A Quantitative Model of Financial Literacy Accumulation

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Abstract

I build and calibrate a quantitative model of financial literacy accumulation and analyze the effect of income expectations on the rate of accumulation. I find that the shape of the age-earnings profile influences the degree to which financial literacy serves as a substitute and/or complement to household savings. Using the calibrated model, I quantitatively analyze two experiments: a negative wealth-shock and a school financial literacy program. While individuals with flat income profiles acquire less financial literacy on average, they respond more sensitively to wealth shocks and the financial literacy program than individuals with steep income profiles. In both cases, they invest more in financial literacy and let more of their financial literacy depreciate. These results are useful to policymakers interested in targeting groups that may benefit the most from financial literacy programs and suggest some cohorts may be resource-constrained with respect to financial literacy accumulation.

1. Introduction

Financial Literacy is a unique kind of human capital, used by almost the entire population. For example, the 2017 Survey of Consumer Payment Choice found that at least 90% of respondents reported having some involvement in household financial matters. Previous research has observed the empirical relationship between financial literacy and wealth (Jappelli and Padula 2013) but has found it difficult to assess the joint decision of financial literacy and wealth. If financial literacy is accumulated in order to better manage savings and if in turn, those resources influence the decision to invest in financial literacy, then a structural model is necessary to capture the interrelationship between financial literacy and a household's assets.

My contribution is to calibrate a life cycle model with endogenous financial literacy accumulate and quantitatively analyze how financial literacy accumulation is influenced under various situations. My model allows me to account for the reverse causality observed in the empirical literature (Fernandes, Lynch and Netemeyer 2014) and analyze the joint distribution of financial literacy and assets. I demonstrate that financial literacy and savings can serve both complements or substitutes depending upon the situation. On the one hand, individuals with a large stock of savings find financial literacy to be complementary because financial literacy raises the return on their savings. On the other hand, financial literacy can serve as a substitute means of consumption smoothing for individuals with low savings.

To motivate the focus on financial literacy as a unique kind of human capital, I document the divergence between financial literacy and work-related human capital using the American Life Panel (ALP). The ALP is a probability-based panel with over 500 surveys in the archive. The panel allows researchers to identify individuals across surveys and I use this feature to build a novel dataset.

I construct a measure of financial literacy as the sum of twelve financial literacy questions answered correctly by individuals in a year. To proxy for work-related human capital, I use an individual's annual income. If financial literacy is merely a work-related acquisition, then it should fall as an individual's income falls. I find that there is a noticeable divergence between the trajectory of income and financial literacy over the life cycle. In particular, individuals continue to accumulate financial literacy after income begins declining in their fifties. This is because individuals are preparing for retirement by informing themselves about retirement financial literacy.

Based on the implications from these facts, I develop a life cycle model of endogenous financial literacy accumulation. In my model, financial literacy determines an individual's return on savings. Consequently, individuals invest in financial literacy after their age-earnings profile has peaked in order to smooth consumption while they draw down their savings over the rest of their life time. I calibrate the model by matching the average financial literacy for two age-cohorts in the American Life Panel and show that the model is able to match well early life financial literacy investment. In addition, the model is able to match the empirical pattern of wealth-to-income ratios at each age-cohort.

I conduct a battery of experiments to evaluate the effect of financial literacy on household welfare under different situations. First, I show how financial literacy investment is affected by an unexpected wealth shock. When the shock hits, individuals respond by investing less than in the no shock case. In particular, individuals with a high school/associates age-earnings profile almost almost completely forgo investing in financial literacy. This experiment implies that negative wealth shocks early in life may completely discourage individuals from acquiring financial literacy by inhibiting them from building up a significant amount of savings to manage with their financial literacy.

Secondly, I simulate the effect of a pre-working age financial education program.[1].

[1]This can be thought of as a program given at a high school or college

Individuals with a high school degree see short-run benefits from the financial literacy program but they let the bonus financial literacy depreciate quickly. Individuals who have a higher age-earnings income profile, such as college-educated persons, accumulate financial literacy for a longer period of their life time. This policy counterfactual shows the importance lifetime expected earnings on influencing the effectiveness of financial education and is useful to policymakers interested in improving financial education design.

The rest of the paper is organized as follows. Following the literature review, I document some motivating facts from the American Life Panel. Next, I will construct a life cycle model with endogenous financial literacy accumulation and shocks to the borrowing interest rate. Finally, I calibrate the model and run a series of policy experiments exploring the implications of the model.

2. Relevant Literature

This paper draws most immediately from the work of Jappelli and Padula (2013) and Lusardi, Michaud and Mitchell (2017) for the model structure. These papers model financial literacy as an investment in the household's return on savings but the investment requires a resource cost. This approach allows the authors to model the observed relationship

The effect of financial literacy on household outcomes is often difficult to describe because financial literacy intersects many other kinds of human capital. Jappelli and Padula (2013) find that about 30% of adult financial literacy can be explained by mathematical ability at the age of 10.[2] However, financial literacy encompasses knowledge beyond mathematical ability; it also includes awareness of certain financial concepts and the

[2]Gramatki (2017) finds that the difference between native and immigrant students' financial literacy is mainly explained by variation in their math score. However, the author matches their estimation on various demographic characteristics, such as age and family structure, that could also influence financial literacy.

planning related to this knowledge (Carpena et al. 2011). For example, Bucher-Koenen and Ziegelmeyer (2011) find that even when controlling for cognitive ability, individuals with low financial literacy are more likely to sell assets at a loss in value and less likely to participate in the stock market.

An alternative story is that financial literacy is not necessary for households if they can rely on financial advice. Previous work has found either that financial literacy and financial advice are complements (Collins 2012; Von Gaudecker 2015) or not related to financial literacy at all (Kramer 2016). This is because even if an individual buys financial advice, they are still required to interpret the value of the information and anticipate potential strategic interests on the part of the financial advisor (Calcagno and Monticone 2015).

This work is also related to literature examining the role of financial literacy under wealth shocks. Klapper, Lusardi and Panos (2013) find that individuals with high financial literacy were better able to handle any shocks to their wealth during the Great Recession.

3. Financial Literacy As A Unique Kind of Human Capital

It is important to distinguish financial literacy from other kinds of human capital. In order to do this, I compare two regressions: one where the dependent variable is the logarithm of Income and one where the dependent variable is level of financial literacy. The idea here is that income is rising with human capital and falls as individuals transition to retirement and face depreciation in their human capital.

3.1 Financial Literacy Measure

I construct an index of financial literacy using 12 questions divided into four categories: basic knowledge (1), sophisticated economic concepts (2), financial knowledge (3) and retirement/tax knowledge (4). Twelve questions is considered sufficient to be a meaningful measure of a person's financial literacy.[3] Each question is weighted equally.

The first three questions are often called the "Big Three" (Hastings, Madrian and Skimmyhorn 2013) because they are very commonly included in financial literacy tests. I then include two questions testing economic concepts, three testing stock market knowledge and three questions about retirement knowledge. This variable will be denoted as $FinancialLiteracy_{it}$.

3.2 Additional Variables

Income is recorded in the ALP in 17 brackets. I transform this variable into a continuous variable by taking the median value of the bracket. I then take the logarithm of this variable; I denote this dependent variable as $Log(Income_{it})$. For education level, I construct a dummy variable that takes the value of 1 if an individual has completed a 4-year college degree or above and zero if they have not. This variable is denoted as $Educ_{it}$.

I include a battery of controls—gender, ethnicity, marital status, etc.— to help control for factors that may influence income and financial literacy.

3.3 Regression Estimation

$$Log(Income_{it}) = \alpha + \gamma_1 Age_{it} + \gamma_2 Age_{it}^2 + \gamma_3 Educ_{it} + W_{it} + \delta_t + \varepsilon_{it} \tag{1}$$

$$FinancialLiteracy_{it} = \alpha + \beta_1 Age_{it} + \beta_2 Age_{it}^2 + \beta_3 Educ_{it} + W_{it} + \delta_t + \varepsilon_{it} \tag{2}$$

[3] See Jayaratne, Lyons and Palmer (2008) and Huston (2010)

where Age_{it} is individual i's age in year t, $Educ_{it}$ is a binomial variable denoting an individual's education ($\leq$High School/Some College and Bachelors+) in year t, W_{it} is a set of demographic controls and δ_t is a year fixed-effect.

Plot 1 and 2 plot the log of income and financial literacy score predictions over the life-cycle. On average, college-educated individuals score about 0.5–1 points above high-school individuals at each age.

Both plots, however, show financial literacy accumulating after income begins to fall. Individuals increase their financial literacy by about 10-12% after the peak in income.

Why would individuals continue to invest in financial literacy even after their incomes have started to fall? As individuals approach retirement, they are faced with a new need to invest in financial literacy. This is due to two effects: one, the accumulated savings and two, the fall in income. Figure plots the average financial literacy score alongside the average retirement financial literacy score (out of three). On average, individuals at age 25 are answering one-out-of-three retirement questions correct, but the rate of increase over the life cycle is more fast than the total score.

