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"NO ONE CAN BORROW" – REASSESSING THE "JUNIOR CAN'T BORROW" EQUITY-PREMIUM PUZZLE RESOLUTION

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ABSTRACT

“The equity premium puzzle” refers to the difficulty, shown in Mehra and Prescott’s seminal 1985 paper, of simulating a realistic equity premium in macro models. “Junior Can’t Borrow,” Constantinides, Donaldson, and Mehra’s (CDM) influential 2002 paper, seeks to resolve this puzzle. Their answer is to fully restrict borrowing by the young. This imposed reduction in bond supply raises the price of safe bonds and lowers their yield, producing a meaningful equity premium. But CDM’s model is highly stylized, an OLG endowment economy with just three periods and a specific configuration of age-specific risks. Our paper revisits CDM’s solution within a large-scale, stochastic, OLG economy. Our model has 80 periods, 81 state variables, and, otherwise, standard RBC modeling of production, endogenous factor returns, and TFP and depreciation macro shocks. For computational convenience, we posit hypothetical steeply rising soft-borrowing costs to shut down bond supply on an age-specific basis. As we show, eliminating borrowing by all, not just young generations, i.e. “No One Can Borrow”, not “Junior Can’t Borrow”, is required to “resolve” the equity premium puzzle. This holds despite our assumption of far larger macro shocks than observed. Overstating macro shocks is required to match the variability of the return on national wealth. Despite our larger-than-life macro shocks, our model’s agents can largely self insure by adjusting their saving and relying on good times to average out bad times. Self insurance explains why generations, regardless of age, are close to indifferent between holding or supplying bonds and equity. Once we omit our borrowing cost function, chosen for illustrative purposes not realism, the equity premium puzzle reemerges full force. Hence, unlike CDM, our paper reinforces, rather than resolves, the puzzle.

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Abstract

"The equity premium puzzle" refers to the difficulty, shown in Mehra and Prescott's seminal 1985 paper, of simulating a realistic equity premium in macro models. "Junior Can't Borrow," Constantinides, Donaldson, and Mehra's (CDM) influential 2002 paper, seeks to resolve this puzzle. Their answer is to fully restrict borrowing by the young. This imposed reduction in bond supply raises the price of safe bonds and lowers their yield, producing a meaningful equity premium. But CDM's model is highly stylized, an OLG endowment economy with just three periods and a specific configuration of age-specific risks. Our paper revisits CDM's solution within a large-scale, stochastic, OLG economy. Our model has 80 periods, 81 state variables, and, otherwise, standard RBC modeling of production, endogenous factor returns, and TFP and depreciation macro shocks. For computational convenience, we posit hypothetical steeply rising soft-borrowing costs to shut down bond supply on an age-specific basis. As we show, eliminating borrowing by all, not just young generations, i.e. "No One Can Borrow", not "Junior Can't Borrow", is required to "resolve" the equity premium puzzle. This holds despite our assumption of far larger macro shocks than observed. Overstating macro shocks is required to match the variability of the return on national wealth. Despite our larger-than-life macro shocks, our model's agents can largely self insure by adjusting their saving and relying on good times to average out bad times. Self insurance explains why generations, regardless of age, are close to indifferent between holding or supplying bonds and equity. Once we omit our borrowing cost function, chosen for illustrative purposes not realism, the equity premium puzzle reemerges full force. Hence, unlike CDM, our paper reinforces, rather than resolves, the puzzle.

Keywords: Equity Premium; Borrowing Constraints; Aggregate Shocks; Incomplete Markets; Stochastic Simulation.

JEL Classification: D91, D58, E1, E2, C63

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1 Introduction

The U.S. equity premium – the difference between mean real returns on U.S. stocks and short-term Treasuries – has averaged 6 percent on an annual basis since 1925. The risk-free real rate averaged 1 percent over the same period. Mehra and Prescott (1985)'s seminal paper features a realistically calibrated representative agent model with an equity premium of at most 0.35 percent and a risk-free rate of 4 percent. The authors dubbed the discrepancy between the observed and their model's risk premium "the equity premium puzzle".

A large literature attempts to resolve the puzzle. Constantinides (1990), Abel (1990), Epstein and Zin (1989), Jermann (1998), Campbell and Cochrane (1999), Tallarini (2000), Ju and Miao (2012), and Liu and Miao (2015) posit alternative preferences. Jermann (1998), Boldrin, Christiano, and Fisher (2001), Mehra, Piguillem and Prescott (2011), and Liu and Miao (2015) consider capital frictions. Rietz (1988), Barro (2006), Gabaix (2012), and Wachter (2013) invoke rare disasters. Krueger and Kubler (2006) assume significant stochastic depreciation. Farmer (2014) turns to non-fundamental shocks (sunspots). Finally, Barberis, Huang, and Santos (2001) resort to behavioral models, including several based on prospect theory.[1]

Our paper revisits Constantinides, Donaldson and Mehra (2002), henceforth CDM, a seminal paper in the resolution literature. CDM suggests that restricting borrowing by the young can resolve the premium puzzle. CDM specifies a three-period OLG model of pure exchange in which the young face a hard (zero-borrowing) constraint. This leaves only middle-aged agents to participate in the bond market since the oldest generation doesn't overlap for the extra period needed to contract intergenerationally. Absent their hard borrowing constraint and given how CDM models generation-specific risk, the young would borrow from (sell bonds to) the middle-aged to invest in equities. By restricting borrowing by the young, CDM limits bond supply, raising bond prices and lowering bond yields. The result is an equity premium that far more closely matches the data. Moreover, since middle-aged agents are identical and have no safe asset to supply, restricting bond sales by the young effectively shuts down the entire bond market. Hence, CDM's equity premium indicates how low the safe yield must be to choke off middle-aged agents' demand for bonds.

CDM is highly stylized, yet the authors suggest that their answer has general applicability, writing, *"... we may increase the number of generations from three to sixty, representing consumers of ages twenty to eighty in annual increments. In such a model, we expect that the youngest consumers are borrowing-constrained for a number of years and invest neither*

[1]See Campbell (2000) for a broad survey of asset pricing and Mehra (2006) for a review of the equity premium puzzle.

in equity nor in bonds ... [This change] will have pricing implications to the extent that the young investors who are currently infra-marginal in the equity and bond markets become marginal. We suspect that ... the essential message of our paper will survive."

We use our 80 period, 81-state-variable, stochastic, GE OLG model, developed in Hasanhodzic and Kotlikoff (2019), Hasanhodzic and Kotlikoff (2026), and Anthropelos et al. (2026) to examine this conjecture. The model's 80 periods represent real-life ages 20 to 100. It incorporates the full state vector, rather than a summary statistic a la Krusell and Smith (1998), Maliar et al. (2010), and Maliar and Maliar (2020). We assume, for computational convenience, soft borrowing constraints, modeled as an increasing cost function, that can be steepened and, thus, hardened to the extent desired.[2] CDM's risk-premium resolution mechanism – cutting off bond supply – survives, but in a manner that renders it implausible. All generations need to be borrowing constrained for a realistic equity premium to emerge. In other words, "No one can borrow" rather than "Junior can't borrow" is the appropriate generalization of CDM.

To be clear, our model doesn't span CDM and, therefore, doesn't deny CDM's findings. The two frameworks are quite different. The CDM model is an endowment economy featuring just three periods – far too few for agents to meaningfully absorb shocks by adjusting their saving. In addition, treating factor incomes as exogenous ignores shock-propagation and its timing via general equilibrium effects.

The ability to adjust saving (and, what we don't include, labor supply) over multiple periods – 80 in our setting – is, as emphasized in Hasanhodzic and Kotlikoff (2013, 2018, 2026), central to understanding the equity premium puzzle, whether in OLG or representative-agent RBC models. This differs from Weil (1989)'s assessment: "There is simply not enough aggregate risk in the model to replicate the risk premium for plausibly risk-averse consumers." We'd modify Weil's statement as follows: There is simply not enough immitigable risk to replicate the observed risk premium for consumers with plausible degrees of risk aversion.

[2]A large literature derives or measures soft borrowing constraints. Milde and Riley (1988) propose a screening mechanism in which lenders offer higher rates on larger loans with borrowers signaling quality through their willingness to pay. Chatterjee, Corbae, Nakajima, and Ríos-Rull (2007) endogenize this relationship by tying higher rates to greater default risk. Wilcox (1989) studies payment-to-income lending limits; our increasing borrowing-cost function can be viewed as a smooth reduced-form approximation to the shadow cost when such limits bind. Kiyotaki and Moore (1997) and Iacoviello (2005) connect reductions in collateral values to tighter borrowing limits, mimicking a graduated cost schedule. Iacoviello and Pavan (2013) apply this logic to a life-cycle framework with cyclical credit access. Camara and Sangiacomo (2022) introduce interest-coverage constraints, where credit availability is tied to expected earnings relative to interest payments – another soft borrowing mechanism. Scott (1996) documents substantial heterogeneity in unsecured borrowing rates in U.K. credit markets. He recommends modeling borrowing opportunities with an upward-sloping interest rate schedule. Caspi, Eshel, and Segev (2024) show that rising mortgage rates drive down consumption, consistent with soft cost constraints. Altonji and Siow (1987), Wirjanto (1995), and Fernandez-Corugedo (2002) also consider borrowing terms that become more costly as borrowing increases.

