ESSAYS ON CREDIT AND FINANCIAL LITERACY ACCUMULATION

by

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Abstract

This dissertation is comprised of two studies on financial literacy accumulation. Both chapters, to my knowledge, are the first time a moment-matching calibration procedure has been used to quantify the effects of financial literacy accumulation. In the first chapter, I examine how adverse borrowing conditions may influence financial literacy accumulation. To do so, I develop a life cycle model with financial literacy investment and borrowing rate uncertainty and calibrate it to the American Life Panel. When households expect borrowing rates to vary often, they invest in financial literacy to insure against borrowing rate variation. I evaluate the effect of two popular policies developed to ameliorate the effects of low financial literacy—an interest rate cap and a financial literacy subsidy. I find that an interest rate cap discourages financial literacy accumulation, while a subsidy of leads households to obtain a higher return by three basis points. In particular, the subsidy improves the welfare the most for low-income, highly leveraged households.

In the second chapter, I build and calibrate a quantitative model of financial literacy accumulation and analyze the effect of permanent income on financial literacy accumulation. I find that the shape of the age-earnings profile influences the rate at which financial literacy accumulates and declines over the life cycle. 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 but also 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.

Chapter 1

Credit Shocks and Financial Literacy Accumulation

1.1 Introduction

Policymakers have promoted financial literacy as a means to improve financial outcomes, but financial knowledge remains low worldwide. The 2014 S&P Global FinLit Survey found that only a third of adults could correctly answer 75% of the questions on a simple financial literacy test.[1] If those adults who scored low were to improve their financial literacy, they might see an increase in their net worth by as much as 80,000.[2] If financial literacy is valuable, what accounts for its low level?

A clue to understanding this low level is that financial literacy is partly a *choice*. If the cost of acquiring financial literacy is too high, an individual may choose not to acquire it. However, a change in circumstances may alter their appraisal. In particular, people who have experienced economic distress often find the benefits of financial literacy outweigh the costs: households in countries that have ex-

[1] The survey tested the respondent's knowledge of compound interest rates and risk diversification.

[2] See Alessie, Rooij, and Lusardi (2011).

perienced hyperinflation, score better on inflation-related literacy questions than the world average (Klapper, Lusardi, and Van Oudheusden 2015). Furthermore, households are more likely to retain financial education when they are bankrupt (Wiener et al. 2005).

I develop and calibrate a life cycle model with financial literacy investment and uncertainty about the rate of borrowing. Individuals do not know the interest rate that they will have to pay when their loan matures and this uncertainty induces people to invest in financial literacy in order to better deal with future borrowing costs. Young individuals are most affected by uncertainty because they have the greatest demand for credit and therefore, benefit the most from financial literacy accumulation. I show that policies that make borrowing cheaper, such as an interest rate cap, discourage financial literacy accumulation and may have unintended consequences.

I motivate my model by documenting several facts 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 construct a novel dataset. I identify individuals by Metropolitan Statistical Area (MSA) and merge the dataset with bank branch-level data using the Federal Deposit Insurance Corporation (FDIC).

I exploit the panel feature of the ALP to construct a time-varying measure of financial literacy, measured as the number of financial knowledge questions answered correctly by an individual in that year. This measure is constructed by combining surveys in the ALP that ask financial literacy questions in that year. As an exogenous measure of credit supply, I use the average loan-loss ratio for multi-state banks located in an individual's MSA. The loan-loss ratio is the ratio of loan-reserves-to-total-assets held in expectation of borrowers defaulting. When this ratio increases, banks decrease their supply of loanable funds and increase the

borrowing interest rate in that region.

I find that a percentage point increase in the loan-loss ratio is associated with a six-percent increase in financial literacy. I explore the heterogeneity of this financial literacy accumulation and find evidence that it is diminishing with age. This is consistent with a standard life cycle model's prediction that older individuals have accumulated savings to buffer against shocks and have a shorter-horizon over which to benefit from financial literacy.

Applying the results of the regression analysis, I develop a life cycle model with financial literacy investment and borrowing rate shocks. In my model, financial literacy is a stock that households can accumulate to raise their savings return. Households with low financial literacy save less and borrow more because their savings return is low, but when the cost of borrowing increases, they save more and invest in financial literacy. I calibrate the model to the ALP and show that it is able to replicate the life cycle profile of financial literacy. The model can also match age-cohort borrowing percentages in the Survey of Consumer Finance 2010.

In order to analyze the novel features of my model, I compare my baseline model to a series of counterfactual models lacking a targeted model feature. In the first counterfactual, individuals cannot borrow but they can invest in financial literacy. In this case, they save more and invest more in financial literacy as an alternative consumption smoothing tool. Individuals with low savings and/or financial literacy suffer the greatest welfare loss because they lose their preferred means of consumption smoothing.

In the second counterfactual, individuals can borrow but cannot invest in financial literacy. Compared to the baseline, individuals borrow more but arrive at retirement age with lower wealth. In this scenario, individuals with high savings suffer the greatest welfare loss because they lose the greatest return on their savings. The experiment demonstrates the changing relationship of borrowing and fi-

nancial literacy investment over the life cycle. Borrowing lets individuals consume more when they have low wealth whereas financial literacy raises their return on savings; but both can serve as tools for consumption smoothing. Individuals can borrow to invest in financial literacy but in doing so, they lower their willingness to borrow because they raise their return on savings and increase the opportunity cost of borrowing.

I perform a sensitivity analysis to examine the effect of borrowing rate uncertainty on financial literacy accumulation. When borrowing interest rates are persistent, borrowers stratify into two groups: those who expect low borrowing rates and are discouraged from acquiring financial literacy and those who acquire financial literacy because borrowing is costly. However, when borrowing rates are not persistent, households expect borrowing to be costlier (cheaper) next period if it is cheap (costlier) today. On average, financial literacy is greater than the persistent case because households acquire financial literacy to insure against borrowing rate variation. This exercise suggests that public policies may have additional effects on financial literacy acquisition by changing expectations about future borrowing conditions.

Finally, I perform a series of policy experiments. Financial literacy has been of recent concern for policy makers (Bernanke 2006) and several proposals have been made to ameliorate the effects of low financial literacy. I simulate two popular policies—a borrowing interest rate cap and a financial literacy subsidy—to test the effectiveness of each for improving household welfare.

I find that the interest rate cap does little to encourage financial literacy investment. Households borrow more when they are young but the gain from the lower borrowing rates is not funneled into greater savings or financial literacy investment. I augment the experiment by simulating a 10% rationing of credit supply and find that the welfare gain from the interest rate cap is wiped out. Notably,

households with low financial literacy suffer the most from the credit rationing because they lack a significant alternative means of consumption smoothing.

I find that a financial literacy subsidy is a better option. For a subsidy which covers 10% of the cost of a financial literacy investment, the average return on savings increases by 3 basis percentage points at retirement from the baseline case. On average, young individuals see a welfare gain of 0.03% but there is significant heterogeneity in welfare gains. Low-income and highly-leveraged individuals benefit the most from the subsidy. They increase their financial literacy by 1% and this leads to an increase in Compensating Equivalent Variation (CEV) by 0.2–0.25%.

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.

1.2 Related Literature

My work builds most immediately on that of Lusardi, Michaud and Mitchell (2017) and Jappelli and Padula (2013). These papers treat financial literacy accumulation as an investment that determines an individual's savings return.The main focus is on the relationship between wealth and financial literacy, a correlation commonly observed in empirical work (e.g. Bernheim and Garrett (2003)). Wealthier individuals acquire financial literacy not just because they have more resources to invest, but also because they face a greater interest forgone for not acquiring in financial literacy.

Jappelli and Padula (2013) build an intertemporal consumption model with financial literacy investment. In their model, financial literacy is paid for with re-

sources and this implies that agents will not acquire financial literacy if the return is too small. The authors test this hypothesis and find that countries with more generous social welfare programs have lower average financial literacy. This suggests that policies that reduce uncertainty about consumption may also reduce the incentive to invest in financial literacy. However, their model is limited in two important ways. First, agents do not have the possibility of borrowing in their model. Borrowing could encourage financial literacy investment by raising the resources that could be invested, but it also may discourage financial literacy investment because borrowing is an alternative form of insurance against negative income shocks. Second, this model is limited in explaining heterogeneity in household response because it is constructed as a deterministic, representative-agent model. However, the effect of more generous welfare programs may vary enormously depending on an individual's state. For example, wealthier individuals may be relatively indifferent to a consumption floor provided by a generous social welfare program.

The effect of heterogeneity is explored more by Lusardi, Michaud and Mitchell (2017). They construct a life cycle model of financial literacy investment with out-of-pocket costs, income shocks and mortality risk.[3] In particular, they find that 30–40% of retirement wealth variation is explained by endogenous financial literacy accumulation in their model. This suggests the significance of life experience in (dis)encouraging financial literacy accumulation and its related outcomes.

However, this model is still limited to explaining variation in financial literacy between individuals with high and low wealth; it cannot account for when individuals are net borrowers, which is common early in one's life. In order to help explain the observed differences in financial literacy for individuals with low savings, the model should be augmented with shocks that are significant for young

[3]Their model also includes a pension plan and a risky-asset choice.

cohorts, such as borrowing interest rate shocks. This is consistent with several meta-analyses of financial literacy that have found financial education to be most effective when offered at a "teachable moment" (Kaiser and Menkhoff 2017) or "just-in-time" (Fernandes, Lynch and Netemeyer 2014). Financially literate households do not necessarily borrow less but rather tend to be more prepared for credit problems. Gorbachev and Luengo-Prado (2019) find that financially literate individuals are more likely to hold significant levels of liquid savings, consistent with the view that they are holding savings for precautionary purposes. This is further supported by Lusardi and Tufano (2015), who find that individuals with high financial literacy report less difficulty handling their debt load.

My main contribution is to extend the financial literacy life cycle model to allow agents to borrow at rate that varies in a stochastic manner. Borrowing experiences early in life have a strong influence on financial literacy accumulation (Brown et al. 2019) and my model is able to capture the effect of early-life borrowing rate shocks. The effect of even small changes should not be understated. Financial literacy accumulation decisions early in life can have large lifetime effects as they compound over the life cycle.

1.3 Credit Cost and Financial Literacy Investment

I begin by documenting patterns of financial literacy change using the ALP. My interest is in testing how a change in the cost of credit may influence the change in financial literacy. I exploit two aspects of the ALP in order to control for unobserved factors that may influence financial literacy accumulation. First, I utilize a panel structure so that I can measure financial literacy changes during the sample-period and use a fixed-effect regression model to control for unobserved invariant characteristics.

Second, I am able to identify individuals by MSA in the ALP and I use this to exploit regional variation in credit cost. Financial literacy may be correlated with the borrowing rate at which an individuals draw a loan, so I construct a plausibly exogenous measure of credit availability to account for this problem. My measure of credit cost for an MSA will be the average loan-loss reserve ratio for banks with a branch in that region. The loan-loss reserve ratio is the amount of reserves set aside in expectation of defaulting loans, to the total amount of bank assets. A larger ratio indicates that a bank is limiting its supply of loanable funds.

1.3.1 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.[4] Each question is weighted equally.

The first three questions fall into the "basic" category. The first question tests individuals about their knowledge of compound interest rates. The second question tests an individual's ability to calculate the real interest rate given a rate of inflation and nominal interest rate. The third question tests a respondent's knowledge of risk diversification. These three questions are regularly adopted in financial literacy research and are commonly referred to as the "Big Three" (Hastings, Madrian and Skimmyhorn 2013).

The next two questions fall into what may be called economic concepts, because they are not reducible to numerical calculation but rather require knowledge of economic-specific concepts. One of the questions tests a respondent's knowledge of the "money illusion" and the other question test a respondent's knowledge of

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

the time value of money. Both of these questions were included in Lusardi and Mitchell (2009).

The next three questions are about stock market related knowledge. Several of these questions - such as those dealing with risk diversification and bond prices - are sometimes referred to as "sophisticated" financial literacy questions (Alessie, Lusardi and Van Rooij 2012). Researchers have been interested in what extent a lack of financial literacy might be a barrier to participation in the stock market, so these questions are included in the measure to capture this particular sphere of financial literacy.

Finally, three questions test a respondent's knowledge of retirement planning and taxation. These questions were included as part of the "Five Steps" financial education program (Heinberg et al. 2014). They cover topics such as knowledge of when IRA distributions are taxed (traditional versus Roth IRA) and when a household must make a minimum withdrawal (every year starting the year one turns 70.5). Retirement planning has seen many innovations in the past few decades but retirement financial literacy remains low (Lusardi and Mitchell 2007).

I perform a simple principal components analysis with the 12 questions and report the "Uniqueness" or 1-Communality of each question in table 1. Communality is the proportion of variance for each question that can be explained by the latent factor. No question has more than 30% of its variance explained by the predicted factor. Therefore, I do not reduce the questions down to a set of more basic factors.

To my knowledge, this is the first time a panel data set has been constructed with time-varying financial literacy index. This allows me to measure changes in financial literacy for an individual over time, as well as compare differences in financial literacy changes across age-cohorts.

1.3.2 Measure of Credit Cost

In order to proxy for local credit cost, I use the average annual loan-loss reserve ratio for an MSA j in year t. Loan loss reserves serve to smooth income for banks that may be negatively impacted by portfolio depreciation during economic downturns (Greenawalt and Sinkey 1988; Balla, Rose and Romero 2012). The loss provisioning directly affects the credit supply, because these assets are put into reserve instead of being lent out. Furthermore, loan loss provisioning has been found to be positively associated with tighter lending standards (Balasubramanyan, Zaman and Thomson 2017). As a robustness check, I report a regression of state mortgages rates on state averaged loan-loss ratios in Table 2 and find that a one-percentage point increase in the loan-loss ratio is positively associated with a 0.07–0.09 percentage point increase in mortgage rates.

It is possible that there are unobservable local conditions that simultaneously affect both banking conditions and financial literacy accumulation in a given MSA. For example, there may be a state policy that encourages a joint financial education initiative between local banks and schools. In order to account for this potential endogeneity regarding the decisions of banks and the local population, I use only multi-state banks for constructing the measure of local credit tightness. Angbazo (1997) finds that super-regional banks (large banks operating in more than one state) are much less sensitive to default risk than local banks.[5] Hence, a multi-state bank should make decisions that are plausibly exogenous to any specific local borrowing market's history and level of financial literacy. Similar to Cooper, Luengo-Prado and Olivei (2016), I weight the contribution of each bank in MSA-

[5] Angbazo (1997) measure of default risk is the proportion of non-performing loans on a bank's balance sheet. For super-regional banks, they find no evidence that this measure is associated with their net interest margin, a measure of the spread between the rate at which banks lend out and the rate they pay to depositors. However, they find that local banks increase their net interest margin in response to an increase in non−performing loans. While this measure is limited, it at least suggests that super-regional banks are less sensitive to any local increase in credit default risk.

level measure by their deposit-share in that market.

1.3.3 Relationship between Credit Shocks and Financial Literacy

In this section, I will detail the regression estimation method. The baseline regression model is:

$$\Delta FinancialLiteracy_{ijt} = \alpha_i + \beta_1 \Delta LoanReserve_{jt} + \gamma \Delta X_{ijt} + \delta_t + \Delta \varepsilon_{ijt} \quad , \qquad (1.1)$$

where the dependent variable is the change in financial literacy for individual i in MSA j from year t–1 to t. The main effect, $LoanReserve_{ijt}$, captures the influence of regional variation in credit tightness on the change in financial literacy. The first-differences regression model controls for the level of financial literacy in the initial year (2009) as well as invariant unobservable characteristics about individuals. In addition to this, the fixed effect α_i, controls for individual-differences in the slope of financial literacy change e.g. individuals may learn at increasing or decreasing rates. Year dummies (δ_t) are included to account for changes in conditions that affect all individuals. This includes not just aggregate economic conditions (such as the US inflation rate) but also practice effects or the potential gain from seeing the test questions again (Hausknecht et al. 2007). All learning requires some degree of memorization but if the change in financial literacy is only the result of retesting, then the inclusion of year dummies should render the main effect's coefficient statistically insignificant.

Table 3 reports the summary statistics for the variables of interest. Financial literacy is increasing on average during this period but the median change is zero. This suggests that only a portion of the general population was acquiring financial literacy and that there may be variation that explains this selective acquisition. Loan-loss reserve ratio is increasing because banks were provisioning reserves during this period of high borrowing risk.

Table 4 lists the correlation matrix for an extended set of variables. The loan-

loss reserve ratio (LRR) is positively correlated with financial literacy and income; the ratio is negatively associated with home ownership. This is consistent with the view that reserves are being provisioned by banks in response to either an increase in mortgage defaults or the expectation of future mortgage defaults. I find that financial literacy is strongly correlated with income and age, two common determinants of financial literacy.

Column 1 in table 5 reports the result from the basic regression. A percentage point change in $\Delta LoanReserve_{jt}$ is associated with a six-percent change in financial literacy change. This translates to about 0.3 of a standard deviation of financial literacy change. The result is statistically significant at the 5% significance level and suggests that credit tightening has an influence on financial literacy change.

