Financial Literacy, Portfolio Choice, and Wealth Inequality: A General Equilibrium Approach*†

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November 13, 2023

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Abstract

I develop a general equilibrium model in which households allocate their wealth to safe and risky assets ("bonds" and "stocks") and accumulate financial literacy to raise their risk-adjusted stock returns. Calibrated to match financial literacy and stock market participation rate of U.S. households, the model demonstrates that a policy subsidizing financial literacy acquisition increases short-run stock investments. In equilibrium, however, the resulting aggregate capital growth lowers the average equity premium, thereby moderating the subsidy's impact. Nevertheless, the policy mitigates wealth inequality by inducing heterogeneous portfolio adjustments across the wealth distribution. With the subsidy, the middle wealth quartiles acquire more financial literacy and shift their portfolios toward stocks. The top quartile attains their maximum literacy level prior to the subsidy and shifts toward bonds to compensate for lower stock returns. Consequently, the ratio of total wealth held by the top quartile versus the rest of the population decreases.

Keywords: Financial literacy, stock market participation, equity premium, return heterogeneity, wealth inequality

*I am indebted to my advisors Dirk Krueger, Olivia S. Mitchell and Joachim Hubmer for their invaluable guidance and continued support. I extend my special thanks to economists at the Federal Reserve Board and the Federal Reserve Bank of St. Louis for the insightful feedback. I also appreciate the inspiration and solidarity shared by the faculty and my fellow Ph.D. students at Penn Economics. All errors are my own.

†This paper was supported through a Quartet Pilot Research award and was funded by the Boettner Center at the University of Pennsylvania. The content is solely the responsibility of the author and does not necessarily represent the official views of the University of Pennsylvania or National Institutes of Health.

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1 Introduction

There is substantial dispersion in both financial literacy and returns to wealth across households in the United States (Lusardi and Mitchell, 2014; Hubmer et al., 2021). As defined in Lusardi and Mitchell (2014), financial literacy refers to people's "*ability to process economic information and make informed decisions about financial planning, wealth accumulation, debt, and pensions.*" Being capable of making informed decisions, more literate individuals tend to have higher portfolio shares in public equities than in interest-bearing assets, as well as higher Sharpe ratios on their stock investment, which together contribute to higher expected returns to net worth (van Rooij et al., 2011; Clark et al., 2017; Gaudecker, 2015). In light of this positive link between financial literacy and investment outcomes, there has been increasing research and policy interest in financial education programs. These initiatives, often delivered in the form of workplace and school-based personal finance education, have positive causal effects on financial behaviors of individuals (Kaiser et al., 2022).

Nevertheless, to date few studies have examined what the effect of scaling these programs to the aggregate level would be. In this paper, I fill this gap by analyzing the macroeconomic interplay between financial literacy disparity and wealth inequality using a general equilibrium framework, which incorporates household portfolio choices and financial literacy accumulation in a heterogeneous-agent incomplete market model. The model can inform us about the aggregate implications of policies subsidizing financial literacy investment, and to which extent such policies can increase aggregate capital and mitigate wealth inequality. Understanding this relationship in a general equilibrium setup is crucial for judging the effectiveness of financial education subsidies, since increasing average financial literacy may not fully translate into aggregate capital growth due to potential price adjustments

In particular, I use an overlapping generations model in which working-age households face a stochastic labor income process and retired households receive deterministic pension benefits. Markets are incomplete: households cannot trade state-contingent securities, yet they can smooth consumption by investing in financial assets. The consumption-saving problem builds on a standard household portfolio choice model with background labor income risks (Cocco et al., 2005; Gomes and Michaelides, 2005). There are two types of assets available in this economy: a safe asset with a risk-free return ("bonds"), and a risky asset whose return is subject to idiosyncratic shocks ("stocks"). Accordingly, households face uninsurable risks in both labor and capital incomes. In each period, households allocate their wealth into either or both assets. Their portfolio choices are impacted by several market frictions, including borrowing and short-sale constraints, as well as a per-period stock market participation cost. Therefore, the equity premium on stocks compensates for both idiosyncratic risk and participation cost.

The model incorporates households' endogenous accumulation of financial literacy, following Lusardi et al. (2017). Financial literacy may represent various drivers of sophisticated wealth accumulation: financial knowledge, investment skills and experience, educated use of financial advising and asset management services, and access to promising investment opportunities. By accumulating financial literacy, households can raise their risk-adjusted stock returns. This assumption is motivated by empirical evidence demonstrating a positive association between measures of household financial literacy and asset returns (Clark et al., 2017; Gaudecker, 2015; Bianchi, 2018). Financial literacy depreciates over time. Households incur a convex cost (in consumption units) for accumulating financial literacy each period.

The household portfolio and financial literacy choice is embedded into to a production economy where the government issues risk-free bonds and a representative firm rents capital on a competitive market. competitively. In equilibrium, productive capital is supplied by aggregate savings in stocks. Financial literacy operates as a schedule to distribute aggregate capital income across households, such that a larger (smaller) share of capital income is allotted to more (less) literate households.[1] I formalize this additional market clearing condition of aggregate capital income as in Hubmer et al. (2021). In my model, the endogenous dis-

1. The model posits that financial literacy does not directly enter the firm's production function; that is, raising aggregate financial literacy has no effect on the economy's fundamental production capacity, or on total factor productivity (TFP).

tribution of financial literacy gives rise to the dispersion in stock returns across households. The capital income consistency condition implies the zero-sum aspect of financial literacy accumulation: if a household improves its financial literacy and expected stock return, its increased return comes at the loss of other households in equilibrium. Accordingly, households' financial literacy accumulation generates pecuniary externalities on overall equity premia.

Such pecuniary externalites lead to the competing aggregate implications of policy interventions that subsidize financial literacy acquisition. On the one hand, an increase in the average level of financial literacy boosts stock demand, while on the other hand, greater capital investment reduces the average equity premium in the long run. The equilibrium effects of raising average financial literacy are then twofold: first, it increases aggregate capital and hence lowers the overall rental rate of capital; and second, it generates a larger pecuniary externality for the entire economy. The total it decreases the expected stock market *participation* premium in the economy. Both the capital rental rate and participation premium are equilibrium objects, where the latter captures the base expected stock return that households can earn by investing in stocks with minimum financial literacy. As the overall economy becomes more financially literate, the capital income clearing condition ensures that the participation premium falls in equilibrium. The resulting decline in the average equity premium, in turn, attenuates the subsidies' effects on aggregate capital accumulation.

The model further demonstrates that these equilibrium channels have heterogeneous impacts on portfolio choices and idiosyncratic equity premia across the wealth distribution, inducing interesting redistributive effects of financial literacy subsidies. I use the model to quantify the net effects of a policy intervention that subsidizes a fraction of the household's financial literacy acquisition cost. In the benchmark case, the government finances this universal subsidy through a constant capital income tax on all financial assets. In alternative model specifications, I discuss the efficacy of alternative policies targeted at different population subgroups such as young workers and middle-age workers closer to retirement.

In order to quantify the aggregate and distributional impacts of the subsidies, I calibrate the model to match financial literacy and stock market participation rate of U.S. households in the Survey of Consumer Finances. The Survey's recent waves provide a measure of financial literacy, determined by survey respondents' understanding of fundamental economic concepts (namely, inflation, interest rates, and risk diversification).[2] Accordingly, the financial literacy *score* ranges from 0 to 3, depending on how many questions the respondents answered correctly. Data from the 2016-2019 SCF shows that the average financial literacy score of the U.S. households between age 26 and 80 is 2.19. Moreover, only 44.2 percent of the aforementioned population can answer all three financial literacy questions correctly, while 54.1 percent reports having positive stock holdings. The model replicates well the hump-shaped life-cycle pattern of financial literacy, as well as the average stock market participation rate across wealth groups. To externally validate the model, I compare the household-level stock market participation elasticities with respect to financial literacy in the data and in the model-simulated cross-sections.

The main policy intervention of the paper evaluates the effect of a universal 75 percent subsidy of the financial literacy investment cost, financed by a tax on capital income. With the cost subsidy, the model predicts that the average financial literacy score rises by 10.1 percent, and the aggregate stock market participation rate rises by 1.9 percentage points in partial equilibrium where only the labor market is cleared. However, in general equilibrium, the net increase in participation rate shrinks to 0.2 percentage points. Underlying this substantial attenuation are the decrease in the average equity premium from 5.38 to 5.28 percents, caused by (1) the decline in the rental rate of capital (from 7.70 to 7.68 percents), and (2) the increase in the capital income tax rate required to finance the subsidy (from 9.8 to 10.8 percents). Calculating the policy effects after accounting only for the rental rate adjustment leads to a predicted 0.8 percentage point increase in the participation rate, indicating that the equilibrium capital return response itself makes a non-negligible impact on aggregate capital.

2. This financial literacy measure is based on the *Big Three Questions* proposed in Lusardi and Mitchell (2014).

In any event, the financial literacy subsidy intervention still mitigates wealth inequality by generating heterogeneous portfolio rebalancing across the wealth distribution. The subsidy increases financial literacy for the middle wealth quartiles the most, but hardly impacts the top and bottom quartiles. The wealthiest households attain their maximum literacy level prior to the subsidy, while the poorest households, who initially hold no stock due to participation costs, still do not acquire financial literacy even when it is heavily subsidized. Despite the decrease in the overall equity premium, the middle wealth quarterlies with improved literacy shift their portfolio toward stocks, *raising* their risky portfolio share by 1.8 percent, whereas the top wealth quartile shifts toward bonds to compensate for lower stock returns, *reducing* their risky share by 0.7 percent. As a result, wealth inequality, measured as a ratio of total wealth held by the top quartile versus the rest of the population, decreases by 1.9 percent. The model finds that the poorest and least financially literate remain out of the stock market due to high participation costs, suggesting a possible benefit of market participation subsidies. In alternative policy experiments, I find that subsidizing both stock market participation and financial literacy investment for young workers under age 40 can substantially increase the average stock market participation rate by 7.87 percent.

Related Literature This paper contributes to the literature at the intersection of macroeconomics and household finance. The paper provides a quantitative framework to assess how the distribution in financial literacy interacts with wealth inequality in equilibrium.