Our OLG-RBC framework follows the RBC literature in incorporating a standard production function with variable factor returns and positing TFP as well as depreciation shocks. These elements deliver a far different stochastic environment than CDM's.

With 80 periods, 79 generations can engage in mutual financial trade. As we show, the larger the number of borrowing constrained generations, the lower the risk-free rate and the greater the equity premium. However, permitting even a single generation to supply bonds at no cost significantly reduces the equity premium. Intuitively, agents are able to self-insure, i.e., save to tide themselves over in bad times. They can also expect, if not fully depend on, good shocks offsetting bad ones over their long lives. Indeed, regardless of age, they are close, in equilibrium, to indifferent between borrowing and lending.

Interestingly, self insurance, not intergenerational risk-sharing among overlapping selfish generations, is the model's means of mitigating risk. The ability of overlapping generations to share risk through the bond market in the absence of borrowing costs makes surprisingly little difference to economic welfare or the economy's functioning. While we exclude Social Security from our baseline model to provide the largest scope for resolving the premium puzzle, our results are little impacted by its inclusion. As Bohn (1999) and Bovenberg and Uhlig (2008) point out, pay-go pension plans can entail intergenerational risk sharing or risk propagation depending on their structure and the nature of shocks. But incorporating Social Security with a fixed payroll tax that finances benefits makes essentially no difference to our results.

We next present our model followed by its calibration and results.

2 The Model

We restrict our framework to CDM's general elements to maintain comparability.[3] Agents work for 45 years, spending their remaining 35 years in retirement. Intertemporal consumption preferences are time separable and isoelastic. Production is Cobb-Douglas. The economy faces serially correlated TFP shocks and i.i.d. depreciation shocks. Agents invest in the economy's two assets – capital and one-period, risk-free bonds, which are in zero net supply.

Like Hasanhodzic and Kotlikoff (2019), Hasanhodzic and Kotlikoff (2026), and Anthropelos et al. (2026), we solve our model using Marcet (1988)'s projection method. The method overcomes the curse of dimensionality by deriving policy functions on a subset of the potential state space – states the economy will visit with a non-trivial probability.

[3]In particular, we don't incorporate idiosyncratic labor earnings shocks as in Harenberg and Ludwig (2019). Doing so would not likely alter our conclusions as they too report a very small equity premium.

Computation details are provided in Section 4. Mean absolute Euler equation errors are on the order of 10^{-3} to 10^{-4}. Deviations from the portfolio-choice first-order conditions are on the order of 10^{-4} and, for some model variants, vanish to the seventh decimal place. These diagnostics are comparable to those reported in Hasanhodzic and Kotlikoff (2026).

Each of our $G = 80$ overlapping agents works through age $R = 45$, dies at age $D = 80$, and maximizes expected lifetime utility. There is an increasing cost of supplying bonds (borrowing). Capital adjustment costs are zero. Hence, equity owners agree on the economy's representative firm's objective – static profit maximization.

Workers supply 1 unit of labor annually. Assuming a hump-shaped age-earnings profile as in Hansen (1993) and Krueger and Kubler (2006) makes a trivial difference to our results. Hence, we simplify and assume the profile is flat. Hence, total labor supply equals R.

2.1 Preferences and Portfolio Choice

Utility is time-separable and isoelastic, with risk aversion coefficient γ:

$$u(c) = \frac{c^{1-\gamma} - 1}{1 - \gamma}. \tag{1}$$

Households invest in risky capital or in one-period safe bonds with yield $\bar{r}_t$.[4] Assets held by household age g at time t are referenced by $\theta_{g,t}$. The household's share of assets invested in bonds is $\alpha_{g,t}$. The aggregate supply of capital at time t, K_t, is the sum of period-t agent asset holdings, i.e.

$$K_t = \sum_{g=1}^{G} \theta_{g,t-1}. \tag{2}$$

Bonds are in zero net supply; hence, by going short (long) bonds, households are borrowing (lending) to each other.

2.2 Technology

Production follows

$$Y_t = z_t K_t^{\psi} L_t^{1-\psi}, \tag{3}$$

where z is total factor productivity, K_t is capital input, ψ is capital's share of output, and L_t is labor demand. The firm takes factor prices as given and chooses inputs (K and L) to maximize profits:

$$\Pi_t = z_t K_t^{\psi} L_t^{1-\psi} - w_t L_t - r_t^{\text{gross}} K_t, \tag{4}$$

[4] $\bar{r}_t$ is received at $t + 1$, but it is indexed by t which is the period in which its value is determined.

with w_t denoting the real wage and r_t^{gross} the gross rental rate of capital.

Profit maximization requires:

$$w_t = z_t(1-\psi)\left(\frac{\sum_{g=1}^{G}\theta_{g,t-1}}{R}\right)^{\psi}, \tag{5}$$

$$r_t^{\text{gross}} = z_t\psi\left(\frac{\sum_{g=1}^{G}\theta_{g,t-1}}{R}\right)^{\psi-1}, \tag{6}$$

Capital depreciates at rate δ_t. Hence, the net return to capital is

$$r_t = z_t\psi\left(\frac{\sum_{g=1}^{G}\theta_{g,t-1}}{R}\right)^{\psi-1} - \delta_t, \tag{7}$$

where depreciation $\delta_t \sim \mathcal{N}(\mu_\delta, \sigma_\delta^2)$, as in Ambler and Paquet (1994).

Total factor productivity, z, obeys

$$\ln(z_{t+1}) = \rho\ln(z_t) + \epsilon_{t+1}, \tag{8}$$

where $\epsilon_{t+1} \sim \mathcal{N}(0, \sigma^2)$.

2.3 Borrowing Costs

We adopt a borrowing-cost function based on Chen and Mangasarian's (1996) smoothing function. The function rises sharply as bond holdings become more negative and is essentially zero when bond holdings are close to zero or positive (see Figure 1). To borrow the amount of $\alpha\theta$, households must pay a cost $f(\alpha)\theta$, where

$$f(\alpha) = 0.2\left(-b\alpha - 1 + \frac{1}{5}\ln(1+\mathrm{e}^{5b\alpha+5})\right) \tag{9}$$

and the parameter b governs the slope of f. Since f is decreasing and convex in the signed bond share α, for a given positive level of assets θ, total and marginal borrowing costs rise as the amount borrowed, $-\alpha\theta$, increases. Our baseline function is parameterized such that the ratio of marginal cost to the risk-free rate equals 14, which, as shown, suffices to shut down borrowing where needed.

Specifying the borrowing costs as $f(\alpha)\theta$ rather than $f(\alpha\theta)$ ensures that the model remains scalable. I.e., if all level variables double, borrowing costs also double. Given α, doubling assets leaves marginal borrowing costs unchanged. This is consistent with Goodfriend (2005)

and Goodfriend and McCallum (2007), where collateral is modeled as an input in loan production, helping banks enforce repayment.

2.4 Households

Our baseline excludes Social Security. But we include it here since we consider a transition to pay-go Social Security. This exercise illustrates that our stochastic economy's transition is, on average, essentially coincident with its deterministic analog. This indirectly affirms our finding that macro shocks make little difference to household behavior, be it investing or saving.