Life Cycle Profile Figure 1.1 plots out the life cycle profile for the percentage of questions answered correctly by 5-year age-band.[6] Individuals accumulate financial literacy over their lifetime but the rate of accumulation decreases after age 50.[7]

If financial literacy is an investment, then the age at which it is acquired should affect the rate of accumulation: younger households have a longer period to benefit from the financial literacy. Furthermore, households may be affected by credit shocks differently over their life cycle. Older individuals have had time to accumulate savings and may able to smooth consumption by drawing on savings rather than borrow. This could also influence the decision to acquire financial literacy.

To estimate the life cycle effect, I augment regression equation 1.1 with a quadratic age term and several interactions.[8] The augmented regression becomes:

$$\Delta FinancialLiteracy_{ijt} = \alpha_i + \beta_1 \Delta LoanReserve_{jt} + \beta_2 \overline{Age^2}_{ijt} + \gamma \Delta X_{ijt} + \delta_t + \Delta\varepsilon_{ijt} \quad . \tag{1.2}$$

[6] I average over 5-year bands because the sample has uneven representation by age.

[7] The peak in figure 1.1 is later than in previous research (e.g. Agarwal et al. 2009) but my measure of financial includes additional questions that test retirement knowledge.

[8] Due to the year fixed-effect, the linear age term is not identifiable.

Column 2 in table 5 reports the result of the regression with the addition of a quadratic age term.[9] I find that the quadratic term, β_2, is negative and statistically significant. This suggests that individuals are decreasing their rate of financial literacy accumulation as they grow older. This result is consistent with a standard life cycle model, where older individuals face a shorter time-horizon to benefit from an investment. In columns 3 and 4, I interact $\Delta LoanReserve_{jt}$ with a linear and quadratic age-term. The coefficients on both terms are negative but statistically insignificant.

Financial Literacy and Assets In the preceding regression analysis, I found that changes in financial literacy are positively correlated with changes in loan-loss ratio. I interpret this as evidence of individuals acquiring financial literacy to better manage their resources when borrowing becomes more expensive. However, I do not observe the returns on savings. My strategy to identify the relationship between financial literacy and liquid wealth, is to partial out the effects of other determinants of liquid wealth and regress the residual on financial literacy. The variation of the residual that is explained by financial literacy should shed light on the relationship of financial literacy and liquid wealth. I first estimate the following regression:

$$Log(Liquid\_Wealth_{ijt}) = \alpha_i + X_{ijt}\gamma' + \delta_t + \varepsilon_{ijt} \quad , \tag{1.3}$$

where $Liquid\_Wealth_{ijt}$ is the sum of an individual's liquid wealth in MSA j in year t. I include individual fixed effects (α_i), year-fixed effects (δ_t) and a vector of controls, X_{ijt}. The vector of controls contains all of the control variables from the preceding regression plus a quadratic age term and the loan-loss reserve ratio in MSA j in year t.

I then regress the residuals from equation 2.8 on financial literacy. Table 6 re-

[9]The quadratic term is constructed by first squaring the linear term and then demeaning the squared term. See McIntosh and Schlenker (2006).

ports the results of the regression. I find that Financial Literacy ($FinLit_{ijt}$) is positively associated with the residual from the regression in equation 2.8 at the 5% level of significance. The R^2 is 0.0502 in the baseline regression, suggesting that about 5% of the residual variation can be explained by financial literacy. In the next two columns, I break down the regression into two subsamples (old and young) and find a similar estimate.

To summarize, I first found that financial literacy change is associated with a plausibly exogenous measure of change in credit tightness. Therefore, my model of financial literacy investment will have an exogenous shock to the borrowing interest rate in order to capture this relationship. Second, I found evidence that individuals acquire financial literacy at a diminishing rate over their lifetimes. My model will be a life cycle model to capture the effect of a diminishing time horizon on financial literacy investment. Last, I found that liquid wealth and financial literacy were correlated, after controlling for other determinants of liquid wealth. This suggests that financial literacy has an effect on the accumulation of liquid wealth and I will model this by letting the financial literacy investment determine the return on savings. The value of having these features in a calibrated model is that it will allow me to give a quantitative assessment of the welfare effects of different scenarios of borrowing and borrowing-related policies.

In the next section, I will develop a model of financial literacy investment under borrowing rate uncertainty. My model draws from Jappelli and Padula (2013) and Lusardi, Michaud and Mitchell (2017). The stochastic borrowing interest rate is most closely related to Ludvigson (1999) and Fulford (2015). Their models have a stochastic credit constraint, but I model a stochastic borrowing rate in my context in order to better link the model to the motivating regression.

1.4 A Model of Financial Literacy Accumulation and Credit Shocks

1.4.1 Household Problem

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

$$\max_{\{c_t\}_{t=1}^{J}} E_0 \left[\sum_{t=1}^{J} \beta^{t-1} \frac{c_t^{1-\gamma}}{1-\gamma} \right]. \tag{1.4}$$

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:

$$y_t = w \cdot e_t \cdot exp(\eta_t), \tag{1.5}$$

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

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:

$$r(\Phi_t)^s = A\Phi_t^\alpha + r_{base}. \tag{1.6}$$

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 relation-

ship between financial literacy and savings assets.[10]

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_{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 Carpena et al. (2011) and Fort, Manaresi, and Trucchi (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 (**29**), so they likely face a diminishing marginal benefit to an additional unit of financial literacy.[11]

Following Jappelli and Padula (2013), I allow individuals to accumulate and de-accumulate financial literacy.[12] 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

[10] See Lusardi and Mitchell (2007), Lusardi and Tufano (2009), Jappelli and Padula (2013), Anderson, Baker, and Robinson (2015), Lusardi, Michaud and Mitchell (2017), and Boisclair, Lusardi, and Michaud (2017)

[11] 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.

[12] 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.

understood as cognitive decline and sd 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:

$$\Phi_{t+1} = (1-\delta)\Phi_t + \ell_{t+1}\,. \tag{1.7}$$

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

$$\ell_{t+1} \geq 0\ . \tag{1.8}$$

1.4.2 Borrowing Decision

Agents can borrow and face a time-varying borrowing interest rate, $r_{b,t+1}$. The natural borrowing constraint is:

$$s_{t+1} \ \geq \ \sum_{k=t+1}^{J} \frac{-y_{min}}{(1+r_b^{max})^k} = \overline{b_{t+1}}\,, \tag{1.9}$$

where y_{min} is the minimum income possible and $r_{b,t+1}^{max}$ is the maximum interest rate possible. Agents will never choose to borrow up to the bound $\overline{b_{t+1}}$, because that would give them a positive probability of consuming zero next period.[13]

The time-varying borrowing interest rate, $r^b(\iota_t)$, follows an log-normal process AR(1):

$$\iota_t = \rho_r \iota_{t-1} + \nu_t\ , \tag{1.10}$$

where $r^b(\iota_t) = exp(\iota_t)$, ρ_r is the persistence parameter of the interest rate shock and ν_{t+1} is the innovation. When agents borrow, they do not know the exact rate they will pay next period but they do know the current period's repayment rate and the distribution of the shock process; they form expectations based on this knowledge.

Note that agents can borrow to finance their financial literacy. Previous models

[13] If agents borrow up to the bound, they will have no savings and may draw the lowest income shock next period. As a result, their entire income would be used in paying off the principal and interest on the loan. Without loss of generality, I will continue developing the model with the bound $\overline{b_{t+1}}$ in order to allow for tractable analysis of the mechanisms of the model.

of financial literacy have lacked this feature but borrowing experience, especially for young adults, has been found to be associated with future financial literacy (Brown, Cookson, and Heimer 2019).

1.4.3 Asset Path

An individual's wealth is dependent upon their income, their asset position, their financial literacy and their borrowing interest rate. Let X_t denote wealth in period t such that:

$$X_t = y_t + (1 + r(\Phi_t))s_t \mathbb{1}\{s_t \geq 0\} + (1 + r^b(\iota_t)s_t \mathbb{1}\{s_t < 0\}\,. \tag{1.11}$$

An agent's borrowing, consumption and financial literacy decisions are conditioned by the current period's state. Financial literacy investment and borrowing serve as two different avenues for consumption smoothing.

On the one hand, an agent can invest in financial literacy through borrowing and raise their return on savings. In this case, financial literacy will be positively correlated with borrowing. Brown, Cookson and Heimer (2019) find that individuals who had access to borrowing in their youth had higher levels of financial literacy than individuals who had grown up without such access.

On the other hand, as the return on savings is increasing through financial literacy investment, the opportunity cost to borrowing is also increasing. Agents will have a lower willingness to borrow and this may help explain why individuals with low financial literacy tend to borrow at higher rates (Lusardi and Scheresberg 2013).[14]

Given an agent's wealth, X_t, the savings asset in period t+1 is determined by the consumption and financial literacy choices in the current period and can be

[14]Furthermore, financially literate individuals tend to have higher retirement wealth (Lusardi and Mitchell 2007), liquid assets and lower debt (Gorbachev and Luengo-Prado 2019).

written as:

$$s_{t+1} = X_t - c_t - p\ell_{t+1}\,. \tag{1.12}$$

1.4.4 Consumer Problem

Combining the savings path (1.12), the financial literacy path (2.7), the income process (2.5) and the credit interest rate process (1.10), I define the state space in period t as $\Omega = \{s_t, \Phi_t, y_t, r_{bt}\}$. In every period, individuals have a stock of savings (s_t), financial literacy (Φ_t), income (y_t) and a realized borrowing interest rate ($r^b(\iota_t)$.

Using a CRRA utility function, I write the value function in period t as the following:

$$V_t(s_t, \Phi_t, y_t, r^b(\iota_t) = \max_{\ell_{t+1}, c_t, s_{t+1}} \frac{c_t^{1-\gamma}}{1-\gamma} + E_t[\beta V_{t+1}(s_{t+1}, \Phi_{t+1}, y_{t+1}, r^b(\iota_{t+1})|y_t, r^b(\iota_t]$$

s.t

$$s_{t+1} = (1 + r(\Phi_t)^s)s_t\mathbb{1}\{s_t \geq 0\} + (1 + r^b(\iota_t)s_t\mathbb{1}\{s_t < 0\} + y_t - c_t - p\ell_{t+1} \tag{1.13}$$

$$\ell_{t+1} \geq 0 \tag{1.14}$$

Each period, individuals make a savings choice, a financial literacy choice and a consumption choice. The reason the savings choice is made separately is because the decision to borrow leads to a different interest rate structure next period than if an individual saves. In either case, an individual can change their consumption level or financial literacy stock in either case.

1.5 Quantitative Analysis

1.5.1 Calibration

The initial level of financial literacy endowment and savings 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 initial distribution, I use the empirical joint distribution of financial literacy, income and liquid net-worth from my sample for individuals ages 30–40.

For the discount factor, I follow Lusardi, Mitchell and Michaud (2017) and choose a value of 0.96. For risk aversion, I set the risk aversion, γ, to 3, following the estimates done by Hubbard, Skinner, and Zeldes (1995).

The age-earnings profile, e_t, is constructed from the sample's age-cohort income means. The AR(1) parameters for the borrowing interest rate and income processes are calibrated so that the mean-to-standard deviation ratio of the stationary distribution of the AR(1) process matches mean-to-standard deviation ratio of the income and borrowing rate data. Following Lusardi, Michaud and Mitchell (2017), I set the cost of financial literacy, p, to 0.06 in order to approximate financial literacy cost to $ 500 dollars a year.[15]

I calibrate the three remaining parameters$-$ the elasticity of financial literacy investment α, the productivity of financial literacy stock A and the depreciation rate $\delta-$by matching financial literacy changes across age-cohorts in the American Life Panel for the years 2009 to 2011. The identification of these parameters follows from the relationship of borrowing and financial literacy over the life cycle. Early in life, the financial literacy stock and savings assets tend to be low. The marginal return to financial literacy investment will be at its highest over the life cycle and this is determined by the parameter α. Individuals are willing to borrow to invest if the marginal return is sufficiently high given their expectations about future borrowing conditions and their expectations about their future income. As individuals accumulate savings assets and financial literacy, their willingness to borrow will fall. Mid-life financial literacy levels and borrowing levels will help identify the productivity parameter A. Finally, individuals stop accumulating financial literacy at the end of their life. The rate of depreciation, δ, will be identified

[15]My model is normalized to $83020.83, implying that 0.06 of $83000 is about $4981 every 10-years or about 500 dollars per year.

by late-life declines in financial literacy.

The model is solved using a grid search method with 160 asset grid points, where 80 of the grid points are negative, and the rest are non-negative. For financial literacy, I use 17 literacy grid points. For the shocks, I use 5 income shock grid points and 4 interest rate shock grid points.

Table 7: Parameter Calibration - Chapter 1

Parameter	Value	Source/Function
β	0.960	Lusardi, Michaud and Mitchell (2017)
γ	3.000	Hubbard, Skinner and Zeldes (1995)
p	0.060	Lusardi, Michaud and Mitchell (2017)
ρ_y	0.911	Income Persistence
σ_ε^2	0.225	Income Shock Std.
ρ_r	0.704	Borrow Rate Persistence
σ_ν^2	0.136	Borrow Rate Std.
α	0.550	Investment Elasticity
δ	0.060	Depreciation Rate
A	0.021	Savings Productivity

Calibrated Parameters The parameter values are tabulated in table 7. The initial distribution's normalized average financial literacy is 0.7 and this implies that the average person receives a gross return (financial literacy + base rate) of about 1.038 over 10-years. The calibrated rate of depreciation, δ, is 0.06 or about 0.6% per year. The calibrated elasticity of investment, α implies that a 10% increase in financial

literacy leads to about a five-percent increase in return on savings.

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 with an absolute error of 0.13. 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 fits the borrowing proportions well for younger cohorts and wealth-to-income ratios for mid-life individuals. The divergence between model and data likely reflects missing features of the model. For example, my model does not have out-of-pocket healthcare costs, which could raise the demand for borrowing later in life as older individuals are hit with health shocks.[16] Furthermore, my model doesn't have a retirement plan or mortality risk, both of which could have an influence on borrowing and financial literacy investment latter in life.

Nonetheless, the addition of these absent model features would likely not greatly affect the outcomes in the early life cycle because those missing features are mainly related to latter life choices.

[16]See Kim et al. (2012) and Babiarz et al. (2013).

Table 8: Targeted: Financial Literacy Mean Change

Age	41–51	52–62	63–73	74–84
Δ FinLit^{Data} (%)	3.7	6.3	4.9	-3.2
Δ FinLit^{Model} (%)	4.7	1.7	-1.0	-1.2
Untargeted				
Negative Networth^{Data} (%)	18.4	15	10.7	7.2
Negative Networth^{Model} (%)	16.5	13	1.0	0.0
Untargeted				
Wealth-to-Income^{Data}	0.53	1.47	2.93	3.11
Wealth-to-Income^{Model}	1.17	1.54	2.04	2.13

$\Delta FinLit$ is the percentage change in the cohort's average financial literacy from previous cohort mean. Liquid Networth is the liquid wealth minus credit card debt and taken from the Survey of Consumer Finance 2010. Negative Networth (%) is the percentage of the age-cohort that has negative networth. Wealth-to-Income is the average ratio of liquid wealth to income for individuals in each cohort.

1.6 Counterfactual Experiments

1.6.1 The Importance of Financial Literacy for Consumption Smoothing

In this section, I analyze the relative contribution of different features in my model. I do this by comparing the baseline model to a series of counterfactual models with a targeted feature absent.

The first distinction of my model from previous work on financial literacy is the inclusion of borrowing. In column 2 of Table 9.A, I report several outcomes of my model when households cannot borrow. The return on savings does not change significantly, although households who cannot borrow save about $2000 more and are more financially literate at age 41 than the baseline. Table 9.B shows the breakdown of the counterfactual for two age-cohorts and two income groups. Young individuals suffer the most when individuals cannot borrow. In particular, low-income, young individuals do not wish to save more and simply consume all the resources they have on hand. Their welfare loss is much greater than that of the average young individual (–0.4% vs. –0.13%), who at least can draw on their savings. In contrast, older and wealthier individuals are relatively unaffected when borrowing is not available.

In the next column, I allow for borrowing but do not allow financial literacy investment. The distribution of welfare losses is now the reverse: households with large, accumulated savings suffer the greatest welfare loss because they lose their interest return. Column three of Table 9.A reports several outcomes for this case. The return on savings falls to the base rate of 2.0% and individuals have about $100–200 less in savings over their life cycle. Table 9.C breaks down the counterfactual by group and compared to the first scenario, it is now older and wealthier

individuals who have the greatest welfare loss. The first column of Table 9.C reports the loss in financial literacy investment—the amount the households would have done if they could invest—and the groups that suffer the greatest welfare loss are those groups that would have increased their initial financial literacy by about 1-5% more at each age.

