asset Pricing as:

$$P_t U'(C_t) = \beta \mathbb{E}_t\left[U'(C_{t+1})\,(P_{t+1} + D_{t+1})\right]$$

It states that the price of the asset today, P_t, multiplied by the marginal utility of consumption today, $U'(C_t)$, equals the expected discounted value of the asset's future payoff $(P_{t+1} + D_{t+1})$ multiplied

[2] $E[g] = e^{\mu_g + \frac{1}{2}\sigma_g^2} \qquad E[g^n] = e^{n\mu_p + \frac{1}{2}n^2\sigma_g^2}$

by the marginal utility of consumption in the next period, $U'(C_{t+1})$.
By yielding an expression for today's price, P_t and inserting the Gross Return, R_{t+1} defined as:

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t},$$

we define Stochastic Euler Equation for Asset Returns as:

$$1 = \beta E_t \left[g_{t+1}^{-\gamma} R_{t+1} \right] \tag{3.2.1}$$

This equation states that the expected discount return on any asset must be equal 1 in equilibrium, reflecting the trade-off between consumption today and consumption tomorrow, which *only* constitutes to the assumption of no-arbitrage.
For the risk-free asset the return, R_f is assumed to be known with certainty, hence by inserting $R_{t+1} = R_f$, the Euler Equation simplifies to:

$$R_f = \frac{1}{\beta E_t \left[g_{t+1}^{-\gamma} \right]}, \tag{3.2.2}$$

which is the definition of the risk-free asset in the Prescott & Mehra setting.
The Euler Equation for a risky asset is defined by inserting the Stochastic Stock Return, $R_{e,t+1}$ into the Euler Equation for the risk-free bond. Moreover, we assume that stock pays a dividend, D_t, that grows at the same rate as consumption:

$$D_{t+1} = g_{t+1} D_t$$

As well as denoting the Price-to-Dividend Ratio as:

$$\frac{P_t}{D_t} = \nu$$

Therefore, the Gross Return of the stock in the next period is said to be:

$$R_{e,t+1} = \frac{1+v}{v} g_{t+1} \tag{3.2.3}$$

As we now have obtained definitions of the Gross Return and the Risk-free Rate, we can compute the Equity Premium used in our Empirical Results on a logarithmic scale, as the Equity Premium would be 0 otherwise (see Appendix 7.1). Therefore, the log of each term following the assumption of g_{t+1} from earlier can be defined as:

$$\ln \left(\mathbb{E}_t \left[R_{e,t+1} \right] \right) = \gamma \mu_g - \ln(\beta) + \gamma \sigma_g^2 - \frac{1}{2} \gamma^2 \sigma_g^2$$
$$\ln \left(R_f \right) = - \ln(\beta) + \gamma \mu_g - \frac{1}{2} \gamma^2 \sigma_g^2$$

Hence, the Equity Premium is given by :

$$\text{Equity Premium} = \gamma \sigma_{g,R_e} \tag{3.2.4}$$

In this framework, the risk premium on equities is effectively the product of the investor's risk aversion coefficient, γ and $\sigma_{g,R_e} \equiv \mathrm{Cov}(g_{t+1}, R_{e,t+1})$ is the covariance between log consumption growth and the equity return. Mehra & Prescott (1985) assume that, in equilibrium, equity returns are perfectly correlated with consumption growth and both follow a log-normal distribution; under this stronger assumption the covariance collapses to the variance of consumption growth, so the premia simplifies to $\gamma\sigma_g^2$. The equation therefore prices risk as the product of how much investors dislike fluctuations (the "price of risk", γ) in consumption and how strongly the asset's pay-offs co-move with those fluctuations (the "quantity of risk", γ and σ_{g,R_e}).

The economic intuition hinges on when the pay-offs are delivered. Returns that arrive in booms coincide with high consumption and low marginal utility $u'(C) = C^{-\gamma}$, i.e., investors value these dollars less, so assets must compensate them with a high expected return. Converserly, pay-offs that materialise in recessions provide consumption when it is scarce and marginal utility is high, acting like insurance. Therefore, investors bid up their prices, driving their expected returns down - often below the risk-free rate.

3.3 Myopic Loss Aversion in Benartzi & Thaler

In the framework of Benartzi & Thaler (1995) they introduce a piecewise S-shaped utility function that captures the asymmetry between gains and losses by incorporating a loss-aversion parameter, $\lambda > 1$. Motivated by Kahneman and Tversky's Prospect Theory (1992) this utility function is represented as:

$$U(x_{t+k}) = \begin{cases} x_{t+k}^{\alpha}, & x \geq 0 \\ -\lambda(-x_{t+k})^{\beta}, & x < 0 \end{cases}, \tag{3.3.1}$$

where x is the return of the asset (either equity or bond) relative to the status quo or reference point, and $\alpha, \beta \leq 1$ reflects the diminishing sensitivity, that is, the subjective impact of a change in wealth or consumption either way grows more slowly than the absolute size of that change. The utility function forms as what is referred to as an 'S-shape' due to its concavity form for $x \geq 0$ and convexity form in $x < 0$ relative to the reference point. This implies that agents in this setting are risk-averse in gains and risk-seeking for losses as they are in fact loss averse.
Drawn from Kahneman and Tversky, the value of the loss aversion parameter can be determined by implementing a fictional 50-50 gamble with payout x_G for $x \geq 0$ and x_L for $x < 0$, that is:

$$E[U(x)] = \frac{1}{2}x_G^{\alpha} + \frac{1}{2}\lambda x_L^{\beta}$$

From the paper's estimated parameter value $\alpha, \beta \approx 0.88$, the subjective agent will accept the gamble for which $E[U(x)] \geq 0$ which according to their study leads to a loss aversion parameter value of $2 < \lambda < 2.5$.

However, instead of using outcomes probability directly, Benartzi & Thaler implies the cumulative approach from Prospect Theory (CPT) by assigning decision weights, ω, derived from a probability weighted function to yield the prospective utility function (See Ingersoll, 2011). Let

$$\tilde{x} = \{x_{-n}, \ldots, x_{-1}, x_0 = 0, x_1, \ldots, x_m\}$$

denote ordered payoff vector with outcome probabilities $\{\pi_{-n}, \ldots, \pi_m\}$, then the CPT prospective utility is of form :

$$\mathbb{E}[U(\tilde{x})] = \sum_{i=-n}^{m} \omega_i(\pi, \tilde{x})U(x_i), \tag{3.3.2}$$

where $U(\bullet)$ is equivalent to equation (3.3.1). The implementation of decision weights replaced outcomes probabilities in Prospect Theory to model two robust behavioral regularities. One being the overweighting of rare events, which explains why individuals are eager to buy lottery tickets despite the minimal objective probability of winning. The other being violations of the independence axiom - accounted in Allais paradox - where people's preferences flip when equal-probability outcomes are combined or segregated. By distorting probabilities through an inverted-S weighting function, Prospect Theory reconciles these phenomena with a single, internally consistent rule.

Under CPT, the construction of the outcomes, x_i, are ordered from lowest to highest, i.e.:

$$x_{-n} < x_{-(n-1)} < \cdots < x_{-1} < x_0 = 0 < x_1 < \cdots < x_m$$

followed by forming the cumulative probability of gains and losses separately in their own regions:

$$\Pi_i^- = \sum_{j=-n}^{i} \pi_j, \quad \Pi_i^+ = \sum_{j=0}^{m-i} \pi_{m-j},$$

with the conventions $\Pi_{-n-1}^- \equiv 0$ and $\Pi_{m+1}^+ \equiv 0$.
Prospect Theory then maps each cumulative probability into a decision (or cumulative) weight through an inverted-S weighting function $\Omega^{\pm}$:

$$\Omega^{\pm}(\Pi) = \frac{\Pi^{\delta_{\pm}}}{\left[\Pi^{\delta_{\pm}} + (1-\Pi)^{\delta_t}\right]^{1/\delta_{\pm}}} \qquad 0 < \delta_{\pm} < 1 \tag{3.3.3}$$

where empirical estimates by Kahneman & Tversky (1992) are $\delta_- \approx 0.69$ for losses and $\delta_+ \approx 0.61$ for gains.
Finally, the elementary weights that replace the raw probabilities in equation (3.3.2) are obtained by differencing the transformed cumulative probabilities:

$$\omega_{-i} = \Omega^-\left(\Pi_i^-\right) - \Omega^-\left(\Pi_{i-1}^-\right), \quad \omega_i = \Omega^+\left(\Pi_i^+\right) - \Omega^+\left(\Pi_{i+1}^+\right), \quad i > 0$$

This guarantees that all ω_i are non-negative and sum to one, so first-order stochastic dominance is preserved even though subjective magnitudes of probabilities are distorted. Substituting these ω_i and the S-shaped utility (3.3.1) into the expectation operator (3.3.2) delivers the CPT-augmented value of any payoff vector, allowing for analyzing how myopic evaluation horizons interact with both loss aversion (λ) and probability weighting ($\delta_{\pm}$) when determining investor's willingness to weigh risky assets in their portfolios.