To summarize, these facts help demonstrate the distinction between financial literacy and work-related human capital. As can be seen in figures 1 and 2, even when households expect to be working less in the future, they still accumulate financial literacy. This suggests that financial literacy is related to savings and a model of financial literacy accumulation should capture some aspect of the relationship between financial literacy and savings. Furthermore, all of the financial literacy plots showed financial literacy growing at a diminishing rate over the average life time, suggesting there is a life cycle character to financial literacy accumulation. In the proceeding section, I develop a life cycle model with endogenous financial literacy accumulation.

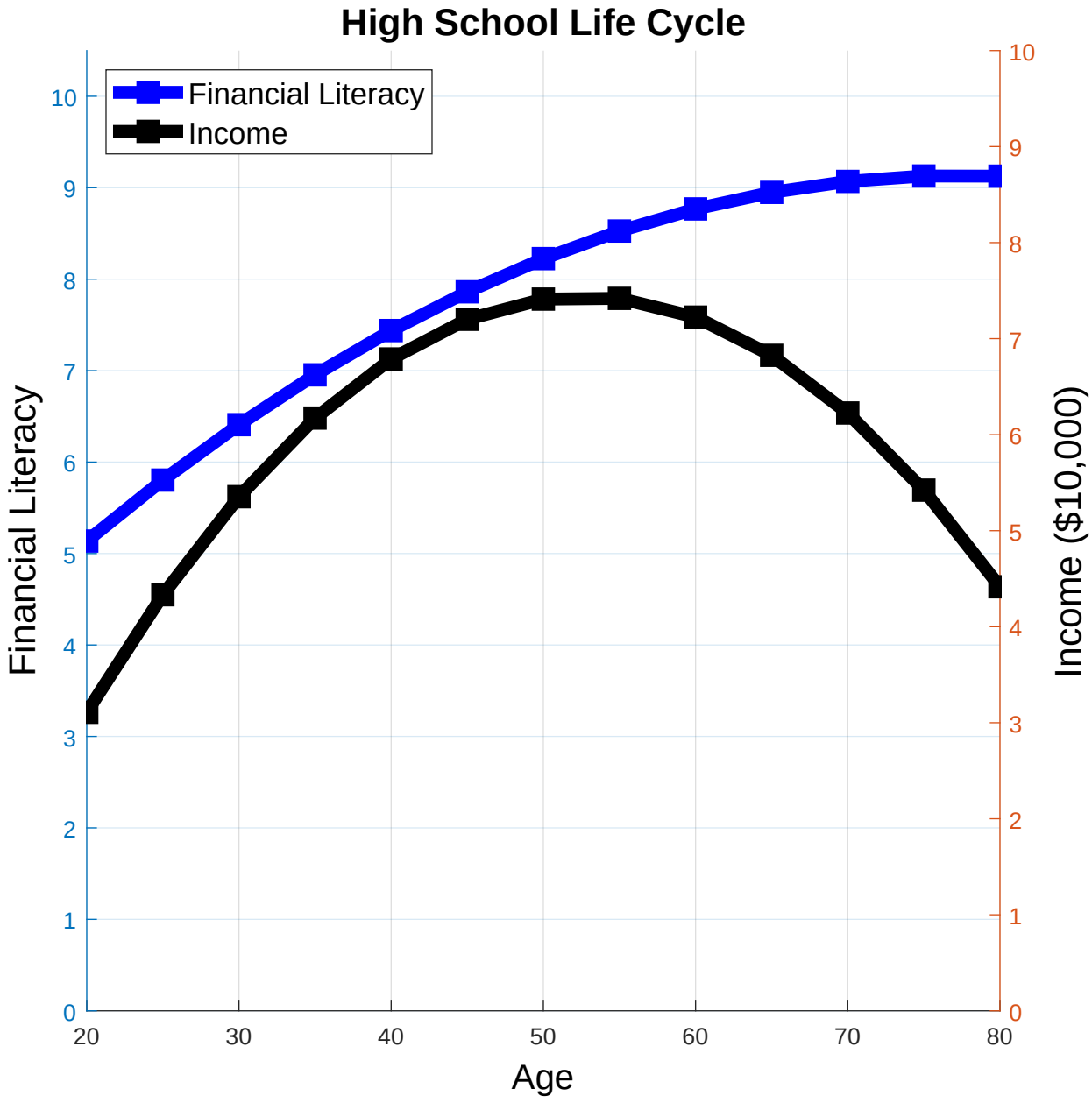

Figure 1: High School

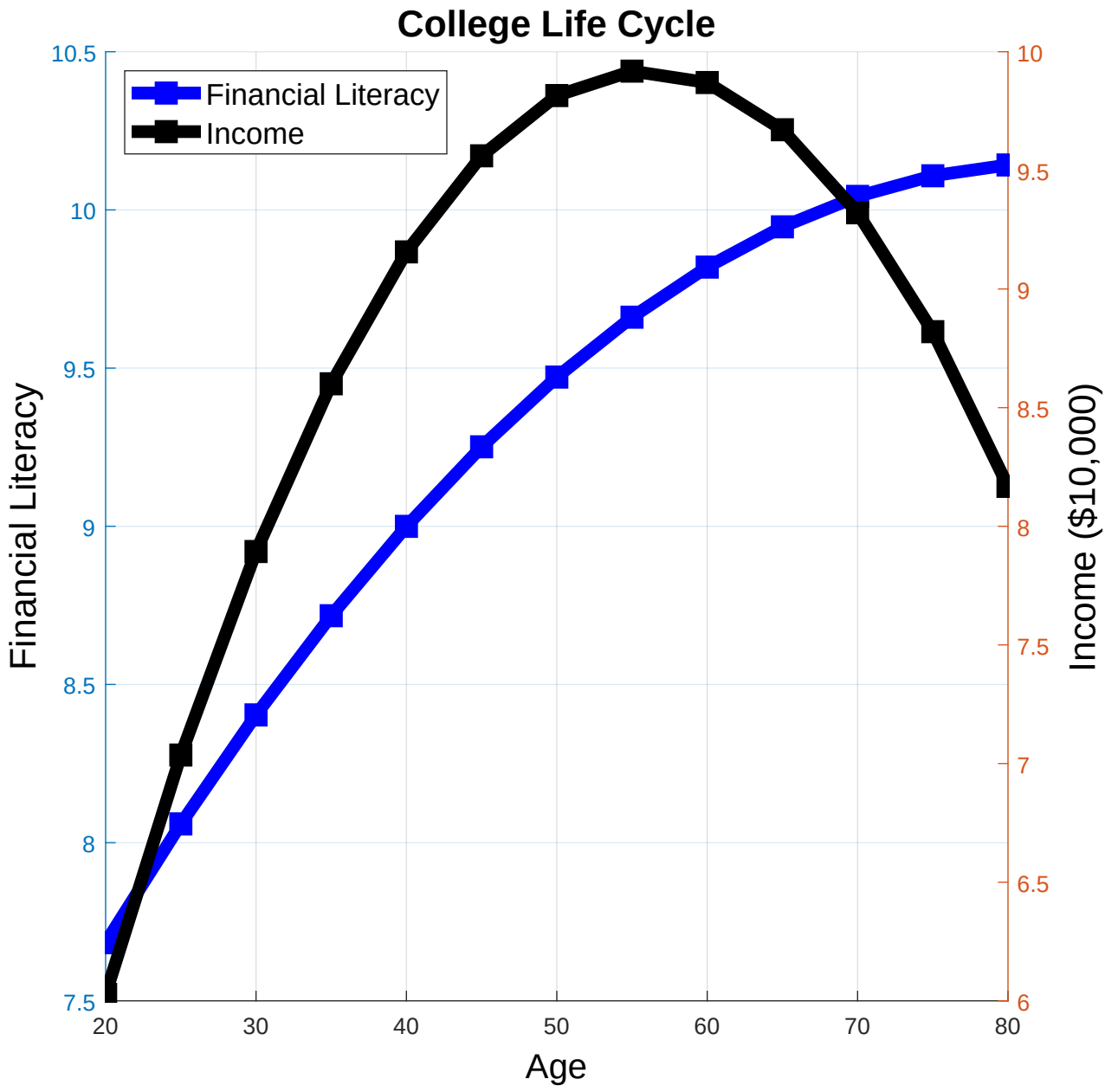

Figure 2: College

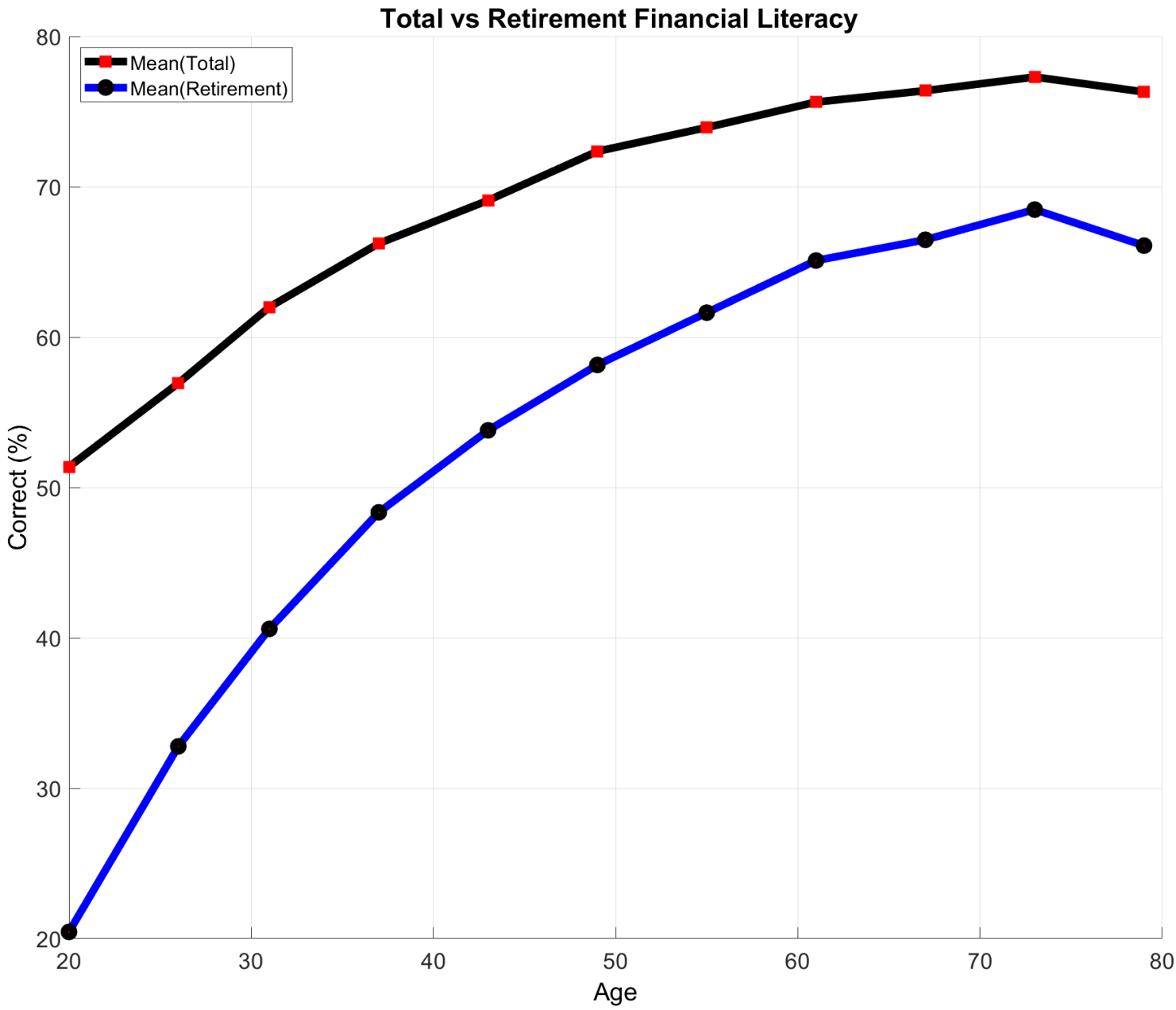

Figure 3: Total vs Retirement Literacy

4. A Quantitative Model of Financial Literacy Accumulation

4.1 Household Problem

The economy is populated by a large number of households indexed by i who live for J years. They have identical preferences that can be represented as a time-separable discounted utility function:

$$\max_{\{c_t\}_{t=0}^{6}} E_0 \left[\sum_{t=0}^{J} \beta^t \frac{c_{t+1}^{1-\gamma}}{1-\gamma} \right] \quad , \tag{3}$$

In every period t, individuals receive income y. This is made up of three parts. First, individuals inelastically supply one unit of labor each period and earn a wage w, which is normalized to 1. Second, individuals face a log-normal income shock denoted by η_t. Third, income follows an age-earnings profile e_t that is normalized to 1 in the initial period. Altogether, the per-period income is as follows:

$$y_t = w \cdot e_t \cdot exp(\eta_t) \, , \tag{4}$$

where $\eta_{t+1} = \rho_\eta \eta_t + \varepsilon_{t+1}$ and $\varepsilon_{t+1} \sim N(0, \sigma_\varepsilon^2)$.

4.2 Asset and Financial Literacy choice

Each period, an individual has an opportunity to make two asset choices: a savings choice and a financial literacy investment. In my model, the return on savings will be determined endogenously. Following Jappelli and Padula (2013), an individual's interest rate is a function of their financial literacy stock:

$$r(\Phi_t) = A\Phi_t^\alpha + r_{base}^s \, . \tag{5}$$

This return is paid at the beginning of period t for the stock of financial literacy accumulated up to that period, Φ_t. The intuition for treating the stock of financial literacy as the determinant of the interest rate follows from the observed relationship between financial literacy and savings assets.[4] Explanations for the relationship include making less fiduciary mistakes (Lusardi and Tufano 2009); knowledge of savings instruments' returns (Deuflhard, Georgarakos and Inderst 2015); and better retirement planning (Lusardi and Mitchell 2007).

The α parameter is the elasticity of financial literacy investment. I assume $\alpha \in (0, 1)$ so that agents face diminishing returns to financial literacy investment, consistent with the empirical findings in section 3.3. The parameter A is the productivity of the financial literacy investment. Finally, r^s_{base} is a base interest rate so that individuals with zero financial literacy still receive a positive return to saving.