Table 9.A: Shut Down Model Features

	Baseline	No Borrow	No Invest
Avg. Return (%) - Age 41–51	3.66	3.66	2.0
Avg. Return (%) - Age 63–73	3.67	3.67	2.0
Savings ($) - Age 41–51	67371	69263	67241
Savings ($) - Age 63–73	90166	90182	90000
Financial Literacy - Age 41–51	8.82	8.86	8.34
Financial Literacy - Age 63–73	9.05	9.07	8.34
Δ Welfare From Baseline (%)	0.00	–0.13	–0.90

Avg. Return is the total the total return on savings over the the total savings for individuals at the reported age. Financial Literacy is the average score out of 12. Welfare is calculated as the Compensating Equivalent Variation (CEV) for the initial age and weighted by the joint empirical distribution.

This experiment demonstrates that both financial literacy and borrowing have complementary effects on life cycle outcomes. When individuals are young, they borrow to both finance consumption and financial literacy. As an individual's stock of financial literacy grows, the opportunity cost of borrowing increases because financial literacy raises their return on savings. Households begin to transition from being net borrowers to net savers. In the next exercise, I will evaluate how borrowing uncertainty influences the transition from net borrower to net saver.

Table 9.B: Percent change in decisions by Group - No Borrowing

State	Δ FinLit Invest (%)	Δ Savings (%)	Δ Welfare (%)
Young (Age 30)	0.535	1.758	–0.130
Low-Income, Young	1.897	0.000	–0.400
Retirement	0.233	0.004	–0.001
Low-Income, Retirement	0.347	0.026	–0.003

Low-Income group reports individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

Table 9.C: Percent change in decisions by Group - No FinLit Investment

State	Δ FinLit Invest (%)	Δ Savings (%)	Δ Welfare (%)
Young (Age 30)	–5.241	–0.211	–0.898
Low-Income, Young	–3.408	0.000	–0.115
Retirement	–4.742	–0.122	–0.914
Low-Income, Retirement	–5.431	–0.012	–1.084

Low-Income group reports individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

6.2 The Importance of Borrowing Rate Uncertainty

In this section, I explore a series of counterfactuals that evaluate the effect of a change in the persistence and variance of the borrowing interest rate shock on individuals decisions. When individuals borrow, they do not know the value that they will have to pay back in the next period. However, individuals do know the borrowing rate process and form expectations based on this process that will influence their financial literacy investment decision.

The motivation behind this exercise is to evaluate how individuals may react in different kinds of credit markets. If interest rates are very persistent, such as in the credit card market (Ausubel (1991)), then individuals may be more discouraged from insuring against borrowing rate variation than they would be in the adjustable-rate mortgage market.

Table 10.A reports the results of the exercise, where the baseline model is reported on the top row for comparison purposes. The second row reports the outcomes for a counterfactual model where the shock persistence ρ_r is low, at 0.2. On average, individuals have about 3–4% more financial literacy at every age and see an increase in the average return of about 3–5 basis points. Table 10.B reports that every group increases their financial literacy and savings compared to the baseline, especially low-income, young individuals. This group is particularly cash-constrained and they increase their savings by about 75% from the baseline; this large magnitude reflects the very low level of savings they have in the baseline case. Based on my model's calibration, the increase in financial literacy for young, low-income individuals raises their return on savings by 15 basis points (0.15 percentage points) and because this will compound over their lifetimes, this has significant effects on savings.

What explains this change in financial literacy investment? When the borrow-

$$r_{bt} = \rho_r r_{bt-1} + \nu_t$$

Table 10.A: Interest Rate - Persistence

	Avg. Return		Debt-to-Income (%)		Financial Literacy (out of 12)		Δ Welfare from Base %
Age	41–51	63–73	41–51	63–73	41–51	63–73	
$\rho_r = 0.704$.	3.66	3.67	6.52	2.64	8.82	9.05	0
Low Persistence							
$\rho_r = 0.200$	3.68	3.72	6.47	5.30	9.50	9.71	-2.61
Double Variance							
$\sigma_\nu^2 = 0.272$	3.66	3.67	5.10	6.40	8.82	9.05	-0.03

Notes: Baseline $\rho = 0.704$ and $\sigma_\nu^2 = 0.136$. Avg. Return is defined as the total return on savings divided by the total savings for individuals at that reported age. Wealth-to-Income is the average wealth to income at reported age, where wealth is defined as (1+r(Φ_t))s_t and income is y_t. Financial Literacy is the average score out of 12 for individuals at the reported age. Welfare is calculated as the Compensating Equivalent Variation (CEV) from the initial age and weighted by the empirical joint distribution.

ing interest rate is low and rate persistence is low, households expect borrowing to become more costly next period. Instead of borrowing, they save and/or invest more in financial literacy as an alternative means of consumption smoothing. When they are in a high borrowing interest rate state, they expect rates to fall next period but this may still be a reason to invest in financial literacy; the repayment will be cheaper and the borrowing rate is likely to rise again.

In the final row, I run a counterfactual where the variance of the interest rate shock is doubled. The breakdown of the counterfactual in Table 10.C shows that the major change is that young individuals increase their savings by about 0.4 percentage points. The reason why the variance does not have as strong of an effect as the persistence is because while it changes the spread of borrowing interest rates, the decision to borrow is still primarily an early-life decision; the persistence affects time-horizon over which one chooses to borrow. Hence, the welfare loss for individuals at retirement is almost exactly zero. Furthermore, individuals who already felt constrained from high borrowing interest rates, will be relatively unaffected by a greater spread in the dispersion of borrowing rates.

Table 10.B: Percent change in decisions by Group - Low Persistence

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	7.80	22.25	-2.61
Low-Income, Young	11.56	75.40	17.74
Retirement	5.64	22.01	-1.36
Low-Income, Retirement	8.41	44.86	1.66

Low-Income group reports individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

Table 10.C: Percent change in decisions by Group - Doubled Variance ($\sigma_\nu^2 = 0.272$)

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	0.004	0.396	–0.030
Low-Income, Young	0.000	0.004	–0.135
Retirement	0.000	0.000	0.000
Low-Income, Retirement	0.000	0.000	–0.001

Low-Income group represents individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

This exercise shows that financial literacy is acquired when individuals expect

borrowing to become more costly on average. From a practical standpoint, policymakers concerned with raising the financial literacy of their country are likely more interested in policies that can be concretely implemented and are welfare improving. The next section will test two policies aimed at either improving financial literacy or mitigating the effects of low financial literacy.

6.3 Effect of An Interest Rate Cap

For my first policy experiment, I evaluate the effect of an interest rate cap. In May 2019, legislation was proposed in congress to cap credit card interest rates at a 15 % interest rate.[17] The common justification for this policy is that regulation is needed to protect households that cognitive biases and/or financial ignorance from strategic pricing on the part of credit lenders (Campbell 2016). Empirical research has found that individuals with low financial literacy tend to borrow at higher interest rates (Lusardi and Bassa Scheresberg 2013), suggesting that an interest rate cap should be especially welfare-improving for this group.

The interest rate cap may encourage or may discourage financial literacy accumulation. On the one hand, individuals will face lower borrowing costs and can borrow more to invest in financial literacy. The gain in savings from the reduction of interest rates above the gap may also encourage greater financial literacy investment later in life. On the other hand, because the cap reduces the mean and variance of borrowing interest rate process, individuals will have less incentive to save and/or invest in financial literacy. This is why a calibrated model is useful to judge the likely outcome of this policy's implementation.

The regulation will likely lead to rationing on the part of lenders because they will be unable to charge higher interest rates to cover the cost of credit risk. There-

[17] Litvan, Laura. "Sanders, Ocasio-Cortez Propose 15% Cap on Credit Card Interest." Bloomberg, May 9, 2019.

$$r_{bt} = \Psi r_{bt-1} + \nu_t$$

Table 11.A: Interest Rate Cap

	Avg. Return (%)		Savings ($)		Debt-to-Income (%)		Δ Welfare from Base %
	41–51	63–73	41–51	63–73	41–51	63–73	
No Cap	3.65	3.67	67371	90166	6.52	2.64	0.00
Interest Cap = $r_{bt}^{max} = 15\%$							
Int. Cap	3.65	3.67	67238	90166	7.18	3.47	0.04
10% Ration	3.65	3.67	68707	90174	5.04	8.42	–0.05

Notes: Baseline $r_{bt}^{max} = 22\%$. Avg. Return is defined as the total return on savings divided by the total savings for individuals at that reported age. Savings is dollar value of savings at reported age. Debt-to-Income is the ratio of average debt to income at reported age, where income is y_t. Welfare is calculated as the Compensating Equivalent Variation (CEV) from the initial age and weighted by the empirical joint distribution.

fore, I will consider two scenarios: one with credit rationing and one without rationing. I report the results of a scenario with no rationing in order to give an upper bound of the expected benefits of the interest rate cap. To model this, I also run the interest-rate cap but reduce the credit limits by 10% for individuals paying the highest interest rate. The intuition behind this is that lenders would like to charge this group higher interest rates but are prohibited due to the regulation; they instead reduce the credit allowed for this group.

Table 11.A reports the results of the interest rate cap, both with and without rationing.[18] The effect of the interest rate cap on financial literacy, for both rationing and non-rationing cases, is negligible. In the previous exercise, I found that doubling the variance of the borrowing interest rate had a small effect on financial literacy accumulation. In this exercise, the interest rate cap operates in the opposite direction, acting like an implicit variance *reduction*, and therefore, the absence of an effect is consistent with the previous exercise. While an increase in variance may discourage borrowing, individuals may save instead of invest in financial literacy, especially if their next best choice was to borrow to finance financial literacy.

Thus, I find that while individuals save slightly less with the interest rate subsidy (no rationing), they save about 2% more when they are young if lenders ration credit. Tables 11.B and 11.C report the breakdown of the results by several cohorts. Young individuals, especially if they are low-income young individuals, benefit the most from the interest rate cap. They have the greatest demand for borrowing because they have low savings and expect their income to rise over their lifetime. This is why when borrowers ration credit, the same group suffers the greatest welfare loss (Table 11.C). Older individuals are almost completely indifferent to the policy because on average, they have accumulated enough savings to draw on.

[18] "No Cap" is the baseline model and included for comparison purposes.

Table 11.B: Percent change in decisions by Group - Int. Cap (No Ration)

State	Δ FinLit Invest (%)	Δ Savings (%)	Δ Welfare (%)
Young (Age 30)	0.000	–0.036	0.038
Low-Income, Young	0.000	–0.001	0.135
Retirement	0.000	0.000	0.000
Low-Income, Retirement	0.000	–0.01	0.002

Low-Income group reports individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

Table 11.C: Percent change in decisions by Group - Int Cap (10% Rationing)

State	Δ FinLit Invest (%)	Δ Savings (%)	Δ Welfare (%)
Young (Age 30)	–0.024	1.847	–0.050
Low-Income, Young	0.000	0.037	–0.070
Retirement	0.000	0.000	-0.001
Low-Income, Retirement	0.010	0.004	0

Low-Income group reports individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

In the last two rows of table 11.A, I repeat the experiment but without financial

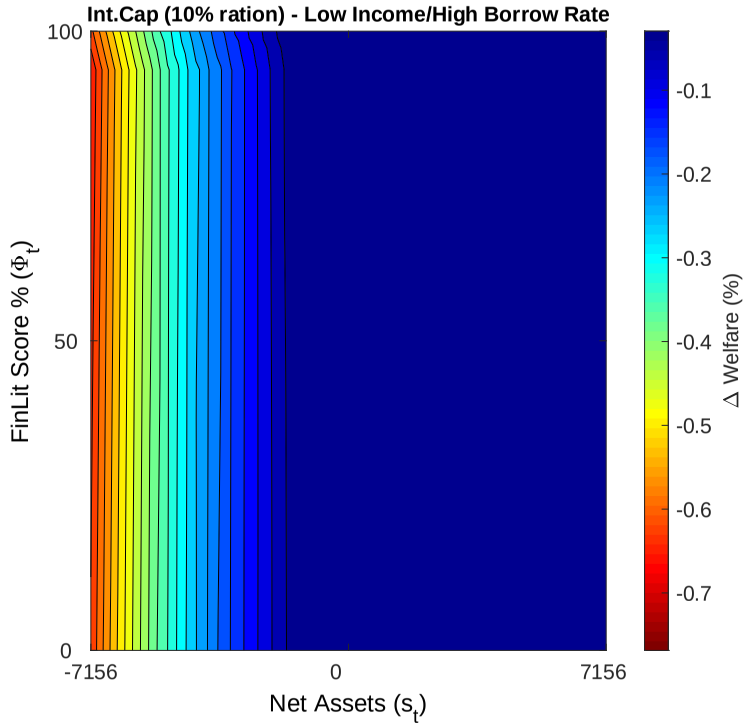
literacy investment. In this scenario, individuals have less savings at each reported age because they do not have the opportunity to increase their return on savings. This is particularly important for the rationing case, where individuals have about $200-300 less than they would if they could invest in financial literacy.

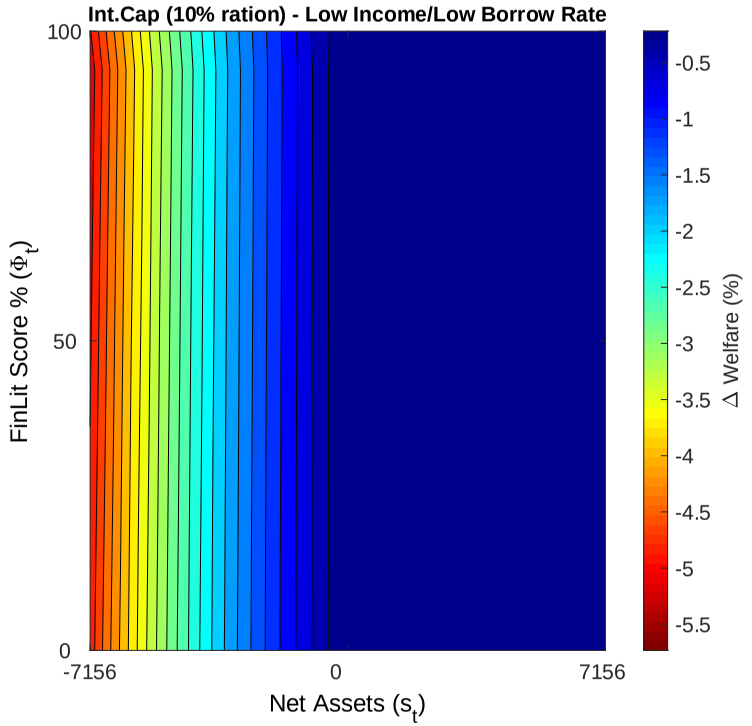
Figure 11.D plots the distribution of welfare losses for four groups in a set of contour plots. The age-group shown is 30–40 year-olds (initial age). The x-axis represents the savings state and the y-axis is the financial literacy stock. The only group that is indifferent to the policy is the high-income, high-borrowing rate group, because they are primarily net savers (bottom left). For members of the high-income, low-borrowing rate group (bottom-right panel), financially literacy allows them to partially insure against the possibility of future credit constraints. Individuals with financial literacy over 75% financial literacy see an attenuation of welfare loss by about 0.02%.

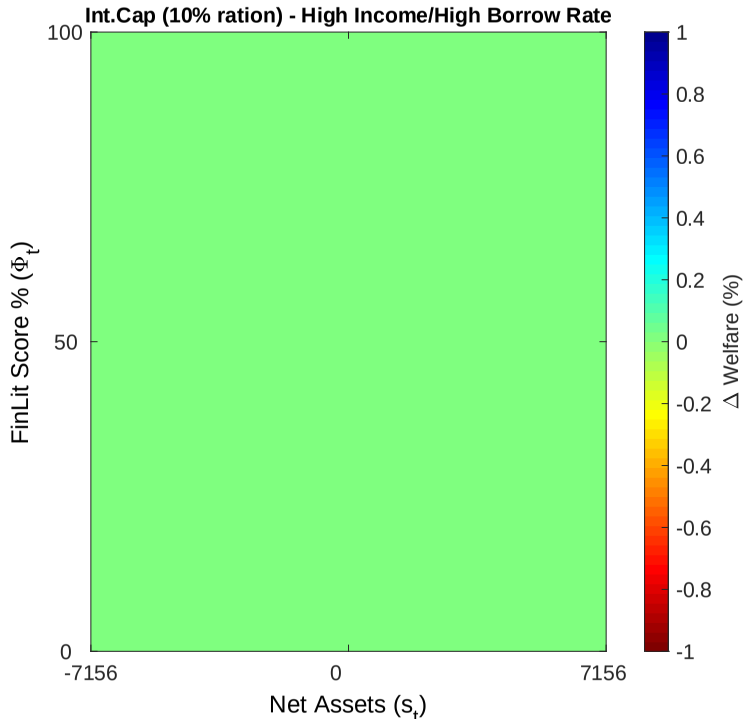
On the contrary, for the low-income groups, welfare slightly decreases as their stock of financial literacy is increasing. For this group, the wealth effect is dominant and the more financially literate individuals would like to borrow against future wealth, but face credit constraints.