The economy's state is $(s,\, z,\, \delta)$, with $s = (x_1,\ldots,x_{G-1})$ denoting the set of age-specific holdings of cash-on-hand. Households of age g in state (s, z, δ) maximize expected remaining lifetime utility given by

$$V_g(s, z, \delta) = \max_{c,\theta,\alpha} \{u(c) + \beta \mathrm{E}\left[V_{g+1}(s', z', \delta')\right]\} \tag{10}$$

subject to

$$c_{1,t} = \ell_1(1-\tau_t)w_t - \theta_{1,t} + (1-\ell_1)H_t, \tag{11}$$

$$\begin{aligned} c_{g,t} = {} & \ell_g(1-\tau_t)w_t + \left[\alpha_{g-1,t-1}(1+\bar{r}_{t-1}) + (1-\alpha_{g-1,t-1})(1+r_t)\right]\theta_{g-1,t-1} - \theta_{g,t} \\ & - f(\alpha_{g-1,t-1})\theta_{g-1,t-1} + (1-\ell_g)H_t, \\ & \text{for } \ 1 < g < G, \text{ and} \end{aligned} \tag{12}$$

$$\begin{aligned} c_{G,t} = {} & \ell_G(1-\tau_t)w_t + \left[\alpha_{G-1,t-1}(1+\bar{r}_{t-1}) + (1-\alpha_{G-1,t-1})(1+r_t)\right]\theta_{G-1,t-1} \\ & - f(\alpha_{G-1,t-1})\theta_{G-1,t-1} + (1-\ell_G)H_t, \end{aligned} \tag{13}$$

where $c_{g,t}$ is the consumption of a g-year old at time t, τ_t is the payroll tax financing pension benefits, H_t is the time-t pension benefit, ℓ_i is labor supply of generation i, and (11)–(13) are budget constraints for age group 1, those between 1 and G, and that for age group G.[5]

2.5 Equilibrium

At time t, the economy's state is $(s_t,\, z_t,\, \delta_t)$, with $s_t = (x_{1,t},\ldots,x_{G-1,t})$ denoting the set of age-specific holdings of cash-on-hand.[6] Given the initial state of the economy s_0, z_0, δ_0, the

[5]Recall that $\ell_i = 1$ for $i \leq R$ and equals 0 otherwise. Also recall that labor-market clearing condition requires that $\sum_{i=1}^{G} \ell_i = R$, where R is the total labor supply.

[6]Although the current depreciation shock δ is not part of the theoretical state space, we retain it as an argument of the functions below and as a regressor in the numerical approximation of the consumption

recursive competitive equilibrium is defined as follows:

Definition. The recursive competitive equilibrium is governed by the collection of the value functions and the household policy functions for total savings $\theta_g(s, z, \delta)$, the share of savings invested in bonds $\alpha_g(s, z, \delta)$, consumption $c_g(s, z, \delta)$ for each age group g, the choices for the representative firm $K(s, z, \delta)$ and $L(s, z, \delta)$, as well as the pricing functions $r(s, z, \delta)$, $w(s, z, \delta)$, and $\bar{r}(s, z, \delta)$ such that:

1. Given the pricing functions, the value functions (10) solve the recursive problem of the households subject to the budget constraints (11)–(13); θ_g, α_g, and c_g are the associated policy functions for all g and for all dates and states.

2. Wages and rates of return on capital satisfy (5) and (7), i.e., at each point, for given w and r the firm maximizes profits.

3. All markets clear: Labor and capital market clearing conditions are implied by $L_t = R$ and (2). Since bonds are in zero net supply, bond market clearing requires

$$\sum_{g=1}^{G} \alpha_g(s, z, \delta)\theta_g(s, z, \delta) = 0. \tag{14}$$

   Market clearing in labor, capital, and bond markets and satisfaction of household budgets imply market clearing in consumption.

4. The government balances its budget, i.e.,

$$\tau_t = \frac{H_t(G - R)}{w_t R}. \tag{15}$$

Finally, for all age groups $g = 1, \ldots, G-1$, optimal intertemporal consumption and investment choice satisfy

$$\begin{aligned} 1 = \beta \mathrm{E}_z \big[\big(1 + r(s', z', \delta') + \alpha_g(s, z, \delta)(\bar{r}(s, z, \delta) - r(s', z', \delta')) \\ - f(\alpha_g(s, z, \delta))\big) \frac{u'(c_{g+1}(s', z', \delta'))}{u'(c_g(s, z, \delta))} \big] \end{aligned} \tag{16}$$

and

$$0 = \mathrm{E}_z \left[u'(c_{g+1}(s', z', \delta'))(\bar{r}(s, z, \delta) - r(s', z', \delta') - f'(\alpha_g(s, z, \delta))) \right], \tag{17}$$

functions.

where E_z denotes expectation over the next-period shocks z' and δ',[7] and $f'(\alpha) = 0.2b\left(-1 + \frac{\mathrm{e}^{5b\alpha+5}}{1+\mathrm{e}^{5b\alpha+5}}\right)$ is the derivative of f given by (9).

3 Calibration

We set the risk aversion parameter, γ, to 2. The quarterly subjective discount factor, β, is set at 0.99. We assume steeply rising borrowing costs permitting agents to access very small amounts of credit at modest rates, while facing a significant cost for larger borrowing. In the case of primary interest – where young people are effectively constrained and other age-groups face no borrowing costs – our findings would be unchanged were we to posit, per CDM, hard borrowing constraints prohibiting young people from borrowing anything whatsoever. Table 1 reports our five values for the borrowing-cost function parameter, b. Figure 1 illustrates the impact of selected values on the function's shape.

Borrowing Cost Function Parameters

Borrowing Costs	b (slope)
Baseline calibration (no depreciation shocks)	
Baseline	28
Steeper	45
Baseline calibration with depreciation shocks	
Baseline	25
Steeper	45
Flatter	15
Flattest	5

Table 1: Parametrization of the borrowing cost function under different calibrations.

Hansen (1985) estimates the quarterly autocorrelation coefficient of the TFP process at $\rho = 0.95$, with the standard deviation of the innovation, σ_ε, ranging from 0.007 to 0.01. Prescott's (1986) estimates are 0.9 for ρ and 0.00763 for σ. Our assumed quarterly values for ρ and σ are 0.95 and 0.01, respectively. On an annual basis they are 0.814 and 0.019, respectively, generating a mean TFP value of 0.997 with a standard deviation of 0.033 and a coefficient of variation of 3.29 percent. The resulting correlation coefficient between the wage and the rate of return on capital is 0.544.

The quarterly value of the standard deviation of the depreciation shock, σ_δ, is set at 0.011, implying an annual value of 0.045. We set mean depreciation at zero. Our value for σ_δ is much higher than the 0.0052 quarterly estimate of Ambler and Paquet (1994) to reproduce

[7] The subscript z indicates that the distribution of z' depends on current z, while δ' is i.i.d.

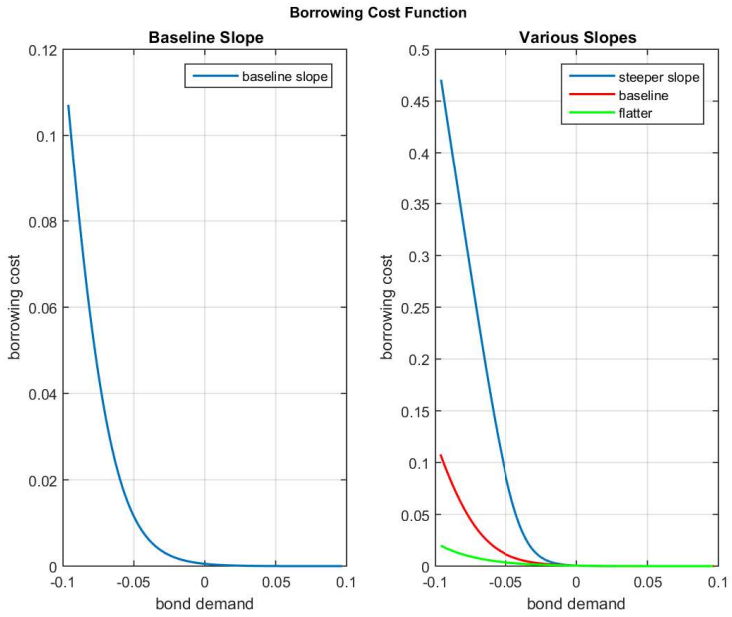

Figure 1: Borrowing cost function with different slopes for a fixed level of assets. The x-axis displays bond demands. Since the asset level is fixed, borrowing costs rise as bond demand becomes more negative.

the standard deviation of the return to national wealth. Under this calibration, the wage has a standard deviation of 0.107 around a mean of 1.905, for a coefficient of variation of 5.62 percent. The correlation coefficient between the wage and the rate of return on capital is -5.46 percent, well within Davis and Willen's (2000) estimate.

We calibrate our model's shocks to reproduce the volatility of the real return to national wealth. This is the relevant risky-return series to compare with that generated by a model of an aggregate economy. In contrast, the literature measures the risky return as the return on U.S. equities. But equity returns are not well defined absent special restrictions. Per Modigliani and Miller (1958), the division of leverage between businesses and households is indeterminate. Stated differently, any equilibrium with a particular reported corporate debt-equity ratio is isomorphic to one with a different ratio, but offsetting household debt-equity positions that leave all agents in exactly the same risk-return position. Consequently, measured equity returns are a matter of language. This is a version of the fiscal labeling (relativity) problem examined in Green and Kotlikoff (2008).