Wealth has been increasingly concentrated in the U.S. (Saez and Zucman, 2016; Gabaix et al., 2016). Underlying this severe wealth disparity, among other factors, is the heterogeneity in returns to wealth (Benhabib et al., 2019; Hubmer et al., 2021; Xavier, 2021). The observed wealth return heterogeneity can be potentially explained by the variation in portfolio choice across households (Cocco et al., 2005; Gomes and Michaelides, 2005; Fagereng et al., 2017; Catherine, 2021). Still, the persistent correlation between household wealth and return suggests that permanent household characteristics can drive return heterogeneity even *within* asset classes (Fagereng et al., 2020; Bach et al., 2020). In particular, low-income and less-educated individuals tend to exhibit poorer financial literacy and make sub-optimal investment decisions or even lack thereof (Calvet et al., 2007, 2009; Lusardi et al., 2017; Jappelli and Padula, 2017).

This paper's main contribution to the literature is to provide novel equilibrium explanation on how raising financial literacy impacts capital accumulation and wealth inequality.

The remainder of the paper is structured as follows. Section 2 presents the model environment. Section 3 describes the data and quantification exercises. Section 4 discusses the quantitative and policy analyses. Section 5 investigates alternative model specifications and conducts sensitivity checks. Section 6 concludes.

2 Model

I develop a finite-horizon general equilibrium model with households' portfolio and financial literacy choices. The distribution of aggregate capital income is shaped by the endogenous distribution of financial literacy. This section outlines the decision problems for households, firms, and the government, and elucidates the equilibrium concepts.

2.1 Household's Problem

2.1.1 Household Life Cycle and Preferences

Time is discrete with t representing the household's age. The economy consists of finitely-lived households born at $t = 0$ (age 25) and living for T more periods (age 80). Each cohort has an identical population size, and there is no population growth. Households derive utility from consuming a single non-durable good c_t, and their preferences are defined à la Epstein and Zin (1989) and Weil (1990):

$$V_t = \left\{ \big(1-\beta\big) c_t^{1-1/\psi} + \beta \mathbb{E}\Big[V_{t+1}^{1-\gamma}\Big]^{\frac{1-1/\psi}{1-\gamma}} \right\}^{\frac{1}{1-1/\psi}} \tag{1}$$

where β is the discount factor, ψ is the elasticity of inter-temporal substitution (EIS), and γ is the coefficient of relative risk aversion (RRA).

2.1.2 Labor Incomes, Pension Benefits, and Housing Costs

Labor supply is exogenous. Households work for the first $T_R < T$ periods of their life, and receive retirement benefits afterwards. Working-age households' labor productivity is stochastic and their efficiency units of labor $\{l_t\}_{t=1}^{T_R}$ follow a log-AR(1) process:

$$\log(l_t) = m_t + \rho \log(l_{t-1}) + \varepsilon_t, \quad \text{for } t \leq T_R \tag{2}$$

where the age-specific drift m_t is a deterministic life cycle component, $\rho \in [0,1)$ is the AR(1) auto-correlation coefficient, and $\varepsilon_t \sim \mathcal{N}(0, \sigma_l^2)$ is an idiosyncratic shock to labor productivity. After retirement, households receive deterministic social security benefits and pension payments which together substitute their final working-age labor income with a replacement ratio $\lambda \in (0,1)$. The corresponding efficiency units of labor for retirees are:

$$l_t = \exp(m_t) \cdot \lambda l_{t_R} \quad \text{for } t > t_R \tag{3}$$

Labor income is taxed at a constant rate τ^l while pension benefit is non-taxable. Households spend an exogenous fraction of their pre-tax labor incomes (or pension benefits) as housing expenditures, where the age-specific fraction is given by $h_t \in (0,1)$.[3]. The households'

3. While the household problem in this paper does not directly incorporate the consumption choice of durable goods or a housing decision, it follows the literature's common practice of introducing housing costs as a faction of labor incomes to capture the life-cycle pattern of household consumption and saving behaviors (Gomes and Michaelides, 2005; Love, 2010; Horneff et al., 2023). The previous studies that include the housing decision in the life-cycle model analyze the correlation between households' real estate holdings and financial asset positions Cocco (2005); Yao and Zhang (2005); Yogo (2016).

disposable labor and pension incomes net of applicable taxes and housing costs read as:

$$\tilde{l}_t = \begin{cases} \left(1-\tau^l\right)(1-h_t)\cdot w\cdot \exp(m_t+\varepsilon_t)\cdot l_{t-1}^{\rho} & \text{if } t\le T^R \\ \lambda\,(1-h_t)\cdot w\cdot \exp(m_t)\cdot l_{t_R} & \text{if } t> T^R \end{cases} \tag{4}$$

where w is a wage per efficiency unit of labor.

2.1.3 Financial Assets and Portfolio Choices

Markets are incomplete: households are not allowed to trade full state-contingent Arrow securities. Still, households may engage in an inter-temporal exchange of resources by the means of savings. There are two types of financial assets: a risk-free asset ("bonds") and a risky asset ("stocks"). Let b_t denote the amount of bonds a household has at the beginning of period t. Bonds yield a risk-free return r^b. Let a_t denote the household's stock holdings. The stock return schedules are characterized by a function of an *idiosyncratic* shock as well as the individual household's financial literacy level at period t.[4] The functional form of household-specific stock returns is specified in Section 2.1.4 which describes a structural link between households' financial literacy decisions and their idiosyncratic equity premia.

Markets are frictional in three aspects. First, borrowing of bonds and short-selling of stocks are not allowed: $b_t \geq 0$ and $a_t \geq 0$. These liquidity constraints ensure that households hold non-negative wealth throughout their life-cycle. Moreover, the borrowing constraint prevents households from leveraging their future stream of incomes to invest in stocks. Second, households with positive stock holdings incur a constant *per-period* stock market participation cost θ (in consumption units) for each period t s.t. $a_t > 0$. Accordingly, these

4. As commonly assumed in the portfolio choice literature, I do not incorporate aggregate shocks in the model. As long as such systematic risks are uninsurable, household financial literacy would have limited role in impacting the magnitude or volatility of those risks. Still, one possible prediction is that more literate households tend to have better diversified portfolios with lower *non-systematic* risks, which allows them to tolerate a higher exposure to *systematic* risks of their portfolios. Potential studies in this direction can shed light on how financial literacy interventions can impact aggregate risk sharing among households with different levels of wealth and financial literacy. Also see a general equilibrium analysis by Zhang (2023), which shows that an economy-wide adoption o target date funds improves risk sharing.

stock investors obtain equity premium as an compensation for both uninsurable shocks and participation costs associated with their risky portfolio choices. Third, capital incomes are taxed at a constant rate τ^r; for simplicity, I assume that bond and stock investments are subject to the same capital income tax rate.

It can be convenient to express household asset positions using portfolio shares. Define $\mathcal{S}_t = a_t + b_t$ as the amount of gross saving a household has in either or both financial assets at the beginning of period t. Also define $\kappa_t = a_t/\mathcal{S}_t$ as the household's risky portfolio share, or the fraction of its financial wealth invested in stocks, at time t. By construction, the wealth share in bonds is given by $(1-\kappa_t) = b_t/\mathcal{S}_t$. The borrowing and short-selling constraints can be formulated as the bounds on portfolio shares: $\kappa_t \in [0, 1]$.

2.1.4 Financial Literacy Accumulation and Equity Premium

As in Lusardi et al. (2017), I augment the life-cycle portfolio choice model with households' investment of financial literacy. A key assumption of the model is households can raise their risk-adjusted stock returns by opting to accumulate financial literacy at the cost of forgoing instantaneous consumption and saving. Let $f_t \in [f_{\min}, f_{\max}]$ denote a household's level of financial literacy at the beginning of age t. Financial literacy depreciates at an annual rate of δ_f, which captures the rate at which households' capacity to process stock market information and utilize investment opportunities decays each period. Against such depreciation, households can spend their resources to acquire additional $e_t > 0$ units of financial literacy. The law of motion of financial literacy then reads as:

$$f_{t+1} = (1-\delta_f)f_t + e_t \tag{5}$$

The resource cost of financial literacy acquisition is shaped by a convex function:

$$\Phi(e_t) = \phi e_t^{\iota} \tag{6}$$

with $\phi > 0$ and $\iota > 1$.[5] As emphasized in Lusardi et al. (2017), this functional form implies an increasing marginal cost of investing in financial literacy, which ensures that households smooth such investments over their life spans.

The marginal benefit of financial literacy investment manifests through an increase in household-specific expected stock returns. At the beginning of each period t, a stochastic stock return for a household with the financial literacy level f_t realizes as:

$$\tilde{r}(f_t) = \underline{r} + r^X(f_t) + \sigma^X \eta_t \tag{7}$$

which consists of an equilibrium component, $\underline{r}$, as well as an idiosyncratic excess return schedule with a standard normal shock, $\eta_t \sim \mathcal{N}(0,1)$, whose mean and standard deviation are given by $r^X(\cdot)$ and σ^X, respectively. Importantly, financial literacy raises the mean excess return with bounds $[r^X(f_{\min}), r^X(f_{\max})] = [0, \bar{r}^X]$. Given the constant standard deviation σ^X, the positive literacy premium on the mean excess return ($r^X_f > 0$) implies that more literate households obtain a higher risk-adjusted return—hence a higher Sharpe ratio—on their stock investments. A potential interpretation of this reduced-form assumption is that more literate households can better identify a composite (or portfolio) of stocks that has a higher expected return, a lower idiosyncratic risk, or both, and such relationships between financial literacy and investment outcomes are empirically supported (e.g., Clark et al., 2017). As discussed in section in further details 3.2.2, the excess return parameters, r^X_f and σ, are externally calibrated based on the empirical findings.

The remaining component of the realized stock return function, $\underline{r}$, is a key equilibrium object which has a symmetric impact on all stock market participants' returns. Assume that households with the minimum level of financial literacy obtain a zero mean excess return:

5. By modeling the financial literacy acquisition cost as a resource cost, I keep the household labor and literacy choices orthogonal to each other while still capturing the intertemporal trade-off between financial literacy and consumption (and saving). Alternatively, one may consider an environment in which households pay time costs, i.e., they allocate their endowed time units over labor, leisure, and financial literacy investment. In this specification, labor choice distorts financial literacy choice and vice versa. Moreover, the counterfactual analysis is likely to be fairly sensitive to (the calibration of) the household-level correlation between labor and capital incomes, which is beyond the scope of this paper.