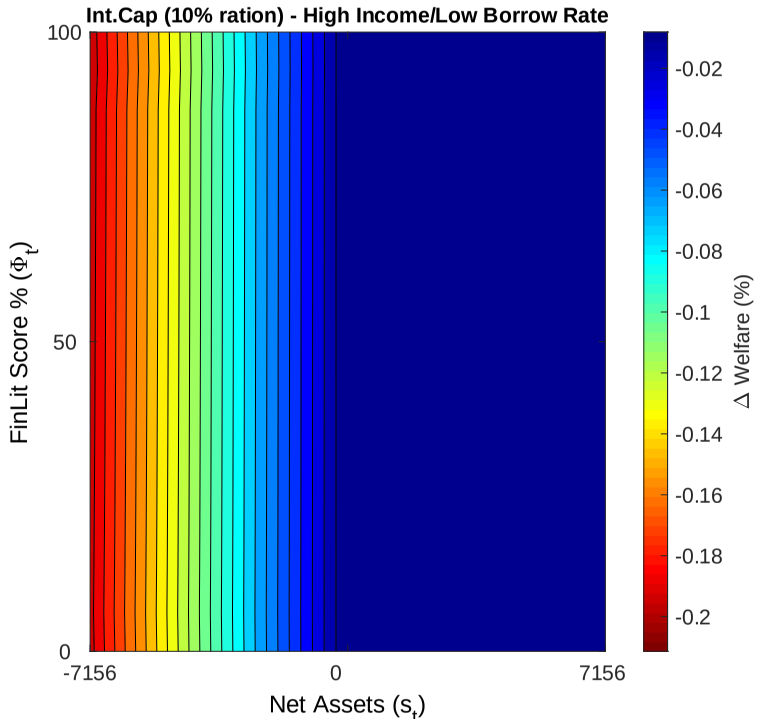
The effect of the interest rate cap is ambiguous. Individuals with low financial literacy and low-income would benefit from lower borrowing prices but credit rationing would harm them the most. A potentially better policy would be to improve their financial literacy and encourage them to shift towards becoming net savers.

Table 11.D: Interest Rate Cap with 10% Rationing









6.4 A Financial Literacy Subsidy

A recent survey found that at least 76% of young adults believe that their high school should have offered a financial education course.[19] It is not clear that simply providing financial education is always effective. For example, financial education tends be less effective for low-income cohorts (Kaiser and Menkhoff 2017). This is consistent with the view that individuals may choose to be financially ignorant. Instead, financial education tends to be most effective when it is immediately relevant to an individual's financial situation (Fernandes, Lynch and Netemeyer 2014).[20] Because individuals in low-income cohorts are more likely to be in a distressing financial situation, this counter-point would suggest that they will be more receptive to the financial literacy subsidy. For this policy experiment, I simulate two amounts of financial literacy investment subsidy (10% and 30%).

The first subsidy, which covers 10% of the cost, leads to a 0.06% increase in welfare from the baseline. Individuals on average receive nearly 0.03 percentage points higher return on savings with 10% subsidy and increase their financial literacy by about 2%. Increasing the subsidy to cover 30% of the cost of financial literacy increases the return on savings by nearly 0.05-0.06 percentage points and increases their welfare gain over the 10% subsidy six-fold.

What is the benefit of financial literacy, given that average savings is relatively constant? A higher return allows agents to more efficiently smooth consumption; they can reach their target wealth but give up less in the present. Table 12.B shows that the welfare gain is greatest for all low-income cohorts. For these cohorts, the marginal utility of consumption is high and they do not have a large enough income to encourage saving.

[19] See Stolba, Stefan. "Survey: Generation Z Keen on Learning About Personal Finance and Credit." *Experian*. September 6, 2019.

[20] For example, individuals who are presently in bankruptcy are more likely retain information regarding bankruptcy

$$X_t - s_{t+1} - p(1-\tau) \cdot \ell_{t+1}$$

Table 12.A: Subsidy Program

	Avg. Return (%)		Savings ($)		Financial Literacy (Out of 12)		Δ Welfare from Baseline %
Age	41–51	63–73	41–51	63–73	41–51	63–73	
No Subsidy	3.65	3.67	67371	90166	8.88	9.05	0.00
Full Population							
τ= .1	3.68	3.69	67376	90232	9.05	9.24	0.06
$\tau = .3$	3.73	3.74	67374	90241	9.36	9.72	0.19
Youth Subsidized Only							
τ= .1	3.70	3.69	67378	90233	9.12	9.24	0.02
$\tau = .3$	3.75	3.72	67307	90232	9.72	9.48	0.06

Avg. Return is defined as the total return on savings divided by the total savings for individuals at that reported age. Savings is the average savings for individuals in age-cohort. Financial Literacy is the average score out of 12 for individuals at the reported age. Welfare is calculated as the CEV from the initial age and weighted by the empirical joint distribution.

Table 12.B: Percent change in decisions by Group - Financial Subsidy

State	Δ FinLit Invest (%)	Δ Savings (%)	Δ Welfare (%)
Young (Age 30)	2.238	0.008	0.060
Low-Income, Young	1.926	0.080	0.121
Retirement	2.130	0.031	0.037
Low-Income, Retirement	2.107	0.148	0.069

Low-Income group reports individuals making under $40,000 a year. Retirement group means the decisions made in the t-1 period going into retirement (Age 63).

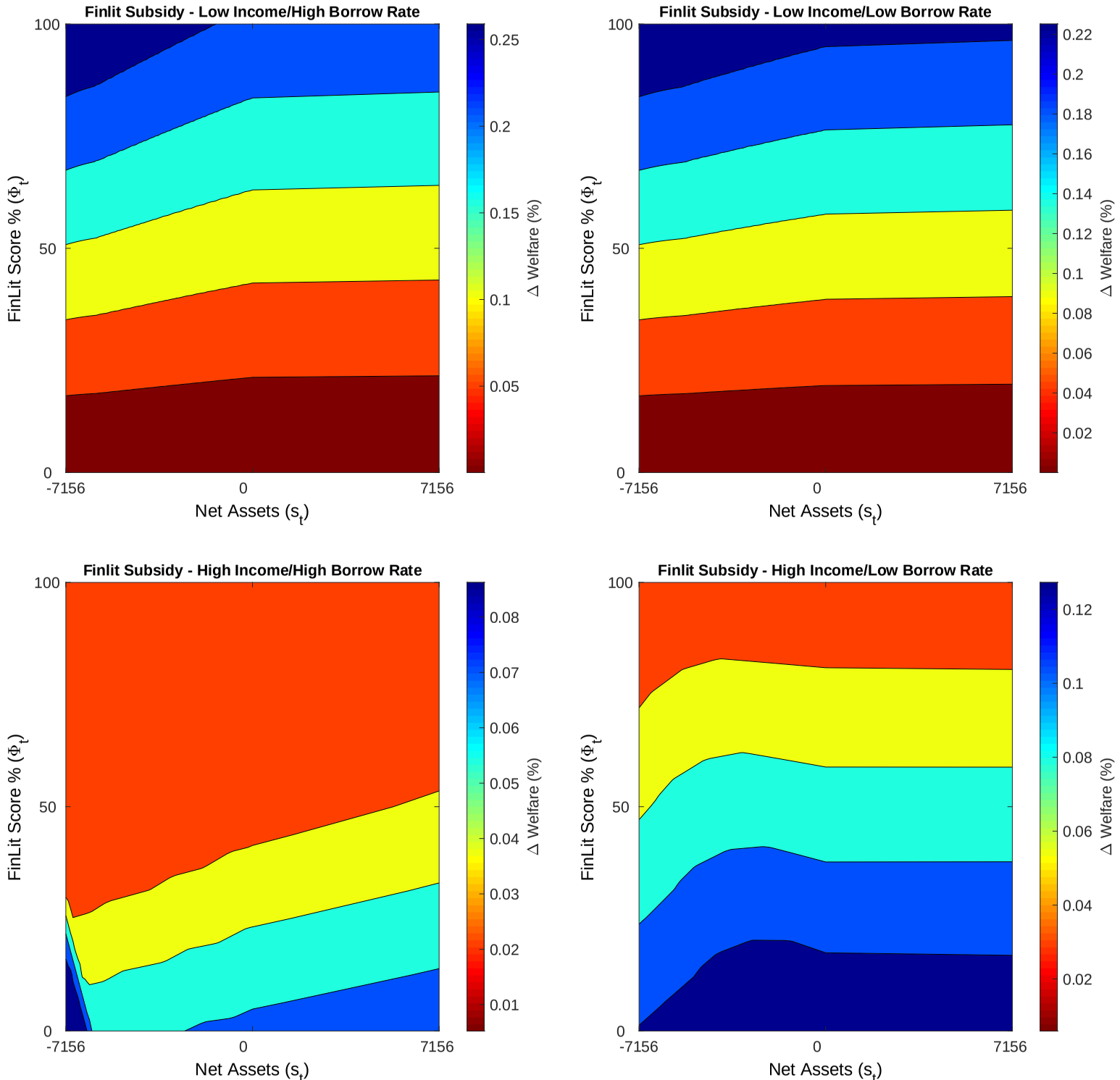
The long-term effect of a one-time subsidy is shown in the last two rows of table 12.A. In this policy, the subsidy is only offered for the initial age. Individuals see their average return increase by more than in the full lifetime subsidy but this is because they into account the increasing cost of financial literacy in future periods; in other words, they front-load their financial literacy investment. Comparing the welfare gains in table 12.A, the one-time subsidy improves welfare by about one-third of the gain in the full subsidy, despite encouraging greater financial literacy accumulation early in life. This is partly because the low-income, young group have lower savings on average and the immediate benefit of the subsidy is relatively less. When the subsidy is offered for all ages, it allows individuals to spread the investment in financial literacy more evenly over their lifetime, something similar to a policy recently suggested by Lusardi, Michaud, and O. Mitchell (2015). This highlights one of the limitations of early-life financial educations. As individuals accumulate savings over their lifetimes, the value of financial literacy

is increasing; a one-time subsidy may be more effective at a later period of life.

Figure 12.D shows the welfare distribution for the 10% subsidy. The greatest welfare gains are for low-income individuals, especially if they face high-borrowing rates and are leveraged. For this group, the financial literacy subsidy is more beneficial the greater the existing stock of financial literacy. These individuals have a high a marginal utility of consumption and the subsidy allows them to upkeep their stock of financial literacy, in order to benefit from it when they pay off their debt. In other words, the subsidy helps them to transition into becoming net savers. However, because income is persistent, they benefit relatively less if they are net savers (to the right of 0 on the x-axis) because they do not expect high-income out of which to save in future periods.

When individuals have high-income (lower two panels), the low financial literacy group benefits the most from the policy because they have a greater marginal return to financial literacy investment. In this case, it is the leveraged groups that benefit less from the subsidy because the high-income cohort expects to save relatively more than the low-income group during their life time.

Table 12.D: 10% Financial Literacy Subsidy



7. Conclusion

In this paper, I develop a model of financial literacy investment and evaluate how borrowing interest rate uncertainty influences financial literacy investment decisions. I find that an agent's expectation about the cost of borrowing has the greatest effect on financial literacy accumulation. When agents expect credit to be expensive, they shift their resources towards investing in financial literacy as an alternative way to smooth consumption over their lives. The effect of experiencing a bad credit shock early in life may induce some individuals to invest more in financial literacy than they would if credit was looser. Inequality in financial literacy levels may be explained by differences in borrowing histories.

While this insight is important for understanding the potential consequences of a public policy, it does not offer a positive prescription. Therefore, I evaluate the effects of two popular policies that have been proposed to ameliorate the effects of low financial literacy. I find that an interest rate cap is only welfare-improving if borrowers do not ration credit. However, even if credit is not rationed, individuals are discouraged from accumulating financial literacy and this may lead them to be unprepared in the case of a future adverse shock. I show that a financial literacy subsidy is a preferable policy to improve welfare for low-income and leveraged households because it leads them to increase their return on savings so as to better insure against potential negative shocks.

The implication of these two policy experiments is that any monetary policy that reduces the cost of borrowing should be coupled with a targeted financial education policy. Future work could extend the insights from this paper to a general equilibrium framework to evaluate how discouraging financial literacy accumulation through looser credit policies may create unintended consequences. Policymakers interested in improving the financial literacy of their citizens will find

these results most fruitful.

1.7 Appendix

A. Additional Regression-Related Tables and Graphs

Table 1: Factor Analysis

Variable	Uniqueness (1-Communality)
Compound	0.80
Inflation	0.76
Risk Diversification	0.64
Interest Rates & Bonds	0.82
Money Illusion	0.91
Time Value of Money	0.80
Highest Return	0.62
Highest Fluctuation	0.72
Highest Spread	0.61
Early IRA Withdrawal	0.83
Traditional vs Roth	0.79
Minimum Withdrawal	0.74

Note: Factor Analysis uses Principal Components Analysis. Communality is the percentage of the variance explained by other variables.

Table 2: Dependent Variable: Average State Mortgage Rate

Variables	Contract	Contract	Contract	Effective	Effective	Effective
$\overline{LoanReserve}_{st}$	.06*	.07***	.07***	.08**	.09***	.09***
	(.038)	(.024)	(.023)	(.04)	(.03)	(.03)
R^2	0.0159	0.7597	0.9204	0.0265	0.7092	0.9110
State Fixed Effects?	N	N	Y	N	N	Y
Year Dummies?	N	Y	Y	N	Y	Y
Observations	150	150	150	150	150	150

Standard errors in parentheses, clustered at the MSA level. Contract and effective mortgage rates are retrieved from the Federal Housing Finance Agency, under "Historical Summary Tables."

Table 3: Summary Statistics

Variable	**Mean**	**Median**	**Std Dev.**
$\Delta FinancialLiteracy_{ijt}$	0.17	0	1.10
$\Delta Log(Income_{ijt})$ (percentage)	0.01	0	0.28
$\Delta LoanReserve_{jt}$ (pct. points)	0.01	-0.03	0.42
Age_{ijt}	57	56	12
N	1482		

All variables are for individual i in MSA j in year t. $\Delta FinancialLiteracy_{ijt}$ is the change in financial literacy score, out of 12, from year t-1 to year t. $\Delta Log(Income_{ijt})$ is the change in the logarithm of individual i's income in MSA j in year t. $\Delta LoanReserve_{jt}$ is the change in loan-loss ratio in MSA j from year $t-1$ to year t.

Table 4: Correlation Matrix

Variables	LRR	FinLit	Log(Income)	Age	Own Home	
LRR	1					
FinLit	0.0456*	1				
Log(Income)	0.0702* *	0.3689*	-0.0156	1		
Age	0.0380	0.2539*	0.0242	-0.0060	1	0.3199*
Own Home	-0.0556*	-0.0502	-0.0330	0.3199*	-0.1321	1

* means correlation is statistically significant at 5% level. LRR is the loan-loss ratio; FinLit is the financial literacy score; Increase Int. Exp is a dummy variable that takes a value of 1 if individuals expect interest rates to increase and zero otherwise and Own Home is a dummy variable that takes a value of 1 if an individual owns a home.

Table 5: Financial Literacy Change

Variables	I	II	III	IV
$\Delta LoanReserve_{jt}$	0.27**	0.27**	0.30**	0.33**
	(0.13)	(0.13)	(0.12)	(0.13)
$\overline{Age}^2_{ijt}$		$-.003^*$	$-.008^*$	$-.008^*$
		(.004)	(.004)	(.004)
$\Delta LoanReserve_{jt} \times \overline{Age}_{ijt}$			-.012	-.012
			(.012)	(.012)
$\Delta LoanReserve_{jt} \times \overline{Age}^2_{ijt}$				-.0002
				(.0002)
N	1482	1482	1482	1482
$Adj\, R^2$	0.6826	0.6842	0.6849	0.6851

Standard errors in parentheses, clustered at the MSA level. Year and individual fixed-effects in all specifications. Dependent Variable, $\Delta FinancialLiteracy_{ijt}$, is the change in financial literacy score from year t-1 to t and is standardized. $\Delta LoanReserve_{jt}$ is the change in the average loan-loss ratio for multi-state banks in MSA j. Controls include the logarithm of income, the number of members in respondent's family and a dummy for home ownership.