To construct annual real returns to national wealth, we combine Federal Reserve National Financial Accounts data with NIPA data from the Bureau of Economic Analysis.

$$r_t = \frac{W_{t+1} - W_t + C_t - E_t}{W_t}, \tag{18}$$

where W_t, E_t, C_t, and r_t reference time-t wealth, labor income, economy-wide consumption, and the rate of return on economy-wide wealth. We measure total labor income assuming that labor's share of proprietorship and partnership income equals its share of national income.

Note, apart from debt liabilities, the components of the Federal Reserve wealth series are carried at market. The fact that loans, no matter their issuer, are, with minor exceptions, marked to market in totaling U.S. assets whereas borrowings, no matter their issuer, are primarily carried at book may overstate our measured variability of the national wealth return. This said, most debt is short- to medium-term. New issues are, by definition, marked to market. Also, the book values of outstanding issues converge, on average, to their market values as the bonds mature, and the two values coincide at maturity.

In any case, the impact of marking bonds to market and debts to book increases measured national-wealth-return volatility. And, since we calibrate our depreciation shock to match this volatility, our model likely overstates return shocks. This, in turn, biases our model toward producing a larger risky-return (equity, to use the standard misnomer) premium – a premium we can't reproduce absent unrealistic borrowing constraints. To summarize, measurement bias in our national wealth return series strengthens our RBC-OLG confirmation of the premium puzzle.

4 Algorithm

The following is a step-by-step description of our algorithm.

Initialization:

- Set $\bar{z}$ and $\bar{\delta}$ to their average values and solve for the deterministic steady state cash on hand of each age group without bond, $\bar{s} = (\bar{x}_1, \ldots, \bar{x}_{G-1})$. Note that the deterministic steady state corresponds to the state vector of age specific cash on hand holdings that arise in the long run with zero economic shocks. Let $(s_0, z_0, \delta_0) = (\bar{s}, \bar{z}, \bar{\delta})$ be the starting point of the simulation. In this initial condition, bond holdings are set to zero.

- Approximate $G-1$ consumption functions by polynomials in the state variables and the shock delta: $c_1(s, z, \delta) = \phi_1(s, z, \delta; b_1), \ldots, c_{G-1}(s, z, \delta) = \phi_{G-1}(s, z, \delta; b_{G-1})$, where

$b_1, \ldots, b_{G-1}$ are polynomial coefficients. We use linear polynomials. To start the iterations, we make the following initial guess for the coefficients:
$b_1 = (0, 0.9\bar{c}_1/\bar{x}_1, 0, \ldots, 0, 0.1\bar{c}_1, 0), \ldots, b_{G-1} = (0, 0, \ldots, 0, 0.9\bar{c}_{G-1}/\bar{x}_{G-1}, 0.1\bar{c}_{G-1}, 0)$.

- Take draws of the exogenous path of shocks for $T = 830$ years.

Outer loop:

- The first step in the outer loop is to simulate the model forward, i.e. compute the state space for $t = 1, \ldots, T$. To do so, at each time t we proceed as follows:
  - Recall that at time t, the state vector consists of the vector of cash-on-hand variables of generations 1 through $G-1$, $s_t = (x_{1,t}, \ldots, x_{G-1,t})$ and exogenous shocks.
  - Using this state vector, for each age group g, calculate its consumption $c_g^{(p)}$ given the current guess of the coefficients $b_g^{(p)}$, where the subscript (p) denotes the current iteration of the outer loop. I.e., $c_{g,t}^{(p)}$ equals the inner product of the vector $(1, s_t, z_t, \delta_t)$ with the vector of coefficients $b_g^{(p)}$. Compute the generation-specific asset demands, $\theta_{g,t}$, as the difference between cash on hand and consumption, $\theta_{g,t} = x_{g,t} - c_{g,t}$. Note that the sum of asset demands of generations 1 through $G-1$ is the capital stock at the beginning of period $t+1$, K_{t+1}.
  - At this point enter the inner loop to compute the agents' choices of bond shares, $\alpha_{g,t}$, for generations 1 through $G-1$, and the risk-free rate $\bar{r}_t$. Recall that these are needed to compute the cash-on-hand variables at time $t+1$.
  - Inner loop:
    * Use Broyden's method to solve (14) for $\bar{r}_t$. To start, make an (arbitrary) initial guess for the value of $\bar{r}_t$.
    * Given $\bar{r}_t$, solve the system of $G-1$ equations given by (17) for $g = 1, \ldots, G-1$, for $G-1$ unknowns, $\alpha_{1,t}, \ldots, \alpha_{G-1,t}$. To do so, approximate the expectation by Gaussian quadrature.[8] Notice that the consumption at time $t+1$, $c_{g+1,t+1}$, on the right-hand-side of each equation (17) needs to be approximated by the polynomial in the state vector plus δ. Hence, each of these equations depends on the entire distribution of the cash-on-hand variables, and through them, on all of the generation-specific α's, $\alpha_{1,t}, \ldots, \alpha_{G-1,t}$. To solve a nonlinear

[8] We use 4 nodes in the quadrature; using more does not change the results.

system of $G-1$ nonlinear equations in $G-1$ unknowns we use the Gauss-Seidel algorithm, which reduces the problem of solving for $G-1$ unknowns simultaneously in $G-1$ equations to that of iteratively solving $G-1$ equations in one unknown.[9] We solve each of these nonlinear equations in one unknown α using Newton's method.

* Use $\alpha_{g,t}$ found above for all g to calculate (14) and update $\bar{r}_t$.

– Given $\alpha_{g,t}$ for $g = 1, \ldots, G-1$, $\bar{r}_t$, K_{t+1}, and exogenous shocks, we can now compute each generation's cash on hand in period t+1 as the sum of their labor and capital income (plus or minus any government transfers) at time t+1.

- Note that for each age group g and each state (s_t, z_t, δ_t), $t = 1, \ldots, T$, (16) implies

$$c_g(s,z,\delta) = (u')^{-1}\Bigg\{\beta \mathrm{E}_t\Big[\Big(1 + r(s',z',\delta') + \alpha_g(s,z,\delta)\big(\bar{r}(s,z,\delta) - r(s',z',\delta')\big) - f\big(\alpha_g(s,z,\delta)\big)\Big)u'\big(c_{g+1}(s',z',\delta')\big)\Big]\Bigg\}. \tag{19}$$

  Denote the right-hand-side of (19) by y_g and evaluate the expectation using Gaussian quadrature.

- For each age group g, regress y_g on (s_t, z_t, δ_t) and a constant term using regularized least squares with Tikhonov regularization. Denote the estimated regression coefficients by $\hat{b}_g^{(p)}$.

- Check for convergence: If

$$\frac{1}{G-1}\sum_{g=1}^{G-1}\frac{1}{T}\sum_{t=1}^{T}\left|\frac{x_{g,t}^{(p-1)} - x_{g,t}^{(p)}}{x_{g,t}^{(p-1)}}\right| < \epsilon,$$

  end. Otherwise, for each age group g update the coefficients as $b_g^{(p+1)} = (1-\xi)b_g^{(p)} + \xi\hat{b}_g^{(p)}$ and return to the beginning of the outer loop. We use $\xi = 0.1$ and $\epsilon \in [10^{-13}, 10^{-7}]$.

[9] As the starting point for Gauss-Seidel we use the α's computed at time t-1.

5 Data Versus Model

Table 2 compares U.S. and model return statistics. The U.S. data span 1950–2025. The model data come from an 830-year simulation after an initial 349-year burn-in. The table considers real returns to capital and bonds. In the data, the corresponding measures are the real return to national wealth and real return on 1-year Treasuries, respectively. The model's counterparts are simply the real return to capital and the 1-year safe bond return.

The real return on U.S. wealth averaged 6.51 percent, far higher than the model's 3.89 percent to 3.91 percent average real return to capital under the table's three borrowing cost assumptions – no costs, universal costs, and universal, but steeper costs. The substantial difference between the two values suggests there is more than one puzzling difference between a generic RBC-OLG model and the real world. The return on 1-year Treasuries averaged 1.08 percent in the data. As for the model, it spans this value for our three borrowing costs.

Of more importance for the issue at hand is the variability of the risky return. As column three shows, the standard deviation of the model's return to capital is close to that of the real return to national wealth in the data. The same can't be said of the standard deviation of the safe real return. Safe, albeit for just one-year, real Treasury returns are more than five-times as variable as those in our model. As for the equity premium and Sharpe ratio, the data and the model are miles apart unless one assumes universally high marginal borrowing costs – leading to full bond-market collapse. Absent borrowing costs, the model's equity premium is 0.17 percent compared with the postwar's recorded 5.43 percent value. And the model's Sharpe ratio is a trivial 0.04 versus the average annual postwar value of 1.11.