Intuitively, Benartzi & Thaler report that using a non-linear probability weighting or adopting a piecewise linear utility (i.e., setting $\alpha, \beta = 1$) does not significantly alter this conclusion. The key insight is that investors' 'Myopia Evaluation' $-$ continually rechecking portfolios and experiencing the disutility of frequent losses $-$ drives them to demand a high premium for holding equities. In other words, they end up "paying" a substantial price for excessive short-term vigilance, as they forego the superior long-term returns of equity in favor of lower-volatility alternatives.

4 Data and Methodology

4.1 Data Sources, Justification and Preprocessing

As mentioned, this study evaluates the Equity Premium Puzzle formulated by Mehra and Prescott (1985) by extending the sample to modern data (December 31^{st} 1989 - December 31^{st} 2024). This period captures both bull and bear markets, including the dot-com bubble, the 2008 financial crisis, and the COVID-19 pandemic.

Monthly values for the Standard & Poor's (S&P) 500 Total Return (TR) Index were retrieved from Yahoo! Finance. Monthly values for the S&P U.S. Treasury Bill (T-Bill) 0-3 Month TR Index were retrieved from the Bloomberg Terminal. Monthly seasonally adjusted values for Personal Consumption Expenditures (PCE) and the Personal Consumption Expenditures Price Index (PCEPI) were retrieved from the Federal Bank of St. Louis (FRED). [3]

The S&P 500 TR Index is used as the market index, as it is a value-weighted index covering about 80 percent of U.S. domestic equity capitalization, thereby satisfying the representative-portfolio requirement of consumption-based asset-pricing tests. The S&P U.S. T-Bill 0–3 Month TR Index is used as the risk-free asset due to the liquidity, negligible default risk, and minimal duration of T-bills. PCE (Personal Consumption Expenditure) is used to measure consumption growth and is deflated using the PCEPI (Personal Consumption Expenditure Price Index). PCEPI is also used to deflate market returns and the risk-free rate. Unlike the CPI (Consumer Price Index), PCEPI is chain-weighted, capturing substitution effects, and is directly tied to the PCE measure.

Python was used for all preprocessing. To examine whether the Equity Premium Puzzle persists, real returns are used. Returns are deflated using the Fisher equation. To assess whether Myopic Loss Aversion (Benartzi and Thaler, 1995) explains the puzzle, simple returns are used, as they reflect what investors actually observe.

4.2 Graphical Inspection of Data

Starting from the sample window used by Benartzi & Thaler's "Myopic Loss Aversion," (1926-1990) our dataset runs in the followed time series from December 31^{st} 1989 through December 31^{st} 2024. Although each series was originally gathered at a monthly frequency, we convert the data to annual observations by taking the value recorded in the final month of every calendar year. To express all variables in real terms, we deflate them with the PCEPI for the full sample horizon. The resulting real series are displayed in Figure 1 below.

[3] Data was retrieved on April 2^{nd} 2025

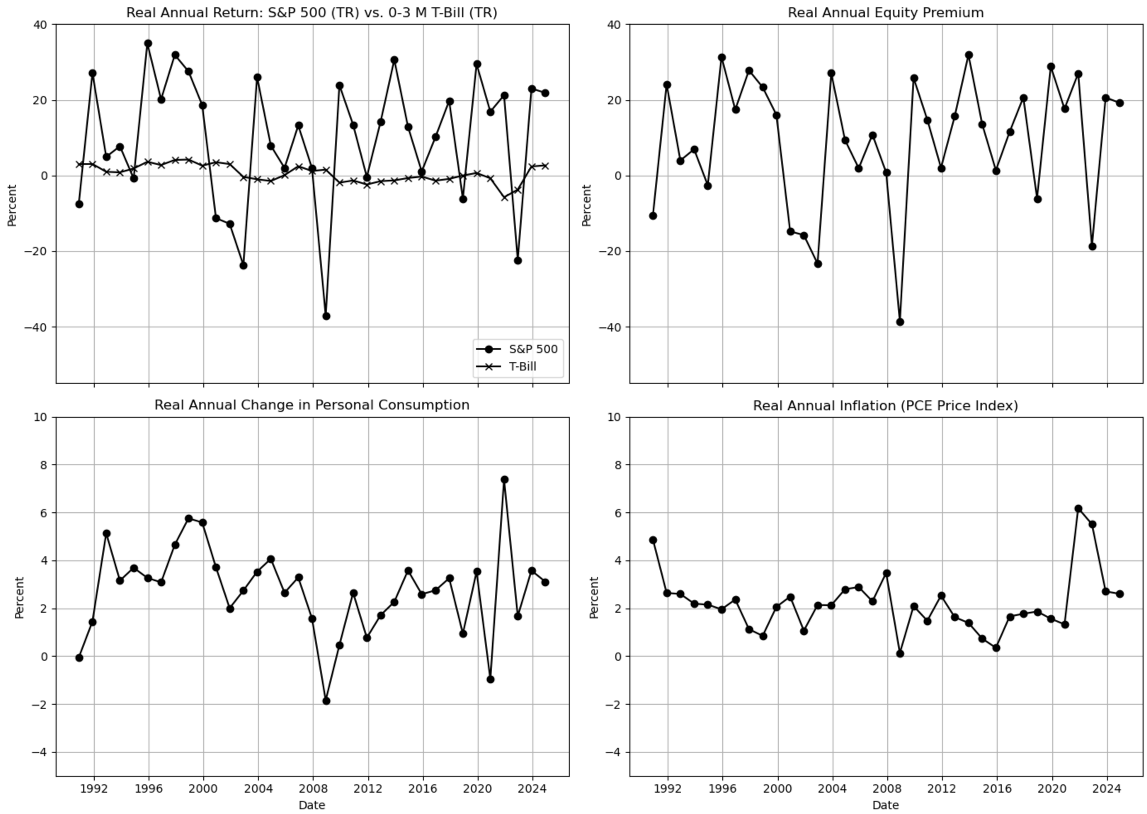

Figure 1: Real Market Data (1989-2024)

The upper-left panel traces two real gross-return series. The heavy dotted line shows the S&P 500 Total Return index deflated by the PCEPI; it ranged from about -40% to 35%, spiking during expansions (1991, 1995-99, 2013-14, 2019, 2023) and crashing in well-known crises - the dot-com bust, the 2008 Global Financial Crisis, the COVID-19 shock, and the 2022 inflation draw-down.
The thin crossed line for S&P 0-3-month T-bills Total Return index stays close to zero, turning slightly negative when ex-post real short rates fell in 2008-09 and 2020-21. Over the full sample the S&P 500 TR earned an average 9.7% a-year whereas real S&P T-bills TR delivered only 0.54%

The upper-right panel plots the premium $R_{e,t} - R_{f,t}$. It varies between roughly -40% and 30%, mirroring the highs and lows of Panel A but centered on zero. Large positive premia coincide with high-growth years whereas sharp negative outliers mark recessions when equities under-preformed T-bills. In the representative-agent framework in equation (3.2.4), the premium equals $\gamma\sigma_{g,R_e}$ (with γ being the risk-aversion and σ_{g,R_e} being the variance of consumption growth), its magnitude and volatility underline the equity-premium puzzle, as matching the 9.1 p.a. mean during our data series, requires implausibly large risk aversion.

The lower-left panel charts Δc_t (growth in real PCE). Most observations lie in a tight 0-6% corridor, with mild business-cycle waves. This stability underpins the consumption-based-asset pricing model (CCAPM) as discussed in Section 3.1. Because aggregate consumption is smoother than dividends or earnings, agents require high premiums on assets whose pay-offs co-vary strongly with Δc_t. The brief 2009 and 2020-21 extremes underscore how rare, large shocks in consumption - so called "disaster states" - drive much of the equity premium despite consumption's ordinary low variance, a core insight of the Barro (2009) disaster framework.

The lower-right plot records inflation, measured as the year-on-year percentage in the PCE deflator. Inflation dynamics are crucial for our real-return calculations because nominal asset yields must be deflated to assess purchasing-power risk. The prolonged Great Moderation(1992-2019) delivered predictable, low real T-bill returns as seen in the top left plot, whereas the 2021-22 spike eroded the real value of short-term nominal instruments and contributed to the negative equity premium that year. The figure therefore illustrates how time-varying inflation risk feeds directly into both the level and volatility of ex-post real returns, reinforcing the necessity of using real, not nominal, data when calibrating consumption-based models.

4.3 Methodology

4.3.1 Equity Premium Puzzle

Examining whether the Equity Premium Puzzle persists is relatively straightforward. It involves estimating the mean change and variance of real consumption over the sample period, and applying Mehra and Prescott's (1985) assumption of joint log-normality of gross returns and consumption growth. Hence, in equilibrium:

$$\mu_x = \ln \mathbb{E}(x) - \frac{1}{2}\sigma_x^2, \quad \sigma_x^2 = \ln\left\{1 + \frac{\mathrm{var}(x)}{[\mathbb{E}(x)]^2}\right\}$$

With these values, only the risk-aversion, (γ), and discount factor, (β), needs to be adjusted for the model to produce equity risk premium.

4.3.2 Myopic Loss Aversion

To examine whether Myopic Loss Aversion can resolve the Equity Premium Puzzle, the analysis proceeds in six steps.

Step 1. Return distributions for stocks and bonds for each horizon $h \in \{1, 2, \ldots, 18\}$ are generated via block bootstrap with block length $l = h$.