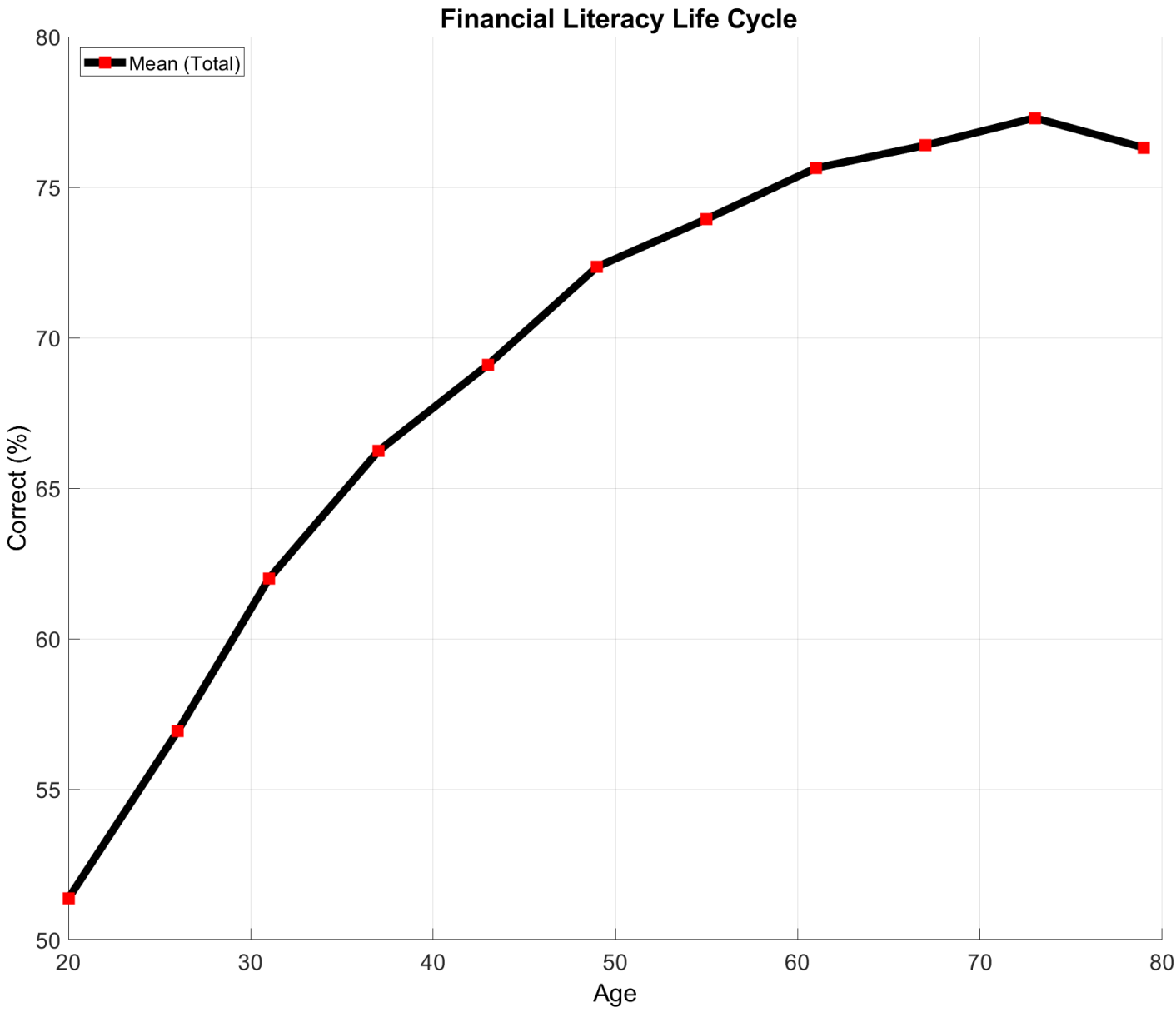


Figure 1.1: Lifetime Financial Literacy

Correct (%) is the percentage of questions answered correctly. Each node is the average financial literacy answered correctly for individuals from the age to 5-years older (e.g. 25–30).

Table 6: Dependent Variable: Residuals from Liquid Wealth Regression

Variables	Full Population	Old (>50)	Young (≤ 50)
$FinLit_{ijt}$	2.14^{***}	1.16^{***}	0.79^{**}
	(0.40)	(0.28)	(0.36)
R^2	0.050	0.028	0.023
Observations	1820	1317	503

Standard errors in parentheses, clustered at the MSA level. Dependent variable is the residual from a regression of the logarithm of liquid wealth on the respondent's age, their age-squared, the average loan-loss ratio for the region they live in, their income, a dummy if they own a home, the number of family members in their household, an individual fixed-effect and a year effect.

1.7.1 Additional Model Variations

Double Longevity

Due to data limitations, my model fits moments for four age periods. The limited time-horizon may have an effect decisions and may be responsible for some of the discrepancy between the model generated moments and the empirical data. In order to account for this, I run the calibrated model for double the time. Note, these results are not directly comparable because the household optimization problem with double longevity is not merely twice a lifespan but a longer period to experience income and credit shocks. Nonetheless, the extended model may give some insight into the effect of a longer time-horizon. Table B.1 reports the results of the double longevity model. Individuals have more financial literacy and savings at

every period because they have a longer time-horizon to reap the reward for their investment and more opportunities to recover from a negative shock.

Financial Literacy Affects Borrowing and Savings Rate

In order to get a sense of how financial literacy may influence an agent's decision if it also improved their borrowing conditions, I extend the model to allow an agent's financial literacy to lower the rate paid on the borrowing interest rate. I do not have the data sufficient to estimate a production function for the effect of financial literacy on borrowing interest rate, so I set the maximum reduction in borrowing interest rate to 500 basis points or 5 percentage points for an individual with complete financial literacy. This to approximate the estimates done by Stango and Zinman (2016) of the "demand-side" or consumer contribution to dispersion in borrowing interest rates. Equation 1.15 shows the new model extension.[21]

$$c_t = X_t - p\ell_{t+1} - s_{t+1}\mathbb{1}\{s_{t+1} \geq 0\} - (1 + r_{b,t} - 0.05\overline{\Phi_t})s_{t+1}\mathbb{1}\{s_{t+1} < 0\} \quad (1.15)$$

where $\overline{max\Phi} = 1$.

Table B.2 reports the effects of effects of the model extension. The most significant change is that the younger-cohort saves less and borrows more, while their financial literacy does not appreciably change. The absence of any change for other variables indicates that the benefit of financial literacy on borrowing primarily encourages greater borrowing but does not lead to individuals saving more.

[21] When the effect of financial literacy on borrowing has been estimated, Huston (2012) found a negative relationship between financial literacy and mortgage rates but no effect of financial literacy on credit card rates.

Table B.1: Double Longevity

	41	**47**	**53**	**59**	**65**	**71**	**77+**
Double Longevity:							
FinLit(%)	81	83	86	89	90	92	93
Savings ($)	115925	151211	189917	218613	239539	245554	210276
Baseline:							
FinLit(%)	74		76		75		74
Savings ($)	67371		87320		90166		57945

Double Lifetime runs the original calibrated model for twice (12) the time periods. Each age-earnings profile state is doubled. Baseline is the original fit. FinLit (%) is the percentage of total possible financial literacy that the average individual has at that age and Savings ($) is the dollar value of savings for the average individual at that age.

Table B.2: Model Extension

	r(Φ)(%)		Savings		$\frac{Debt}{Income}$ (%)		Δ Welfare
Age	41	63	41	63	41	63	
No Effect	3.65	3.67	67371	90166	6.52	2.64	0.00
Extension	3.65	3.67	67261	90166	7.62	3.41	0.04

1.8 Data Construction

1.8.1 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 Index

Four of my financial literacy questions are part of the "Big 5" (Hastings, Madrian and Skimmyhorn 2013). For 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? or don't know?"

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; Survey 118 (ms118_CI2) in year 2010 and survey 179 (int_rate_literacy), Survey 182 (ms118_CI2), Survey 186(q47), Survey 189 (bf1) and Survey 196 (q59) for year 2011.

Question 2 - Interest rates and Bond Prices

Observations for this question are taken from surveys 21, 50 and 64 for year 2009 and surveys 180 (in1) and 189 (in1) in year 2011. For the year of 2010, I take the median of the individual's score from 2009 and 2011. An example of this question is:

"If the interest rates fall/rise, what should happen to bond prices?

1. They should rise
2. They should fall
3. They should stay the same
4. Don't know

Question 3 - Inflation

This question is part of the "Big Three" (Hastings, Madrian, and Skimmyhorn 2012). The basic form of this question is:

"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

This question is part of the "Big Three" (Hastings, Madrian, and Skimmyhorn 2012). The basic form of this question 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 6 - Time Value in Money

This question has a few variations but the only difference is usually the quantity inherited. The basic question is:

"Assume a friend inherits $10,000 today and his sibling inherits $10,000 three years from now. Who is richer because of the inheritance?"

A version is in 21 (2009), 50 (2009), 64 (2009) and 189 (2011).

Question 7 - Highest Return

"Considering a long time period (for example 10 or 20 years), which asset normally gives the highest return?"

1. Savings Accounts
2. Bonds
3. Stocks
4. Don't Know

I use surveys 21, 64 (2009) and 180 (2011). For the year of 2010, the ALP does not have a survey that asks this question. As a consequence, I take the median score between an individual's response in 2009 and 2011.

Question 8 - Highest Fluctuation

This question has the form of:

"Normally, which asset described below displays the highest fluctuations over time: Savings accounts, Bonds or Stocks?"

1. Savings Accounts
2. Bonds
3. Stocks
4. Don't Know

I use surveys 21, 64 (2009) and 180 (2011). For the year of 2010, the ALP does not have a survey that asks this question. As a consequence, I take the median score between an individual's response in 2009 and 2011.

Question 9 - Highest Spread

""When an investor spreads his money among different assets, does the risk of losing money"

1. True

2. False

3. Don't Know

I use surveys 21 (2009), 50 (2009) and 189 (2011).

Question 10 - Difference between Traditional and Roth IRA

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

Question 11 - Early Withdrawal

"A person who withdraws money from a standard 401(k) plan or IRA after he turns 59½ does not pay taxes on the money that he withdraws."

1. True

2. False

3. Don't Know

I use surveys 64 (2009) and 189 (2011). For the year of 2010, the ALP does not have a survey that asks this question. As a consequence, I take the median score between an individual's response in 2009 and 2011.

Question 12 - Minimum Withdrawal

Question 12 asks about the minimum withdrawal

The question is asked as follows:

"After age 70 1/2, you have to withdraw at least some money from your 401(k) plan or IRA."

1. True
2. False
3. Don't Know

I draw from surveys 64, 189, 215. I do not observe this question in 2010, so I take the median between the score the years 2009 and 2011 for individuals in the sample.

Construction of Liquid Wealth

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 wealth is 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.

Construction of MSA identifier

The nearest Metropolitan Statistical Area (MSA) of individuals is first identified using surveys 227,238, 250, 254, 261 and 287. All of the surveys are called "Asset Price Expectations" and question "_FL_city" asks individuals to fill in the city closest to their zipcode.[22] Only survey 227 falls within the years of my sample, so I need to identify the migration patterns of

In particular, I use surveys 36 and 300 in order to encircle my sample years and identify the region someone was in during that period. In both surveys there are several questions asking respondents about how long they live in an area and when they moved to the area. For my sample, I choose individuals who report living at their main residence since before 2009

[22]The variable label says "fill for city nearest to R zip code," where R means respondent.

For example, take someone who reports living in the Houston-Baytown-Sugarland MSA in 2012. If in 2012 or later they report having lived at their main residence since 2008 or earlier, they are included in my sample since I know they were in this MSA in 2009-2011. However, if they reported the same thing but in **2010**, I *cannot* include them, because I do not know if they moved in 2011.[23]

Since there are MSA's with the same name but in different states (e.g. Springfield), I use surveys 300 and 312 ("Global Warming and Other Survey for mixed mode [Sample2]") to gather information on the state that individuals reside in order to match the individuals with the correct MSA.

The American Life Panel also identifies multi-respondent households. If I am missing the location of an individual but I have the response of someone else in their household, I fill in their location based on the response from the household member.[24]

1.8.2 Bank-Related Data from FDIC

Construction of Loan Reserve to Total Loans Variable

MSA-level bank data is taken from the Federal Deposit Insurance Corporation (FDIC). For each MSA, I construct a weighted-average of the loan-reserve-to-total-loan ratio for multi-state banks in that area. I use only data from banks that operate in multiple states as their decisions should be plausibly exogenous from any one region's local conditions. The MSA average is constructed by weighing each bank's loan-reserve-to-total-loan ratio by its deposit-share for its branches in that

[23] This applies only to survey 36, which was in field form 2008 to 2013.

[24] In the American Life Panel, the first seven numbers of the key identifier "prim_key" identify the household. After the colon, the last number identifies respondents within a household. Therefore, certain information, such geographical residence, can be assumed to hold for all members of the household, even if not directly asked. The reason I can do this is because an individual who moves out of a household but remains in the American Life Panel is assigned a new identifier (See "Frequently asked questions," American Life Panel).

MSA for multi-state banks in order to appropriately quantify a bank's impact on local credit conditions.

The FDIC Call Report data is given quarterly but my household panel data is yearly. Therefore, I take the yearly average for each of the bank's reported data. In the FDIC Call Report data, I use *lnlsgr* as the total loans on a bank's balance sheet in year t.[25] For the loan loss allowance, I use *lnatres* as the loan loss allowance.

$$LoanReserveRatio_{jt} = \frac{Loan\ Loss\ Allowance_{jt}}{Total\ Loans_{jt}} \times 100 \tag{1.16}$$

1.8.3 Model Features and Calibration

Construction of Average Return

I reported the Savings return as the weighted average return on savings received by individuals savings. In order to calculate the rate, I do the following for each period t:

1. Calculate the total interest accrued in period t
2. Calculate the total saving amount drawn in period t

Then the weighted rate is calculated as follows:

$$Average\ Return_t = \frac{Interest\ Factor_t}{Total\ Saving\ Amount_t} \tag{1.17}$$

This can then be multiplied by 100 to put this calculation in conventional percentage expression. The Weighted Savings Rate is calculated in the same way, with the appropriate changes.

[25] Total loans and lease financing receivables, net of unearned income.

Construction of Interest Rate Shock Process

To construct the interest rate shock process, I use the Survey of Consumer Finance 2010 since that overlaps with the American Life Panel data taken from 2009-2011. I use question X7132 " What interest rate do you pay on the card where you have the largest balance?"

I drop observations that report paying a non-positive interest rate.[26] The average interest rate is 14.6, with little variation across age cohorts.

[26]Individuals are asked to write "-1" if they are not paying interest on a credit balance. I drop observations that report 0%, since this means they are either not borrowing or face a 0% on their card for a limited time (e.g. interest payments are delayed for the first 12 months).

Chapter 2

A Quantitative Model of Financial Literacy Accumulation

1. Introduction

Financial Literacy is a unique kind of human capital because it is 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. While this gives a strong justification for providing financial education for students, the effectiveness of financial education programs remains mixed.[1] If financial literacy is almost universally relevant, why are some individuals more motivated to acquire this human capital earlier in life?[2]

My contribution is to calibrate a life cycle model with endogenous financial literacy accumulation and quantitatively analyze the financial literacy choice under different circumstances. In particular, compared to previous life-cycle models with a financial literacy choice, my model is disciplined by empirical data using a moment-matching procedure. This allows me to make a realistic, quantitative

[1] See Mandell and Klein (2009).
[2] See Mandell and Klein (2007)

evaluation of various proposed policies.

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. I construct a measure of financial literacy as the sum of twelve financial literacy questions answered correctly by individuals in a year and compare it to a proxy for work-related human capital−permanent income. If financial literacy is merely a work-related acquisition, then financial literacy should rise and decline with the income-profile over an individual's life. I find, on the contrary, that there is a noticeable divergence between the trajectory of income and financial literacy over the life cycle, especially as individuals approach retirement. Individuals continue to accumulate financial literacy after income begins declining mid-life because as they prepare for managing their household portfolios in retirement.

Following the motivation, I develop a life cycle model with endogenous financial literacy accumulation and education-specific earnings profiles. In my model, financial literacy determines an individual's return on savings. Individuals invest in financial literacy to raise their return on savings and more efficiently smooth consumption between time-periods. The shape of the earnings profile affects the decision to acquire financial literacy by influencing an individual's expectations of future resources but also by influencing the amount of income to be saved, a complement to the financial literacy investment.

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 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.[3]. 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

The effect of financial literacy on household outcomes is often difficult to describe because financial literacy intersects many other kinds of human capital. Jappelli

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

and Padula (2013) find that about 30% of adult financial literacy can be explained by mathematical ability at the age of 10; Christelis, Jappelli, and Padula (2010) find that cognitive ability is strongly associated with the propensity to participate in the stock market. While cognitive skills may play a part, financial literacy still encompasses knowledge beyond mathematical ability, such as the understanding of financial concepts and household planning competency (Carpena et al. 2011b). 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.[4]

A potential alternative to acquiring financial literacy is to rely on the specialized knowledge of a financial advisor. In this case, an individual with a low level of financial literacy should not be concerned because they can delegate their portfolio to a financial specialist. However, previous work has found that either financial literacy and financial advice are complements (Von Gaudecker 2015) or that financial advice is 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.

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,

[4]Gramaṭki (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.

where individuals pay for this investment out of their wealth. This model choice is made in order to match the observed positive relationship between wealth and financial literacy.

2.1 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.

2.1.1 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.[5] Each question is weighted equally.

The first three questions are often called the "Big Three" (Hastings, Madrian, and Skimmyhorn 2012) because they commonly included as part of a financial literacy test. I then include two questions testing economic concepts, three testing stock market knowledge and three questions about retirement knowledge. The sum of the correct answers is denoted as $FinancialLiteracy_{it}$.

[5]See (Huston 2010).

Additional Variables

Income is recorded in the ALP in 17 brackets. I transform this bracketed variable into a continuous variable by taking the median value of each bracket that an individual reports representing their income. 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 demographic controls−gender, ethnicity, marital status, etc.− to help control for factors that may influence income and financial literacy.