Table 3 shows that our model's de minimis equity premium, absent the extreme counterfactual of essentially no private borrowing, is not an artifact of small shocks. In contrast, in combination our TFP and depreciation shocks make the model's output scaled by its trend over 15 times more variable than in the data. This implies what the table also shows – far larger consumption and investment variability than that observed. These discrepancies arise whether one considers standard deviations or coefficients of variation of the three normalized macro aggregates.

The main driver of these discrepancies between what's observed and what's modeled is depreciation shocks. With TFP shocks alone, the model's output and consumption and investment components fluctuate to a much smaller degree. But the standard deviation of capital's return is far less than that in the data, producing an even larger equity premium puzzle. In short, we opted to dramatically overstate the magnitude of shocks to give the model its best shot at explaining the equity premium puzzle.

Summary Statistics of Rates of Return

	Mean Return to Capital (%)	Mean Safe Rate of Return (%)	S.D. Return to Capital (%)	S.D. Safe Rate of Return (%)	Equity Premium (%)	Sharpe Ratio
MODEL						
No Borrowing Costs	3.91	3.74	4.63	0.41	0.17	0.04
Borrowing Costs	3.89	0.24	4.62	0.36	3.65	0.79
Steeper Borrowing Costs	3.91	-2.42	4.62	0.36	6.32	1.37
DATA BASED ON RETURN TO U.S. WEALTH						
	6.51	1.08	4.89	2.20	5.43	1.11

Table 2: Summary statistics of rates of return in the model and in the data.

Standard Deviations, Coefficients of Variation, and Means: Model vs Data

	Standard Deviation of Variables Normalized by Trend Output			Coefficient of Variation of Variables Normalized by Trend Output			Mean of Variables Normalized by Trend Output		
	Output	Cons	Invest	Output	Cons	Invest	Output	Cons	Invest
Model	0.3308	0.1827	0.4036	0.3348	0.1779	-10.3497	0.9881	1.0271	-0.0390
Model Without Depreciation Shocks	0.0126	0.0209	0.0253	0.0126	0.0209	-26.4934	0.9999	1.0009	-0.0010
Data	0.0173	0.0490	0.0323	0.0173	0.0491	0.3189	0.9999	0.9982	0.1012

Table 3: Standard deviations, coefficients of variation, and means of output, consumption, and investment as share of trend output, models vs. data. Annual U.S. data are National Income at Producer Prices, Household Consumption, and Net Domestic Investment from Bureau of Economic Analysis, 1947 to 2025. Nominal net domestic investment and national product at producer prices are converted to real 2017 dollars using the GDP deflator. Trends are computed using an HP filter (with $\lambda = 6.25$). Reported entries are the above-mentioned statistics of Y_t/Y_t^{trend}, C_t/Y_t^{trend} and I_t/Y_t^{trend}, where Y_t^{trend} is the trend component of national income. Analogous operations were applied to the model, where simulation years 350–830 were used to ensure that the calculations reflect the stochastic steady state.

6 Results

We first discuss our equity-premium findings. Next we describe the associated age-structure and size of the bond market. Then we compare the variability of our model's aggregates with those in the data. Finally, we compare stochastic and deterministic transition paths of our economy. This comparison recapitulates Anthropelos et al. (2026)'s finding that macro shocks, in our plain-vanilla RBC-OLG model, are second order. Deviations of the model's output, capital, and wages from their deterministic counterparts are on average and almost always close to zero. Were macro risk major, we would see not only a large equity premium, even absent any borrowing costs, but also substantial precautionary household saving that would produce materially different paths of stochastic and deterministic macro variables.

6.1 The Equity Premium

Asset Demands and Rates of Return, Subsets of Generations Face Borrowing Costs

Model	Total Bond Demand*	Total Stock Demand	Avg Return on Capital (%)	Avg Risk-Free Rate (%)	Equity Premium (%)
No Borrowing Costs	238.92	1077.64	3.91	3.74	0.17
Baseline Borrowing Costs on Ages 1-30	77.92	1070.82	3.92	3.67	0.26
Baseline Borrowing Costs on Ages 1-70	24.06	1069.04	3.92	3.43	0.49
Baseline Borrowing Costs on All Ages Except 20	33.23	1077.57	3.90	3.47	0.43
Baseline Borrowing Costs on All Ages Except 40	24.50	1072.79	3.91	3.40	0.52
Baseline Borrowing Costs on All Ages Except 60	19.04	1070.79	3.92	3.25	0.67
Flattest Borrowing Costs on All Ages (slope 5)	2.76	1061.00	3.94	2.97	0.97
Baseline Borrowing Costs on All Ages (slope 25)	0.12	1082.31	3.89	0.24	3.65
Steeper Borrowing Costs on All Ages (slope 45)	0.04	1076.56	3.91	-2.42	6.32

*Note: Total bond supply is the negative of the total bond demand.

Table 4: Asset demands and rates of return when subsets of generations face borrowing costs.

Table 4 conveys our central findings. The first row shows that, absent borrowing costs/constraints, the equity-premium puzzle emerges in full force. The model's premium is 0.17 percentage points, miles below our measured 5.43 percentage point premium. This observed premium is the average annual difference between the real return on national wealth and the real yield

on 1-year Treasuries. In this case, bonds are in substantial supply, comprising 22.2 percent of the economy's capital stock.

Row 2 considers CDM's conjecture. It imposes our steep baseline borrowing costs on those ages 1-30 (real ages of 20 through 50). Since younger cohorts are natural borrowers in our model, as in CDM's, eliminating their bond supply leads to a collapse of the bond market. It now comprises just 7.3 percent of the capital stock. Yet, the equity premium remains virtually unchanged – rising from 0.17 to only 0.26. Thus, preventing juniors and only juniors from borrowing does not, as it does in CDM, resolve the equity premium puzzle.

The second to the last row shows results when all cohorts face our baseline borrowing-cost function. Now, the equity premium is 3.65 percentage points. Equilibrium bond supply is essentially zero with the safe rate declining from 3.74 percent, the no borrowing-cost case, to 0.24 percent. With a steeper than baseline marginal borrowing cost function – the last row of Table 4, the equity premium is 6.32 percentage points.

If even a single generation can borrow at no extra cost, the premium collapses relative to our baseline and steeper borrowing cost assumptions. For example, if generation 40 (real-life age 60) can borrow cost free, the risk premium falls to 0.52 percent. The reduction in the premium is essentially invariant to which generation is unconstrained. If it's generation 20 (real age 40), the premium falls to 0.43 percent. If it's generation 60, the premium falls to 0.67 percent. Even allowing the nine oldest generations – the generations who would lend absent borrowing costs – to borrow at no cost, while making it prohibitively costly for generations 1 through 70 to borrow, reduces the premium to 0.49 percentage points.

Interestingly, the case where all generations except the last nine are constrained looks much like the case where only a single generation – either generation 20, 40, or 60 – is unconstrained. In the former case, bond supply equals 24.06, the risk-free rate averages 3.43 percent, and the equity premium is 0.49 percent. In the latter case, bond supply ranges from 19.04 to 33.23, the risk-free rate ranges from 3.25 to 3.47 percent, and the equity premium ranges from 0.43 to 0.67 percent. In particular, when generation 60 is the sole supplier, the bond supply (19.04) is less than two-thirds of what it is when generation 20 is the sole supplier (33.23). Thus, as in CDM, the young are natural bond suppliers given that their resources primarily comprise human wealth, which isn't subject to capital depreciation shocks.

As the table's bottom-three rows indicate, even a relatively flat borrowing cost function slope suffices to wipe out the bond market. Yet, the equity premium is very low – 0.97 percentage points. The hypersensitivity of the equity premium and scope of the bond market to the shape of our cost function is noteworthy. Agents at most risk from macro shocks are willing to pay a high price (earn a low return) to protect themselves, but only to a very

limited degree. Intuitively, someone with a very limited desire for apples may be willing to pay a high price for a few apples. This is the opposite of the well known proposition that absent any risk, introducing a very small (formally, infinitesimal) amount of risk has a second-order impact on welfare. But it confirms the standard finding that risk averse agents are willing to partially insure, even at high costs (loads), important risks.

A second implication of the equity premium's hypersensitivity is that measuring bond prices in the absence of a meaningful bond market is highly dependent on who is able to participate and to what degree. As we raise the slope of our borrowing cost function (our implicit tax on bond sales), bond suppliers (younger cohorts) are less and less willing to sell, leaving bond demanders (older cohorts) less and less willing to buy given the higher and higher price of the available supply. Thus, the equity premium is being set by different demanders as the cost function steepens.

This raises a basic question that also applies to CDM. Can valuing an endogenous variable, in this case the equity premium, at an equilibrium, far removed from that actually observed, resolve its observed value? The private U.S. bond market comprises, by some measures, close to half of the U.S. capital stock. But to achieve a reasonable equity premium, we need to make that ratio essentially zero (exactly zero in CDM).