Step 2. The CPT utilities for stocks and bonds are determined separately for each horizon, and the horizon at which the stock and bond utilities are equal (intersect) is identified.

Step 3. Given the point of intersection, the utility-maximizing portfolio weights of stocks and bonds are determined and compared to actual portfolio weights.

Step 4. The model-implied annualized equity premium is determined and compared to the historical equity premium.

Step 5. The model's parameters are optimized (with bounds and constraints) by minimizing the sum of squared errors (SSE) between the model-implied and historical equity premiums.

Step 6. Using the optimized parameters, Steps 2 and 3 are repeated.

Step 1: Block Bootstrap Return Distributions

To generate return distributions, a block bootstrap is applied separately to the historical monthly stock and risk-free bond returns. Let T denote the total number of monthly returns. The block bootstrap procedure is performed for each horizon $h \in \{1, 2, \ldots, 18\}$ as follows:

Step 1.1 Set the block length $l = h$.

Step 1.2 For each sample $j = 1, 2, \ldots, 100{,}000$:

a. Draw a random start index from the uniform distribution

$$t \sim \mathrm{U}\{1, \ldots, T - l + 1\}.$$

b. Select l consecutive historical returns

$$(r_t, r_{t+1}, \ldots, r_{t+l-1}).$$

c. Compute

$$R^j_{\text{block},h} = \prod_{i=0}^{l-1}(1 + r_{t+i}) - 1,$$

and store it in row j of the horizon-h series.

The horizon-h series then contains 100,000 entries $R^j_{\text{block},h}$ of block length l, forming the return distribution at horizon h. The block-bootstrap distributions preserve the serial dependence and time-series structure of the original data—such as autocorrelation and volatility clustering—while providing robust finite-sample inference (see Politis and Romano, 1994).

Step 2: CPT Utility and Evaluation Horizon

For each horizon h, CPT utilities for stocks and bonds are determined separately using the bootstrapped return distributions. The analysis initially uses the parameters from Kahneman and Tversky (1992):

$$\alpha = \beta = 0.88, \quad \lambda = 2.25, \quad \delta_+ = 0.61, \quad \delta_- = 0.69.$$

CPT is derived from equation (3.3.2) and the piecewise value function (Equation 3.3.1) and the non-linear probability-weighting function applied to the ordered returns (Equation 3.3.3). The horizon at which the stock and bond utilities intersect is interpreted as the evaluation horizon investors use when assessing their portfolios.

Step 3: CPT Utility-Maximizing Portfolio Weights

Given the evaluation horizon h, portfolio return distributions are generated by convex combinations of the stock and bond bootstrapped return series at horizon h, with stock weights $w_s \in \{0, 0.05, \ldots, 1\}$. Specifically, for each horizon h portfolio returns are computed as

$$R^j_{p,h} = w_s \, R^j_{s,h} \; + \; (1 - w_s) \, R^j_{b,h},$$

where $R_{s,h}$ and $R_{b,h}$ denote the jth bootstrapped cumulative return for stocks and bonds at horizon h, respectively. The weight w_s that maximizes the CPT utility of the portfolio at horizon h is then identified as the utility-maximizing stock allocation.

Step 4: Model-Implied Annualized Equity Premium

For each evaluation horizon h, a CPT-based certainty equivalent premium r_h is calculated. The certainty equivalent is the additional return an investor with CPT utility would require to be indifferent between holding bonds and stocks. Solving for r_h such that

$$\mathbb{U}_h^{\text{CPT}}\big(R_{\text{bond},h} + r_h\big) \;=\; \mathbb{U}_h^{\text{CPT}}\big(R_{\text{stock},h}\big),$$

using Brent's method over $[-0.35, 0.35]$ with tolerance 10^{-5}. Horizons with no solution are excluded. The model-implied annualized equity premium is then

$$\pi_h^{\text{model}} = \mathbb{E}\Big[(1 + R_{\text{stock},h})^{12/h} - 1\Big] - \mathbb{E}\Big[(1 + R_{\text{bond},h} + r_h)^{12/h} - 1\Big].$$

Step 5 and 6: Parameter Estimation

Model fit is assessed via the sum of squared errors (SSE) between model-implied and historical annualized equity premium:

$$\text{SSE} = \sum_{h=1}^{18} \big(\pi_h^{\text{model}} - \pi_h^{\text{realized}}\big)^2.$$

A multi-start constrained optimization (SLSQP, 25 starts) estimates $\alpha = \beta$, λ, δ_+, and δ_-, enforcing $\delta_+ < \delta_-$ and initial bounds derived from Walasek, Mullett, and Stewart (2024):

$$\alpha = \beta \in [0.754,\ 1.342], \quad \lambda \in [1.1,\ 1.53], \quad \delta_+ = \delta_- \in [0.682,\ 0.996],$$

The best-fit parameters are then used to reassess whether CPT reproduces the evaluation horizon, portfolio composition, and equity premium observed in actual investor behavior.

5 Empirical Results

5.1 Is it Still a Puzzle?

With modern data, the Mehra and Prescott (1985), model produces even more extreme results, intensifying the equity premium puzzle. To match observed risk premia, it requires even less plausible values of the preference parameters γ and β. Given the model's linearity in these parameters, the severity of the puzzle can be quantified directly in the table below.

	Mehra and Prescott, 1985 1889-1978	Modern Data 1989-2024	Historical Returns 1989-2024
$\ln[R_e^*]$	13.22%	26.78%	9.26%
$\ln[R_f^*]$	11.97%	26.46%	0.54%
$\ln[EP^*]$	1.25%	0.32%	8.72%
$\ln[R_e^{**}]$	-	9.26%	-
$\ln[R_f^{**}]$	-	0.54%	-
$\ln[EP^{**}]$	-	8.72%	-

Table 1: Equity Premium: Mehra & Prescott Model

Note: For "*" $\gamma = 10$ $\beta = 0.99$, and "**" $\gamma = 268.892835$ $\beta = 0.011695$.

Table 1 contrasts the log-return prediction of the Mehra & Prescott (1985) representative-agent model with actual historical outcomes. Using the same parameterization ($\gamma = 10$, $\beta = 0.99$), the model predicts an equity risk premium of only 0.32 % with modern data, compared to 1.25 % using the original Mehra and Prescott data. This estimation of the same model on modern consumption data roughly doubles both predicted returns ($\ln[R_e] = 26.78\%$ $\ln[R_f] = 26.46\%$), which yields an logarithmic equity premium of only 0.32%. Hence, the gap between Mehra & Prescott's data to modern data widens dramatically by a factor of approximately 3.85.[4]. The lower panel shows that matching the observed premium with modern data is feasible only under extreme preference parameters, i.e., $\gamma \approx 269$ $\beta \approx 0.012$ (labeled "**"), which drive the model to predict a realistic premium of 8.72% and risk-free rate of 0.54% but at the cost of utterly implausible risk aversion and an annual discount factor that implies near-myopic impatience. This aligns with the predicted parameter estimation Section 3.1.

5.2 Myopic Loss Aversion - a Solution?

With modern data confirming the persistence of the equity premium puzzle, the paper examines Myopic Loss Aversion as a potential solution. To ascertain if Myopic Loss Aversion solves the equity premium puzzle, the paper examines the following questions:

1. Does the intersection of CPT utility for stock and bond returns imply a frequent and realistic evaluation period?
2. Given this evaluation period, does the CPT utility-maximizing portfolio of stocks and bonds align with historical fund portfolio weights?
3. Is the model-implied annualized equity premium consistent with the historical premium?

Following Step 2 of Section 4.3, *Methodology*, the paper calculates CPT utilities separately for stocks and bonds over horizons $h \in \{1, 2, \ldots, 18\}$, using the parameter values from Kahneman and Tversky (1979).

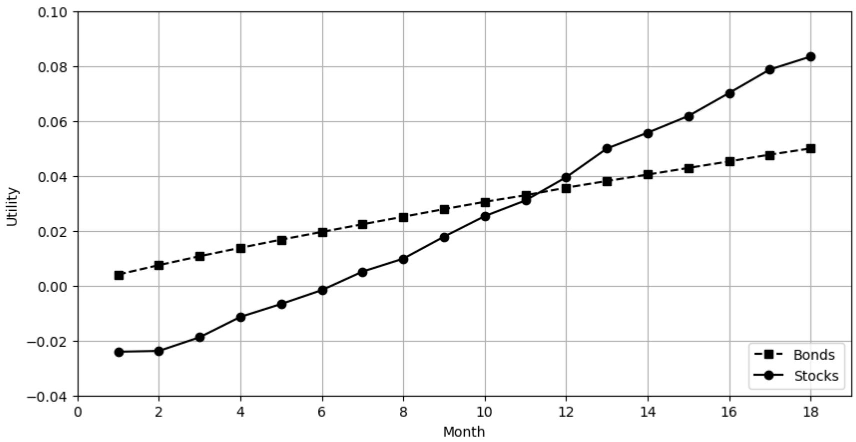

Figure 2: Cumulative Prospect Theory Utility from Stocks and Bonds

[4] $\frac{1.24979}{0.32429}$

Figure 2 shows that the CPT utilities of stocks and bonds intersect around the 11-month mark, slightly short of the 12-month evaluation horizon proposed by Benartzi and Thaler (1995). At the point of intersection, stocks and bonds are viewed as equally attractive by investors with CPT utilities. Before the intersection, stocks are viewed as less attractive than bonds, resulting in negative CPT utilities until the 6-month evaluation horizon, due to the substantial downside risk of stocks over short horizons. After the intersection, stocks are seen as more attractive than bonds, due to the cumulative impact of positive returns at longer horizons. Across all evaluation horizons, bonds consistently generate positive CPT utility, as nominal bond returns are equal to or exceed zero for nearly all observations in the historical and bootstrapped datasets. The minimum return observed in all datasets is -0.065 basis points (bps), not far from zero.

