Credit Shocks and Financial Literacy Accumulation

(Job Market Paper)

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Abstract

Do adverse borrowing conditions induce financial literacy accumulation? I calibrate a life cycle model with financial literacy investment and borrowing rate uncertainty 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 10% of the cost of investment leads households to increase their savings return by three basis points. In particular, the subsidy improves the welfare of low-income, highly leveraged households, by 0.2-0.25%.

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. 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 (Van Rooij, Lusardi, and Alessie 2011). 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 experienced hyperinflation, score better on inflation-related literacy questions than the world average (Klapper, Lusardi and Panos 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 in 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.

When individuals cannot borrow, they save more and invest slightly 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.

If instead individuals can borrow but cannot invest in financial literacy, they borrow more but arrive at retirement age with lower wealth than in the baseline case. 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 financial 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 investigate this trade-off by examining how the borrowing interest rate process affects household saving and financial literacy accumulation. When borrowing 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. On the contrary, when borrowing rates are not persistent, households expect borrowing to be costlier (cheaper) next period if they are cheap (costlier) today. On average, financial literacy is greater than the persistent case because households acquire financial literacy to insure against borrowing rate variation. An increase in the variance of the interest rate shock also encourages saving and financial literacy but less so; what matters the most is the households expectation of long-run

borrowing conditions. This exercise suggests that public policies may have additional effects on financial literacy acquisition by changing expectations about future borrowing conditions.

I follow up this exercise with a set of policy experiments. Financial literacy has been of recent concern for policy makers (Bernanke, 2011) and several proposals have been made to ameliorate the effects of low financial literacy. I simulate two of these 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.

A better option could be a financial literacy subsidy. 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%.

This 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.

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, paid with resources, that determines an individual's savings return.

The main focus is on the relationship between wealth and financial literacy, a correlation is commonly observed in empirical work (e.g. Bernheim et al. 2012). 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 investing in financial literacy.

Jappelli and Padula (2013) derive an estimable equation from their life cycle model with financial literacy investment and find that a one-point increase in financial literacy is associated with a 9% increase in wealth. Their model is limited because it constructed a deterministic, representative-agent model and therefore, cannot account for heterogeneity in agents.

The effect of idiosyncratic shocks is explored by Lusardi, Michaud and Mitchell (2017).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, these models are limited in explaining variation in financial literacy for individuals with low to negative wealth; for example, individuals tend to be net borrowers early in life. In order to account for observed differences in financial literacy, a financial literacy model should be augmented with shocks that are significant for young 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 et al. 2014).

My main contribution is to extend the financial literacy life cycle model to allow agents to borrow at a time-varying rate. Borrowing experiences early in life have a strong influence on financial literacy accumulation (Brown et al. 2019). Even small influences on financial literacy accumulation early in life can have large lifetime effects because they compound over the life cycle.

Credit Tightness and Financial Literacy Investment

I begin by documenting patterns of financial literacy investment using the ALP. The ALP is a probability-based panel that allows researchers to study financial literacy in a longitudinal setting and combine different surveys in order to construct unique datasets (Mottola and Kieffer 2017).

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 many unobserved factors that may influence financial literacy accumulation. First, I utilize the panel structure so that I can measure when financial literacy changes and account for invariant unobserved factors by estimating a fixed-effects regression model.

Second, I am able to identify individuals by Metropolitan Statistical Area (MSA) in the ALP and use this to exploit regional variation in credit tightness. Financial literacy may be correlated with the borrowing rate at which an individuals draw a loan and I construct a plausibly exogenous measure of credit availability to account for this. My measure of credit tightness 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 bank assets. A larger ratio indicates that a

bank is limiting its supply of loanable funds.

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.[1] 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 so often adopted in financial literacy research, that they 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, since they are not reducible to numerical calculation but require knowledge of specific economic concepts. These include a question testing the "money illusion" and a question on 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 (Van Rooij et al. 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 (Van Rooij et al. 2011).

Finally, three questions test a respondent's knowledge of retirement planning and

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

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 an 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; Fisch, Hasler and Lusardi (2019).