Regression Estimation

$$Log(Income_{it}) = \alpha + \gamma_1 Age_{it} + \gamma_2 Age_{it}^2 + \gamma_3 Educ_{it} + W_{it} + \delta_t + \varepsilon_{it} \tag{2.1}$$

$$Financial Literacy_{it} = \alpha + \beta_1 Age_{it} + \beta_2 Age_{it}^2 + \beta_3 Educ_{it} + W_{it} + \delta_t + \varepsilon_{it} \tag{2.2}$$

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.

Figures 2.1 and 2.2 plot the predicted fits from regressions 2.1 and over the age range of 20–80. On average, college-educated individuals score about 0.5–1 points higher than high-school individuals at each age on their financial literacy test. Both plots show that financial literacy continues to accumulate even after income begins to fall; the latter life financial literacy accumulation is about 10-12%.

Why would individuals continue to invest in financial literacy even after their

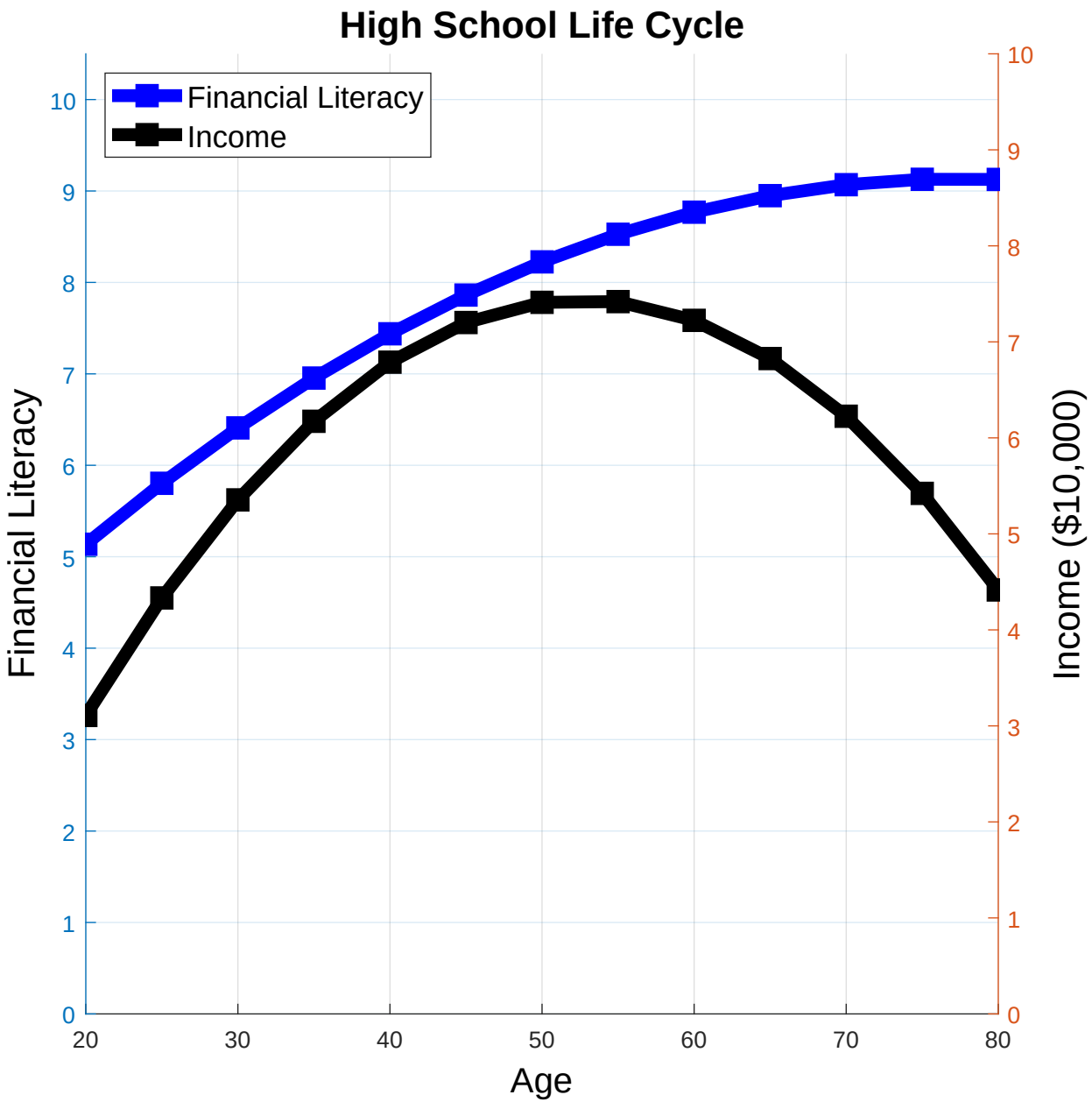


Figure 2.1: High School Life Cycle

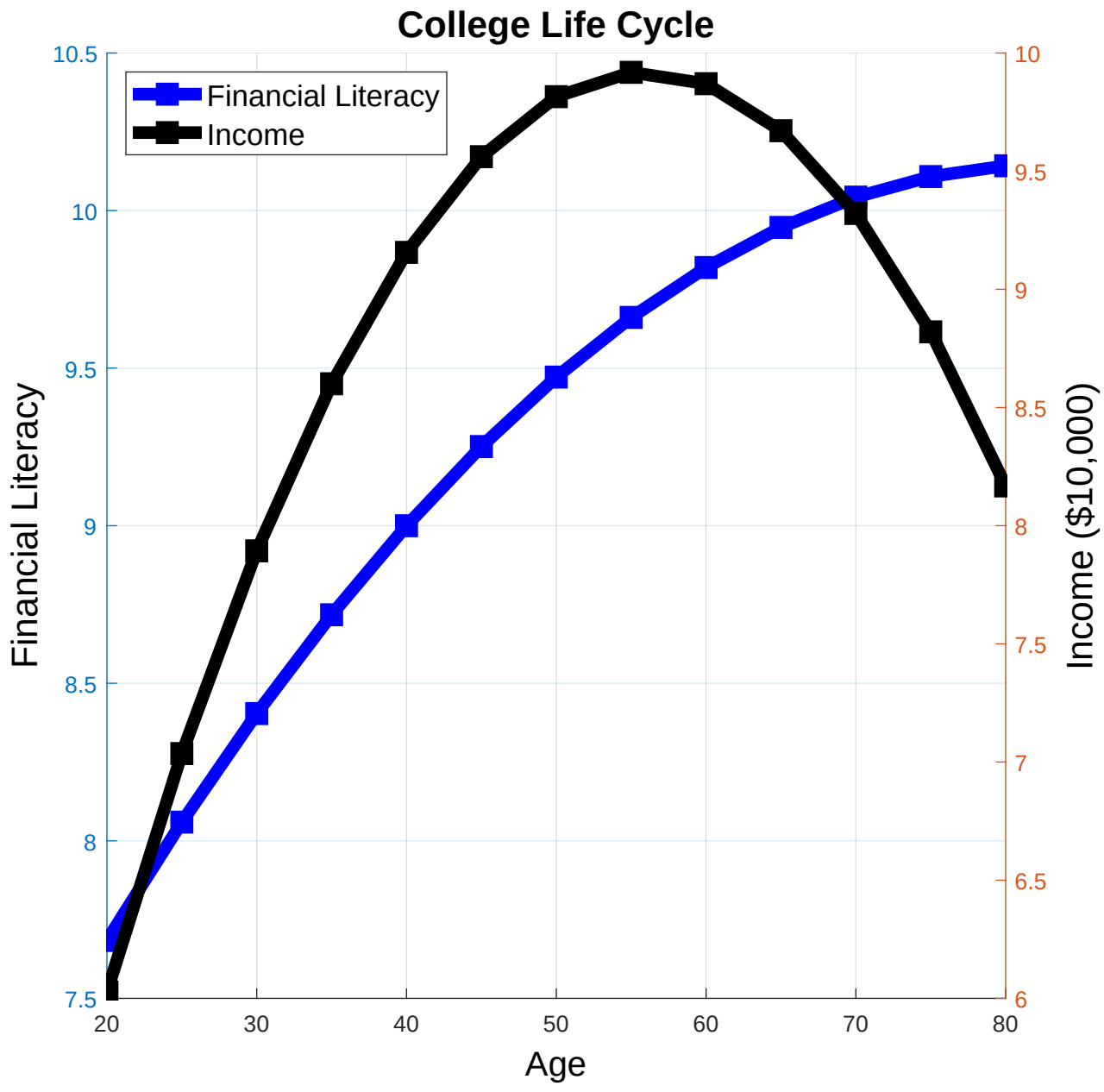


Figure 2.2: College Life Cycle

incomes have started to fall? As individuals approach retirement, they are faced with a fall in income and the need to re-balance their household portfolios (Kim, Maurer, and O. S. Mitchell 2016). Figure 2.3 plots the average financial literacy score alongside the average retirement financial literacy score (out of three). On average, individuals at age 20 answer about one-out-of-three retirement questions correctly. However, compared to the average financial literacy score, the growth rate of retirement financial literacy is more fast, suggesting the relevance of the knowledge later in life.

I interpret these figures as follows. As can be seen in figures 2.1 and 2.2, even when households expect to be working less in the future, they still accumulate financial literacy. I infer from this that financial literacy can be treated as a kind of human capital that is unique from work-related human capital. Furthermore, because households rely on savings accumulated in retirement, I find that these figures suggest 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. Finally, 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.

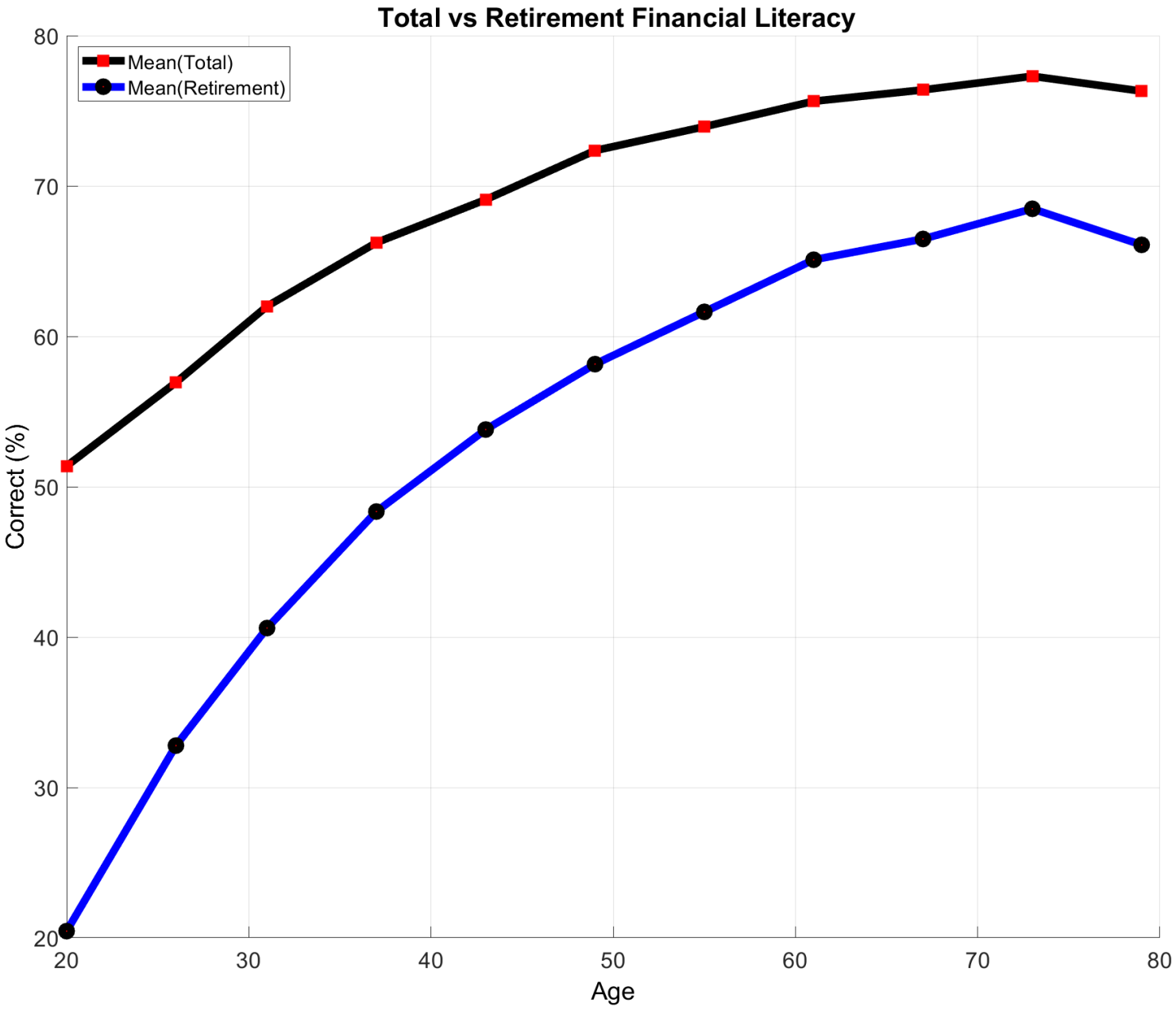


Figure 2.3: Total vs Retirement Literacy

2.2 A Quantitative Model of Financial Literacy Accumulation

2.2.1 Household Problem

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

$$\underset{\{c_t\}_{t=1}^{J}}{max}\ E_0\left[\sum_{t=1}^{J}\beta^{t-1}\frac{c_t^{1-\gamma}}{1-\gamma}\right] \quad , \tag{2.3}$$

2.2.2 Budget and Asset Choices

Each period, an individual has an opportunity to make two asset choices: a savings choice and a financial literacy investment. Following Jappelli and Padula (2013), an individual's return on savings is a function of their financial literacy stock:

$$r(\Phi_t) = A\Phi_t^{\alpha} + r_{base}^{s}\,. \tag{2.4}$$

This return is paid at the beginning of period t for the stock of financial literacy accumulated up to that period, Φ_t. 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 diminishing rate of increase in financial literacy shown in figure 2.3. The parameter A is the savings productivity of the financial literacy investment. Finally, r_{base}^{s} is a base interest rate so that individuals with zero financial literacy still receive a positive return to saving.

The return on savings is modeled as a function of financial literacy to reflect the fact that financially literate individuals tend to have a greater knowledge of

savings instruments' returns (Deuflhard, Georgarakos, and Inderst 2019) and plan better for retirement (Lusardi and O. Mitchell 2007) & emergency situations (Klapper, Lusardi, and Panos 2013). But how does an individual acquire financial literacy?

In every period t, individuals receive income y^i. This is made up of three parts. First, individuals inelastically supply one unit of labor each period and earn a wage w, which I normalize to one. Second, individuals face a log-normal income shock denoted by η_t. Third, income follows one of two age-earnings profiles denoted by e^i_t, where i= High-School, Bachelors. The per-period income for individual with education i is as follows:

$$y^i_t = w \cdot e^i_t \cdot exp(\eta_t)\,, \tag{2.5}$$

where $\eta_t = \rho_\eta \eta_{t-1} + \varepsilon_t$ and $\varepsilon_t \sim N(0, \sigma^2_\varepsilon)$. 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. A individual's response to a financial education program will be conditioned by an individual's expectation about future income. Previous research has found that individuals with college education are more likely to participate in an offered financial education program (Meier and Sprenger 2013). This may reflect expectations about future income and the relevance of financial literacy for future wealth management. This is mirrored by the finding that financial education appears to be less effective for low-income cohorts (Kaiser and Menkhoff 2017).

Following Jappelli and Padula (2013), I will allow individuals to accumulate and de-accumulate financial literacy.[6] 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 de-

[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.

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

$$\ell_{t+1} \geq 0\,. \tag{2.6}$$

2.2.3 Asset Paths

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

$$\Phi_{t+1} = (1-\delta)\Phi_t + \ell_{t+1}\,. \tag{2.7}$$

The dynamic budget constraint for an individual with education i is the following:

$$s^i_{t+1} = (1 + r(\Phi_{t+1}))(y^i_t + s^i_t - c_t + p(1-\delta)\Phi_t - p\Phi_{t+1})\,, \tag{2.8}$$

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

$$s^i_{t+1} \geq 0\ . \tag{2.9}$$

2.2.4 Consumer Problem

Using the CRRA utility function and combining the constraints in equations 2.8, 2.6 and 2.9 the consumer problem for an individual with education type i can be written as:

$$V^i_t(s^i_t, \Phi_t, y^i_t) = \max_{\ell_t, c_t}\ u(c_t) + E_t[\beta V(s^i_{t+1}, \Phi_{t+1}, y^i_{t+1})|y^i_t]$$

such that

$$s^i_{t+1} = (1 + r(\Phi_{t+1}))(y^i_t + s^i_t - c_t - p\Phi_{t+1} + p(1-\delta)\Phi_t) \tag{2.10}$$

$$\ell_{t+1} \geq 0 \; s^i_{t+1} \geq 0 \tag{2.11}$$

2.3 Quantitative Analysis

2.3.1 Calibration

I take the initial distribution for financial literacy and liquid assets 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 (1997), as well as family background Lusardi, O. Mitchell, and Curto (2010). 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).