The economic intuition behind examining whether CPT utilities of stocks and bonds intersect at the 12-month mark is to assess the rationale for frequent portfolio evaluation. As Benartzi and Thaler (1995) note, "*if one had to pick a single most plausible length for the evaluation period, one year might well be it.*" This reflects the fact that individual investors typically file taxes annually and receive their most comprehensive financial reports once a year, while institutional investors treat annual performance reports with particular importance. These behavioral biases support the use of the one-year horizon as a time frame for evaluating CPT utility.

Overall, the intersection of CPT utilities for stock and bond returns around the 11-month mark, combined with the behavioral rationale for annual portfolio evaluation, supports using a 12-month evaluation horizon. Furthermore, this horizon is both frequent enough to capture investors' myopic tendencies and realistic in terms of financial decision-making. Consequently, this paper adopts the 12-month horizon to estimate portfolio weights that maximize CPT utility.

At the 12-month evaluation horizon, CPT utility is computed across portfolio returns formed by convex combinations of bootstrapped 12-month stock and bond returns, with stock weights $w_{s,12} \in \{0, 0.05, \ldots, 1\}$ and bond weights $w_{b,12} = 1 - w_{s,12}$, as outlined in Step 3 of Section 4.3, *Methodology.*

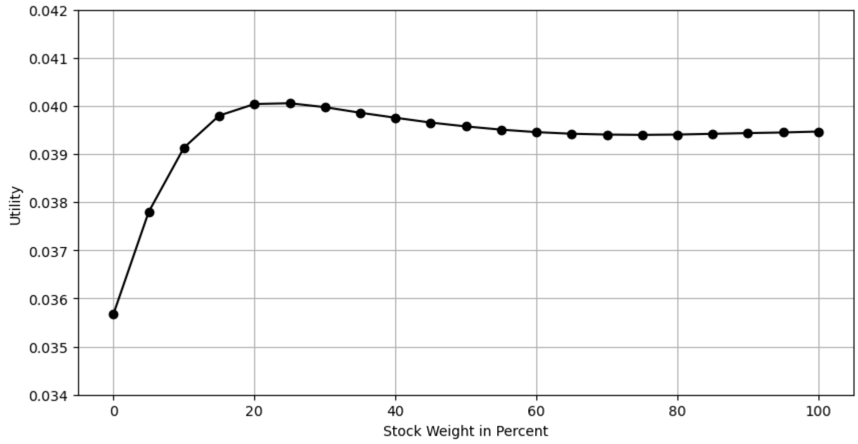

Figure 3: Cumulative Prospect Theory Utility as a Function of Portfolio Weights

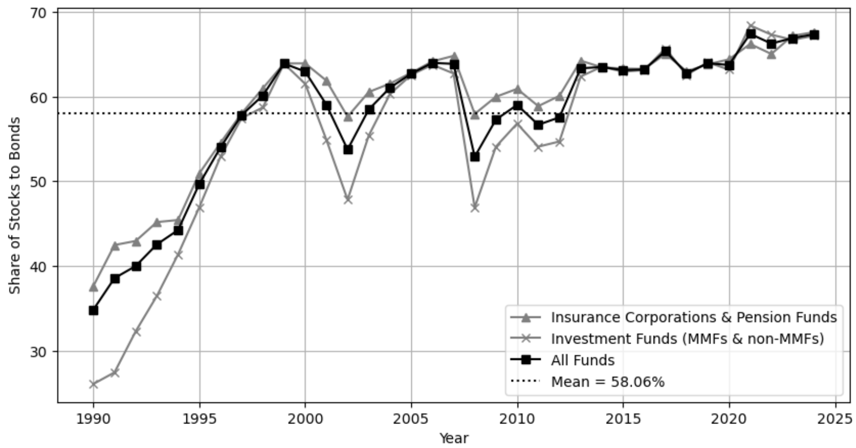

Figure 4: Share of Stocks to Bonds in U.S. Investment, Insurance and Pension Funds, 1990–2024

Figure 3 shows that CPT utility is maximized with a portfolio comprised of 25 % stocks and 75 % bonds. More generally, stock weights of 15 to 40 % (with bonds comprising 60 to 85 %) result in near-optimal CPT utilities. However, as shown in Figure 4, these utility-maximizing portfolio weights are inconsistent with historical fund data. Apart from a brief alignment from 1990 through 1993, All Funds' maintain stock weights from 40 to 70 %, exceeding the 15 to 40 % near-optimal stock weights from the CPT utility-maximizing portfolios.

These findings are in contrast with Benartzi and Thaler (1995), who report CPT utility-maximizing portfolio weights of 30 to 55 % stocks and 45 to 70 % bonds, aligning with contemporary fund data. As they note: "*Greenwich Associates reports that institutions (primarily pension funds and endowments) invest, on average, 47 % of the assets on bonds and 53 % in stocks.*"

The economic intuition behind examining whether a 12-month evaluation horizon leads to realistic portfolio weights is to test the models' adherence to reality. Overall, the CPT utility-maximizing portfolio implies lower stock weights than historical fund data. This indicates that the model–with its current parametrization–is not fully able to replicate realistic investor behavior.

Bringing light on investors' perceived risk in short-term evaluation periods, the paper shifts focus to replicating the annualized equity premium for historical data.
For each horizon $h \in \{1, \ldots, 18\}$, the CPT-utility Certainty Equivalent Premium (CEP) r_h is determined. The CEP is the additional bond return r_h required to equalize the CPT utility of stocks and bonds. This premium is added to each block-bootstrapped bond return $R_{\text{bond},h}$. Both the adjusted bond and the stock series $R_{\text{stock},h}$ are annualized and averaged. The difference in mean annualized returns is the model-implied equity premium π_h^{model}, which is compared to the historical equity premium $\pi_h^{\text{historical}}$.

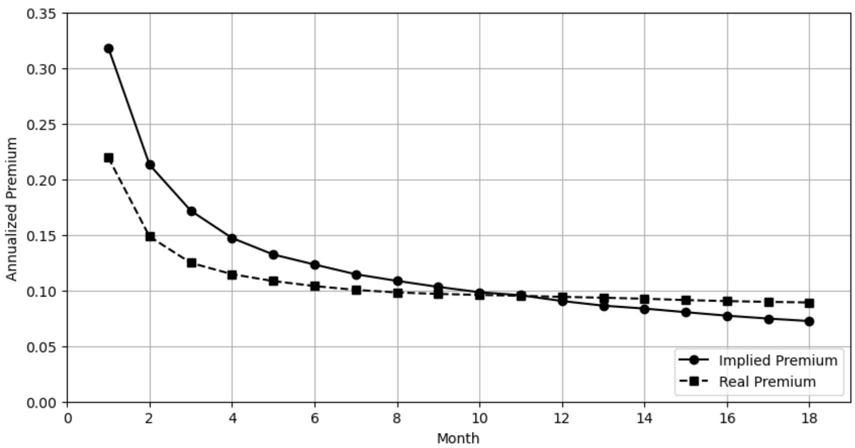

Figure 5: Real and Model Implied Equity Premium

Figure 5 shows the model-implied and historical annualized equity premiums across evaluation horizons. At short horizons (1 to 6 months), the model-implied premium is notably higher than the historical premium. For example, at the one-month mark, the model-implied premium is 31.83 %, compared to 21.95 % for the historical premium. This difference reflects the heightened sensitivity of CPT investors to short-term losses, driven by loss aversion and the overweighting of low-probability negative outcomes. After 6 months, the model-implied premium flattens, and from months 9 to 13, it remains nearly equal to the historical premium. At the 11-month evaluation horizon, the model-implied and historical premiums are the closest, at 9.57 % and 9.51 %, respectively. After the intersection around the 11-month mark, the series begins to diverge, with the model-implied premium falling below the historical premium, which stabilizes around 9 %. The model-implied premium continues to decline, albeit at a considerably slower rate than first observed. This pattern is consistent with Myopic Loss Aversion, which posits that frequent evaluation amplifies perceived risk. If returns are assessed over longer horizons, perceived volatility declines, reducing the required compensation for holding risky assets.

Overall, these findings are broadly consistent with Benartzi and Thaler (1995), who, using real returns, find that the model-implied equity premium decreases steadily as the evaluation horizon increases—from 6.5 % at one year to 1.4 % at twenty years. Notably, as in the analysis by Benartzi and Thaler (1995), this paper finds that the 12-month model-implied premium is nearly equal to the historical premium. While the estimates are not directly comparable due to the difference between nominal and real returns as well as sample periods, the downward-sloping relationship between the evaluation horizon and the required model-implied equity premium reflects a similar behavioral mechanism.