While each of these questions may be independently related to the loan-loss ratio, this does not mean they can necessarily be treated as a cohesive measure of financial literacy. To test the reliability of my financial literacy index, I calculate the Cronbach Alpha. This statistic is a measure of internal consistency or the degree to which the financial literacy questions covary with each other. I calculate a score of 0.73, which suggests the measure of financial literacy is acceptable and the score for my index is comparable to other studies of financial literacy (e.g. Hung et al. 2009).

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.

2 Measure of Credit Tightness

In order to proxy for local credit tightness, I use the average annual loan loss reserve to total loan ratio for an MSA 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, since these assets are put into reserve instead of being lent out. These changes signal to investors bank expectations about future losses (Docking, Hirschey and Jones 1997; Ahmed, Takeda and Thomas 1998) and may cause investors to withdraw funds. As a result of these different effects, 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 loan-loss ratio is positively associated with a .07–.09 percentage point increase in mortgage rates.

3 Relationship between Credit Shocks and Financial Literacy

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

$$\Delta FinancialLiteracy_{ijt} = \alpha_i + \beta_1 \Delta LoanReserve_{jt} + \gamma \Delta X_{ijt} + \delta_t + \Delta \varepsilon_{ijt} \quad , \tag{1}$$

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 individual fixed effects, denoted by α_i, control for the stock of financial literacy that individuals may have at the beginning of the panel as well as other invariant characteristics such as their demographic background. 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.

In order to account for 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.[2] 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-level measure by their deposit-share in that market.

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

[2]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.

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 plots out the life cycle profile for the percentage of questions answered correctly by 5-year age-band.[3] Individuals accumulate financial literacy over their lifetime but the rate of accumulation decreases after age 50.[4]

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 with a quadratic age term and several interactions.[5] The augmented regression becomes:

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

Column 2 in table 5 reports the result of the regression with the addition of a quadratic age term.[6] 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

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

[4] The peak in figure 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.

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

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

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:

$$Log(Liquid\_Wealth_{ijt}) = \alpha_i + X_{ijt}\gamma' + \delta_t + \varepsilon_{ijt} \quad , \tag{3}$$

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 3 on financial literacy. Table 6 reports the results of the regression. I find that Financial Literacy ($FinLit_{ijt}$) is positively associated with the residual from the regression in equation 3 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 (high and low financial literacy) and find a similar estimate. This result is consistent with previous research that has found financial literacy and wealth to be positively correlated (Bernheim et al. 2012; Jappelli and Padula 2013).

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 (1998) and Fulford (2011). Their models have a stochastic credit constraint but I chose a stochastic borrowing rate in my context in order to better link the model to the motivating regression.

A Model of Financial Literacy Accumulation and Credit Shocks

1 Household

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:

$$\max_{\{c_t\}_{t=0}^{J}} E_0 \left[\sum_{t=0}^{J} \beta^t \frac{c_{t+1}^{1-\gamma}}{1-\gamma} \right] \quad . \tag{4}$$

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:

$$y_t = w \times e_t \times exp(\eta_t) \quad , \tag{5}$$

where $\eta_{t+1} = \rho_\eta \eta_1 + \varepsilon_{t+1}$ and $\varepsilon_{t+1} \sim N(0, \sigma_\varepsilon^2)$.

2 Asset and Financial Literacy choice

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

$$r(\Phi_t) = A\Phi_t^\alpha + r_{base}^s \quad . \tag{6}$$

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 relationship between financial literacy and savings assets.[7] Explanations for the relationship include making less fiduciary mistakes (Lusardi and Tufano 2009); knowledge of savings instruments' returns (Deuflhard, Georgarakos and Inderst 2015); and better retirement planning (Lusardi and Mitchell 2007).

The α parameter is the elasticity of financial literacy investment. I assume $\alpha \in (0, 1)$ so that agents face diminishing returns to financial literacy investment. The parameter A is the 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.

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

The structure of the production function follows from previous empirical work that has found diminishing returns to financial literacy education. Both Cole el al. (2011) and Fort et al. (2016) find that financial literacy interventions are less effective for higher educated individuals. This is likely because higher-educated individuals tend to already have high financial literacy (Lusardi et al. 2010), so that the benefit to additional financial literacy investment is lower than it is for less educated individuals. A life cycle profile has also been observed in terms of financial literacy accumulation and depreciation. Older individuals tend to have at least accumulated some financial literacy from experience (Eberhardt et al. 2019), so they likely face a diminishing marginal benefit to an additional unit of financial literacy.[8]

Following Jappelli and Padula (2013), I will allow individuals to accumulate and de-accumulate financial literacy.[9] In every period t, an individual can invest ℓ_{t+1} in their financial literacy stock. They face a cost of p per unit of financial literacy.