The structure of the production function follows from previous empirical work that has found diminishing returns to financial literacy education. Both Cole el al. (2011) and Fort et al. (2016) find that financial literacy interventions are less effective for higher educated individuals. This is likely because higher-educated individuals tend to already have high financial literacy (Lusardi et al. 2010), so that the benefit to additional financial literacy investment is lower than it is for less educated individuals. A life cycle profile has also been observed in terms of financial literacy accumulation and depreciation. Older individuals tend to have at least accumulated some financial literacy from experience (Eberhardt et al. 2019), so they likely face a diminishing marginal benefit to an additional unit of financial literacy.[5]

Following Jappelli and Padula (2013), I will allow individuals to accumulate and de-

[4]See Lusardi and Mitchell (2007), Lusardi and Tufano (2009), Jappelli and Padula (2013), Beckmann (2013), Anderson, Baker and Robinson (2017), Lusardi, Michaud and Mitchell (2017), and Boisclair, Lusardi and Michaud (2017)

[5]If the structure of financial literacy production was constructed as a linear function, then we should expect to see similar changes in financial literacy between age-cohorts.

accumulate financial literacy.[6] In every period t, an individual can invest ℓ_{t+1} in their financial literacy stock. They face a cost of p per unit of financial literacy.

Individuals cannot reduce their financial literacy by selling or consuming their stock but can only choose to let it depreciate. I designate $\delta \in (0,1)$ the depreciation rate of the financial literacy stock. The depreciation of financial literacy can be understood as not just cognitive decline, but also the obsolescence of an existing financial knowledge (Lusardi, Michaud and Mitchell 2017).

Combining the investment, stock and depreciation variables, the financial literacy law of motion for my model can be written as the following:

$$\Phi_{t+1} = (1-\delta)\Phi_t + \ell_{t+1}\,. \tag{6}$$

Financial literacy investment cannot be negative, implying that individuals face the investment constraint:

$$\ell_{t+1} \geq 0\,. \tag{7}$$

4.3 Asset Path

The dynamic budget constraint is the following:

$$s_{t+1} = (1 + r(\Phi_{t+1}))(y_t + s_t - c_t + p(1-\delta)\Phi_t - p\Phi_{t+1})\,, \tag{8}$$

where $p(1-\delta)\Phi_t - p\Phi_{t+1} = p\ell_{t+1}$. Individuals also face a non-negative savings constraint,

$$s_{t+1} \geq 0 \tag{9}$$

[6] Lusardi, Michaud and Mitchell (2017) and Jappelli and Padula (2013) both show that some level of financial ignorance may be optimal. If financial literacy is treated as a stock that requires as cost to accumulate, then some individuals may rationally choose to remain financially ignorant.

1 4.4 Consumer Problem

Using the CRRA utility function and combining the constraints in equations 8, 7 and 9 the consumer problem can be written as:

$$V_t(s_t, \Phi_t, y_t) = \max_{\ell_t, c_t} u(c_t) + E_t[\beta V(s_{t+1}, \Phi_{t+1}, y_{t+1})|y_t]$$

s.t

$$s_{t+1} = (1 + r(\Phi_{t+1}))(y_t + s_t - c_t - p\Phi_{t+1} + p(1-\delta)\Phi_t) \tag{10}$$

$$ell_{t+1} \geq 0 \tag{11}$$

$$s_{t+1} \geq 0 \tag{12}$$

Quantitative Analysis

5.1 Calibration

The initial distribution for financial literacy and liquid assets is taken from the empirical joint distribution in my sample for individuals 30–40. This distribution is likely the result of differences in high−school and college education requirements (Bernheim, Garrett and Maki 2003). as well as family background (Lusardi, Mitchell and Curto 2009). For the discount, I follow Lusardi, Mitchell and Michaud (2017) and choose a value of 0.96. For risk aversion, I set γ to 3, following the estimates done by Hubbard, Skinner and Zeldes (1995).