5.3 Are the parameter estimates outdated?

With the initial parameter values from Kahneman & Tversky (1979), the fit between the model-implied and historical annualized equity premiums results in a sum of squared errors (SSE) of ≈ 0.0209. To examine whether this fit can be improved while remaining consistent with modern parameter estimates, the paper applies a multi-start minimization algorithm with 25 random initializations, as well as parameter constraints and bounds, as described in Steps 5 and 6 of Section 4.3, *Methodology.* The estimation imposes the constraints $\alpha = \beta$ and $\delta_+ < \delta_-$, along with the initial parameter bounds

$$\alpha = \beta \in [0.754,\ 1.342], \quad \lambda \in [1.1,\ 1.53], \quad \delta_+ = \delta_- \in [0.682,\ 0.996],$$

derived from Walasek, Mullett, and Stewart (2024) (See Appendix: Graph and Data). Walasek et al. (2024) find the median of $\lambda = 1.31$ with a 95% CI of $[1.10, 1.53]$, which is strictly less than Kahneman and Tversky's (1979) λ estimate of 2.25, as well as other early estimates ranging from 2 and upwards. Furthermore, Walasek et al. (2024) report estimated medians of $\alpha = \beta$ and $\delta_+ = \delta_-$ from 19 and 7 studies, respectively. However, Walasek et al. (2024) do not specify a distribution for the median of either. Hence, the paper uses the 10th and 90th percentiles of the reported medians as bounds for α and δ. Thus, $\alpha = \beta \in [0.754, 1.342]$ and $\delta_+ = \delta_- \in [0.682, 0.996]$. These percentiles are used to ensure realism while not allowing for overly extreme values.

With the initial bounds the estimated parameter values are $\alpha = \beta = 0.754$, $\lambda = 1.53$, $\delta_+ = 0.682$ and $\delta_- = 0.683$ with a SSE of ≈ 0.0092. With the estimated parameter values right on their bounds, the paper continues by extending one bound at a time:

> **First**, the paper extends the upper bound of λ to 1.9, allowing for more extreme loss aversion. With the extended bounds of λ, the parameter values are $\alpha = \beta = 0.754$, $\lambda \approx 1.761$, $\delta_+ = 0.682$, and $\delta_- = 0.683$, with an SSE of ≈ 0.0077. As λ is within its bounds, the paper shifts its focus to δ.
>
> **Second**, the lower bound of δ is extended to the 5th percentile of the estimated medians, 0.676. With the extended bounds of δ, the parameter values are $\alpha = \beta = 0.754$, $\lambda \approx 1.736$, $\delta_+ = 0.676$, and $\delta_- = 0.677$, with an SSE of ≈ 0.0076. While the δ estimates continue to extend to their lower bounds, further extending the lower bound is deemed unrealistic given the estimates presented by Walasek et al. (2024). Furthermore, their minimum median estimate for δ is 0.67, not far from 0.677; thus, extending the lower bounds would have a limited effect. Lastly, extending the lower bounds could cause the estimated δ parameters to intersect with Kahneman and Tversky's δ_+ estimate of 0.61, which lacks support in the modern literature.
>
> **Third**, as with δ, the α bounds is extended to the 5th percentile of the estimated medians, 0.597. With the extended bounds of α, the parameter values are $\alpha = \beta = 0.597$, $\lambda \approx 1.557$,

$\delta_+ = 0.676$, and $\delta_- = 0.677$, with a SSE of ≈ 0.0024. As with δ estimates, α estimates continue to extend to their lower bounds. Further extending the lower bounds is deemed unrealistic, as only TomF in Walasek et al. (2024) find a median under 0.6, specifically ($\alpha = 0.48$) with a very large standard error (SE) of 0.35 (See Appendix: Graph and Data).

The optimized parameters are given by $\alpha = \beta = 0.597$, $\lambda = 1.557$, $\delta_+ = 0.676$, and $\delta_- = 0.677$. The parameters are mostly unlike those of Kahneman and Tversky (1979), partly due to nonidentical estimate bounds. The $\alpha = \beta$ parameters are optimized using Kahneman and Tversky's (1979) estimate, $\alpha = 0.88$, within its bounds, but the parameters converge to their lower bound for all optimization routines, also for λ with an extended upper bound, 1.9. The lower value of α increases the value function's curvature, causing large returns (negative and positive) to have relatively less influence on CPT utility than small and moderate returns. The λ parameter is optimized without Kahneman and Tversky's (1979) estimate, $\lambda = 2.25$, in its bounds, and only tends towards it with the initial bounds. Decreasing the lower bounds of α and δ, λ tends to $\lambda = 1.557$. A lower λ decreases loss aversion, such that investors bear losses way less heavily. Both δ_+ and δ_- converge to their lower bounds for all optimization routines. Only δ_- is optimized with Kahneman and Tversky's (1979) estimate, $\delta_- = 0.69$, within its bounds. Slightly decreasing δ_- from 0.69 to 0.677 steepens the loss probability weighting function, increasing investors' perception of the likelihood of low-probability losses while decreasing their perception of the likelihood of high-probability losses. Conversely, increasing δ_+ from Kahneman and Tversky's (1979) estimate of 0.61 to 0.676 flattens the gain probability weighting function, decreasing investors' perception of the likelihood of low-probability gains while increasing their perception of the likelihood of high-probability gains.

Overall, the paper finds that the model-fit improves using parameter bounds based on modern estimates derived from Walasek et al. (2024). Using the optimized parameters, the SSE is minimized from, using Kahneman and Tversky's (1979), ≈ 0.19 to ≈ 0.0024. Furthermore, the optimized loss-aversion parameter, $\lambda = 1.557$, lies within a reasonable distance from the 95% CI of the median $\lambda \in [1.10, 1.53]$, Walasek et al. (2024).

To evaluate if the improved fit increases the model's explanatory power, the optimized parameters are used to reexamine the questions of the analysis:

1. Does the intersection of CPT utility for stock and bond returns imply a frequent and realistic evaluation period?
2. Given this evaluation period, does the CPT utility-maximizing portfolio of stocks and bonds align with historical fund portfolio weights?
3. Is the model-implied annualized equity premium consistent with the historical premium?

The paper computes CPT utilities separately for stocks and bonds over each evaluation horizon using the optimized parameter values.

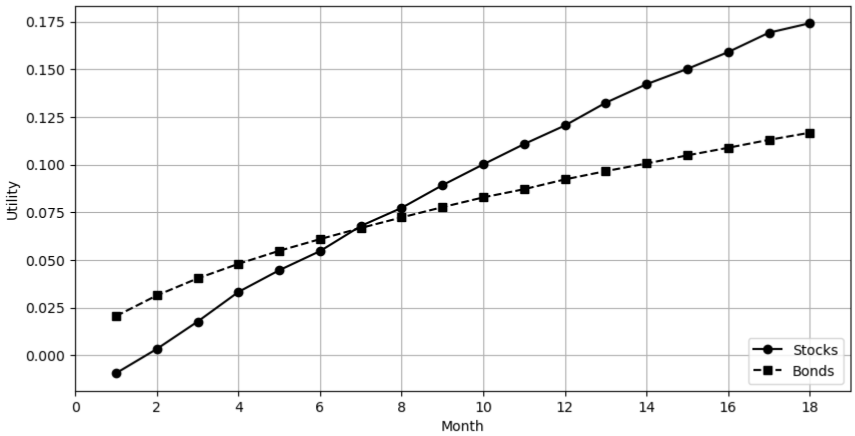

Figure 6: Cumulative Prospect Theory Utility from Stocks and Bonds

Figure 6 shows that the CPT utilities of stocks and bonds intersect around the 7-month mark. While an intersection around 6 months would have a simpler economic interpretation, as it aligns with semiannual reassessments based on quarterly reports, a 7-month horizon remains reasonable, as investors may re-weight their portfolios after a short waiting period.
CPT utilities for stocks and bonds are higher for all horizons under the optimized parameters than under the parametrization of Kahneman and Tversky (1979), as shown in Figure 2. For stocks, only the first evaluation horizon results in negative utility, compared to the first six horizons under Kahneman and Tversky's (1979) parametrization. This discrepancy is primarily due to the optimized parameters placing less emphasis on loss aversion and reducing sensitivity to extreme returns.

Overall, the intersection of CPT utilities for stocks and bonds at a 7-months evaluation horizion implies a frequent and realistic evaluation period, though much shorter than under the parametrization of Kahneman and Tversky (1979). In the following, the 7-month evaluation horizon is used to assess whether the CPT utility-maximizing portfolio weights align with historical portfolio weights.

Using the optimized parameter values, the paper computes CPT utilities for portfolio returns generated from convex combinations of bootstrapped 7-month stock and bond return series.