6.2 The Composition of Bond Demand and Supply by Age

Capital depreciation shocks aren't necessary to produce an equity premium. But unlike TFP shocks, which raise or lower wage rates and real capital returns by the same percentage, depreciation shocks differentially impact agents of different ages. This lets the model match the empirically observed pattern of increasing bond holdings with age. With only TFP shocks, the young – asset-poor and highly exposed to labor income volatility – are the primary demanders of safe bonds. Holding labor income is effectively equivalent to holding equity, prompting them to hedge by acquiring assets that perform well in downturns. The elderly should supply these bonds since TFP shocks impact market returns, but don't increase or reduce principal. Once capital depreciation shocks are introduced, agents' wealth holdings, not just returns on those holdings, are at risk. This turns older agents into demanders, not suppliers, of bonds. Since the safe asset is in zero net supply, younger agents supply bonds, just as in CDM.

Figures 2 and 3 show the bond and equity demands by age under different cohort-specific borrowing-cost assumptions. These values are averages taken from the economy's stochastic steady state. Figure 2's top panels assume zero borrowing costs. Its bottom panels assume universal borrowing costs. Both rows show the same general pattern of portfolio holdings

by age, with the young supplying and the old demanding bonds. All cohorts hold capital with capital holdings peaking in the early 40s (real world age of early 60s). Since very young cohorts have very little if any wealth, they short bonds (sell bonds yielding 3.74 percent) to purchase stocks yielding just 3.91 percent, on average – the equity premium puzzle.

But when all cohorts face borrowing costs, the bond market collapses, with the risk-free rate falling to 0.24 percent and the equity premium rising to 3.65 percent. The low risk-free rate is the choke yield – the yield that reduces total bond demand to the level of total bond supply, namely zero. But, as the bottom-left panel makes clear (note the dimensions of the Y axis), none of the elderly purchase much, at all, in the way of bonds.

Figure 3 shows that portfolio holdings by age are highly dependent on the pattern of borrowing costs by age. Imposing borrowing costs on those ages 1 to 30 (20 to 50) leads those in their middle ages to dramatically reduce their bond supply and older age groups to dramatically reduce their bond demands.

6.3 The Trivial Macro Impact of Micro Risk

As discussed in Anthropelos et al. (2026), if macro risk were major, our model would produce not only a large equity premium, but also substantial precautionary saving. This extra saving would place our RBC-OLG model in a very different long-run stochastic steady state than its deterministic counterpart. By deterministic counterpart we mean computing our model with minuscule TFP and depreciation shocks.

Figure 4 shows the average paths of capital, output, the real wage, and the real return to capital arising from introducing a pay-go Social Security system whose benefits are financed by a fixed 15 percent payroll tax. Our averages are based on running 10,000 stochastic transition paths starting from a representative position of the economy.[10] The figure also shows the paths of the four macro variables in the deterministic economy. Average stochastic paths closely track their deterministic counterparts.

Table 5 reports the TFP-and-depreciation-shock results also presented in Table 1 of Anthropelos et al. (2026). It complements Figure 4's comparison of average transition paths by examining individual simulated histories. At each reported horizon, fewer than 10 percent of histories have output or wage deviations exceeding 10 percent, and about 1 percent have capital deviations exceeding 10 percent; none of these deviations exceeds 25 percent. The return to capital is the clear exception: more than 90 percent of histories have return deviations exceeding 10 percent, and about 60 percent have deviations exceeding 50

[10]Specifically, we ran multiple simulations of the economy for 350 years and chose the year-350 state whose capital stock was closest to the mean level of the economy's capital stock in year 350.

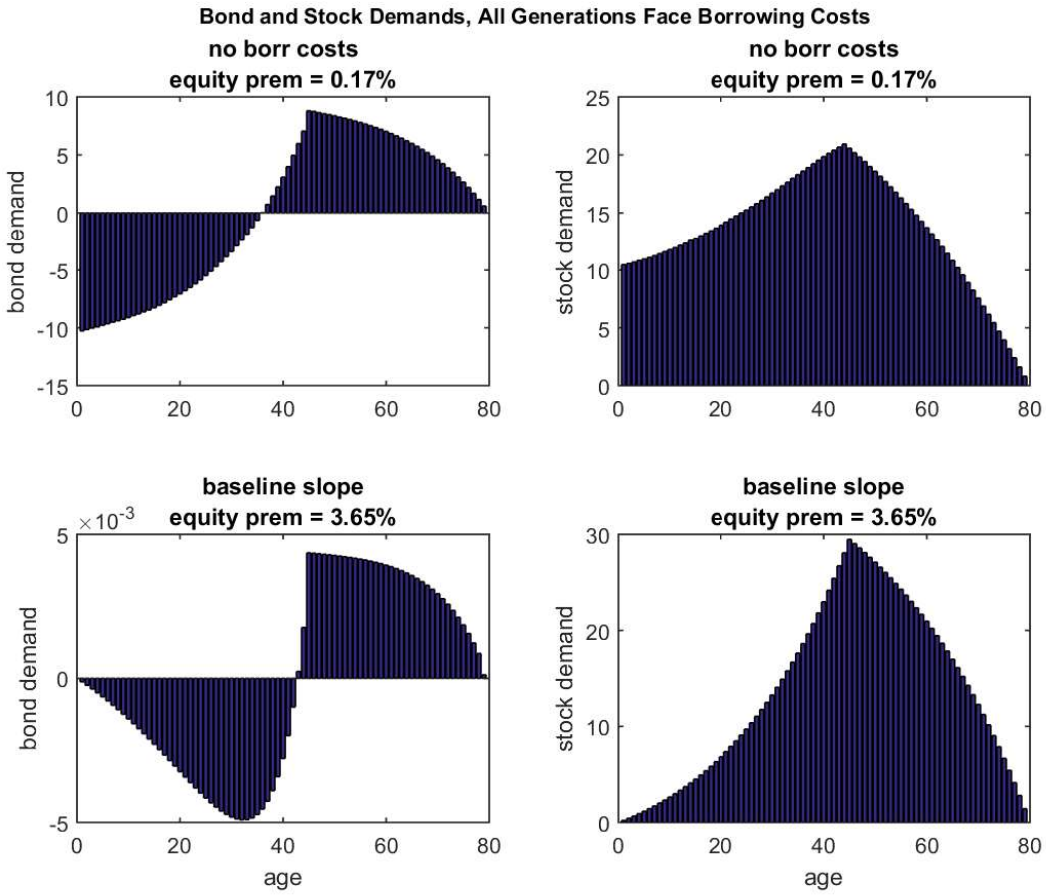

Figure 2: Bond and stock demands in our model, shown with and without borrowing costs. When borrowing costs are present, they apply to all generations. The equity premia are shown at the top of each panel.