$r^X(f_{\min}) = 0$. Then, the aggregate component represents the expected stock return for the least finacially literate houseoholds, $\underline{r} = \mathbb{E}[\tilde{r}(f_{\min})]$, which is determined in equilibrium according to the stock market clearing conditions specified in Section 2.4. In other words, individual households take this *base stock return* $\underline{r}$ as given when making portfolio and financial literacy decisions. On top of the base return, households can accrue additional excess return $r^X(f)$ by accumulating financial literacy.

2.1.5 Recursive Household Problem

Households enters each period t with their own financial literacy level f_t, financial wealth $\mathcal{S}_t$, and the realized efficiency unit of labor l_t. The corresponding disposable labor income and pension pension benefit $\tilde{l}_t$ are defined in equation (4). The wealth stock $\mathcal{S}_t$ and disposable labor income flow $\tilde{l}_t$ constitute the amount of *cash on hand* that households can spend in period t: $\mathcal{X}_t = \mathcal{S}_t + \tilde{l}_t$. The cash on hand evolves according to the following law of motion:

$$\mathcal{X}_{t+1} = \underbrace{\Big[\kappa_{t+1}\tilde{R}(f_{t+1}) + (1-\kappa_{t+1})R^b\Big]}_{\text{weighted average return to wealth}} \underbrace{\Big(\mathcal{X}_t - c_t - \theta \cdot \mathbb{1}(\kappa_{t+1} > 0) - \Phi(e_t)\Big)}_{\equiv \mathcal{S}_{t+1},\text{ gross saving}} + \tilde{l}_{t+1} \tag{8}$$

where R^b and $\tilde{R}(f_{t+1})$ denote the after-tax gross returns on bonds and stocks, respectively:

$$\tilde{R}(f_{t+1}) = 1 + (1-\tau^r)\tilde{r}(f_{t+1}) \tag{9}$$

$$R^b = 1 + (1-\tau^r)r^b \tag{10}$$

and τ^r is a constant capital income tax rate. The household problem is to maximize the Epstein-Zin utility function (Eq. 1) subject to constraints (Eqs. 2-10). The recursive household problem in period $t \leq T$ defined as below:

$$V_t\Big(\mathcal{X}_t, f_t; l_t, \eta_t\Big) = \max_{c_t, e_t, \kappa_{t+1}} \left\{(1-\beta)c_t^{1-1/\psi} + \beta\mathbb{E}\Big[V_{t+1}^{1-\gamma}\Big(\mathcal{X}_{t+1}, f_{t+1}; l_{t+1}, \eta_{t+1}\Big)\Big]^{\frac{1-1/\psi}{1-\gamma}}\right\}^{\frac{1}{1-1/\psi}}$$

$$\text{s.t.} \quad \mathcal{X}_{t+1} = \Big[\kappa_{t+1}\tilde{R}(f_{t+1}) + (1-\kappa_{t+1})R^b\Big]\Big(\mathcal{X}_t - c_t - \theta \cdot \mathbb{1}(\kappa_t > 0) - \Phi(e_t)\Big) + \tilde{l}_{t+1}$$

$$f_{t+1} = (1-\delta_f)f_t + e_t$$

$$\tilde{R}(f_{t+1}) = 1 + (1-\tau^r)\left(\underline{r} + r^X(f_{t+1}) + \sigma\eta_{t+1}\right)$$

$$R^b = 1 + (1-\tau^r)r^b$$

$$\mathcal{X}_{t+1} \geq 0, \kappa_t \in [\underline{\kappa}, \overline{\kappa}] = [0, 1]$$

where $\tilde{l}_t$ is the disposable labor income defined in eqaution 4). The household's *endogenous* state variables include cash on hand and financial literacy $\big(\mathcal{X}_t, f_t\big)$ and the *exogenous* state variables include labor income productivity and stock return shock $\big(l_t, \eta_t\big)$. The choice variables include consumption, financial literacy acquisition, and risky portfolio share $\big(c_t, e_t, \kappa_{t+1}\big)$. The household decisions are subject to the borrowing and short-selling constraints $\kappa_{t+1} \in [0, 1]$ as well as the resource costs for financial literacy acquisition and stock market participation $\big(\Phi(\cdot), \theta\big)$.

Take note of the timing when the returns on financial literacy investment manifest: assume a household acquires $[e_t]$ units of financial literacy in period t. This literacy investment is immediately reflected in the quality of the portfolio choice $[k_{t+1}]$ made in the same period, consequently raising the mean excess return on stocks $[r^X_{t+1}(\cdot)]$ the household holds between period t to period $t+1$.

2.2 Production Economy

Consider a Bewley-Huggett-Aiyagari type economy, wherein a representative firm operates in perfectly competitive markets (Aiyagari, 1994). The firm rents capital K and employs labor L with a standard Cobb-Douglas production function:

$$g(K, L) = AK^{\alpha}L^{1-\alpha}$$

where A represents a constant total factor productivity (TFP). The capital K depreciates at a rate $\delta_K \in (0, 1)$. The firm's optimality condition determines the rental rate of capital $r^{\star} = g_K(F^{\star}, K^{\star}, L^{\star}) - \delta_K$ and the wage rate for an efficient unit of labor $w = g_L(F^{\star}, K^{\star}, L^{\star})$. A crucial assumption of the model is that household financial literacy does not directly impact the firm's production process. It is not utilized as a direct input in the firm's production function and remains orthogonal to the economy's fundamental production capacity, or TFP.

2.3 Government's Budget Balance

In this economy, the government plays dual roles: firstly, providing retirement benefits, and secondly, issuing risk-free bonds. The associated budgets are balanced separately: the pension system is exclusively funded by the labor income tax, whereas bond return payments are covered by the capital income tax.

2.3.1 Retirement Benefits

The government administers a pay-as-you-go social security and pension system, imposing a constant labor income tax τ^l on workers at age $t \leq t_R$ and redistributing the tax revenue to retirees at age $t > t_R$. The retirement benefit replaces the final working-age labor income at a ratio denoted by λ. The government's budget constraint for labor income tax revenue is:

$$\int \tau^l w l_t d\Gamma(\mathcal{X}, f; l, \eta, t \leq t_R) = \int \lambda w l_t d\Gamma(\mathcal{X}, f; l, \eta, t > t_R) \tag{11}$$

where w represents the wage rate, l_t is the realized labor productivity, t_R is the retirement age, and $\Gamma(\cdot)$ denotes the invariant distribution of households. Recall that the labor process $\{l_t\}_{t=0}^{T}$ is exogenous; hence, the labor income tax rate is computed independently of the remaining endogenous equilibrium components of the model. In essence, it is the ratio of retirees' to workers' labor productivity, multiplied by the replacement rate λ:

$$\tau^l = \lambda \frac{\int l_t d\Gamma(\mathcal{X}, f; l, \eta, t > t_R)}{\int l_t d\Gamma(\mathcal{X}, f; l, \eta, t \leq t_R)}$$

2.3.2 Government bonds

The government issues a risk-free bond with a return denoted by r^b. Given the aggregate output Y, the gross debt issuance level B is adjusted to sustain a constant government debt-to-GDP ratio, $\mathscr{B} = \frac{B}{Y}$. To fund debt payments and general expenditures, the government imposes a constant capital income tax on both bonds and stocks at rate τ^r. The budget constraint for capital income tax revenue is:

$$G + r^b B = \int \tau^r \left(r^b(1-\kappa) + \tilde{r}(f)\kappa \right) \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{12}$$

where G denotes the government's general expenditure, and $\mathcal{S}$ denotes a household's gross savings in both financial assets. A straightforward algebraic solution yields the constant capital income tax rate:

$$\tau^r = \frac{G + r^b B}{r^b \int (1-\kappa)\mathcal{S} d\Gamma + \int \tilde{r}\kappa\mathcal{S} d\Gamma} = \frac{G + r^b B}{r^b \int b d\Gamma + \int \tilde{r} a d\Gamma}$$

where $b = (1-\kappa)\mathcal{S}$ and $a = \kappa\mathcal{S}$ represent a household's bond and stock holdings, respectively. In the baseline economy, the assumption is that the government incurs no general expenditures $G = 0$, allocating the entire revenue from capital income taxes to cover bond return payments. Section 4 explores counterfactual economies, where the government supports households in enhancing financial literacy and participating in the stock market. The magnitude of these policy interventions is quantified by positive expenditure $G > 0$.

2.4 General Equilibrium

The economy consists of T-overlapping generations with a stationary age distribution.[6] In equilibrium, government bonds are in net positive supply and stocks serve as productive capital. The formal definition of the general equilibrium is as follows:

2.4.1 Definition

Given the social security replacement rate λ, the government-debt-to-GDP ratio $\mathscr{B}$, and the excess stock return schedules $\left(r^X(\cdot), \sigma^X\right)$, a steady-state equilibrium of the economy is characterized by aggregate quantities $(F^\star, B^\star, K^\star, L^\star)$, asset returns $(r^{b\star}, r^\star, \underline{r}^\star)$, and wage rate w. Tax rates (τ^l, τ^r) are endogenously determined in the equilibrium.

[1] The representative firms' optimality conditions characterize the factor prices:

$$r^\star = g_K(K^\star, L^\star) - \delta_K \tag{13}$$

$$w^\star = g_L(K^\star, L^\star) \tag{14}$$

[2] Given $(r^{b\star}, r^\star, \underline{r}^\star, \tau^{l\star}, \tau^{r\star})$, households solve the decision problems (defined in Section 2.1.5). The household policy functions include gross savings, risky portfolio share, and financial literacy, $(\mathcal{S}, \kappa, f)$, which gives rise to an invariant distribution $\Gamma(\mathcal{X}, f; l, \eta, t)$.

[3] The labor market clears *exogenously*:

$$L^\star = \int l d\Gamma(\mathcal{X}, f; l, \eta, t)$$

[4] Aggregate financial literacy $F^\star$ evolves according to

$$F^\star = \int f d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{15}$$

6. In this paper, I posit that households face no mortality or health risks.

[5] The stock market clears:

$$K^\star = \int \kappa \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{16}$$

$$r^\star K^\star = \int \left(\underline{r}^\star + r^X(f) + \sigma^X \eta\right) \kappa \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{17}$$

[6] The bond market clears:

$$B^\star = \int (1-\kappa) \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{18}$$

where the outstanding government debt $B^\star = \mathscr{B} Y^\star = \mathscr{B} g(K^\star, L^\star)$.