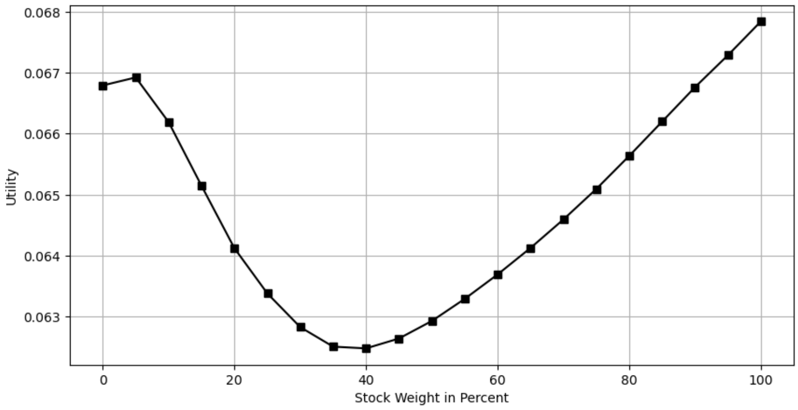

Figure 7: Cumulative Prospect Theory Utility as a Function of Portfolio Weights

Figure 7 shows that CPT utility at the 7-month evaluation horizon is maximized by a portfolio holding 100 % stocks. Near-optimal stock weights lie in the ranges of 0 to 5 % and 85 to 100 %, corresponding to bond weights of 100 to 95 % and 0 to 15 %, respectively. Interestingly, CPT utility as a function of stock weights are minimized around the values that maximize utility at the 12-month evaluation horizon when using Kahneman and Tversky's (1979) parameterization (see Figure 3). However, as with the 12-month evaluation horizon under Kahneman and Tversky's (1979) parameter values, the CPT utility-maximizing stock weights—including the near-optimal ones—do not align with historical fund portfolio weights, generally ranging from 40 to 70 % stocks (see Figure 4).

Overall, given the 7-month evaluation period, the CPT utility-maximizing portfolio based on the optimized parameter values does not align with historical fund portfolio weights, implying that the model fails to replicate realistic investor behavior. This misalignment holds for both the optimized parameters and, as shown earlier, Kahneman and Tversky's (1979) parameterization using a 12-month evaluation horizon.

Next, it is evaluated whether the model-implied annualized equity premium aligns with the historical equity premium.

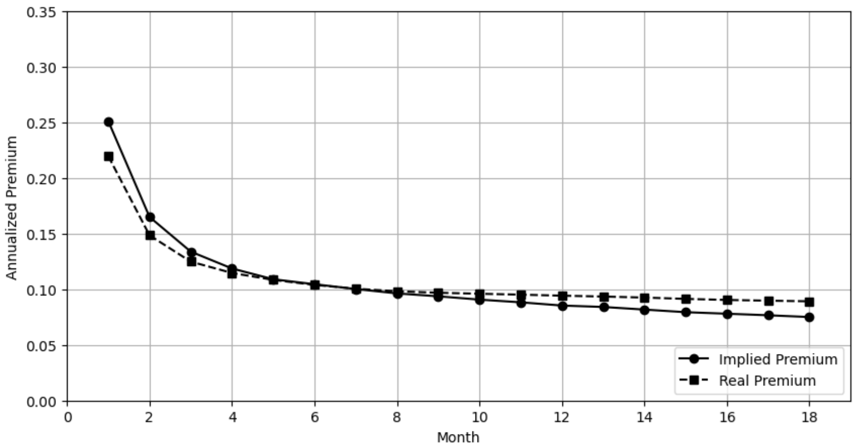

Figure 8: Real and Model Implied Equity Premium

With the optimized parameters, the Certainty Equivalent Premium r_h is added to bond returns to compute the model-implied equity premium π_h^{model}, which is then compared to the historical premium $\pi_h^{\text{historical}}$.
Figure 8 shows the fit of the model-implied equity premium to the historical premium using the optimized parameters. Given an SSE of ≈ 0.0024, the fit is strong compared to that obtained using Kahneman and Tversky's (1979) parameter values (≈ 0.0209), though still far from perfect. As the figure shows, clear discrepancies remain between the model-implied and historical premiums.

Compared to Figure 5, which uses Kahneman and Tversky's (1979) parameters, the fit is overall closer. Notably, the model-implied premium improves substantially at shorter evaluation horizons. At the one-month mark, the premium using Kahneman and Tversky's (1979) parameters exceeded the historical premium by roughly 10 percentage points, whereas under the optimized parameters, the gap is reduced to less than five.

From months 1 to 4, the model-implied premium remains above the historical premium. Between months 5 and 8, the two curves closely align. Beyond that, the historical premium flattens, while the model-implied premium under the optimized parameters continues to decline—albeit more gradually than in the initial months and more slowly than in Figure 5.

Overall, the fit of the model-implied premium can be improved using modern parameter bounds. Given the optimized parameter values, the intersection of stock and bond CPT utilities is reasonable, but the model is not able to capture actual portfolio weights.

6 Discussion and Conlusion

6.1 Discussion

6.1.1 The Puzzle in Reterospect

In reflection of our findings, we first restate that re-calibrating the Mehra & Prescott (1985) model with U.S. data from 1989-2024 shows the Equity Premium Puzzle is now more acute than before:

standard preference parameters can explain approximately 0.32% points, whereas historical equity returns exceed risk-free rates by approximately 8.72% points as seen in Table 1. By implementing the parametrization of Kahneman and Tversky's (1979), we find that investors who evaluate performance every 11 months generate an implied premium that aligns well with the data as seen in Figure 5. As the holding period extends beyond a year, the required compensation falls in line with the decrease in perceived variance ($\frac{\sigma^2}{T}$), producing a time profile for the premium that closely mirrors the way volatility smiles flatten for longer-dated options.

This behavioral interpretation suggests that the Equity Premium gap is not simply a mismeasurement of long-run consumption risk but rather a consequence of how frequently loss-averse agents review short-run fluctuations. Frequent portfolio checks magnify the disutility of temporary losses, over weighting tail-probability outcomes and demanding a steep short-horizon premium even when long-term fundamentals look profitable. When evaluation periods lengthen, idiosyncratic noise is smoothed out, tail risk diminishes and investors demand progressively less reward for bearing equity risk. The striking parallel with the maturity effect in implied volatility underscores that both equity holders and option traders share a common bias: heightened sensitivity to near-term tail events (See Serup, 2024).

Although loss-aversion preferences provide a coherent narrative for the time-series behavior of the premium, our representative-agent, U.S.-centralized framework inevitably abstracts from investor heterogeneity, trading frictions and cross-country institutional differences highlighted in studies like those of Ang and Maddaloni (2005). Nor does it endogenize the source of myopia or fully address the role of extremely rare disasters, whose scarcity has been shown by Julliard and Ghosh (2008) to be insufficient to resolve the puzzle on its own. Despite these limitations, our results carry important implications: Reporting performance less frequently or re-framing short-term losses within a longer-term context could materially lower perceived risk and required returns.

While structural adjustments—such as incorporating corporate taxes, intangible capital, and regulatory frictions—offer a rationalist path to closing the equity premium gap, their integration into a tractable, predictive model faces serious challenges. Mehra and Prescott (2003) argue that when these factors are accounted for, observed equity returns are no longer puzzling. However, operationalizing such features requires strong assumptions about the tax code's intertemporal effects, the valuation of non-observable capital (like brand equity or R&D), and the exact mechanisms through which regulation suppresses returns. These additions often make models unwieldy, heavily calibrated, and difficult to validate empirically. Moreover, as Imrohoroglu (2004) points out, even when such features are included, reconciling them with observed returns still demands extreme assumptions—such as persistently negative risk-free rates and implausibly high firm alphas—that are inconsistent with broader asset pricing evidence. Thus, while conceptually valuable, these structural approaches lack the predictive discipline and empirical robustness that behavioral models—especially those based on prospect theory and myopic evaluation—can sometimes provide.

6.1.2 Relevant parameter estimations in modern day?

Applying twenty-first century data to a model presented nearly 40 years ago exposes a clear mismatch in parameter estimations: legacy parameter estimates no longer capture the realities of today's markets. Advances such as mobile trading apps and fractional shares have lowered entry barriers, drawing in a younger, more risk-tolerant cohort. According to CNBC, 2023, they find that more than half of young Americans expect to build wealth through trading on the stock market. Because risk aversion is positively correlated with age, this demographic shift implies lower effective loss aversion.

Recognizing this, the paper re-optimizes the behavioral parameters, reducing the loss-aversion coefficients from the Kahneman & Tversky (1979) benchmark of $\lambda = 2.25$ to a lower value of $\lambda = 1.557$. The exercise underscores a broader issue: should models cling to behavioral estimates calibrated in the late 1970s, or should they adapt to technological and societal changes that have reshaped investing? Updating parameters in line with current conditions may be essential for closing persistent gaps - such as the Equity Premium Puzzle - between theory and observed data.

6.2 Conclusion

Revisiting the Equity Premium Puzzle with U.S. data from 1989-2024 shows that the standard consumption-based model still fails to explain most of the premium. Introducing Cumulative Prospect Theory with Myopic Loss Aversion brings the model-implied premium close to the observed one once investors are assumed to evaluate outcomes over multi-month horizons, yet it still understates the large equity shares actually held.
Three takeaways follow: First, pure consumption risk remains insufficient; stronger amplifiers of marginal utility are needed. Second, behavioral loss aversion narrows the gap but cannot on its own match portfolio data. Third, residual discrepancies point to additional forces - rare disasters, market frictions, or heterogeneous beliefs - that should be integrated and jointly estimated.