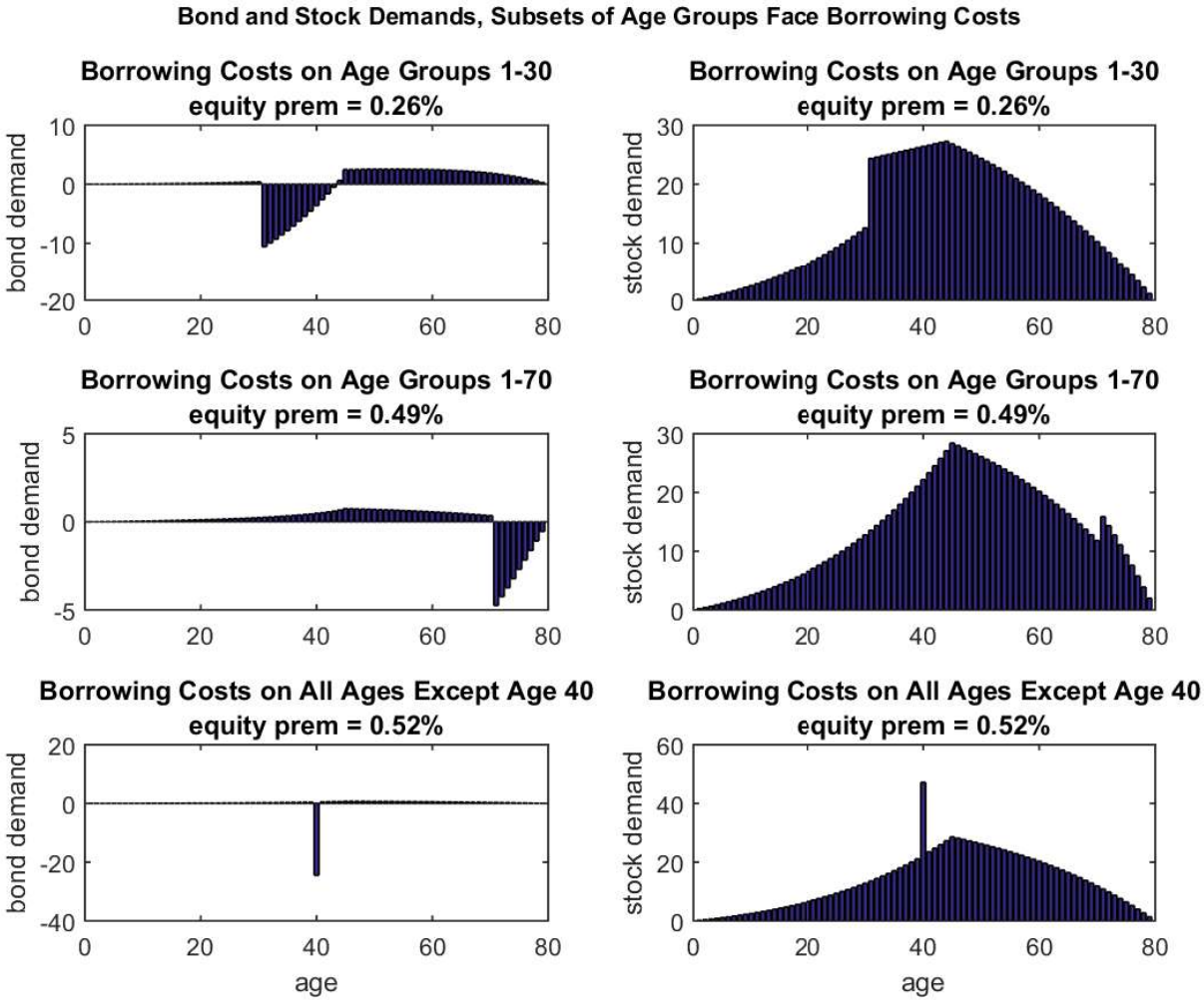

Figure 3: Bond and stock demands where subsets of generations face borrowing costs.

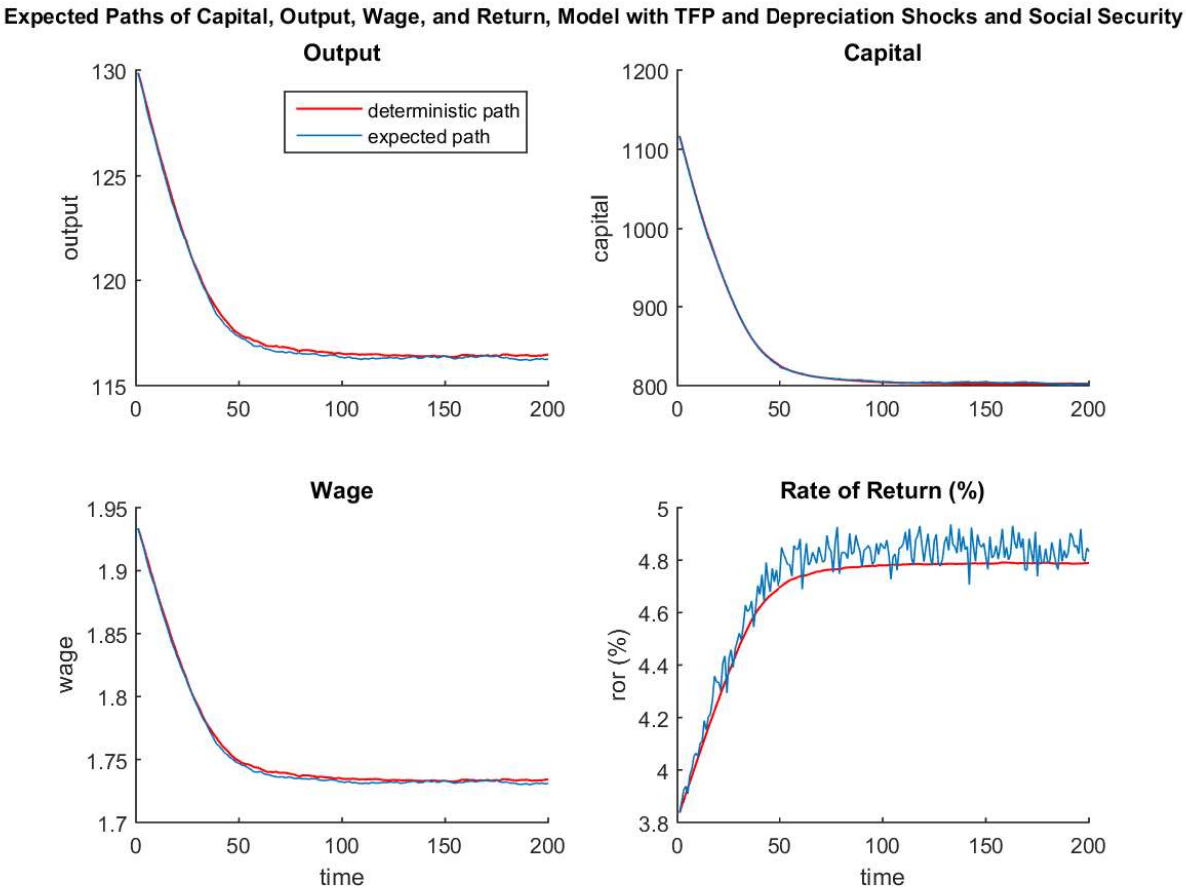

Figure 4: Expected path of output, capital, wage, and rate of return in deterministic model and in the model with both TFP and depreciation shocks. Social Security is present under both calibrations. Expectations are computed over 10,000 simulated paths.

percent. Thus shocks leave the long-run levels of output, capital, and wages relatively close to their deterministic counterparts, even though returns respond sharply to realized shocks.

Fraction of Absolute Deviations from Deterministic Counterparts (in Percent)

	Threshold				Threshold			
	5%	10%	25%	50%	5%	10%	25%	50%
Years Out	OUTPUT				CAPITAL			
50	41.44	9.82	0	0	20.10	1.03	0	0
75	40.49	9.54	0	0	20.39	1.28	0	0
100	40.97	9.43	0	0	20.38	1.18	0	0
	WAGE				RATE OF RETURN			
50	41.44	9.82	0	0	96.09	91.77	79.63	60.16
75	40.49	9.54	0	0	95.63	91.18	78.94	60.60
100	40.97	9.43	0	0	95.98	91.53	79.47	60.52

Table 5: Fraction of absolute percentage deviations from deterministic benchmark values that exceed thresholds of 5, 10, 25, and 50 percent. The table reports results at horizons of 50, 75, and 100 years. Fractions are computed across 10,000 simulated histories of aggregate shocks. All simulations are based on model variants that include depreciation shocks and Social Security.

7 Sensitivity Analysis

Tables 6 and 7 show that our results are not sensitive to the inclusion of either Social Security or depreciation shocks. Table 6 incorporates Social Security into our baseline model and Table 7 excludes depreciation shocks. As a comparison of Table 6 and Table 2 shows, adding Social Security changes the levels of the return to capital and the safe rate, but it makes essentially no difference to the equity premium. Without borrowing costs, the equity premium is 0.15 percent with Social Security compared to 0.17 percent without it. With the baseline borrowing costs, the equity premium is 3.59 percent with Social Security compared to 3.65 percent without it, and with the steeper borrowing costs it is 6.26 percent with Social Security compared to 6.32 percent without it. Sharpe ratios are also very similar with and without Social Security.

The same point can be seen by comparing Table 7 with Table 2. When depreciation shocks are excluded, the equity premium is still close to zero absent borrowing costs. It

Summary Statistics of Rates of Return

	Mean Return to Capital (%)	Mean Safe Rate of Return (%)	S.D. Return to Capital (%)	S.D. Safe Rate of Return (%)	Equity Premium (%)	Sharpe Ratio
MODEL WITH SOCIAL SECURITY						
No Borrowing Costs	4.91	4.75	4.64	0.5	0.15	0.03
Borrowing Costs	4.90	1.32	4.63	0.44	3.59	0.77
Steeper Borrowing Costs	4.89	-1.38	4.63	0.44	6.26	1.35
DATA BASED ON RETURN TO U.S. WEALTH						
	6.512	1.083	4.886	2.195	5.429	1.111

Table 6: Summary statistics of rates of return in the model with Social Security and in the data.