The age-earnings profile (e_t) is calibrated to match the averages of each age−band, normalized to the starting age band of individuals 30-40. For the income shock process, I calibrate the persistence parameter and innovation parameter so that the stationary distribution of the shock process matches the ratio of the mean−to−standard deviation of the income in the sample data.

I estimate three structural parameters: the the elasticity of financial literacy investment (α) and a productivity parameter (A). I target two moments in the data $-$ percent changes in the financial literacy for the first two age-bands.

Table 7: Parameter Calibration

Parameter	Value	Source/Function
β	0.96	Lusardi, Michaud and Mitchell (2017)
γ	3	Hubbard, Skinner and Zeldes (1995)
p	0.06	Lusardi, Michaud and Mitchell (2017)
δ	0.06	Lusardi, Michaud and Mitchell (2017)
ρ	0.911	Income Persistence
σ_ε^2	0.225	Income Shock Std.
α	0.350	Investment Elasticity
A	0.019	Savings Productivity

The model is solved using a grid search method with 160 saving asset grid points, 13 literacy grid points and 5 income shock points. Both the financial literacy and the saving asset grids are equally spaced. After solving for the asset and financial literacy policy functions, I feed the empirical joint distribution of income, assets and financial literacy into the initial age and use the policy functions to induce the stationary distribution.

The initial distribution is normalized such that the average financial literacy is 0.7. This implies a return on savings of $0.015 \cdot (0.7)^{.810} + .02$ or about 3% over 10-years.

Model Fit Table 8 reports the fit of the model for the targeted moments as well as the untargeted moments for model validation. The model fits the financial literacy profile well, although it overshoots. The largest difference is found at around age 63, where the model's agents begin de-accumulating financial literacy before the sample de-accumulates. The absence of a pension plan in my model means that individuals do not expect to face a

drop in income at retirement later in life. A model with a pension plan would likely lead to greater savings and financial literacy at this part of the life cycle.

The model also matches wealth-to-income ratios well. The greatest difference between the model and the data is in the final age, because households accumulate less financial literacy and therefore, have a lower return on saving than in the calibrated model.

Table 8: Targeted: Financial Literacy Mean Change

Age	41–51	52–62	63–73	74–84
Δ FinLit^{Data} (%)	3.7	3.3	4.9	-3.2
Δ FinLit^{Model} (%)	3.7	-1.2	-0.3	-0.2
Untargeted: Wealth-to-Income				
$W2I^{Data}$	0.53	1.47	2.93	3.11
$W2I^{Model}$	0.86	1.17	1.62	1.62

W2I: Wealth-to-Income is the ratio of assets to income.

5.2 Effect of Age-Earnings Profile

The decision to invest in financial literacy is not necessarily driven by the level of income, so much as the need to smooth consumption (Lusardi, Michaud and Mitchell 2017). I evaluate the effect of different age-earnings profiles on financial literacy accumulation. I construct two additional age-earnings profiles to match the lifetime earnings of individuals who are college educated and high school/associates educated. Table **??** reports the age-earnings profile normalized to a wage of 1 in the first period. Both of the additional income profiles are more steep from 30 to 51 than the baseline model but the latter-life pattern also diverges based on education. The High School/Associates profile begins declining before the baseline and eventually falls to less than half of the average 30–40

year-old's income in the college model.[7] College-educated individuals see their income rise early in life but decline less after age-cohort 52–62.

Table 9: Income Age-Earnings Profile

Age	30–40	41–51	52–62	63–73	74–84
Baseline	1	1.04	1.06	0.93	0.71
College	1.13	1.19	1.23	1.06	1.03
High School/Associates	0.77	0.90	0.87	0.77	0.47

Income is normalized to $83202. High School/Associates is the income profile for individuals who have at most completed their associates degree. College is the income profile for individuals who have completed college.

These differences in the age-earnings profile have an effect on both financial literacy investment and savings decisions. In Table **??** reports the results of the age-earnings counterfactuals. Note that the High School/Associates group accumulates financial literacy for a greater portion of their life cycle than either the baseline or college-educated group. This is for two reasons. First, individuals with this education level prepare for the income fall following ages 52–62. Second, because the high school/associates group invest less in financial literacy early in their life, the marginal return on average is higher for this group. Nonetheless, this group has the lowest financial literacy of any the reported age-earnings profiles.

College-educated individuals also invest less than the baseline but for a different reason. First, this group has the lowest Wealth-to-Income ratio but the greatest Average Savings Return for ages 41–51. This means that they consume more and when they do save, they save at a higher interest rate on average. This is consistent with Lusardi, Michaud and Mitchell 2017, who find that individuals invest in financial literacy not necessarily because of higher income *per se* but because of the need to smooth consumption across time periods.

[7] The final period earnings-profile for High School/Associates is about $40,000 a year.

Table 4: Age-Earnings Counterfactual

Age	41–51	52–62	63–73	74–84
Financial Literacy Change				
Baseline (%)	3.7	-1.2	-0.3	-0.2
High School/Associates (%)	1.7	0.3	-0.4	-0.1
College (%)	2.8	-0.1	-0.2	-0.2
Wealth-to-Income				
Baseline	0.86	1.17	1.62	1.62
High School/Associates	0.78	1.23	1.74	2.5
College	0.74	0.88	1.28	0.81
Average Savings Return (%)				
Baseline	3.67	3.67	3.67	3.67
High School/Associates	3.66	3.66	3.66	3.66
College	3.69	3.67	3.67	3.67

Baseline is the empirical age-earnings profile for the whole sample. High School/Associates is the empirical age-earnings profile for individuals with an associates degree or less education completed. College is the empirical age-earnings profile for individuals with a 4-year college degree or more completed. Wealth is defined as the stock of savings scaled by an individual's savings return. The Wealth-to-Income ratio is the average wealth-to-income for individuals in the reported age-cohort. The Average Savings Return is the total return on savings divided by the total savings value for individuals in the reported age-cohort.

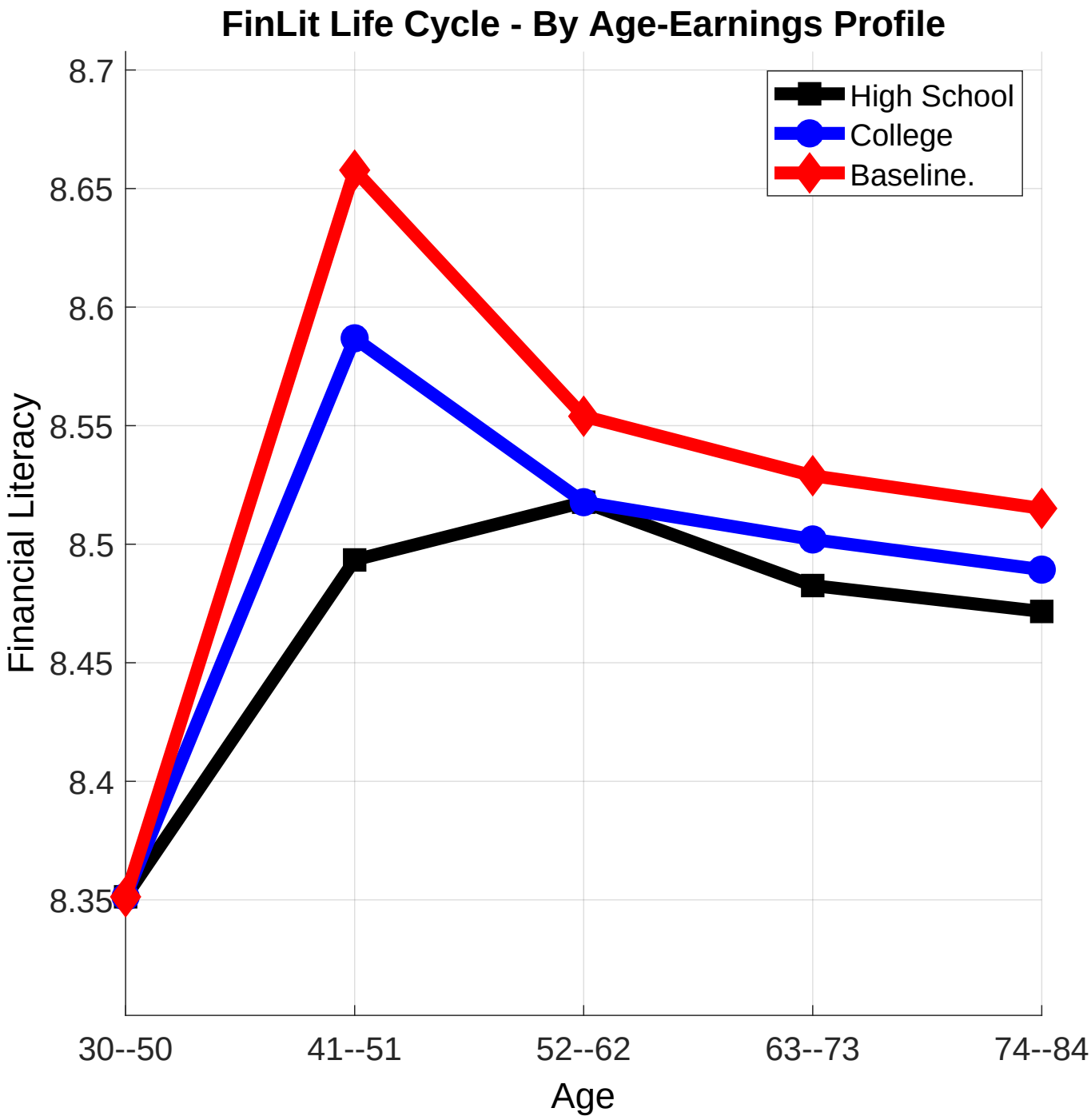
FinLit Life Cycle - By Age-Earnings Profile
High School
College
Baseline.
Financial Literacy
8.7
8.65
8.6
8.55
8.5
8.45
8.4
8.35
30--50
41--51
52--62
63--73
74--84
Age