Future work should blend behavioral preferences with explicit frictions and disaster risk, test these combinations internationally, and draw on household-level data and surveys of horizon choice. Only such richer frameworks are likely to reconcile both the level of Equity Premium and investors' enduring appetite for equity.

References

Papers

Ang, A., and Maddaloni, A., Do Demographic Changes Affect Risk Premiums? Evidence from International Data, The Journal of Business, 2005.

Bansal, R., and Yaron, A., Risks for the Long Run: A Potential Resolution of Asset Pricing Puzzles, 2004.

Barro, R. J., Rare Disasters, Asset Prices, and Welfare Costs, American Economic Review, 2009

Benartzi, S., and Thaler, R. H., Myopic Loss Aversion and the Equity Premium Puzzle, Oxford University Press, 1995.

Breeden, D. T., An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities, Journal of Financial Economics, 1979.

Campbell, J. Y., and Cochrane, J. H., By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior, Journal of Political Economy, 1999.

Cochrane, J. H., Asset Pricing, Princeton University Press, 2005.

Constantinides, G. M., Donaldson, J. B., and Mehra, R., Junior Can't Borrow: A New Perspective on the Equity Premium Puzzle, Oxford University Press, 2002.

Imrohoroglu, S., a note on the McGrattan and Prescott (2003) adjustments and the equity premium puzzle, University of Library of Munich, 2004.

Ingersoll, J. E. Jr., Cumulative Prospect Theory and the Representative Investor, Yale School of Management, 2011.

Julliard, C., and Ghosh, A., Can Rare Events Explain the Equity Premium Puzzle?, London School of Economics, 2008.

Kahneman, D., and Tversky, A., Prospect Theory: An Analysis of Decision under Risk, Econometrica 47(2), 1979.

Kocherlakota, N. R., The Equity Premium: It's Still a Puzzle, American Economic Association, 1996.

Lucas, R. E. Jr., Asset Prices in an Exchange Economy, Econometrica, 1978.

Mehra, R., and Prescott, E. C., The Equity Premium: A Puzzle, Journal of Monetary Economics, 1985.

Mehra, R., and Prescott, E. C., The Equity Premium in Retrospect, National Bureau of Economic Research, 2003.

Mehra, R., The Equity Premium: Why Is It a Puzzle?, National Bureau of Economic Research, 2003.

Politis, D. N., and Romano, J. P., The Stationary Bootstrap, Journal of American Statistical Association, 1994.

Serup, J. L., Lecture IX: Interest Rate Options, Fixed Income Derivatives, University of Copenhagen, 2024.

Siegel, J. J., and Thaler, R. H., Anomalies: The Equity Premium Puzzle, Journal of Economic Perspectives, 1997.

Walasek, L., Mullet, T. L., and Stewart, N., A meta-analysis of loss aversion in risky contexts, Journal of Economic Psychology, 2024

Weil, P., The Equity Premium and the Risk-Free Rate Puzzle, Journal of Monetary Economics, 1989.

Websites

Federal Reserve History

Brent's Solver - Scipy

More than half of young Americans believe in building wealth through the stock market, according to CNBC—Generation Lab "Youth & Money in the USA" Survey

Appendix

Derivation of the Mehra & Prescott Model

Model Setup

The Mehra and Prescott Model (1985) is based on a representative agent economy with the following assumptions:

- **Discrete Time**: $t = 0, 1, 2, \ldots, T$
- **Consumption growth is stochastic**: The growth rate of consumption, g_t, follows a Markov Process (memory less)

Preferences: The The representative agent has time-separable utility with constant relative risk aversion (CRRA):

$$U = E_0 \left[\sum_{t=0}^{\infty} \beta^t U\left(C_t\right) \right], \tag{1}$$

We assume that the agent faces the following budget constraint:

$$\begin{aligned} C_t + P_t a_{t+1} &= Y_t + \left(P_t + D_t\right) a_t \\ \Leftrightarrow Y_t + \left(P_t + D_t\right) a_t - C_t - P_t a_{t+1} &= 0, \end{aligned} \tag{2}$$

where:

- P_t is the price of the asset at time t
- a_t is the quantity of shares held in the asset at time t
- Y_t is income at time t
- D_t is the dividend paid by the asset at time t

Consumption Process

We define the consumption growth as the Markov Process accordingly with Mehra & Prescott, 1985, as:

$$\frac{C_{t+1}}{C_t} = g_{t+1}$$

Here, they consider the case where growth rate of consumption is I.I.D and lognormal, hence:

$$E[g] = e^{\mu_g + \frac{1}{2}\sigma_g^2}$$
$$E\left[g^n\right] = e^{n\mu_g + \frac{1}{2}n^2\sigma_g^2}$$

We start by defining the Marginal Rate of Consumption Growth:

$$\frac{U'\left(C_{t+1}\right)}{U'\left(C_t\right)} = \frac{\frac{(1-\gamma)C_{t+1}^{-\gamma}}{1-\gamma}}{\frac{(1-\gamma)C_t^{-\gamma}}{1-\gamma}} = \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}$$

and inserting the consumption growth yields:

$$\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \Rightarrow g_{t+1}^{-\gamma}$$

Asset Returns
We solve these returns by constructing Lagrange:

$$\mathcal{L} = E_0\left[\sum_{t=0}^{\infty}\beta^t U\left(C_t\right)\right],$$

and inserting equation (2) yields:

$$\mathcal{L} = E_0\left[\sum_{t=0}^{\infty}\beta^t U\left(C_t\right) + \lambda_t\left(Y_t + \left(P_t + D_t\right)a_t - C_t - P_t a_{t+1}\right)\right]$$

Taking the F.O.C w.r.t C_t and a_{t+1} gives:

$$\begin{aligned}\frac{\partial\mathcal{L}}{\partial C_t} &= 0\\ \beta^t U'\left(C_t\right) - \lambda_t &= 0\\ \lambda_t &= \beta^t U'\left(C_t\right)\end{aligned}$$

and

$$\begin{aligned}\frac{\partial\mathcal{L}}{\partial a_{t+1}} &= 0\\ -\lambda_t P_t + \mathbb{E}_t\left[\lambda_{t+1}\left(P_{t+1} + D_{t+1}\right)\right] &= 0\\ \lambda_t P_t &= \mathbb{E}_t\left[\lambda_{t+1}\left(P_{t+1} + D_{t+1}\right)\right]\end{aligned}$$

Now inserting for λ_t λ_{t+1} given from the F.O.Cs:

$$\begin{aligned}\beta^t U'\left(C_t\right)P_t &= \mathbb{E}_t\left[\beta^{t+1}U'\left(C_{t+1}\right)\left(P_{t+1} + D_{t+1}\right)\right]\\ P_t U'\left(C_t\right) &= \mathbb{E}_t\left[\beta U'\left(C_{t+1}\right)\left(P_{t+1} + D_{t+1}\right)\right]\\ P_t U'\left(C_t\right) &= \beta\mathbb{E}_t\left[U'\left(C_{t+1}\right)\left(P_{t+1} + D_{t+1}\right)\right],\end{aligned}$$

From there, we can define the price of the asset, P_t, by inserting the marginal utility:

$$\begin{aligned}P_t C_t^{-\gamma} &= \beta\mathbb{E}_t\left[C_{t+1}^{-\gamma}\left(P_{t+1} + D_{t+1}\right)\right]\\ P_t &= \beta\mathbb{E}_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\left(P_{t+1} + D_{t+1}\right)\right] \qquad (*)\\ P_t &= \beta\mathbb{E}_t\left[g_{t+1}^{-\gamma}\left(P_{t+1} + D_{t+1}\right)\right]\end{aligned}$$

Now, we define the Gross Return of the asset as the future payoff of the asset divided by today's price, P_t:

$$R_{t+1} = \frac{P_{t+1} + D_{t+1}}{P_t}$$

and inserting this in (*) yields the Stochastic Euler Equation for asset returns:

$$1 = \beta E_t\left[g_{t+1}^{-\gamma}R_{t+1}\right] \tag{3}$$

Risk-Free Rate
For the risk-free asset the return, R_f, is assumed to be known with certainty. By inserting $R_{t+1} = R_f$ simplifies the Euler Equation to:

$$\begin{aligned}1 &= \beta E_t\left[g_{t+1}^{-\gamma}R_f\right]\\ R_f &= \frac{1}{\beta E_t\left[g_{t+1}^{-\gamma}\right]}\end{aligned} \tag{4}$$