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

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

$$\Phi_{t+1} = (1 - \delta)\Phi_t + \ell_{t+1} \quad . \tag{7}$$

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

[8] 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.

[9] 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.

investment constraint:

$$\ell_{t+1} \geq 0 \ . \tag{8}$$

3 Borrowing

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

$$s_{t+1} \ \geq \ \sum_{t}^{J} \frac{-y_{min}}{1 + r_b^{max}} = \overline{b_{t+1}} \quad , \tag{9}$$

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.[10]

The time-varying borrowing interest rate, $r_{b.t+1}$, follows an AR(1) log-normal process:

$$r_{b,t} = \rho_r r_{b,t-1} + \nu_t \quad , \tag{10}$$

where ρ_r is the persistence parameter of the interest rate shock and ν_t is the innovation. Agents know the distribution of the shock process and form expectations based on this knowledge. 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.

Note that agents can borrow to finance their financial literacy. Previous models of financial literacy have lacked this feature but it allows me to model people with low or negative assets but increasing financial literacy, such as young persons.

[10] 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.

4 Asset Path

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

$$X_t = y_t + (1 + r(\Phi_t))s_t \mathbb{1}\{s_t \geq 0\} + (1 + r_{b,t})s_t \mathbb{1}\{s_t < 0\} \quad . \tag{11}$$

Their borrowing, consumption and financial literacy decisions are conditioned by the current states and their knowledge of the income and credit interest rate process. Financial literacy investment and borrowing serve as two different avenues for consumption smoothing. They are both complementary and contradictory.

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) found that individuals who had access to borrowing reported higher levels of financial literacy than individuals who had grown up without such access.

As the return on savings is increased by financial literacy investment, the opportunity cost to borrowing also increases. As a consequence, the realized borrowing rate will fall since more financially literate individuals will refrain from borrowing unless they get a sufficiently low interest rate. In other words, they 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). Furthermore, financially literate individuals tend to have higher retirement wealth (Lusardi and Mitchell 2007), liquid assets and lower debt (Gorbachev and Luengo-Prado 2019).

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 written as:

$$s_{t+1} = X_t - c_t - p\ell_{t+1} \quad . \tag{12}$$

5 Consumer Problem

Combining the savings path (12), the financial literacy path (7), the income process (5) and the credit interest rate process (10), I define 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 ($\hat{r}$).

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

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

s.t

$$s_{t+1} = (1 + r(\Phi_t))s_t \mathbb{1}\{s_t \geq 0\} + (1 + r_{b,t})s_t \mathbb{1}\{s_t < 0\} + y_t - c_t - p\ell_{t+1} \tag{13}$$

$$\ell_{t+1} \geq 0 \tag{14}$$

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.

Quantitative Analysis

1 Calibration

The initial distribution for financial literacy and liquid networth is taken from the empirical joint distribution of my sample for individuals 30–40. This distribution is likely

the result of differences in high-school and college education requirements (Bernheim, Garrett and Maki 2003), as well as family background (Lusardi, Mitchell and Curto 2009).

For the discount 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.[11] Following Lusardi, Michaud and Mitchell (2017), I set the cost of financial literacy, p, to .06 in order to approximate financial literacy cost to $ 500 dollars a year.[12]

I calibrate the three remaining parameters−the the elasticity of financial literacy investment (α) , the productivity of financial literacy stock (A) and the depreciation rate (δ)−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 will be willing to borrow to invest is 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 change and borrowing 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 by late-life

[11]This can also be thought of as the inverse of the coefficient of variation. Details can be found in Appendix.

[12]My model is normalized to $83000 and .06 of $83000 is $4980 or about 500 dollars per year.

declines in financial literacy.