Figure 4

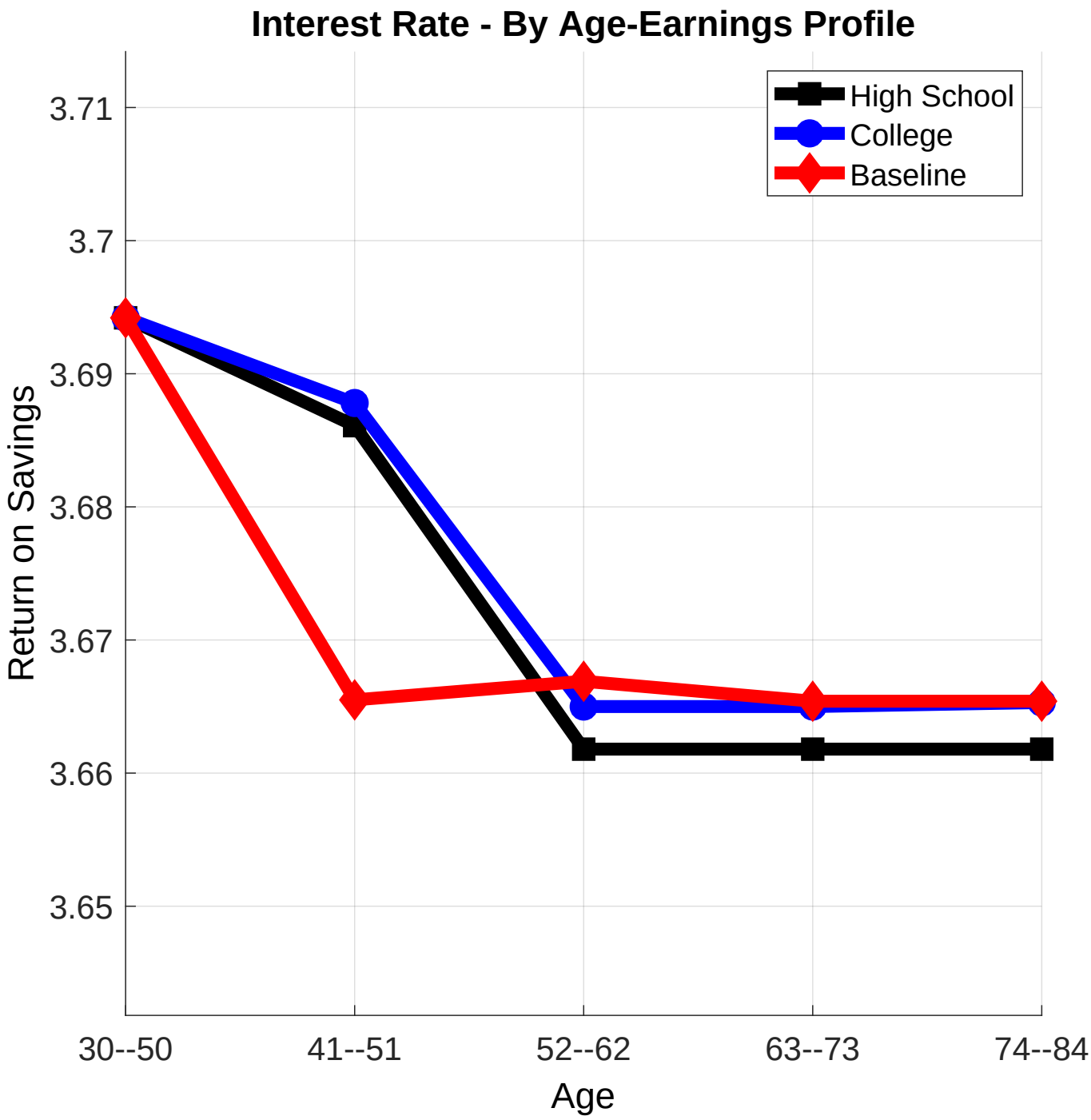
Interest Rate - By Age-Earnings Profile
High School
College
Baseline
3.71
3.7
3.69
3.68
3.67
3.66
3.65
Return on Savings
30--50
41--51
52--62
63--73
74--84
Age

Figure 5

5.3 Wealth Shock

Klapper, Lusardi and Panos (2013) find that Russian households with high financial literacy report being better able to withstand the Great Recession.[8] Therefore, a negative wealth shock may be attenuated if an individual has a high level of financial literacy. If one's resources financial literacy investment, it may be the case that a wealth shock leads to a lower overall level of financial literacy.

To simulate this exercise, I redistribute every agent to a portion of their expected wealth at age 4 (41-51). Table 5 reports the results of the wealth shock. High school/associate-educated households are most sensitive to the wealth shock. This group lets more of their financial literacy depreciate in response to the wealth shock than the college-educated group. For this group, consumption is smoothed by giving up resources used in financial literacy upkeep for current period consumption.

[8] In particular, they report that individuals with financial literacy tended to have higher unspent income and higher spending capacity.

Table 5: Wealth Shock Counterfactual

Age	41–51	52–62	63–73	74–84
High School/Associates				
Baseline FinLit	8.49	8.52	8.48	8.47
Wealth Shock FinLit	8.49	8.48	8.48	8.47
Baseline Avg. Return	3.68	3.66	3.66	3.66
Wealth Shock Avg. Return	3.68	3.68	3.66	3.66
College				
Baseline FinLit	8.59	8.52	8.50	8.49
Wealth Shock FinLit	8.59	8.50	8.50	8.48
Baseline Avg. Return	3.69	3.66	3.66	3.66
Wealth Shock Avg. Return	3.69	3.68	3.66	3.66

Baseline is the empirical age-earnings profile for the whole sample. High School/Associates is the empirical age-earnings profile for individuals with an associates degree or less education completed. College is the empirical age-earnings profile for individuals with a 4-year college degree or more completed. The Avg. Return is the total return on savings divided by the total savings value for individuals in the reported age-cohort.

Figures 6 and 7 plot out financial literacy life cycle profile for college-educated and high school-educated individuals. Again, the shock has a much greater effect for the high school individuals, causing them to depreciate their financial literacy earlier than in the baseline case.

This experiment shows just how important a wealth shock can be for individuals with relatively flat age-earnings profiles. In response to the wealth shock, the college-educated individuals were able to attenuate most of the shock's influence on their financial literacy accumulation but the high school/associates group immediately let their financial literacy decline. In the next counterfactual, I will further explore the difference in sensitivity between age-earnings profiles but with respect to a positive financial literacy shock.