Equity Return
The Euler Equation for a risky asset (stocks) is defined by inserting the Stochastic Stock Return, $R_{e,t+1}$ into the Euler Equation:

$$1 = \beta \mathbb{E}_t \left[g_{t+1}^{-\gamma} R_{e,t+1} \right]$$

We assume that the stock pays a dividend, D_t, that grows at the same rate as consumption:

$$D_{t+1} = g_{t+1} D_t$$

Moreover, we denote the Price-to-Dividend Ratio as:

$$\begin{aligned} \frac{P_t}{D_t} &= \nu \\ P_t &= \nu D_t \end{aligned}$$

From the definition for the price of the asset, we can compute the following:

$$\begin{aligned}
P_t &= \beta \mathbb{E}_t \left[g_{t+1}^{-\gamma} \left(P_{t+1} + D_{t+1} \right) \right] \\
v D_t &= \beta \mathbb{E}_t \left[g_{t+1}^{-\gamma} \left(v D_{t+1} + D_{t+1} \right) \right] \\
v D_t &= \beta \mathbb{E}_t \left[g_{t+1}^{-\gamma} \left(D_{t+1} (1+v) \right) \right] \\
v D_t &= \beta \mathbb{E}_t \left[g_{t+1}^{-\gamma} g_{t+1} D_t (1+v) \right] \qquad \text{using } D_{t+1} = g_{t+1} D_t \\
v D_t &= \beta \mathbb{E}_t \left[g_{t+1}^{1-\gamma} D_t (1+v) \right] \\
v &= \beta \mathbb{E}_t \left[g_{t+1}^{1-\gamma} (1+v) \right] \\
v &= \beta \mathbb{E}_t \left[g_{t+1}^{1-\gamma} (1+v) \right] \\
v &= \kappa (1+v), \qquad \text{where } \kappa \equiv \beta \mathbb{E}_t \left[g_{t+\gamma}^{1-\gamma} \right] \\
v &= \kappa + \kappa v \\
v(1-\kappa) &= \kappa \\
v &= \frac{\kappa}{1-\kappa}
\end{aligned}$$

Inserting back for κ yields the final result for the Price-to-Dividend ratio, v:

$$v = \frac{\beta E_t \left[g_{t+\gamma}^{1-\gamma} \right]}{1 - \beta E_t \left[g_{t+1}^{1-\gamma} \right]} \tag{5}$$

Now, we turn to the Gross Return, $R_{e,t+1}$ as defined earlier and insert the price-to-dividend ratio:

$$\begin{aligned}
R_{e,t+1} &= \frac{P_{t+1} + D_{t+1}}{P_t} \\
&= \frac{v D_{t+1} + D_{t+1}}{v D_t} \\
&= \frac{(1+v) D_{t+1}}{v D_t} \\
&= \frac{1+v}{v} g_{t+1},
\end{aligned} \tag{6}$$

which is the Gross Return of the stock in the next period.

Equity Premium
Now, we show why we need to define the Equity Premium on a logarithmic scale following the assumption of the Consumption Growth Rate defined earlier.
We have the Equity Premium expressed as:

$$\text{Equity Premium } = \mathbb{E}\left[R_e\right] - R_f$$

and inserting equation (4) & (6), we get:

$$\text{Equity Premium } = \frac{1+v}{v} g_{t+1} - \frac{1}{\beta \mathbb{E}_t\left[g_{t+1}^{-\gamma}\right]}$$

Rewriting $\frac{1+v}{v}$, we simplify the term:

$$\frac{1+v}{v} = \frac{1+\frac{\kappa}{1-\kappa}}{\frac{\kappa}{1-\kappa}} = \frac{\frac{1-\kappa+\kappa}{1-\kappa}}{\frac{\kappa}{1-\kappa}} = \frac{\frac{1}{1-\kappa}}{\frac{\kappa}{1-\kappa}} = \frac{1-\kappa}{\kappa(1-\kappa)} = \frac{1}{\kappa}$$

Hence, the Equity Premium is simplified to:

$$\begin{aligned}
\text{Equity Premium } &= \frac{1}{\kappa} g_{t+1} - \frac{1}{\beta \mathbb{E}_t\left[g_{t+1}^{-\gamma}\right]} \\
&= \frac{1}{\beta \mathbb{E}_t\left[g_{t+1}^{1-\gamma}\right]} g_{t+1} - \frac{1}{\beta \mathbb{E}_t\left[g_{t+1}^{-\gamma}\right]} \\
&= \frac{1}{\beta \mathbb{E}_t\left[g_{t+1}^{-\gamma}\right]} - \frac{1}{\beta \mathbb{E}_t\left[g_{t+1}^{-\gamma}\right]} \\
&= 0
\end{aligned}$$

Logarithmic Scale
Therefore, we turn to the Equity Premium on a logarithmic scale using the log-normal distribution of the consumption growth, g and setting:

$$\begin{aligned}
\mathbb{E}_t\left[R_{e,t+1}\right] &\equiv \mathbb{E}_t\left[\frac{1+v}{v} g_{t+1}\right] \\
&= \frac{\mathbb{E}_t\left[g_{t+1}\right]}{\beta E_t\left[g_{t+1}^{1-\gamma}\right]} \\
&= \frac{e^{\mu_g + \frac{1}{2}\sigma_g^2}}{\beta e^{(1-\gamma)\mu_g + \frac{1}{2}(1-\gamma)^2 \sigma_g^2}}
\end{aligned}$$

Now taking the log on each side:

$$
\begin{aligned}
\ln\left(\mathbb{E}_t\left[R_{e,t+1}\right]\right) &= \ln\left(e^{\mu_g+\frac{1}{2}\sigma_g^2}\right) - \ln(\beta) - \ln\left(e^{(1-\gamma)\mu_g+\frac{1}{2}(1-\gamma)^2\sigma_g^2}\right) \\
&= \mu_g + \frac{1}{2}\sigma_g^2 - \ln(\beta) - (1-\gamma)\mu_g - \frac{1}{2}(1-\gamma)^2\sigma_g^2 \\
&= \gamma\mu_g - \ln(\beta) + \frac{1}{2}\sigma_g^2 - \frac{1}{2}(1-\gamma)^2\sigma_g^2 \\
&= \gamma\mu_g - \ln(\beta) + \frac{1}{2}\sigma_g^2 - \frac{1}{2}\sigma_g^2 + \frac{2\gamma}{2}\sigma_g^2 - \frac{1}{2}\gamma^2\sigma_g^2 \\
&= \gamma\mu_g - \ln(\beta) + \gamma\sigma_g^2 - \frac{1}{2}\gamma^2\sigma_g^2
\end{aligned} \tag{7}
$$

Similarly, we take the log of the risk-free rate, R_f, where we similarly assume a log-normal distribution:

$$
\begin{aligned}
R_f &= \frac{1}{\beta\mathbb{E}_t\left[g_{t+1}^{-\gamma}\right]} \\
&= \frac{1}{\beta e^{-\gamma\mu_g+\frac{1}{2}\gamma^2\sigma_g^2}}
\end{aligned}
$$

Now taking the log:

$$
\begin{aligned}
\ln\left(R_f\right) &= \ln(1) - \left(\ln(\beta) - \gamma\mu_g + \frac{1}{2}\gamma^2\sigma_g^2\right) \\
&= -\ln(\beta) + \gamma\mu_g - \frac{1}{2}\gamma^2\sigma_g^2
\end{aligned} \tag{8}
$$

Hence, we have that the Equity Premium on a logarithmic scale is given by the following using equation (7) & (8):

$$
\begin{aligned}
\text{Equity Premium } &= \ln\left(\mathbb{E}_t\left[R_{e,t+1}\right]\right) - \ln\left(R_f\right) \\
&= \gamma\mu_g - \ln(\beta) + \gamma\sigma_g^2 - \frac{1}{2}\gamma^2\sigma_g^2 - \left(-\ln(\beta) + \gamma\mu_g - \frac{1}{2}\gamma^2\sigma_g^2\right) \\
&= \gamma\sigma_{g,R_e}, \qquad\qquad \text{where } \sigma_{g,R_e} \equiv \operatorname{Cov}\left(\ln(g), \ln\left(R_e\right)\right)
\end{aligned} \tag{9}
$$

Graphs and Data

Table 2: Median Estimated CPT Parameter Values and Standard Errors

Author(s)	λ	**SE** λ	α	**SE** α	γ	**SE** γ
BrooksP	1.90	0.14	1.01	0.03	NA	NA
BrooksZ	2.93	8846.85	1.60	0.23	1.20	0.10
CanessaC	1.25	0.10	0.80	0.11	NA	NA
ChibD	2.15	0.11	0.96	0.07	NA	NA
ErnerK	0.65	0.05	1.04	0.02	0.69	0.02
FrydmanC	1.48	0.12	1.19	0.19	NA	NA
GlöcknerP	1.70	0.42	0.61	0.04	0.82	0.02
KocherP	3.45	370.46	1.28	0.56	0.81	0.07
LorainsD	2.09	0.64	1.59	0.57	NA	NA
PahlkeS	2.41	498.03	1.00	0.01	0.67	0.09
PighinB	1.73	0.36	0.79	0.20	NA	NA
Rieskamp	1.10	0.14	1.00	0.06	0.77	0.06
Sokol-HessnerC_A	1.42	0.17	0.91	0.03	NA	NA
Sokol-HessnerC_R	1.11	0.09	0.95	0.04	NA	NA
Sokol-HessnerH09_A	1.18	0.24	0.87	0.06	NA	NA
Sokol-HessnerH09_R	0.95	0.09	0.90	0.05	NA	NA
Sokol-HessnerH14	1.23	0.20	0.96	0.10	NA	NA
TomF	1.08	0.21	0.48	0.35	NA	NA
ZeisbergerV	0.93	0.05	0.96	0.01	0.86	0.03

Source: Walasek, L., Mullet, T. L., and Stewart, N., A meta-analysis of loss aversion in risky contexts, Journal of Economic Psychology, 2024