[7] Given the labor income tax rate $\tau^{l\star}$, the government pension system budget is balanced:

$$\tau^{l\star} \int w^\star l d\Gamma(\mathcal{X}, f; l, \eta, t \leq T_R) = \lambda \int w^\star l d\Gamma(\mathcal{X}, f; l, \eta, t > T_R) \tag{11}$$

[8] Given the capital income tax rate $\tau^{r\star}$, the government budget for general expenditures and debt payments

$$G^\star + r^{b\star} B^\star = \int \tau^{r\star} \left(r^{b\star}(1-\kappa) + \tilde{r}(f)\kappa\right) \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{12}$$

2.4.2 Discussion

In this general equilibrium framework, asset returns are not only adjusted with the levels of aggregate savings in each assets, but also with the level of aggregate financial literacy.[7] Hence, the model allows to quantify the equilibrium effects of financial literacy on aggregate asset positions as well as the resulting distribution of equity premia.

As in standard neoclassical growth models, the first stock market clearing condition (16) asserts that total household savings in stocks equals aggregate capital. In an economy where

7. Recall that the labor process is exogenous; therefore, in equilibrium, aggregate labor $L^\star$ plays no active role in determining the asset returns as well as the wage rate.

the endogenous distribution of financial literacy results in heterogeneous stock returns across households, an additional consistency condition (17) ensures that the sum of stock investment income for all households equals the aggregate capital income.

The equilibrium mechanism through which financial literacy impacts asset returns operates in two ways: (1) through the elasticity of stock investment concerning literacy, and (2) through the pecuniary externalities of literacy on expected stock returns. The assumption that financial literacy is not employed in the production process has important equilibrium implications in both channels. While a household's literacy acquisition raises its own mean excess return, improving overall financial knowledge and investment skills does not translate into productivity growth. Instead, it indirectly affects output by influencing households' stock investments, which constitute aggregate capital in equilibrium. Then, the firm's optimality condition (13) characterizes the marginal product of capital $r^\star$ solely as a function of aggregate capital. To the extent that an increase in aggregate financial literacy prompts greater capital accumulation, it leads to a decline in the corresponding input price.

Meanwhile, equation (17) ensures that the total capital income of the economy is distributed among households according to their levels of financial literacy and corresponding mean excess returns $r^X(\cdot)$. If $r^X_f(\cdot) > 0$ and $r^X(f_{\min}) = 0$ as assumed in Section 2.1.4, then the equilibrium residual $\underline{r}^\star$ represents the *base* return that households expect to obtain when investing in stocks with the minimum level of literacy. Given the level of total capital income $r^\star K^\star$, which is not directly impacted by overall literacy, the *base expected stock return* $\underline{r}^\star$ adjusts to account for the change in aggregate mean excess return, $r^X(F^\star)$. The capital income consistency condition (17) precisely captures this zero-sum aspect of financial literacy: as a household raises its $r^X(\cdot)$ by accumulating literacy, it puts downward pressure on $\underline{r}^\star$. That is, the individual household's financial literacy choice generates a *pecuniary externality* on the base expected stock return

In summary, the assumption that financial literacy is not employed in the production process implies that overall literacy impacts the rental rate of capital $r^\star$ only *indirectly* through aggregate capital, whereas it *directly* shapes the base expected stock return $\underline{r}^{\star}$. Moreover, the capital income consistency condition (17) establishes that, in equilibrium, the rental rate of capital is equal to the unconditional mean stock return of all households: $r^{\star} = \underline{r} + r^{X}(F^{\star})$.[8] Additionally, the endogenous distribution of financial literacy heterogenous equity premia and portfolio choices across households. The household-specific expected equity premium is expressed as:

$$\mathbb{E}\left[\tilde{r}(f)\right] - r^{b} = \underline{r} + r^{X}(f_t) - r^{b}$$

Here the *base equity premium* for the least financially literate households is defined as $\mathbb{E}\left[\tilde{r}(f_{\min})\right] - r^{b} = \underline{r} - r^{b}$. One can interpret this base equity premium as the *stock market participation premium* that households expect to obtain by participating in the stock market with the minimum level of literacy.

2.5 Subsidies for Financial Literacy and Participation

The proposed general equilibrium provides a framework to investigate how households' portfolio and financial literacy choices systematically interact with market asset returns. A crucial policy question emerges: to what extent does enhancing financial literacy improve households' investment outcomes, particularly by promoting stock market participation, and thus alleviate wealth inequality? Evaluating the policy effects in an equilibrium framework is crucial because market returns adjust with households' counterfactual decisions, in turn potentially affecting the overall effectiveness of the subsidy intervention. This section illustrates how to formulate the paper's main policy experiments: subsidizing financial literacy acquisition costs and stock market participation costs.

Consider an environment where the government subsidizes either $\varphi \in (0,1)$ fraction of financial literacy acquisition costs $\Phi(\cdot)$, $\vartheta \in (0,1)$ fraction of per-period fixed stock costs θ,

8. See Section I.1 for proof.

or both. With the policy interventions, the household budget constraint at age t reads as:

$$\mathcal{S}_{t+1} = \mathcal{X}_t - c_t - (1-\vartheta)\theta \cdot \mathbb{1}(\kappa_{t+1} > 0) - (1-\varphi)\Phi(e_t) \tag{19}$$

where $\mathcal{S}_{t+1}$ is gross saving in financial assets, $\mathcal{X}_t$ is the beginning-of-the-period cash on hand, c_t is consumption, κ_{t+1} is the risky portfolio share choice. Let G denote the amount of subsidy expenditures that the government incurs:

$$G \equiv \int \Big(\varphi_t \Phi(e_t) + \vartheta_t \theta \cdot \mathbb{1}(\kappa_{t+1} > 0)\Big) d\Gamma(\mathcal{X}, f; l, \eta, t)$$

where $\Gamma(\cdot)$ is the invariant distribution of households. The subsidy expenditures are funded by capital income tax revenues, which also serve to cover debt payments. Recall the associated government budget constraint (12):

$$G + r^b B = \int \tau^r \left(r^b(1-\kappa_{t+1}) + \tilde{r}(f)\kappa_{t+1}\right) \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \tag{12}$$

where B is outstanding government debt, and $(r^b, \tilde{r}(\cdot), \tau^r)$ are the risk-free return, household-specific realized stock returns, and the constant capital income tax rate, respectively.

This condition highlights two channels through which policy interventions may impact the average equity premium: (1) as households adjust their portfolio and literacy choices in response to subsidized costs, aggregate asset positions change, influencing equilibrium asset returns; and (2) the resulting increase in the tax rate elicits households to demand higher returns for both assets. Then, characterizing the net policy effects on the equity premium is inherently a quantitative exercise. Section 3 discuss the quantification strategy and Section 4 presents the model predictions, decomposing the policy effects into the equilibrium return adjustment effect versus the tax effect.

3 Calibration

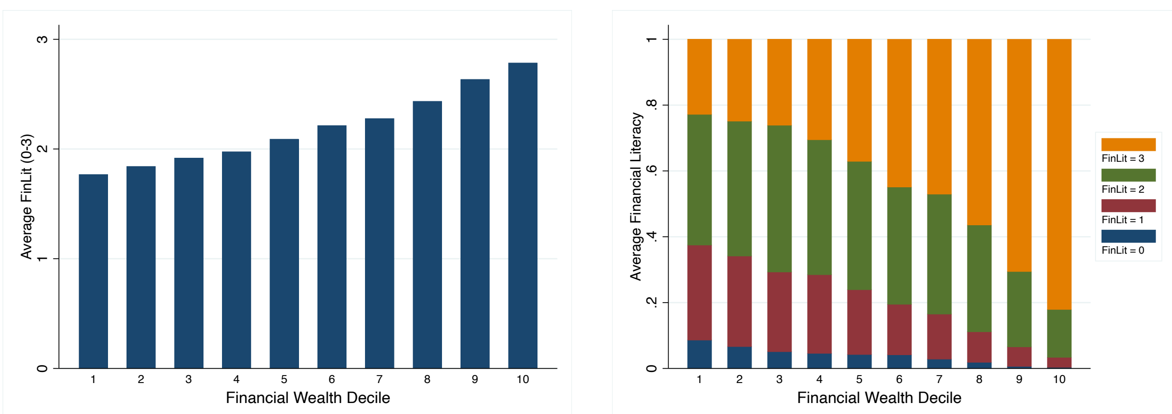
The general equilibrium model is disciplined to match the average financial literacy level and stock market participation rate of U.S. households in the Survey of Consumer Finances (SCF). The calibrated model replicates crucial empirical patterns: the life-cycle of trajectory of financial literacy and wealth disparity in stock investment. This section describes the target data moments observed in the SCF, the quantification strategy, and the model fit.