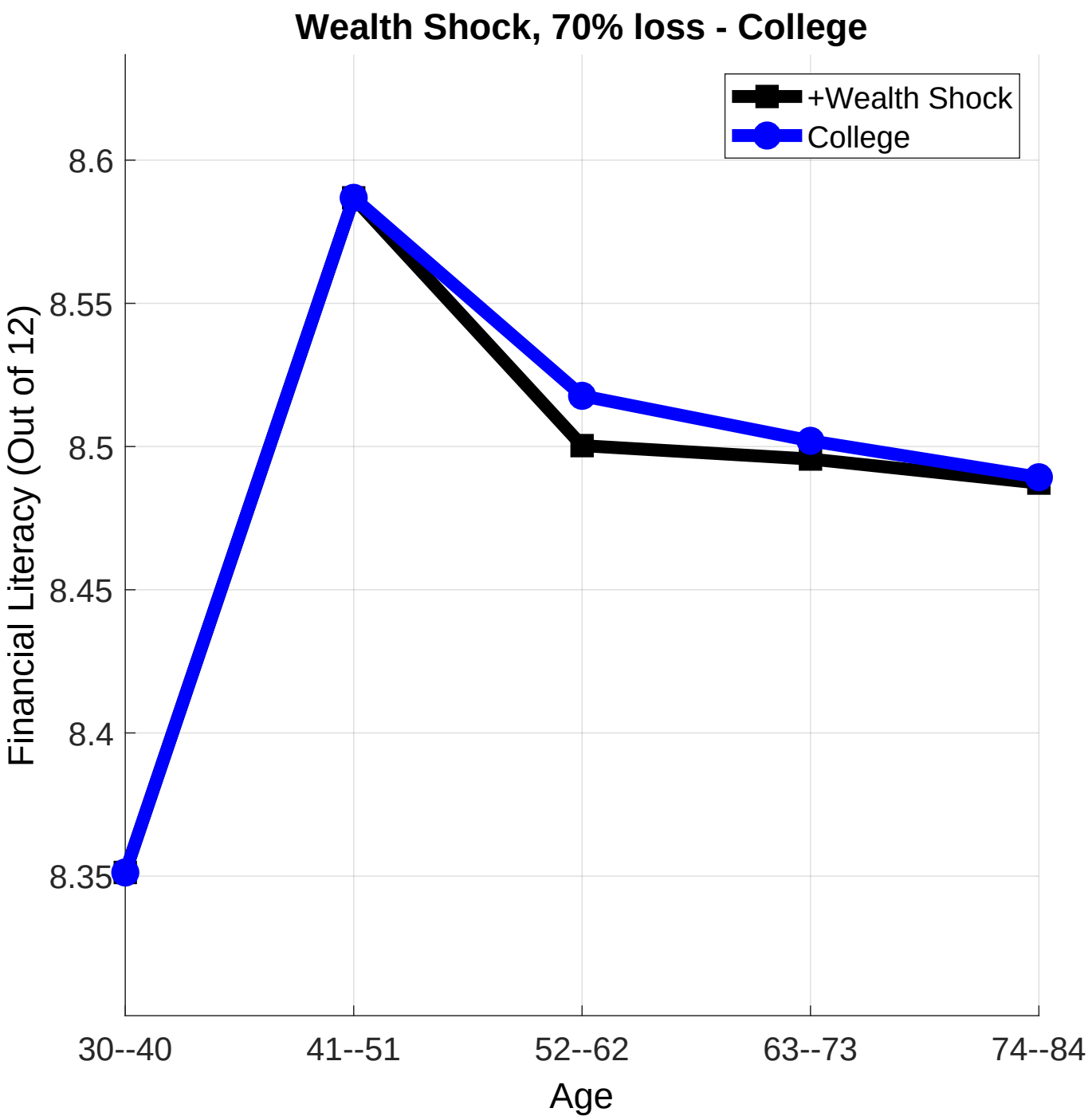
Wealth Shock, 70% loss - College
+Wealth Shock
College
8.6
8.55
8.5
8.45
8.4
8.35
Financial Literacy (Out of 12)
30--40
41--51
52--62
63--73
74--84
Age

Figure 6

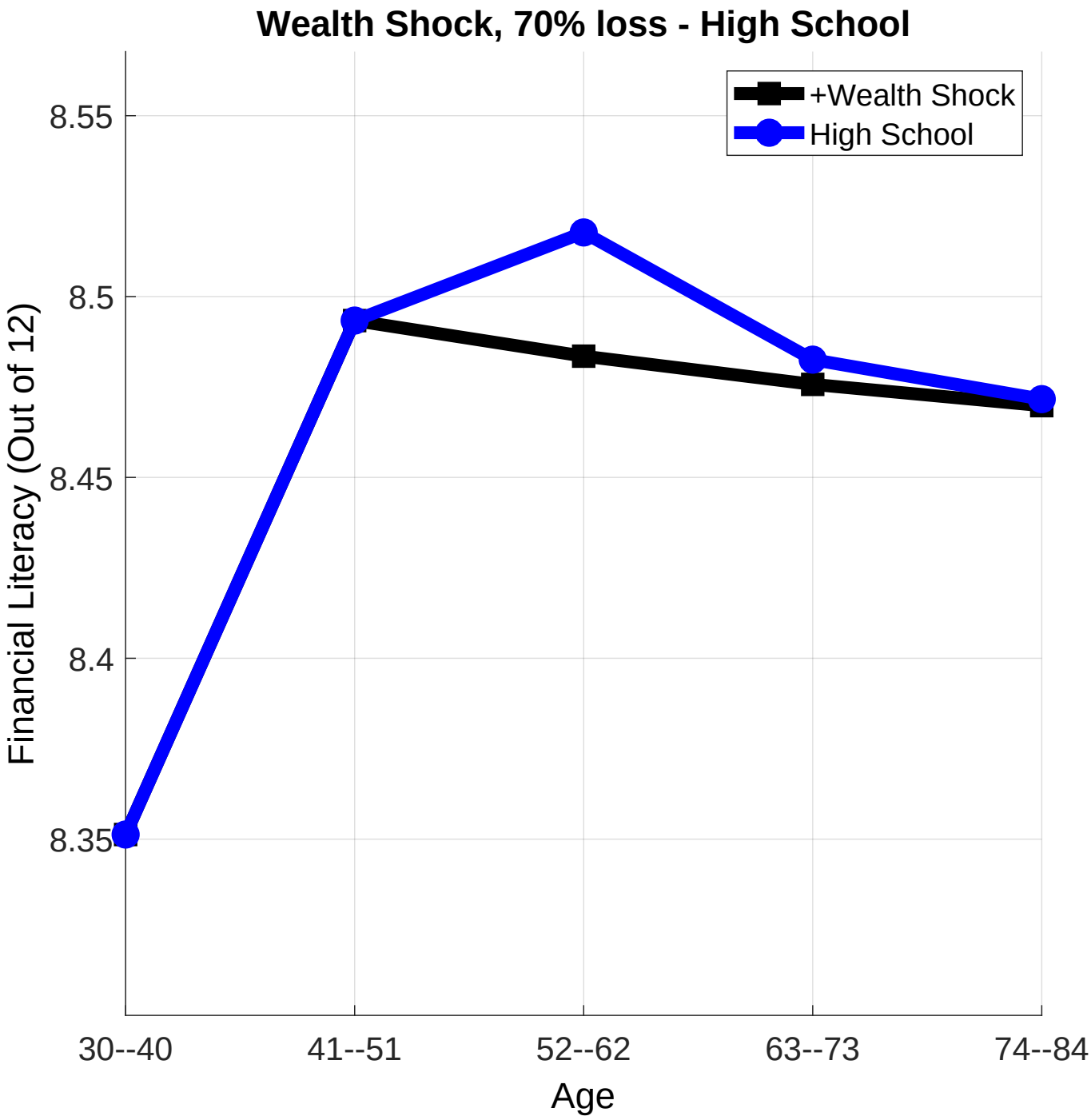
Wealth Shock, 70% loss - High School
+Wealth Shock
High School
8.55
8.5
8.45
8.4
8.35
Financial Literacy (Out of 12)
30--40
41--51
52--62
63--73
74--84
Age

Figure 7

1 Financial Education Program

Twenty-four states in the U.S. require some form personal financial literacy instruction to be provided at the high school level (Center for Financial Literacy, 2017). The effectiveness of financial education, especially when provided in high school, is mixed. Bernheim, Garrett and Maki (2001) find that high school financial education programs have an effect on later-life saving behavior, but the effectiveness of high school education programs on personal financial literacy appears to be insignificant (Mandell 2009).

If financial literacy is needed primarily for consumption smoothing, then what expected lifetime earnings should influence the retention of a financial literacy endowment. In order to simulate a high school Financial Education program, I increase the endowment for individuals in the initial age. If individuals do not need the extra financial literacy, then they will let the knowledge depreciate and they should arrive at a similar level of financial literacy after a few periods.

Table 6: Education Program Counterfactual

Age	41–51	52–62	63–73	74–84
High School/Associates				
Baseline FinLit	8.49	8.52	8.48	8.47
Education Program FinLit	9.49	9.38	9.37	9.37
Baseline Avg. Return (%)	3.68	3.66	3.66	3.66
Education Program Shock Avg. Return (%)	3.75	3.73	3.73	3.73
Baseline Savings ($)	63330	117289	121624	84616
Education Program Savings ($)	89250	112505	121050	49600
College				
Baseline FinLit	8.59	8.52	8.50	8.49
Education Program FinLit	9.36	9.38	9.37	9.36
Baseline Avg. Return	3.69	3.66	3.66	3.66
Education Program Avg. Return	3.75	3.73	3.73	3.73
Baseline Savings ($)	89167	112405	120826	49597
Education Program Savings ($)	63350	117298	121699	84616

Baseline is the empirical age-earnings profile for the whole sample. High School/Associates is the empirical age-earnings profile for individuals with an associates degree or less education completed. College is the empirical age-earnings profile for individuals with a 4-year college degree or more completed. The Avg. Return is the total return on savings divided by the total savings value for individuals in the reported age-cohort.