In order to calibrate the model, I use the age-earnings profile for the entire sample. However, for the counterfactusls, I also use the education-specific age-earnings profiles to evaluate how individuals with different income expectations respond to an exogenous shock. 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 - Chapter 2

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 early in life but depreciates too quickly. The largest difference is found

at around age 63, where the model's agents begin de-accumulating financial literacy before the empirical sample begins de-accumulating. 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, particularly earlier in the life-cycle. 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. An insight into the the deviation between the model and data may be found in one of the untargeted moments, the correlation between savings and financial literacy. The correlation between financial literacy and savings is more than double the empirical correlation for the first two age-cohorts. This difference may reflect the relationship between education and cots of financial literacy investment (Spataro and Corsini 2013). In my model, every individual faces the same financial literacy investment cost, but if low education increases this cost, some individuals may save more early in life and delay their financial literacy investment until later in life.

Table 8: Structural Model Fit

Age	41–51	52–62	63–73	74–84
Targeted: Financial Literacy Change				
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	1.63
Untargeted: Corr(Savings, Financial Literacy)				
$Correlation^{Data}$	0.14	0.11	0.15	0.21
$Correlation^{Model}$	0.32	0.28	0.26	0.22

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

2.3.2 Effect of Age-Earnings Profile

The decision to invest in financial literacy is not necessarily influenced by an individual's level of income, so much as the need to smooth consumption over their lifetime (Lusardi, Michaud and Mitchell 2017). I evaluate the effect of different age-earnings profiles on financial literacy accumulation by constructing an age-earnings profiles to match the lifetime earnings of individuals with at least a bachelors degree and a age-earnings profile to match the lifetime earnings of individuals with an associates or less education. Table 9 reports the age-earnings profile. Both of the additional income profiles are more steep from 30 to 51 than

the baseline model but the latter-life pattern 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. Table 9 reports the results of the age-earnings counterfactuals. Note that the High School/Associates group accumulates financial literacy for a greater duration of their life cycle than either the baseline or college-educated group. This is because the high school/associates group acquire less financial literacy early in their life, and therefore have a higher marginal return to an additional unit of investment compared to the Baseline and College groups. However, because the high school/associates group has less income and wealth on average, they have less resources to spend on financial literacy and less savings stock to bear an interest return. This may help explain why individuals without higher-education are less likely to participate in the stock market (Grin-

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

blatt, Keloharju, and Linnainmaa 2011) and require the financial literacy needed to manage a stock portfolio, despite the significant return to stock market participation (Calvet, Campbell, and Sodini 2007).

College-educated individuals also invest less than the baseline but not due to resource constraints. This group has the lowest Wealth-to-Income ratio but the greatest Average Savings Return for ages 41–51. The higher return allows them to consume more because they can more efficiently smooth consumption across time periods. 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 rather because of changes in income over their lifetimes.

Table 11: 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.

2.3.3 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. However, if wealth serves as a resource for financial literacy investment, it may be the case that a wealth shock leads to a lower overall level of financial literacy. Intuitively, a person who suffers a significant depreciation in their assets and forgoes improving their financial literacy in order to instead have resources to cover their consumption and desired precautionary savings.

To simulate this exercise, I redistribute every agent to a fraction of their savings choice at age group 4 (41-51). Table 12 reports the results of the wealth shock. I report three results for both education levels, both with and without the shock: average financial literacy (out of 12), average return (total interest received/total savings) and average savings (in 1000's).

Comparing the no shock case to the counterfactual, the high school/associate-educated group lets more of their financial literacy depreciate in response to the wealth shock than the college-educated group. For this group, their permanent income is lower and declines earlier in life, so they give up resources used for financial literacy to smooth consumption. The college group saves less, but they have a higher average return on their savings because they tend to be more financial literate on average. This helps explain why financially literate individuals may be more resilient to a wealth shock, because they are able to rely on their ability to get higher returns to make up for the shock.

Figures 2.6 and 2.7 plot out financial literacy life cycle profile for college-educated and high school-educated individuals. Again, the shock has a much greater effect

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

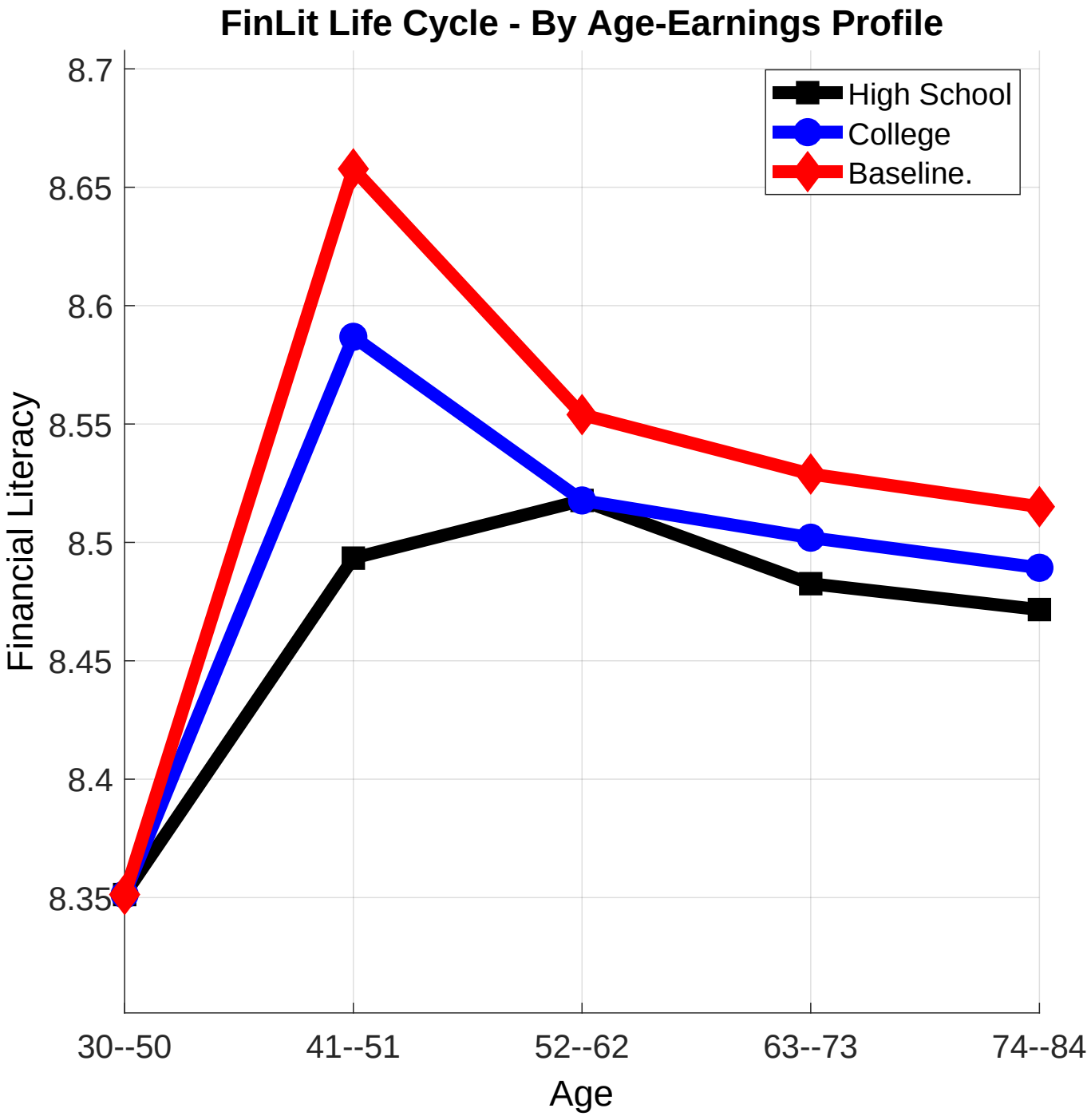


Figure 2.4: Financial Literacy by Age-Earnings Profile

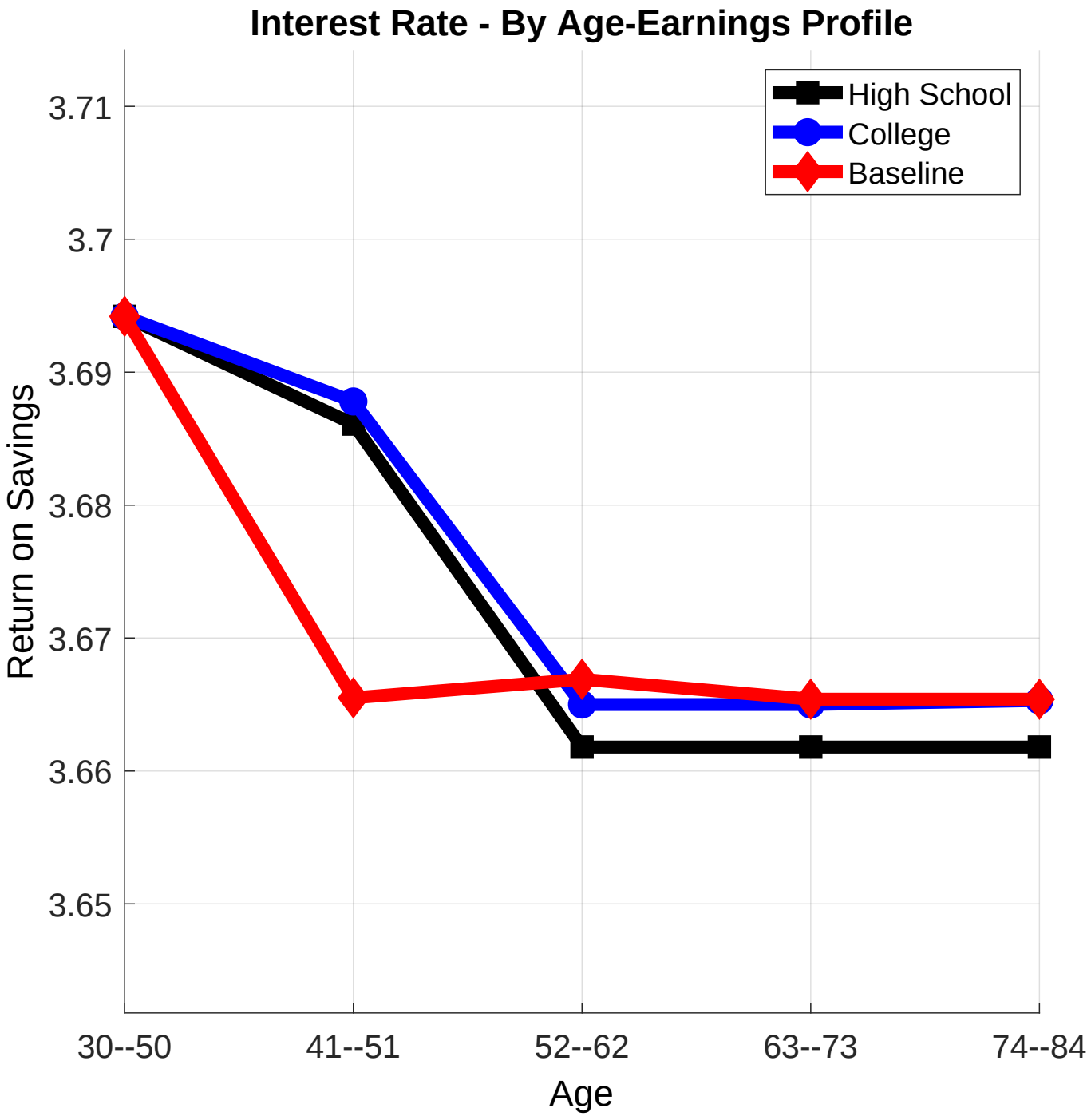


Figure 2.5: Interest Rate by Age-Earnings Profile

Table 12: Wealth Shock Counterfactual - 70% Wealth Depreciation

Age	41–51	52–62	63–73	74–84
High School/Associates				
No Shock FinLit (out of 12)	8.49	8.52	8.48	8.47
No Shock Avg. Return (%)	3.69	3.66	3.66	3.66
No Shock Savings ($1000)	63.0	117	122	85.0
Counterfact FinLit (out of 12)	8.49	8.48	8.47	8.47
Counterfact Avg. Return (%)	3.69	3.69	3.66	3.66
Counterfact Savings ($1000)	63.0	69.0	92.0	72.0
College				
No Shock FinLit (out of 12)	8.59	8.51	8.50	8.49
No Shock Avg. Return (%)	3.69	3.67	3.67	3.67
No Shock Savings ($1000)	89.0	112	121	50.0
Counterfact FinLit (out of 12)	8.59	8.50	8.50	8.49
Counterfact Avg. Return (%)	3.69	3.69	3.67	3.67
Counterfact Savings ($1000)	89.0	66.0	94.0	38.0

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. FinLit is the average financial literacy score out of 12 for age-cohort listed in column. Avg. Return the sum interest paid over the sum saved for the age-cohort listed in column. Savings is the average savings for individuals in the age-cohort listed in the column, reported in thousands of dollars.

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.

2.3.4 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 (Pelletier 2017). The effectiveness of financial education, especially when provided in high school, is mixed. Bernheim, Garrett, and Maki (1997) 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 and Klein 2009).

If financial literacy help individuals smooth more effectively between time periods, then 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.