3.1 Financial Literacy in SCF

Figure 1: Dispersion in financial literacy across and within wealth groups

(a) Average Financial Literacy Score

(b) Composition of Financial Literacy score



The Survey of Consumer Finances (SCF) is a triennial cross-sectional survey that provides extensive information on income flows and asset allocations of U.S. households. The detailed records of asset holdings and the careful sample design provided by the survey helps better understand wealth inequality and disparities in portfolio choices across various demographic groups. Additionally, starting from 2016, the survey includes a measure of financial literacy scores, facilitating empirical analysis of the link between financial literacy and investment decisions and outcomes based on a nationally representative sample. The Survey asks each respondent three fundamental economic concepts, based on the *"Big Three Questions,"* proposed in (Lusardi and Mitchell, 2014):

① **Risk Diversification** Buying a single company's stock usually provides a safer return than a stock mutual fund. *True, False, Do not know, Prefer not to say*

② **Inflation** Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account? *More than today, Exactly the same, Less than today, Do not know, Prefer not to say*

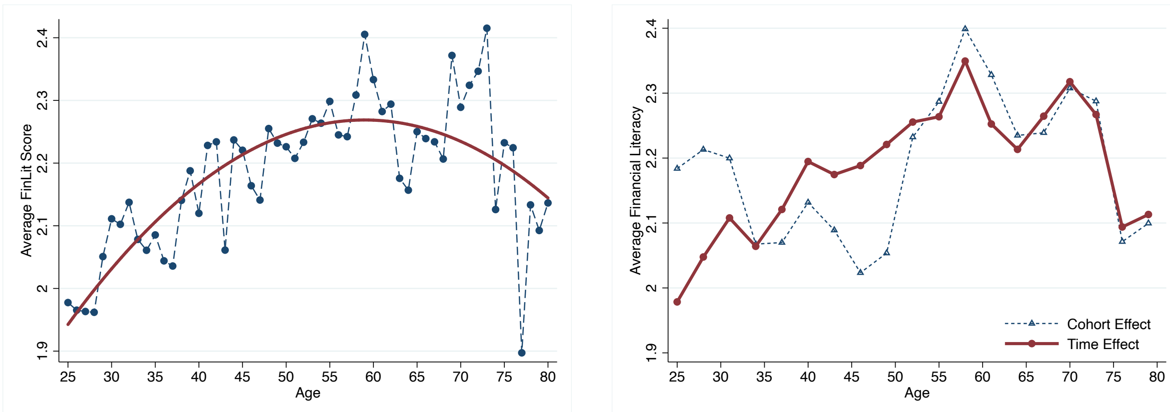
③ **Interest Rate** Suppose you had $100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow? *More than $102, Exactly $102, Less than $102, Do not know, Prefer not to say*

The financial literacy score is then based on the number of questions, ranging from 0 to 3. Consistent with the previous findings, the SCF shows that only 44.2% of U.S. households between age 26 and 80 can answer all three questions. The corresponding average level of financial literacy is 2.19. Financial literacy is not only low on average, but also dispersed across and within wealth groups. The left panel of Figure 1 shows that financial literacy is positively correlated with financial wealth, and the right panel shows that there still exists the variation in financial literacy *within* financial wealth deciles, which implies that there may exist a channel in which households' financial knowledge and investment skills generate a further gap in investment outcomes in addition to the effect of wealth itself.

Moreover, the SCF illustrates that the average level of financial literacy increases with age until (slightly a few years before) retirement, and then depreciates. Figure 2 plots the humped-shape life cycle of financial literacy observed in the 2016-2019 SCF, where the left panel shows a simple-weighted average across age while the right panel shows the average net of time and cohorts effects. Assuming that there is no cohort effect and U.S. households' literacy has had a consistent distribution across generations, the hump shape over age indicates that financial literacy evolves along the life cycle until households retire.

Figure 2: Lifecycle of Financial Literacy

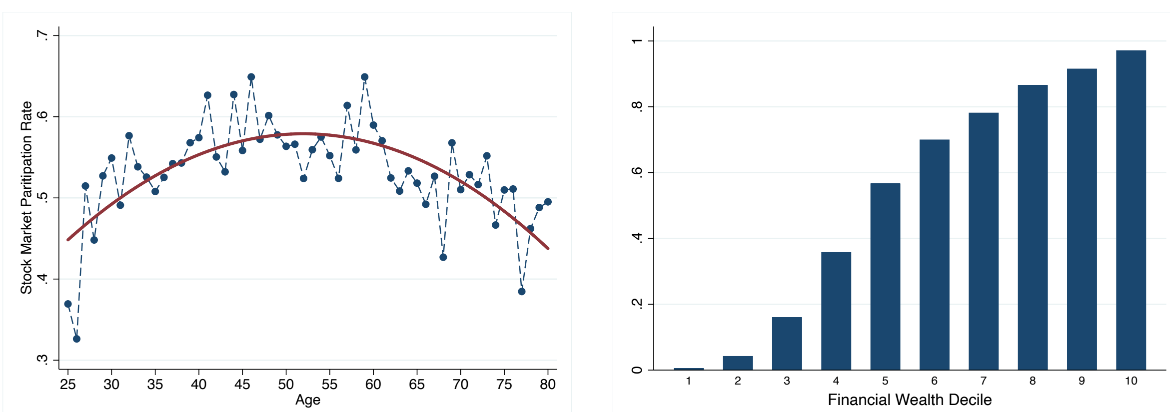
(a) Average Financial Literacy Score (b) Composition of Financial Literacy score



It is also well documented that U.S. households have low tendency to participate in the stock market. The overall stock market participation rate of U.S. households between age 26 and 80 is 54.1% in the 2016-2019 SCF. Figure 3 shows that stock market participation varies across both age and wealth distribution, mirroring the patterns in financial literacy.

Figure 3: Stock Market Participation Across Age and Wealth

(a) Life Cycle Participation (b) Wealth Disparity in Participation



The key data moments I target to calibrate the model are (1) the average level of financial literacy level and (2) the overall stock market participation rate of U.S (see Section 3.2.3). I also use the granularity of the SCF data to externally validate the calibrated model by analyzing the household-level financial literacy effect on stock market participation in the data versus in the model (see Section 3.3).

3.2 Quantification of the Model

3.2.1 Numerical Algorithm

Given a set of exogenous parameters, I simulate the labor income process for $N = 50,000$ households, each of them living for 56 periods (from age 25 to 80). The labor income tax rate τ^l is computed according to the government budget constraint (11). Since the labor process is exogenous; i.e., orthogonal to other aggregate components of the model, the labor income tax rate remains unaffected by the other general equilibrium objects. Given this simulated labor process and a set of initial guesses for asset returns and tax rates $(r^b, r, \underline{r}, \tau^l, \tau^r)$, I solve the life-cycle household problem backwards using a grid search over future choices $(\mathcal{S}', \kappa', f') \in \mathscr{S} \times \mathscr{K} \times \mathscr{F}$ for each set of state variables $(\mathcal{X}, f; l, \eta, t)$.[9]. With the acquired policy functions, I simulate a partial equilibrium economy for a pre-defined population. In this partial equilibrium economy, only the labor market is cleared (exogenously). The simulated life-cycles give rise to an invariant distribution $\Gamma(\mathcal{X}, f; l, \eta, t)$. With sufficiently large N, the simulated economy represents a steady-state economy with T overlapping generations, where each generation t consists of N individuals. Using a non-linear solver, I solve for a general equilibrium where the characterized prices $(r^{b\star}, r^\star, \underline{r}^\star, \tau^{l\star}, \tau^{r\star})$ and the corresponding distribution $\Gamma(\cdot)$ satisfy the government balance conditions (11)-(12) and the market clearing conditions (15)-(18). I use the method of simulated moments to calibrate the model.

3.2.2 External Parametrization

Household Preference and Life cycle The preference parameters are set to a standard choice in the household finance literature with a discount factor $\beta = 0.96$, a relative risk aversion $\gamma = 5$ and an intertemporal substitution coefficient $\psi = 0.5$. The model's initial

9. In solving their optimization problem, households do not necessarily need to be informed about the market average of stock returns $r^\star$ itself. This is because their realized stock returns depend on the base expected return $\underline{r}^\star$ and their individual financial literacy. In fact, households condition on the competitive wage rate $w^\star$ to calculate the value of their cash on hand. Here, I express that household condition on $(r^\star, \underline{r}^\star)$ because the set of capital and labor input prices are uniquely determined by the firm's optimality conditions; and also because the exogenous labor process and corresponding wage rate are not central pieces of the model.

Table 1: Benchmark Parameter Values

Parameter		Value	Source
Household Preference			
Discount factor	β	0.96	
Elasticity of substitution	ψ	0.5	Gomes and Michaelides (2005)
Risk aversion	γ	5.0	
Labor process			
Persistency	ρ^l	0.91	Rupert and Zanella (2015)
Variance	σ^l	0.21	
Pension replacement rate	λ	0.36	Congressional Budget Office (2019)
Financial literacy			
Deprecation rate in literacy	δ_f	0.02	$\star$
Investment cost: coefficient	ϕ	0.22	$\star$
Investment cost: convexity	ι	1.75	Lusardi et al. (2017)
Stock market			
Mean excess return	$r^X(f_{\max})$	0.01	Clark et al. (2017)
Standard deviation	σ^X	0.157	Cocco et al. (2005)
Per-period fixed participation cost	θ	0.09	$\star$
Production			
Depreciation rate in capital	δ_K	0.08	
Capital Intensity	α	0.36	
Government debt to GDP ratio	$^B/_Y$	0.82	U.S. Data

$\star$ Internally calibrated parameters. See Section 3.2.3.

period $t = 0$ corresponds to a real age of 25, while the terminal period $T = 55$ corresponds to age 80. Mortality risk and bequest motives are beyond the scope of this paper. At $t = 0$, households are born with initial levels of financial literacy, labor productivity, and bequest denoted as $(f_0, l_0, \mathcal{S}_0)$. The model's initial literacy distribution is calibrated to the population shares of each financial literacy group among the total survey respondents in the 2016-2019 SCF aged between 18 and 25. The bequest is drawn as a function of the realized initial literacy, capturing the observed correlation between financial literacy and wealth among the young households. Appendix (II.1) discusses details on the initial distribution calibration. Note that I posit that households receive bequest in *cash* terms; that is, at the beginning of $t = 0$, household do not have initial bond and stock holdings.

Labor Income and Housing Cost The stochastic labor productivity process for the working population (Eq. 2) is calibrated to the persistent component of a log wage process estimated in Floden and Lindé (2001), with an autocorrelation coefficient of $\rho = 0.9136$ and a standard deviation of $\sigma_l = 0.2064$. Retirement choice is exogenous, and households retire at the end of $t = 40$ (age 65).The retirement benefit replacement rate is set to $\lambda = 0.36$ as reported in a recent article by the Congressional Budget Office (2019).[10] The age-specific deterministic component $\{m_t\}$ is directly mapped to the estimated wage profile in Rupert and Zanella (2015).[11] Moreover, I estimate the age-specific housing cost share h_t as by regressing the ratio of annual housing expenditure to labor income on a cubic age polynomial and year dummies using the 2016-2019 SCF data following a similar approach in Gomes and Michaelides (2005).[12] Figure (A.1) shows the cross-sectional average of the simulated labor income process across age, before and net of the housing costs.

Financial Literacy and Stock Returns The grid for the financial literacy level is discretized into 5 equally spaced ranges, spanning from $f_{\min} = 0$ and $f_{\max} = 3$. Given its current financial literacy f, a household chooses the level of literacy acquisition between range $\mathscr{E}(f) \in \left[0, f_{\max} - (1 - \delta_f) \cdot f\right]$, discretized into 5 values spread with equal spacing.