Summary Statistics of Rates of Return

	Mean Return to Capital (%)	Mean Safe Rate of Return (%)	S.D. Return to Capital (%)	S.D. Safe Rate of Return (%)	Equity Premium (%)	Sharpe Ratio
MODEL WITHOUT DEPRECIATION SHOCKS						
No Borrowing Costs	3.83	3.83	0.13	0.10	0.00	0.01
Borrowing Costs	3.84	0.09	0.14	0.11	3.75	27.72
Steeper Borrowing Costs	3.87	-2.16	0.14	0.11	6.02	44.20
DATA BASED ON RETURN TO U.S. WEALTH						
	6.512	1.083	4.886	2.195	5.429	1.111

Table 7: Summary statistics of rates of return in the model without depreciation shocks and in the data.

increases to 3.75 percent under baseline borrowing costs and to 6.02 percent under the steeper borrowing costs. In Table 2, the corresponding values are 3.65 and 6.32 percent. Therefore, depreciation shocks aren't critical to our "no-one-can-borrow" finding.

A comparison of Figures 5 and 2 shows that depreciation shocks matter for the pattern of borrowing and saving over the life cycle. As previously indicated, absent depreciation shocks, younger households demand bonds and older households supply them. With depreciation shocks, this pattern is reversed because older households want to protect their accumulated wealth from depreciation risk, while younger households can use their labor income as a hedge. However, even though the age pattern of bond holdings changes, the main asset-pricing result does not. In both cases, borrowing costs reduce bond trading, lowering the safe rate, and increasing the equity premium.

8 Conclusion

Simulating a sizable equity premium in standard macroeconomic models has proved difficult, hence the appellation "equity premium puzzle". The Constantinides, Donaldson, and Mehra (2002) resolution, eliminating borrowing (bond supply) by the young, produces a realistic premium. But their model is highly stylized, featuring pure exchange, just three generations, and a particular configuration of intergenerational risks. Moreover, its success, though not apparent from its title, entails shutting down bond supply in its entirety, not just bonds supplied by the young.

This paper examines CDM's answer within Hasanhodzic and Kotlikoff's (2026) large-scale RBC-OLG model. The model features neoclassical production, endogenous factor prices, plus TFP and capital-depreciation shocks. Our U.S.-calibrated model comprises 80 overlapping generations with isoelastic preferences. Its 81-state-variable solution is based on Marcet's (1988) ingenious projection method, which overcomes dynamic programming's curse of dimensionality by considering only states in the model's ergodic state. The model's shocks are calibrated to reproduce the variability of the risky return to capital, which dramatically overstates the variability of macro aggregates. This makes our model's trivially small equity premium, absent borrowing constraints, even more striking.

In our model, as in CDM, restricting borrowing – the supply of one-period safe bonds – increases the equity premium. But full puzzle resolution – producing a realistic premium – requires closing down the bond market entirely, i.e., preventing not just the young, but *all* generations from borrowing. Permitting any one of our 80 generations to borrow (supply bonds) lowers the premium far below that observed. Thus, "No One Can Borrow" rather

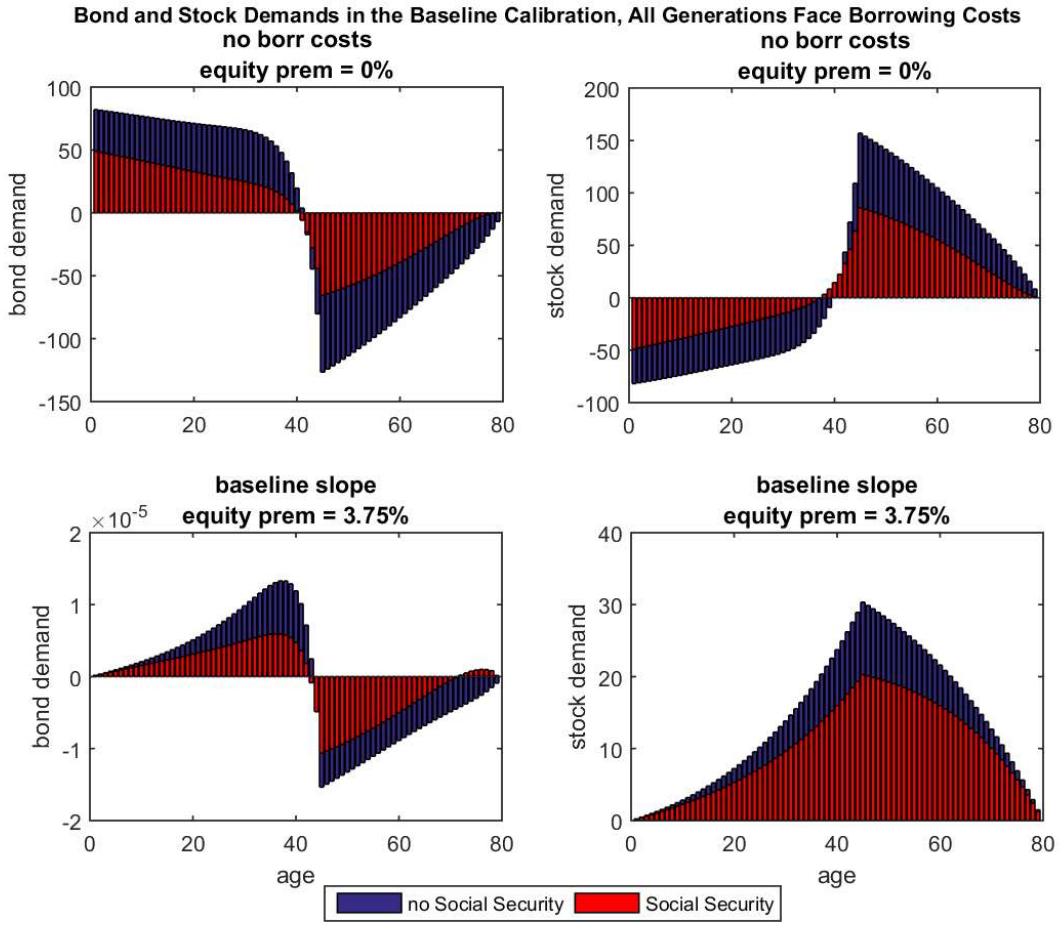

Figure 5: Bond and stock demands in the model without depreciation shocks, shown with and without borrowing costs and with and without Social Security. When borrowing costs are present, they apply to all generations. The equity premia shown at the top of the panels refer to the cases without Social Security (blue bars) and correspond to the first two rows of Table 7.

than "Junior Can't Borrow" is the natural generalization of CDM.

But shutting down all borrowing, which we operationalize via a steeply rising borrowing-cost function, renders CDM's resolution implausible. Yes, many households face rising borrowing costs depending on the nature of their borrowing. But others can and do borrow at zero or minor marginal cost, for example, from family members. Yet others are charged substantial amounts to borrow, but charges that are largely fixed, not sharply rising with the amount borrowed. One-time mortgage origination fees are an example. Moreover, all agents can effectively borrow at zero marginal cost to purchase risky capital by investing in leveraged corporations, a key point of Modigliani and Miller (1958). These points aside, private borrowing is massive, not minuscule, relegating the "No One Can Borrow" equity-puzzle solution to an interesting theoretical curiosum, not a meaningful resolution of the unresolved mismatch between theory and evidence.

As in representative-agent models, macro risk is small in OLG-RBC settings. It is small not because macro shocks are or need be small relative to observed output variability. It is small because macro shocks can be well insured by saving in good times and dissaving in bad times. Consequently, absent borrowing costs, agents, no matter their age, are willing to hold bonds rather than equities but only if bonds return close to what they can expect to earn on equities. Alternatively, they are willing to borrow to buy shares because they perceive little risk in using stock returns to cover repayment.

Our findings not only deepen the equity premium puzzle. They help clarify Anthropelos et al. (2026)'s important message: macro shocks are second order. They are not large enough to materially alter our economy's transition paths. Indeed, the average paths of our stochastic economy's macro variables are essentially coincident with their deterministic counterparts. This macroeconomic finding is predicated on the microeconomic behavior identified here and in Hasanhodzic and Kotlikoff (2026). Since household consumption and saving decisions are little changed by macro risk, neither is the macro economy.

In closing, we ponder whether the equity premium puzzle, which has resisted resolution for more than four decades, represents a feature, not a bug. If reasonably risk-averse agents in reasonably-calibrated models would treat calibrated macro shocks as second order – in remarkable contrast to observation, actual agents may simply be over assessing their exposure to macro risk. Alternatively, the majority may correctly perceive that a plethora of day traders, as suggested by large numbers of crypto-currency, prediction-market, lottery-ticket, and casino gamblers, makes equity investing too risky. Economists can respond, a la Campbell and Mankiw (1989), by adding the right dose of irrational agents to "explain" the premium puzzle. But "Crazy is as crazy as does." Rather than "rationalize" irrationality by assuming a specific form of economic crazy, economists might simply treat the equity puzzle

as a measure of financial pathology. But doing so infers an obligation to help households make rational financial decisions – to prescribe healthy financial behavior, not simply catalog financial mistakes. By analogy, physicians try to cure, not just study, disease.

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