Table 6 reports the results of the financial education program. High school/associates-educated individuals benefit greatly from the additional endowment by receiving on average 10 basis points more on their savings, but the financial literacy depreciates quickly and rapidly. College-educated individuals have a different pattern. Rather than accumulating financial literacy quickly and letting the stock depreciate, the college-educated individuals accumulate financial literacy for a longer period of their lifetime at a slower rate.

This reflects the difference in consumption smoothing needs required by the different

age-earnings profiles. Individuals with a high school/associates education see their age-earnings profile decline early in their life, before they have an opportunity to accumulate significant savings. For this group, financial literacy serves as a substitute for a stock of savings. Consequently, the education program leads the high school/associates group to have less savings than in their baseline case. In the college-educated case, the program leads individuals to accumulate greater savings. The delayed and gradual accumulation of financial literacy reflects that in this case, financial literacy is a complement to the life cycle savings accumulation.

My results are consistent with both Bernheim, Garrett and Maki (2001) and Lusardi, Michaud and Mitchell (2019) but they add an additional insight into the mechanism that they observed. Bernheim, Garrett and Maki (2001) find that individuals who were exposed to a state financial education mandate save more and that this is jointly statistically significant with being college-educated. This result is consistent with the college-educated individuals in my model but not the high school/associates group. This is because while the program is useful, the cost of upkeep is too great for the high school/associates group. Lusardi, Michaud and Mitchell (2019) conclude that financial education should be either provided later in life when individuals have more savings (age 40) or in small but continuous amounts in order to account for depreciation.

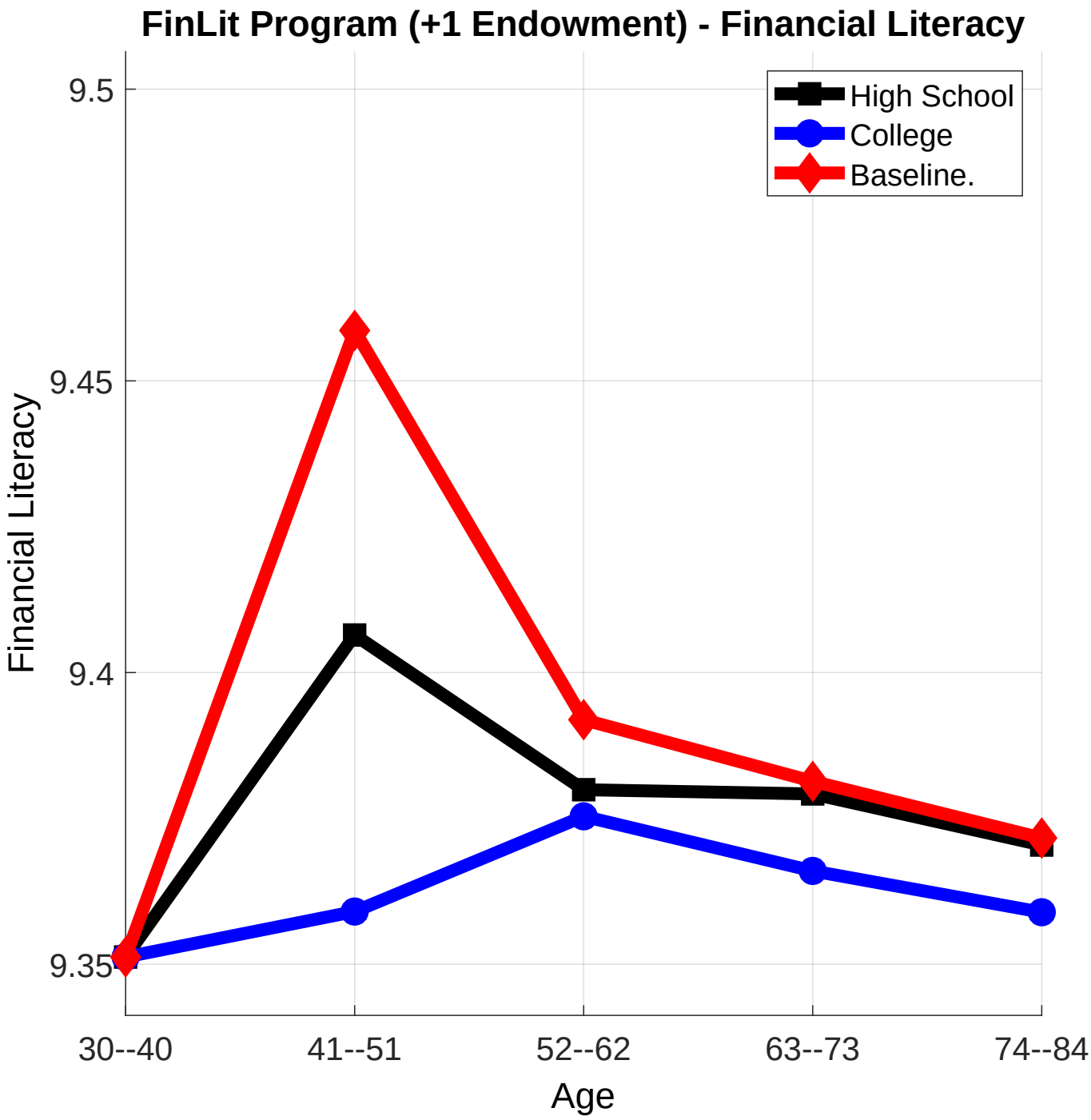
FinLit Program (+1 Endowment) - Financial Literacy
High School
College
Baseline.
9.5
9.45
9.4
9.35
Financial Literacy
30--40
41--51
52--62
63--73
74--84
Age

Figure 8

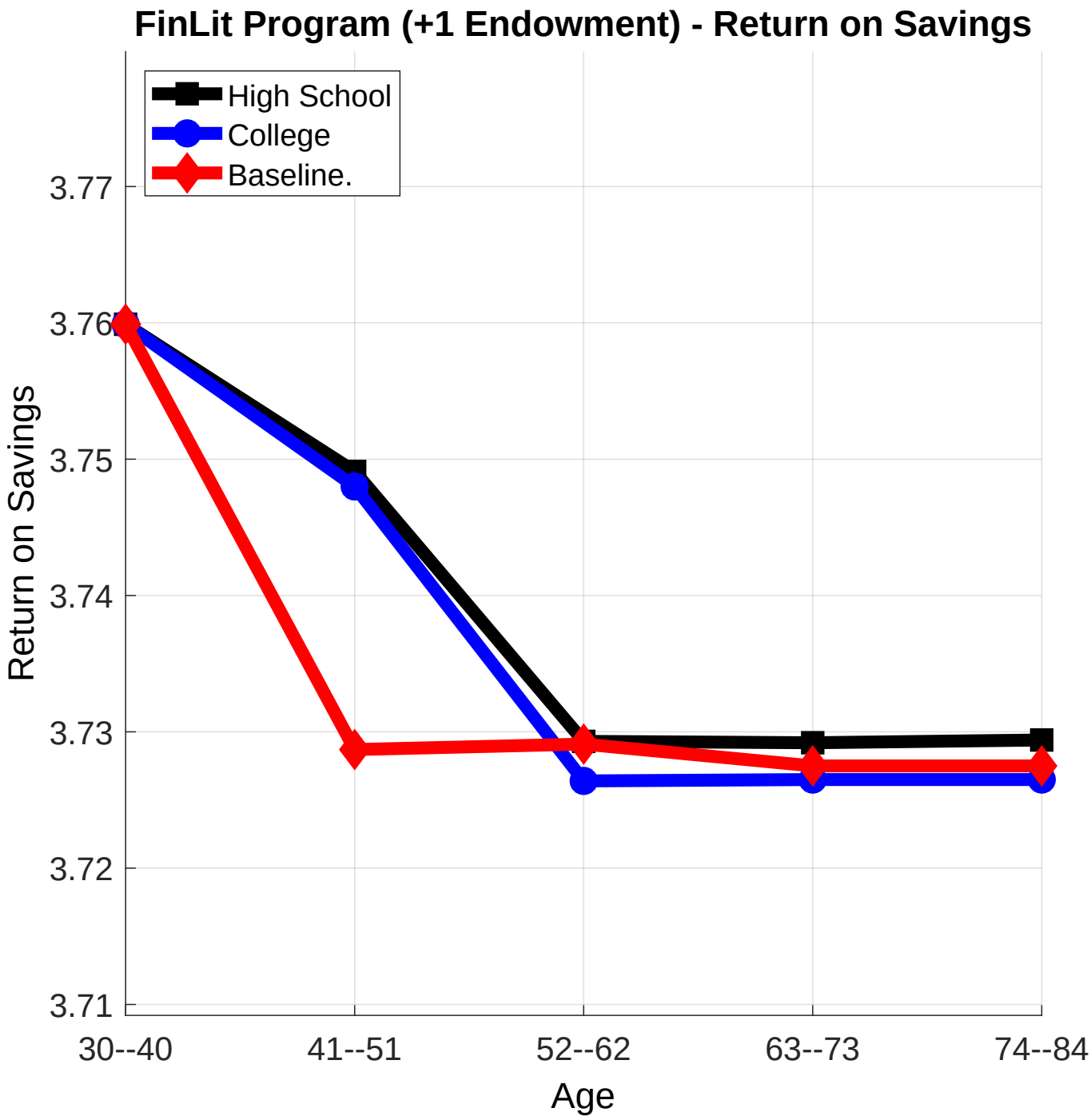
FinLit Program (+1 Endowment) - Return on Savings
High School
College
Baseline.
Return on Savings
3.77
3.76
3.75
3.74
3.73
3.72
3.71
30--40
41--51
52--62
63--73
74--84
Age