The financial literacy premium on the mean excess stock return, $r_f^X > 0$, is the key mechanism incentivizing households' stock investments. Ideally, one can estimate the elasticity using a micro-level panel containing both financial literacy and stock return measures. While the SCF provides a rich set of records of U.S. households' asset holdings, the cross-sectional dataset lacks sufficient information to compute annual realized stock returns.[13].

Alternatively, I calibrate the literacy-return premium based on the findings from Clark et al. (2017), which uses an administrative data on financial literacy and 401(k) investment

10. The value corresponds to the Social Security replacement rates of the last 5 years of substantial earnings for individual long-career workers born in the 1960s. See www.cbo.gov/publication/55038 for details.
11. Rupert and Zanella (2015) provides the wage profile at a biennial frequency for ages 52 and above. Following Wu and Krueger (2021), I interpolate the profile for all ages between 25 and 80.
12. The total housing expenditure includes rent (`rent`) and mortgage (`mortpay`) payments. For households below age 65, labor income corresponds to wage income (`wageinc`), while for households aged 66 or above, it corresponds to retirement income (`ssretinc`).
13. The SCF includes information on a household's overall dividend incomes (`x5710`) as well as *net realized capital gains* from sale of mutual funds, stocks, bonds, or real estate (`kginc`) from the previous calendar year. However, these variables do not provide robust measures of dividend and realized capital gain from public equities per se; plus, the dataset has no information on *unrealized* capital gains from stock holdings, which is likely to be the major source of stock returns.

performance of employees at the Federal Reserve System. The unique administrative contains investment history at the employee-product level, allowing Clark et al. (2017) to document that the most financially literate investors tend to (i) experience about 42 (3.5) basis point larger annual (monthly) asset returns basis point monthly, and (ii) hold portfolios with 1.71 percentage point less idiosyncratic risk, as compared with their least counterparts. While carefully considering the potential caveat that the dataset used in Clark et al. (2017) lacks information on direct stock holdings and less likely to be nationally representative, I adopt their estimates as a reference point. I linearly scale the literacy-return premium, ranging from $r^X(f_{\min}) = 0$ to $r^X(f_{\max}) = 0.01$; that is, the stock return for the most literate households is 100 basis points higher than that for the least literate, assuming constant idiosyncratic risk. This value falls within the range of results reported in studies that have conducted similar analyses using Dutch and French data (Bianchi, 2018; Gaudecker, 2015).

Recall the functional form of the financial literacy acquisition cost: $\Phi(e) = \phi e^{\iota}$. The coefficient ϕ is internally calibrated.The convexity component $\iota = 1.75$ is taken from Lusardi et al. (2017), where this value is derived from various anecdotal data on financial advisory fees. Lusardi et al. (2017) includes sensitivity checks indicating that an increase in the cost convexity has a non-linear effect on wealth inequality. In this paper, I focus on the multiplicand component ϕ's direct effect on overall financial literacy of U.S. households.

In the benchmark model, I assume the standard deviation of innovations to stock return σ^X is constant across households with different financial literacy. The standard deviation is a historical value of 0.157 (Cocco et al., 2005). The household finance literature estimates this value to be in a range between 0.15 and 0.18. Again, given the constant standard deviation, the positive literacy-return premium $r_f^X > 0$ implies that a more literate household obtain a higher risk adjusted return. I assume there is no correlation between capital income risk and labor income risk: $\mathrm{corr}(\eta, \nu) = 0$.

Firm and Government The production function parameters are calibrated to standard values in the literature.The productive capital share is set to $\alpha = 0.36$ and the annual depreciation rate $\delta_K = 0.08$. The TFP level is normalized to $A = 1$. The steady-state government debt-to-GDP ratio $\mathscr{B} = \frac{B}{Y} = 0.823$ is set to the U.S. historical average from 2001:Q1 through 2019:Q4, assuming that the distribution of U.S. household financial literacy and stock market participation rate have been relatively table during the specified periods.[14]

3.2.3 Internal Calibration

I jointly calibrate the per-period fixed stock market participation cost, the financial literacy acquisition cost coefficient, and the depreciation rate of financial literacy (θ, ϕ, δ_f) using the method of simulated moments. The participation and literacy costs are, respectively, disciplined to match the average stock market participation rate (0.541) and the average financial literacy score (2.19) of the U.S. households between age 26 and 80. Note that I exclude the household at age 25 in the average calculation, because the model assumes that households are born with no bond holdings and no stock holdings (see Appendix II.1). The identifying assumption is that households do not accumulate financial literacy well after retirement, and hence, financial literacy only depreciates after age 70. Recall that the government general expenditure is set to zero in the baseline economy.

3.3 Model Fit

3.3.1 Targeted Moments

The internal calibration results read as: $\phi = 0.22$, $\theta = 0.09$ and $\delta_f = 0.02$. These numbers imply that, in the baseline economy, acquiring 0.03 additional units of financial literacy, which raises the mean excess return $r^X(\cdot)$ by 1 b.p., costs 1.8% of the equilibrium average

14. While there is very limited data on the historical records of financial literacy, Angrisani et al. (2020) finds that the overall distribution of financial literacy in the U.S. appears to remain stable for a six-year observation period (2012-2018), using the RAND American Life Panel (ALP). I chose 2001 as the starting period, since the average stock market participation rate in the SCF has remained roughly around 50% starting 2001.

Table 2: Baseline Model Fit

		Model	Data	
Distribution of financial literacy				
Avg. FinLit age 18-25	$\mathbb{E}[f \mid t=0]$	1.98	1.98	⋆
Avg. FinLit age 26-80	$\mathbb{E}[f]$	2.18	2.19	⋆
S.D. FinLit age 26-80	$\mathbb{S}.\mathbb{D}(f)$	0.93	0.86	
(Avg. FinLit age 76-80)/(Avg. FinLit age 71-75)	$\mathbb{E}[f \mid 71 \leq \text{age} \leq 65] / \mathbb{E}[f \mid 75 \leq \text{age} \leq 80]$	0.93	0.91	⋆
Stock market participation				
Avg. saving rate (%)	$\mathbb{E}[\mathbb{1}(\mathcal{S} > 0)]$	97.5	95.5	
Avg. participation rate (%)	$\mathbb{E}[\mathbb{1}(\kappa > 0)]$	54.1	54.1	⋆
Conditional risky portfolio share (%)	$\mathbb{E}[\kappa \mid \kappa > 0]$	84.4	46.4	
Baseline Equilibrium				
Risk-free return (%)	r^b	2.32		
Avg. equity premium (%)	$r - r^b$	5.38		
Base equity premium (%)	$\underline{r} - r^b$	4.41		
Capital income tax rate (%)	τ^r	9.77		
Capital-output ratio	K/Y	2.29		

⋆ Internally calibrated. Data source: SCF 2016-2019.

pre-tax wage income. On average, households acquire 0.045 units of literacy each period. Similarly, the per-period stock market participation cost is equivalent to 5.8% of the average pre-tax wage income. This participation cost should not be simply interpreted as a direct monetary expense for households; instead, it rather symbolizes various potential hindrances that impede stock market participation, reframed as a resource cost in the model.

Table 2 shows the baseline model fit and general equilibrium results. Note that the financial literacy at $t = 0$ is drawn from the population shares of financial literacy groups among households aged 18-25 in the SCF; hence the model and data average are matched by construction. The simulated standard deviation of financial literacy across households is slightly larger than in the data, which potentially implies that the (externally) calibrated exponent of the literacy acquisition cost $\iota = 1.75$ can be further adjusted.

In the baseline economy, the simulated risk-free return is $r^{b\star} = 2.32\%$, and the cross-sectional average equity premium is $r^\star - r^{b\star} = 5.38\%$, which align well with historical values. The base expected equity premium, $\underline{r}^\star - r^{b\star}$, is approximately one percentage point below the average, reflecting the endogenous return heterogeneity.

The model also replicates the saving rate (the share households with positive financial wealth) reasonably well. However, it exhibits a relatively high simulated average share of financial wealth invested in stocks, conditional on participation (84.4% in the model compared to 46.4% in the data). Conventional life-cycle portfolio choice models often predict such a high conditional risky share. Potential adjustments addressing this issue could involve introducing a positive correlation between capital and labor income shocks, as well as considering tail shocks in labor income.

3.3.2 Non-targeted Moments

Figure 4: Life Cycle Financial Literacy

(a) Data (b) Model

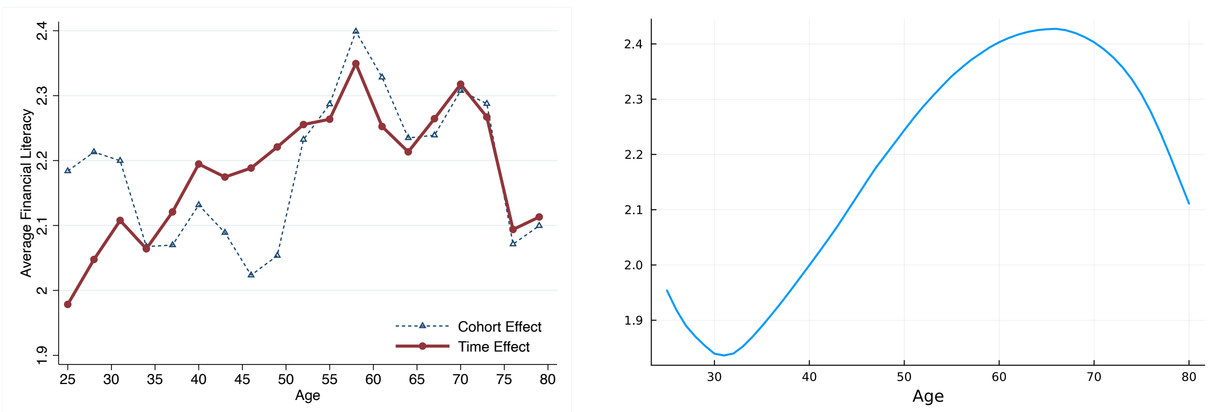
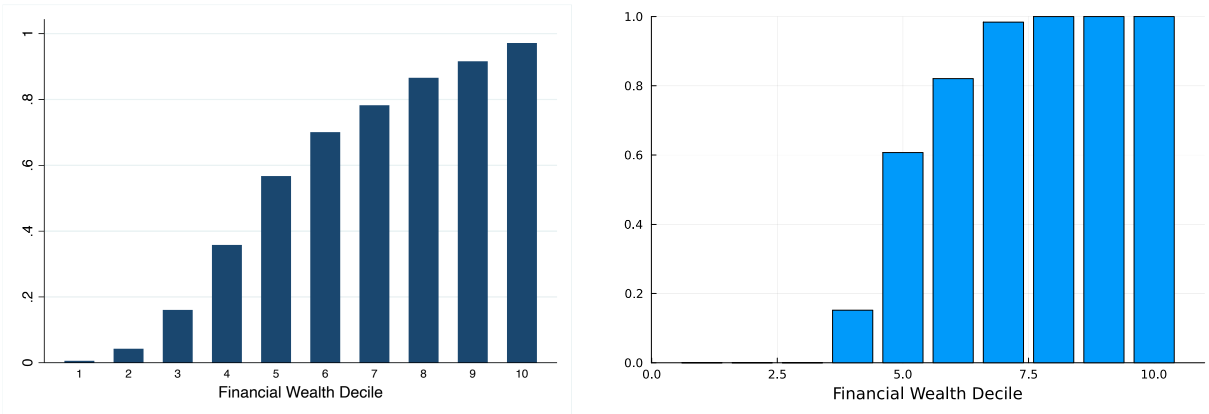