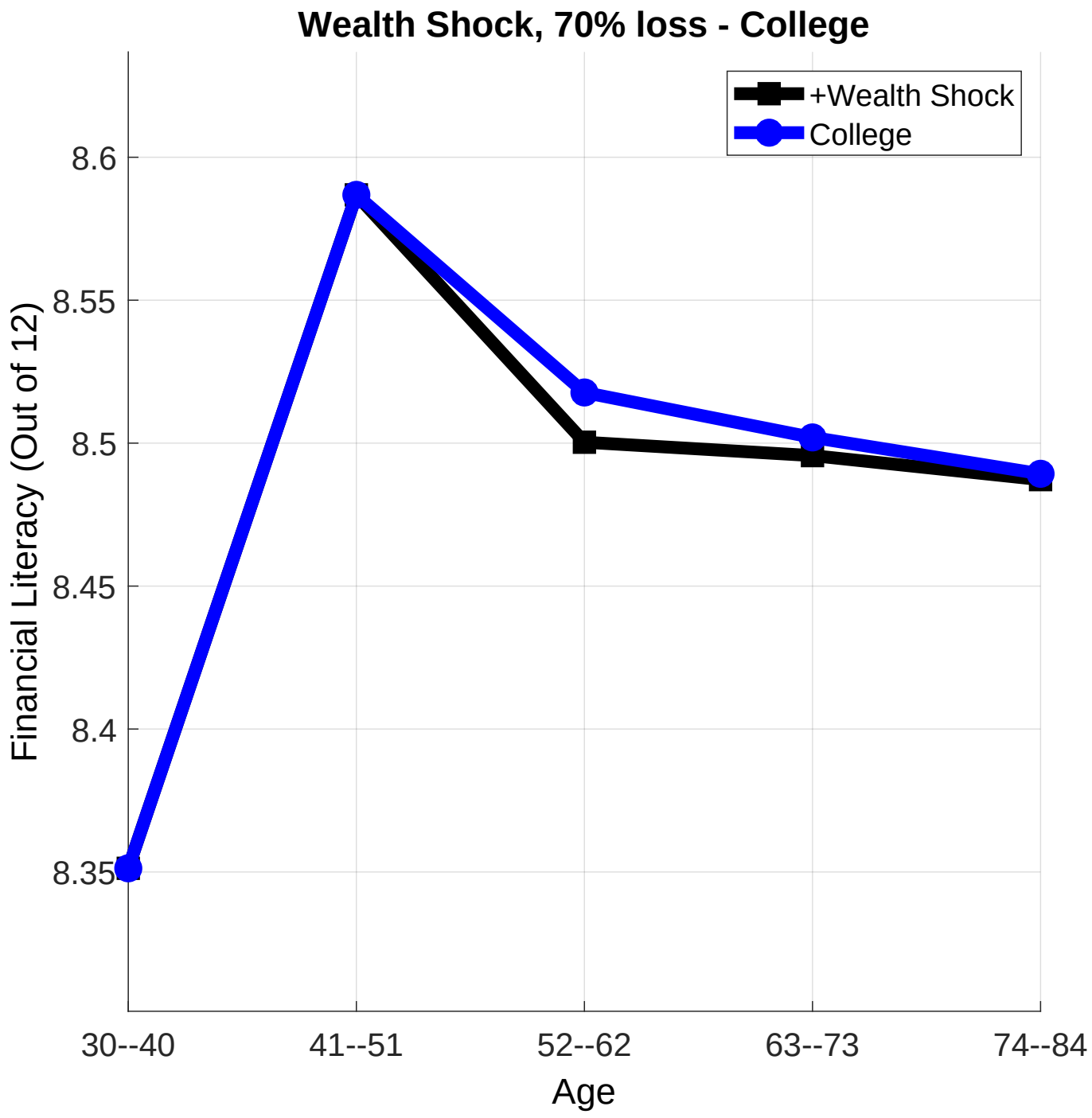


Figure 2.6: Wealth Shock - College Age-Earnings Profile

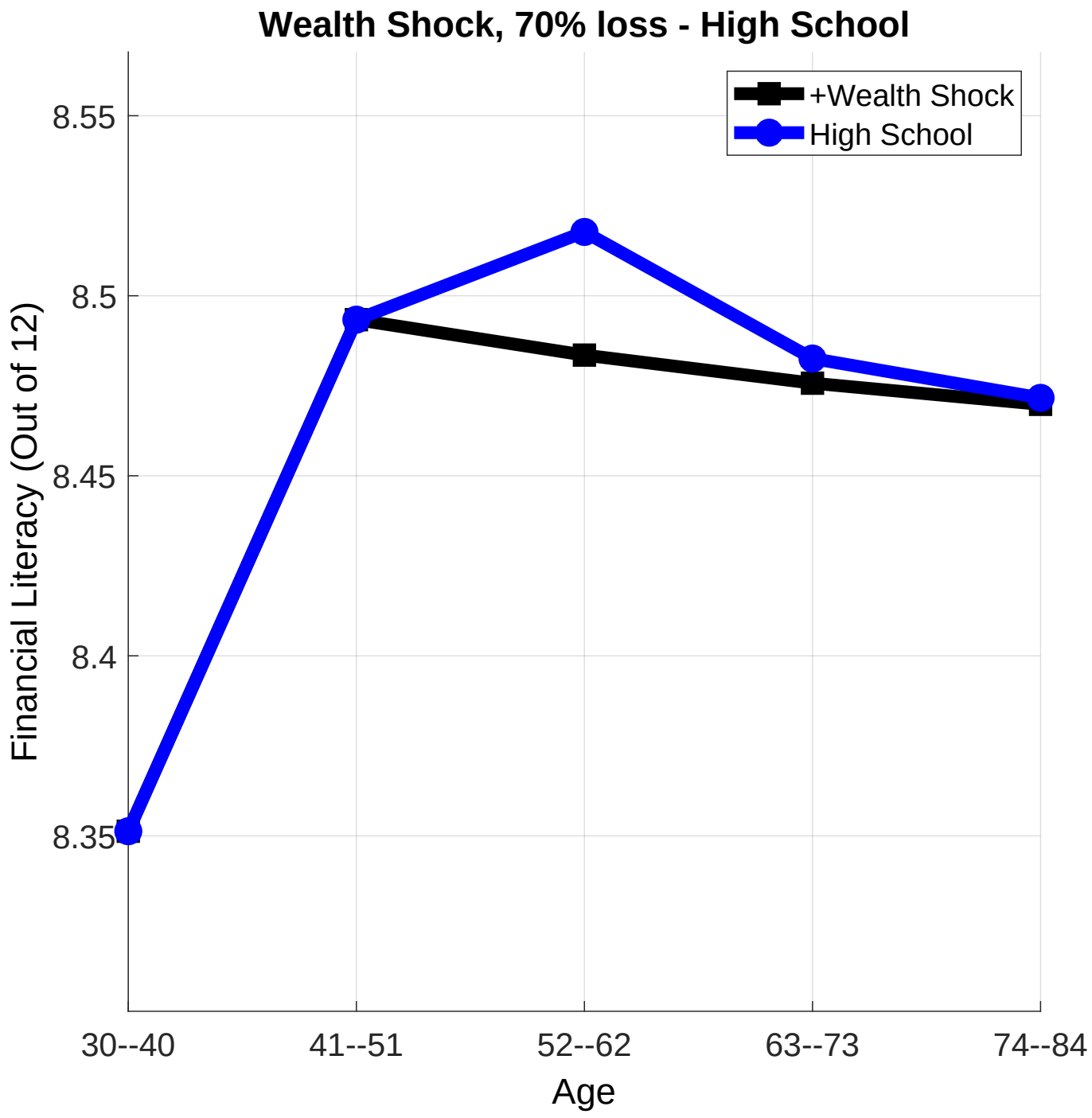


Figure 2.7: Wealth Shock - High School/Associates Age-Earnings Profile

Table 13: 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
Baseline Avg. Return (%)	3.68	3.66	3.66	3.66
Baseline Savings ($)	63330	117289	121624	84616
Education Program FinLit	9.49	9.38	9.37	9.37
Education Program Shock Avg. Return (%)	3.75	3.73	3.73	3.73
Education Program Savings ($)	89250	112505	121050	49600
College				
Baseline FinLit	8.59	8.52	8.50	8.49
Baseline Avg. Return	3.69	3.66	3.66	3.66
Baseline Savings ($)	89167	112405	120826	49597
Education Program FinLit	9.36	9.38	9.37	9.36
Education Program Avg. Return	3.75	3.73	3.73	3.73
Education Program Savings ($)	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 13 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 early in their life 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. Consequently, the education program leads the high school/associates group to have less savings than in their baseline case because they take advantage of having an endowment in financial literacy. This may

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 (1997) and Lusardi, Michaud, and O. Mitchell (2015) but I show how these results are influenced by income expectations. On the one hand, Bernheim, Garrett, and Maki (1997) 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. That 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 for individuals who expect their income to be rising significantly over the rest of their lives, the cost of upkeep is too great for the high school/associates group. On the other hand, Lusardi, Michaud, and O. Mitchell (2015) 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. This policy may be more effective at preparing individuals without a college education for later-life, by providing financial education when it is more relevant.

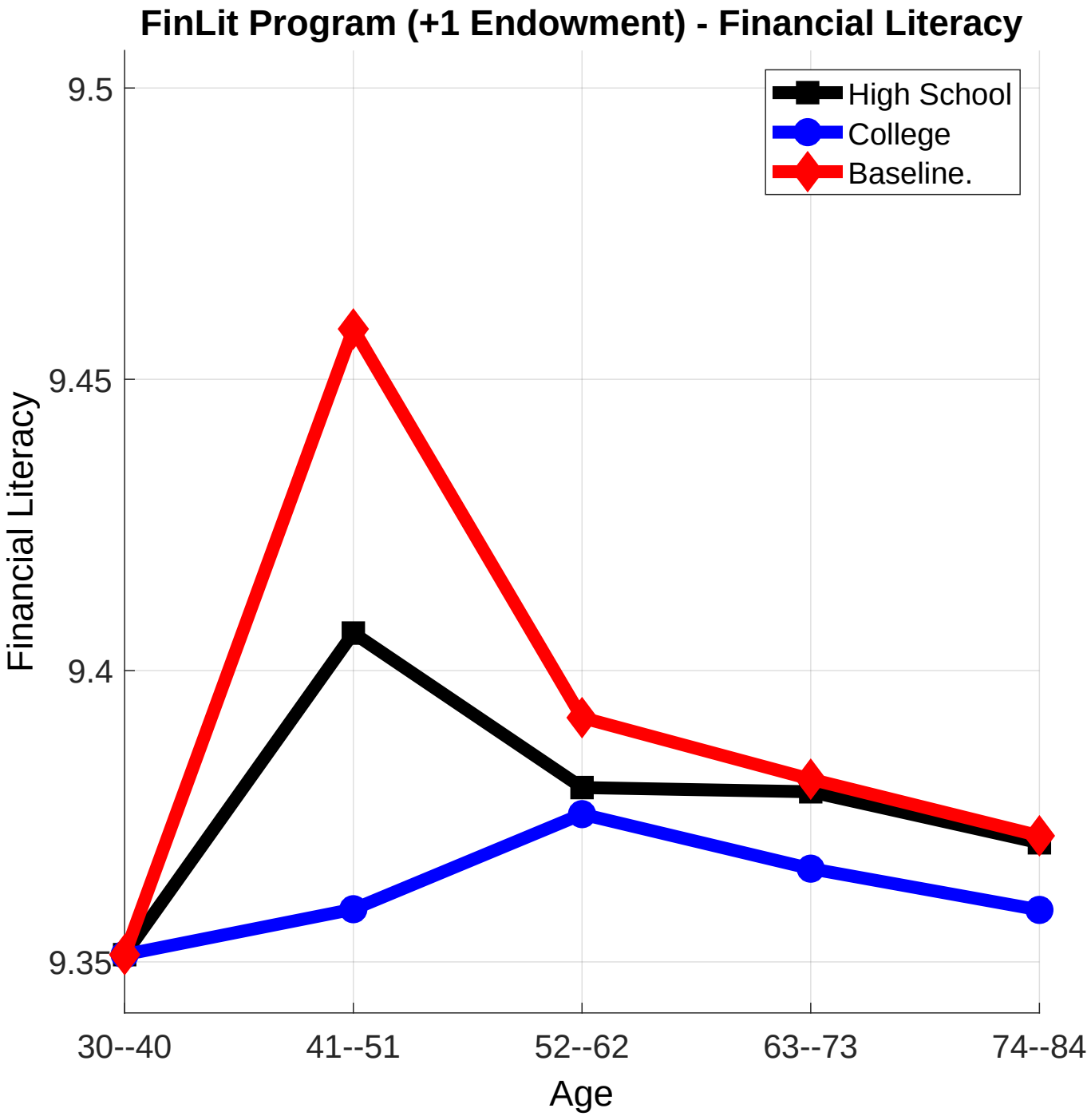


Figure 2.8: Financial Education Program - Financial Literacy

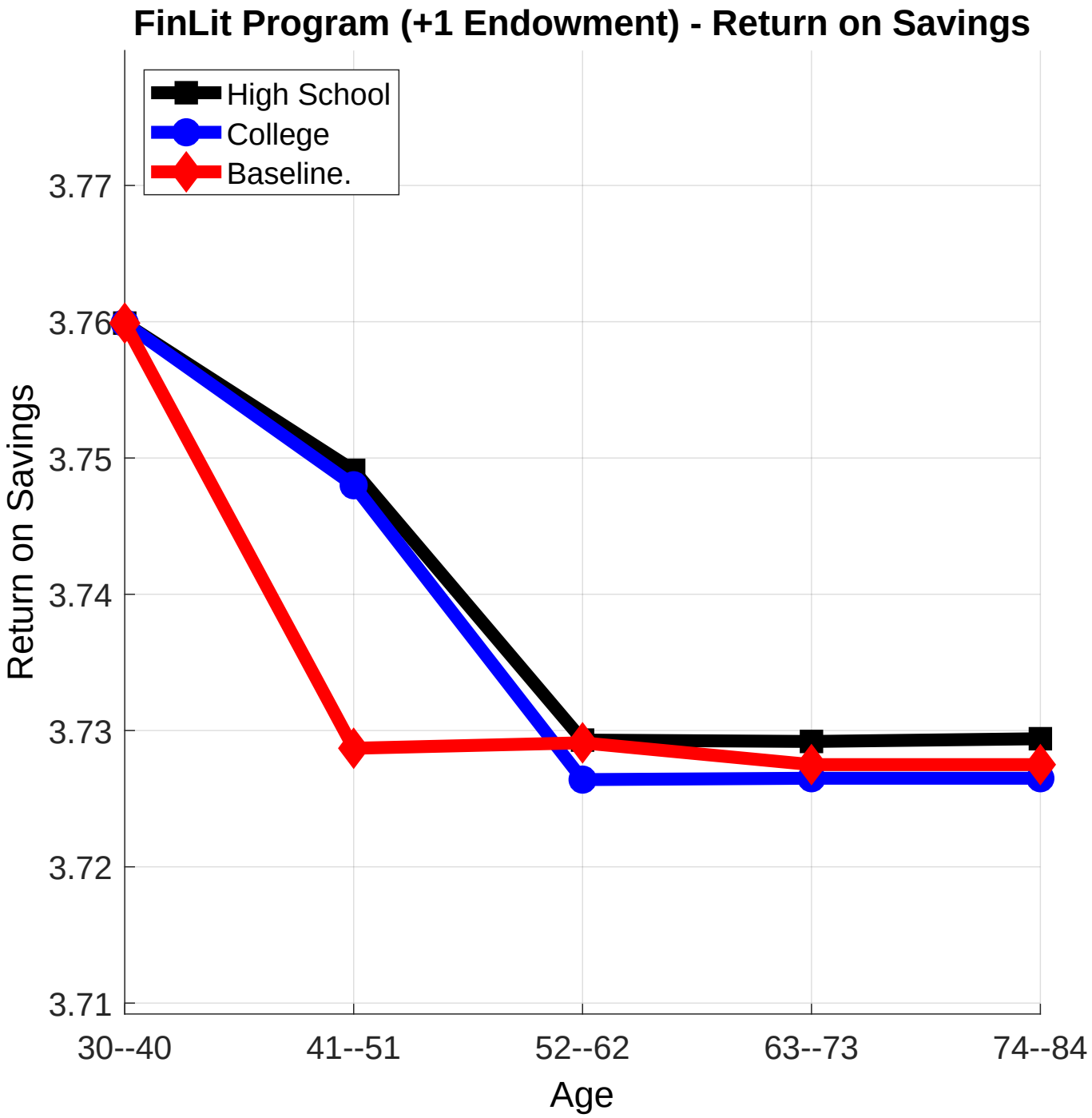


Figure 2.9: Financial Education Program - Interest Rate

2.4 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.

2.5 Appendix

2.5.1 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

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

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 Index

Four of my financial literacy questions are part of the "Big 5" (Hastings, Madrian and Skimmyhorn 2013). For 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? or don't know?"

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; Survey 118 (ms118_CI2) in year 2010 and survey 179 (int_rate_literacy), Survey 182 (ms118_CI2), Survey 186(q47), Survey 189 (bf1) and Survey 196 (q59) for year 2011.

Question 2 - Interest rates and Bond Prices

Observations for this question are taken from surveys 21, 50 and 64 for year 2009 and surveys 180 (in1) and 189 (in1) in year 2011. For the year of 2010, I take the median of the individual's score from 2009 and 2011. An example of this question is:

"If the interest rates fall/rise, what should happen to bond prices?

1. They should rise

2. They should fall

3. They should stay the same

4. Don't know

Question 3 - Inflation

This question is part of the "Big Three" (Hastings, Madrian, and Skimmyhorn 2012). The basic form of this question is:

"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

This question is part of the "Big Three" (Hastings, Madrian, and Skimmyhorn 2012). The basic form of this question 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 6 - Time Value in Money

This question has a few variations but the only difference is usually the quantity inherited. The basic question is:

"Assume a friend inherits $10,000 today and his sibling inherits $10,000 three years from now. Who is richer because of the inheritance?"

A version is in 21 (2009), 50 (2009), 64 (2009) and 189 (2011).

Question 7 - Highest Return

"Considering a long time period (for example 10 or 20 years), which asset normally gives the highest return?"

1. Savings Accounts
2. Bonds
3. Stocks
4. Don't Know

I use surveys 21, 64 (2009) and 180 (2011). For the year of 2010, the ALP does not have a survey that asks this question. As a consequence, I take the median score between an individual's response in 2009 and 2011.

Question 8 - Highest Fluctuation

This question has the form of:

"Normally, which asset described below displays the highest fluctuations over time: Savings accounts, Bonds or Stocks?"

1. Savings Accounts
2. Bonds
3. Stocks
4. Don't Know

I use surveys 21, 64 (2009) and 180 (2011). For the year of 2010, the ALP does not have a survey that asks this question. As a consequence, I take the median score between an individual's response in 2009 and 2011.

Question 9 - Highest Spread

""When an investor spreads his money among different assets, does the risk of losing money"

1. True
2. False
3. Don't Know

I use surveys 21 (2009), 50 (2009) and 189 (2011).

Question 10 - Difference between Traditional and Roth IRA

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

Question 11 - Early Withdrawal

"A person who withdraws money from a standard 401(k) plan or IRA after he turns 59½ does not pay taxes on the money that he withdraws."

1. True

2. False

3. Don't Know

I use surveys 64 (2009) and 189 (2011). For the year of 2010, the ALP does not have a survey that asks this question. As a consequence, I take the median score between an individual's response in 2009 and 2011.

Question 12 - Minimum Withdrawal

Question 12 asks about the minimum withdrawal

The question is asked as follows:

"After age 70 1/2, you have to withdraw at least some money from your 401(k) plan or IRA."

1. True

2. False

3. Don't Know

I draw from surveys 64, 189, 215. I do not observe this question in 2010, so I take the median between the score the years 2009 and 2011 for individuals in the sample.

Construction of Liquid Wealth

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 wealth is 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.

Construction of Average Return

I reported the Savings return as the weighted average return on savings received by individuals savings. In order to calculate the rate, I do the following for each period t:

1. Calculate the total interest accrued in period t
2. Calculate the total saving amount drawn in period t

Then the weighted rate is calculated as follows:

$$Average\ Return_t = \frac{Interest\ Factor_t}{Total\ Saving\ Amount_t} \tag{2.12}$$

This can then be multiplied by 100 to put this calculation in conventional percentage expression. The Weighted Savings Rate is calculated in the same way, with the appropriate changes.

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