Figure 9

Conclusion

I develop a life cycle model with endogenous financial literacy accumulation and perform a quantitative analysis to analyze how financial literacy is influenced by age-earnings profiles, wealth shocks and financial literacy endowment. I motivated this model by documenting the divergence in financial literacy accumulation and income. Individuals have a reason to accumulate financial literacy, even when their income is falling, as a tool smooth consumption.

A potential limitation of this study is the absence of heterogeneity in financial literacy production. I found that individuals with an associates degree or less responded more sensitively to the high school financial education immediately but that individuals with a college degree accumulated for a longer part of their lifetime. However, both groups have the same financial literacy production technology. A useful augmentation of the existing model would be to allow the financial literacy productivity to be influenced education level.[9]

I show in several counterfactuals the importance of wealth and expected life time earnings on the decision to invest and retain financial literacy. My results are both consistent with the existing literature on financial education but help provide both a quantitative analysis of the effects of financial education and an insight into the underlying mechanisms influencing financial literacy accumulation.

[9]For example, see Spataro and Corsini (2013).

Appendix

Empirical Data

1 American Life Panel

The American Life Panel is a probability-based panel that is open for researchers to construct their own experiments. Since the ALP has a unique individual identifier and the time stamp for each individual's participation in a given survey, I can match different surveys that run parallel in order to get an observation of that individual for that year.

Construction of financial literacy

Four of my financial literacy questions are often called the "Big 5" sample (Hastings, Madrian and Skimmyhorn 2013) and I include one other quetsion - "money illusion." Certain questionnaires, such as survey 21, are in the field between two years. For sake of consistency, I only take those individuals who answer and complete the survey in a year in my sample.

Question 1 - Numeracy

"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?"

Observations for this question are taken from Well-Being Survey 21 (Economics and Retirement Scenarios), 50 (Cognition and Aging in the USA Internet Decision Making Survey [W02]) and 64 (Financial Literacy March 09) for year 2009;

Question 2 - Interest rates and Bond Prices

Observations for this question are taken from surveys 21, 50 and 64.

Question 3 - 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?"

Observations for this question are taken from Well-Being Survey 21 (Economics and Retirement Scenarios), 50 (Cognition and Aging in the USA Internet Decision Making Survey [W02]) and 64 ((Financial Literacy March 09) for the year 2009;

Question 4 -Risk Diversification

There are many variations on this question but the basic form is:

""Buying company stock usually provides a safer return than buying a stock mutual fund."

Observations for this question are drawn from survey 50 and 64 for the year 2009; using questions ms179_ SAFER, ms179_ FLsafer1 and ms179_ FLsafer2 from Well-Being Survey 179 (Please tell us whether this statement is true or false. Buying a [single company stock/stock mutual fund] usually provides a safer return than a [stock mutual fund/single company stock]); using question ms186_ Q48 from Well-Being Survey 186 ("True or false? Buying company stock usually provides a safer return than buying a stock mutual fund.");

Question 5 - Money Illusion

Question 5 was also included in Klapper, Lusardi and Panos (2013). For the year of 2009, observations for this question are taken from surveys 21, 50 and 64.

For the year of 2010, the ALP lacks a sufficient amount of observations for individuals answering question 3 (Interest Rates and Inflation). As a consequence, I fill in observations based on an individual's outcomes in the years 2009 and 2011. I take the median.

Question 10 - IRA taxation

Question 10 asks

"Which of the following statements are true?

1. **In any type of IRA or 401(k) account, all of the money in your account grows tax-free.**

2. **If you have a traditional IRA or 401(k), you make contributions out of pre−tax income and pay income tax at your future tax rate when you withdraw the funds.**

3. **Both are true**

4. **Don't know**

Recent research has found that financial education interventions are effective helping individuals to understand and plan the timing of their IRA withdrawal taxation , leading to higher welfare(Boyer et al. 2019). This is important, as their is substantial evidence that households make sub−optimal decisions regarding their choice retirement account with respect to their life−time incomes (see Burman et al. (2001)).

Assets

2009

I use two surveys for liquid wealth in 2009 - Survey 48 (Cognition and Retirement Survey) and Survey 62 (HRS Module Q). Survey 48 is in field from 11/08 to 09/09. For liquid wealth, I use the questions q113 (checking accounts, savings accounts, money market accounts, certificates of deposit, short-term treasury Bills, and cash), q120 (U.S. index funds), q121 (sector funds), q122 (other U.S. stock funds, such as growth, income or value funds), q125 (stock of company that currently employs you), q126 (stock of a company that formerly employs you), q128 (foreign stock) and q129 (company bonds).

For the years of 2009 and 2011, I also rely on observations from the on-going Health and Retirement Study Module Q (Income and Asset Section). In the ALP, this is survey

62. I am able to make up for some missing observations in year 2009 using this survey and I do so by summing up the following responses:

q317_amtstock (stocks total value), q331_amtbonds (bond asset total value), q344_amtchksave (Checking, savings and money market total value) and q357_amtcd (CDs, Government Savings Bonds and Treasury Bills)

If instead of answering the total value version of the question, the individuals give a range (e.g. q317_range), I take the median of the bracket and use this as the value for the question.

2010

Information on liquid is very sparse for the ALP in the year 2010. Only 345 individuals report any liquid wealth values in 2010 for the survey 62 (HRS Module Q Income and Assets Section). At the very beginning of 2011 (01/03-01/13), the "Effects of the Financial Crisis" added a section to their survey entitled "Assets." In order to match the other surveys, I sum up the answers to:

ST003 (worth of stock holdings), A008_amount (corporate, municipal, government or foreign bonds, or bond funds amount asset) , A009_amount (checking or savings accounts, or money market fund amount asset), and A010_amount (CDs, Government Savings Bonds, or Treasury Bills amount asset)

Finally, for any individuals in my sample that I still do not have observations for in 2010, I take the median value of their 2009 and 2011 liquid wealth values.

2011

For 2011, I again use the survey 62 for households that are interview during 2011.

I also rely on survey 189 - "Savings Behavior." In order to match the other surveys used in my dataset, I sum up the values for the following questions:

al6a1 + al6a2 (checking, savings and money market accounts value), al72a (stocks and mutual funds value), al8a (bonds value) and al9a (CDs, Government Savings Bonds, or U.S. Treasury Bills value)

Finally, I use survey 236 - "Effects of the Financial Crisis," for any remaining individuals in my sample whom I do not have observations of their assets for in 2011. This survey was fielded from January 1 to January 11 of 2012. Like survey 162, I sum up the answers to the following questions:

ST003 (worth of stock holdings), A008_amount (corporate, municipal, government or foreign bonds, or bond funds amount asset) , A009_amount (checking or savings accounts, or money market fund amount asset), and A010_amount (CDs, Government Savings Bonds, or Treasury Bills amount asset)

Once the data is gathered, I deflate the values (which are given in dollar terms) with a base year of 2009.

Income

Income is constructed from two demographic variables available in every American Life Panel survey. For example, given survey 50, the two variables "ms50_familyincome" and "ms_familyincome_part2." The question is

Which category represents the total combined income of all members of your family (living here) during the past 12 months? This includes money from jobs, net income from business, farm or rent, pensions, dividends, interest, social security payments and any other money income received by members of your family who are 15 years of age or older.

If the respondent answers "75,000 or more," then they asked a second question:

You told us that the total combined income of all members of your family (living here) during the preceding 12 months was more than $75,000. Thinking about the total combined income of your family from all sources, approximately how much did members of your family receive during the previous 12 months?

Respondents who select into this second question are then asked to then choose between four more brackets. I combine these two questions to form a 17-bracket scale of income. In order to construct a continuous variable, I take the median value for each income bracket except the highest bracket - "200,000 or more" - which I replace with the number 200,000.

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