Figure 4 illustrates that the model does a decent job replicating the humped-shaped life cycle of financial literacy, or the cross-sectional average literacy across age, despite that it has a parsimonious set of target moments: average financial literacy and the literacy patterns after age 70. The model predicts that financial literacy is highest right around retirement and then depreciates afterward. The observed decrease before age 30 indicates that young workers, who are relatively wealth-poorer than their older counterparts, allow their initial literacy to depreciate for a while because maintaining or accumulating literacy is too costly for them. After accumulating sufficient wealth to afford both literacy and participation costs after age 30, households begin to acquire literacy again and increase their risk-adjusted stock returns. The model also reproduces the observed wealth disparity in stock market participation. Figure 5 demonstrates that the predicted stock market participation rate increases with wealth, consistent with the patterns in the SCF. Still, the model does not fully capture the

Figure 5: Life Cycle Financial Literacy

(a) Data (b) Model



non-zero participation rate at the bottom of the wealth distribution. It is possible that the small participation in the first three percentiles observed in the data includes those who are indirectly participating through their retirement accounts.

3.3.3 External Validation

To externally validate my overall calibration, I analyzed the household-level correlation between financial literacy and investment outcomes in the simulated economy, compared with the 2016-2019 SCF data. Following Cupák et al. (2022), I run an OLS regression:

$$(\text{Investment Outcome})_i = c + \beta \cdot \text{FinLit}_i + age_i + age_i^2 + \Gamma X_i + \epsilon_i$$

where i denotes household and the demographic controls X_i include financial wealth and labor income. In the data regression, I further control for gender, race, education, race, employment status, business ownership, marital status, household size, the number of kids, and the year fixed effect. Table 3 reports the regression results; in columns (1) and (3), I replicate the similar regression results from Cupák et al. (2022), pooling both survey years 2016 and 2019 (note Cupák et al. (2022) focuses on the 2019 SCF data).

The first two columns shows that the 1 unit increase in financial literacy score is associated

Table 3: Correlation Between Financial Literacy and Stock Investments

	Positive holdings of public equities?		**Conditional wealth share in stocks**	
	Data	Model	Data	Model
	(1)	(2)	(3)	(4)
Financial literacy score (0-3)	0.061***	0.089***	0.012*	0.101***
	(0.006)	(0.000)	(0.006)	(0.000)
ihs(net worth)	0.012***	0.310***	0.004***	-0.090***
	(0.001)	(0.000)	(0.001)	(0.000)
ihs(income)	0.096***	0.050***	0.007	0.141***
	(0.008)	(0.000)	(0.005)	(0.000)
Mean value	0.541	0.546	0.441	0.844
R-sq.	0.321	0.731	0.025	0.304
No. Obs	10997	2.75M	6858	1.5M

- Col (1), (3): Author's replication of Cupák et al. (2022) .

- Source: SCF 2016-2019. +p<0.10, *p<0.05, **p<0.01, ***<0.001.

with a 6.1 percentage points increase in the probability of stock market participation in the SCF data. The estimates are statistically significant at 0.1 percent level, even controlling for demographic factors. The model delivers a slightly higher prediction, which is indicative of potential omitted variables impacting both financial literacy and stock market participation.

4 Policy Analysis: Universal Literacy Subsidy

I use the calibrated model to examine the hypothetical impact of enhancing household financial literacy on aggregate capital accumulation and wealth inequality. Specifically, I explore a counterfactual economy where the government subsidizes 75 percent of the financial literacy acquisition cost for all households electing to accumulate a positive level of literacy each period. The subsidy is financed through capital income tax revenues. Given the parameters calibrated in the baseline economy, I solve for the counterfactual equilibrium with the subsidy ratio $\varphi = 0.75$ using the household budget constraint (19) and the government budget balance condition for the capital income tax (12) outlined in Section 2.5.

Table 4: Comparative Statics: Counterfactual Equilibrium Results

		Baseline (1)	ΔPE (2)	ΔHE (3)	ΔGE (4)
Avg. FinLit (out of 3)	$\mathbb{E}[f]$	2.18	0.25	0.23	0.22
Risk-free return (%)	r^b	2.32		-0.01	0.08
Avg. equity premium (%)	$r - r^b$	5.38		-0.06	-0.10
Base. equity premium (%)	$\underline{r} - r^b$	4.41		-0.09	-0.13
Capital income tax rate (%)	τ^r	9.77		-0.01	1.00
Aggregate capital (level)	$\mathbb{E}[\kappa \cdot \mathcal{S}]$	4.40	0.15	0.03	0.01
Capital-output ratio	K/Y	2.29	0.05	0.01	0.00

* The baseline returns and the tax rate in column (1) are in percentage term (%).
* Columns (2)-(4) are the difference between counterfactual economies and the baseline economies. The returns and tax rate are in percentage point term (%p).

4.1 Comparative Statics

Table 4 presents the comparative statics results: column (1) is the baseline economy with no government expenditure $G = 0$, and columns (2)-(4) are the *change* between the counterfactual equilibrium results and the baseline results. There are three sets of counterfactuals:

- **Partial equilibrium (PE)**: Only the labor market is cleared, while the asset markets remain uncleared. Consequently, the asset returns and the capital income tax rate remain unchanged from the baseline economy, as they have not yet adjusted to reflect the new aggregate levels. Any changes in aggregate outcomes can be interpreted as short-run changes under these conditions (column 2 in table 4).

- ***Hypothetical* (general) equilibrium ("HE")**: While all asset markets clear, the government budget has not yet accounted for the rise in subsidy expenditures. Essentially, this represents a hypothetical (general) equilibrium where the subsidies are financed without cost. In other words, the equilibrium returns and capital income tax rate have adjusted to the new steady-state aggregate bond and stock holdings but not yet to the increased federal expenditure level (column 3).

- ***Full* general equilibrium ("GE")**: This represents the main scenario where all markets, including the labor and asset markets, clear, and both government budgets are fully balanced. As the subsidies are funded through the tax system, this intervention introduces additional distortions to the competitive market equilibrium. The asset returns and the capital income tax rate undergo complete adjustments (column 4).

Note that the hypothetical (general) equilibrium is an intermediate step from the partial equilibrium to the general equilibrium, which allows disentangling the return adjustment effect from the tax adjustment effect.

In all counterfactuals, the increase in financial literacy remains more or less similar: the universal subsidy raises the average level of financial literacy from the baseline value 2.18 to (0.22-0.25), which corresponds to 10.16 to 11.26 percentage growth. In the partial equilibrium (PE), given the base expected stock return $\underline{r}$ unchanged, the overall economy now experiences a higher risk-adjusted return on average. Therefore, the amount of the aggregate demand, or the *pseudo* aggregate capital, increases by 3.4 percent (from 4.40 to 4.55 in levels). The aggregate capital-output ratio also rises.

Then, in the hypothetical equilibrium (HE), markets clear. Since the increase in financial literacy is assumed to have no impact on total factor productivity (TFP) and does not directly augment output, the growth in aggregate capital automatically leads to a decline in the marginal product of capital, or equivalently, a decrease in the average stock return. This reduction in overall stock returns diminishes households' incentive to invest in stocks compared to the partial equilibrium case. The new steady state is reached when the adjustments in aggregate outcomes and returns stabilize. The average equity premium falls $\Delta(r-r^b) = -0.06$. The decline in the base equity premium is larger: $\Delta(r-r^b) = -0.09$. The net increase in aggregate capital shrinks from $\Delta(K) = 0.15$ in the partial equilibrium case to $\Delta(K) = 0.03$ in this hypothetical equilibrium case. Consequently, the policy intervention has repercussions on the asset returns, which, in turn, attenuates the net policy effects. Also note that the risk-free return r^b also decreases by 1 percentage point.

The full general equilibrium (GE) further accounts for the tax channel. The government raises the capital income tax rate by 1 percentage point in order to finance the subsidy expenditure. Due to this increase in the tax rate, households demand a larger risk-free return $\Delta(r^b) = 0.08$ compared to the baseline economy. The net aggregate capital growth is even smaller but remains positive. This is accompanied by a decrease in the rental rate of return, represented by $\Delta(r) = -0.02$. Consequently, the average equity premium experiences the largest decline among all three counterfactuals, with $\Delta(r - r^b) = -0.10$.

4.2 Effects on Stock Market Participation

Figure 6: Average Stock Market Investments

(a) Financial Literacy

(b) Participation Rate

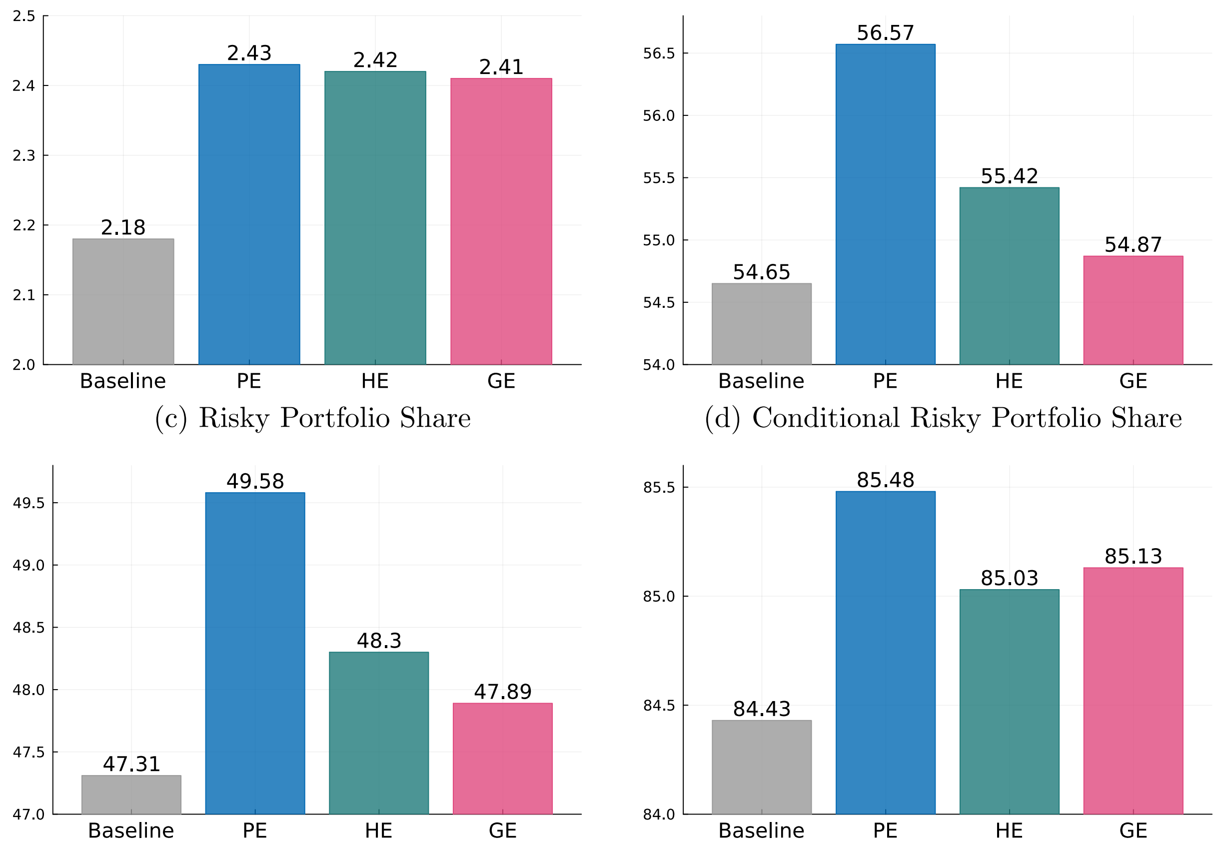


Figure 6

4.3 Heterogeneous Portfolio Adjustments

4.4 Inequality Implications

This increase in financial literacy translates into an increase in aggregate capital,

(i)

The general equilibrium framework allows for multiple potential impacts of financial literacy accumulation on the aggregate economy. Raising average financial literacy in the economy may incentivize household stock market participation, expand capital supply, and generate output growth. However, in equilibrium, more aggregate capital translates into a lower return on capital, making marginal participants worse off. Moreover, an increase in capital gains of now more financially literate households comes at a loss for other households with relatively poorer levels of literacy. This model prediction precisely captures pecuniary externalities from financial literacy: as the economy becomes more financially literate on average, the least literate households (who also tend to be the poorest) actually lose ground.

In net, the aggregate impact from financial literacy is ambiguous: it may result in positive pecuniary externalities by producing more output, or in negative externalities by deepening return heterogeneity and wealth inequality. The paper will formalize such an interplay between household financial literacy, portfolio choice, and wealth inequality through economic theory, and quantify the net aggregate consequences of endogenous accumulation of financial literacy through a computational model.

The equilibrium model suggests that it is the *dispersion* in financial literacy that amplifies wealth inequality, not the lack of overall knowledge in the economy. A natural policy question that arises is what is an optimal policy intervention to close the wealth gap. Using the quantitative predictions from the model, I plan to propose and evaluate three policy interventions: financial literacy investment subsidies ϑ, capital income taxes τ, and stock market participation subsidies ζ. Then the household budget constraint is given as:

$$c_t + b_{t+1} + a_{t+1} = (1 + r^b)b_t + a_t + (1 - \tau)\tilde{r}(f_t)a_t + wy_t - (1 - \vartheta)\theta \cdot \mathbb{1}(a_{t+1} > 0) - (1 - \zeta)\mathcal{C}^f(e_t)$$

and the government budget constraint reads as:

$$\int \Big(\vartheta\theta\mathbb{1}(a_{t+1} > 0) + \zeta\mathcal{C}^f(e)\Big)d\Gamma = \int \tau\Big(\left[\underline{r}^\star + r^X(f) + \sigma^X\eta\right] a\Big)d\Gamma$$

Incorporating financial literacy subsidies in the model help judging the aggregate effects of financial education subsidies, often suggested as a useful policy intervention to mitigate wealth inequality. Moreover, the quantitative framework can be employed to compare feasibility and effectiveness of the alternative policy interventions. For example, if a capital income tax and a literacy subsidy are equally effective in mitigating wealth inequality, households and policymakers may find themselves in favor of the latter policy, which can particularly target to support low-income and moderate-income households and enhance their portfolio decisions and investment outcomes.

5 Alternative Model Specifications and Discussion

6 Conclusion

The U.S. wealth distribution has rapidly widened in the past three decades, and it is now even more dispersed than the income distribution, which suggests that there is a wide variety in how Americans make investment decisions and outcomes. A thorough policy analysis requires an understanding of what drives such heterogeneous patterns in wealth accumulation across households. In this paper, I focus on financial literacy, a household-specific characteristic akin to human capital. The main goal of this study is to analyze the macroeconomic interplay between financial literacy dispersion and wealth inequality. In particular, I provide a novel general equilibrium explanation, which informs competing aggregate effects from the accumulation of financial literacy: on one hand raising the average level of household financial literacy induces stock market expansion and output growth, while on the other hand, it makes wealth returns more heterogeneous by generating larger gaps in the quality of investment decisions of different wealth groups, in turn widening the wealth gap. Understanding the equilibrium effects of financial literacy informs the important policy discussions on achieving financial education parity and bridging the wealth gap.

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Appendix

I Model Details

I.1 Marginal product of capital and average stock return

Given an exogenous excess return schedule $r^X(\cdot)f$ with $r^X(f\min) = 0$, the capital income consistency condition (17) asserts that, in equilibrium, the rental rate of capital $r^\star$ equals the unconditional mean stock return across all households:

$$\begin{aligned}
r^\star K^\star &= \int \left(\underline{r}^\star + r^X(f) + \sigma^X \eta\right) \kappa \mathcal{S} d\Gamma(\mathcal{X}, f; l, \eta, t) \qquad (17)\\
&\equiv \mathbb{E}\left[\left(\underline{r}^\star + r^X(f) + \sigma^X \eta\right) a\right]\\
&= \underline{r}^\star \mathbb{E}\big[a\big] + \mathbb{E}\big[r^X(f) a\big] + \mathbb{E}\big[\sigma^X \eta a\big]\\
&= \underline{r}^\star \mathbb{E}\big[a\big] + \mathbb{E}\big[\mathbb{E}[r^X(f) a|f]\big] + \mathbb{E}\big[\mathbb{E}[\sigma^X \eta a|a]\big]\\
&= \underline{r}^\star \mathbb{E}\big[a\big] + r^X(F^\star)\mathbb{E}\big[\mathbb{E}[a|f]\big] + \mathbb{E}\big[\underbrace{\mathbb{E}[\sigma^X \eta|a]}_{=0} a\big]\\
&= \left(\underline{r}^\star + r^X(F^\star)\right) \cdot \underbrace{\mathbb{E}[a]}_{\equiv K^\star}\\
\Rightarrow \quad r^\star &= \underline{r} + r^X(F^\star)
\end{aligned}$$

II Notes on the Quantification Exercises

II.1 Initial Distribution

The intial state is characterized by At $t = 0$, households are born with initial levels of financial literacy, labor productivity, and bequest denoted as $(f_0, l_0, \mathcal{S}_0)$, which denotes financial literacy, labor productivity, and bequest at $t = 0$. The initial literacy is drawn from the following *categories*, $f_0 \in \{0, 0.5, 1, 2, 3\}$, where the probability of drawing each category is based on the population shares of each financial literacy group among the total survey respondents in the 2016-2019 SCF aged between 18 and 25. While there are only 4 discrete values of financial literacy scores in the SCF ($\hat{f} \in \{0, 1, 2, 3\}$), I imputed the population share to have five distinct values, matching the number of grid points for financial literacy choices. Specifically, I randomly assigned the imputed level $f_0 = 0.5$ to households aged 18–25 with financial literacy scores $\hat{f} \in \{0, 1\}$ in the data, with a probability of one half.

To proxy for the observed correlation between financial literacy and wealth early in the life cycles, I draw the bequest $\mathcal{S}_0$ as a function of the initial literacy f_0. In particular, for each literacy group, I compute the median financial wealth scaled by the population median wage of all households aged 18-20 in SCF: $\omega_f = \frac{\text{median}(\texttt{fin}|f)}{\text{median}(\texttt{wageinc})}$. In the simulated model, a household's bequest $\mathcal{S}_0 = \omega_f \times \bar{l}_0$ is a multiple of the simulated median labor income for all households at $t = 0$, where the corresponding factor ω_f is subject to its realized initial literacy level f_0. This initial bequest is assumed to be delivered as *cash*, and households at $t = 0$ do not have initial bond and stock holdings. Instead, at the beginning of $t = 0$, their cash on hand realizes the sum of the labor income and the bequest in cash $\mathcal{X}_0 = \mathcal{S}_0(f_0) + \tilde{l}_0$.

II.2 Labor Income and Housing Cost

Figure A.1: Simulated Life Cycle of Labor Productivity Process