The model is solved using a grid search method with 160 saving 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

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)
ρ_y	0.911	Income Persistence
σ_ε^2	0.225	Income Shock Std.
ρ_r	0.703	Borrow Rate Persistence
σ_ν^2	0.136	Borrow Rate Std.
α	.55	Investment Elasticity
δ	0.06	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) is 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 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 follows the borrowing profile over the life cycle. 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.[13] Similarly, 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 general trend of the outcomes in the early life cycle because they are mainly related to latter life choices.

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 Liquid Net Worth				
$Borrowing^{Data}$(%)	18.4	15	10.7	7.2
$Borrowing^{Model}$(%)	16.5	13	1	0

Liquid Net Worth: liquid wealth- credit card debt.

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

Counterfactual Experiments

1 The Importance of Financial Literacy for Consumption Smoothing

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

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 have about $2000 more in savings 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 the resources they have on hand. Their welfare loss is more than double 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 instead do not allow financial literacy investment. The distribution of welfare losses is now the reverse: households with 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 $200–400 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
Savings Return (%) - Age 41	3.77	3.77	2.0
Savings Return (%) - Age 63	3.78	3.78	2.0
Savings ($) - Age 41	67212	69104	67090
Savings ($) - Age 63	90227	90243	89803
Financial Literacy (out of 12) - Age 41	8.73	8.73	8.34
Financial Literacy (out of 12) - Age 63	8.83	8.83	8.34
Δ Welfare From Baseline (%)	0	–0.13	–0.95

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)	–.01	1.8	–.13
Low-Income, Young	0	0	–.40
Retirement	0.01	0	–.01
Low-Income, Retirement	0.01	0	–.003

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).

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

State	Δ FinLit Invest (%)	Δ Savings (%)	Δ Welfare (%)
Young (Age 30)	–4.60	–0.20	–0.95
Low-Income, Young	–2.00	0.00	–0.11
Retirement	–0.60	–0.19	–0.97
Low-Income, Retirement	–4.90	–0.15	–1.12

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).

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. When individuals borrow, they do not know the real value that they will have to pay back in the next period. However, individuals do know the borrowing rate process and form expectations 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. The credit card market, for example, is relatively sticky (Ausbel 1991) and may not put pressure of uncertainty on individuals in the same way that could happen in the adjustable-rate mortgage market. This suggests that a market with greater interest rate uncertainty should encourage greater financial literacy investment.

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 set to zero. This is effectively an independent and identically distributed (iid) shock process. On average, individuals have about 3–4% more financial literacy at every age and see an increase in the average return of about 2 basis points. Table 10.B that every group is increasing financial literacy and savings, especially young individuals with low-income. They increase their financial literacy by 8.2% and their savings by almost 100% from the baseline model. Borrowing is especially important for this group because they are cash-constrained. Based on my model's calibration, the increase in financial literacy for young, low-income individuals raises their return on savings by 10 basis points (0.1 percentage points) and because this will compound over the life cycle, this has significant effects on savings. The wealth-to-income ratio is more than 100% greater than the baseline. The reason for this change can be inferred from the welfare loss (2.2%); individuals are saving more and investing in financial literacy for precautionary purposes.

When households are in a low borrowing interest state, they expect borrowing to become costlier 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

Table 10.A: Interest Rate - Persistence

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

	Savings Return		Wealth-to-Income		Financial Literacy (out of 12)		Δ Welfare from Base %
Age	41	63	41	63	41	63	
$\rho_r = .7037.$	3.77	3.78	1.18	1.79	8.73	8.83	0
No Persistence							
$\rho_r = 0$	3.77	3.80	2.5	3.3	9	9.2	-2.2
Increase in Variance							
$\nu_t = 0.272$	3.77	3.78	1.18	1.2	2.05	.04	-.03

Notes: Baseline is $\rho_r = .7037$ and $\nu_t = 0.272$.

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 realized outcomes (wealth-to-income, savings return) do not significantly change. The breakdown of the counterfactual in table 10.C shows that the major change is that young individuals increase their savings by about a percent (approximately $2000). The reason why the variance does not have as strong of an effect is because while it changes the spread of borrowing interest rates, the decision to borrow is still primarily an early-life decision. Hence, the welfare change 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 - No Persistence

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	3.0	30	-2.2
Low-Income, Young	8.2	93.2	30
Retirement	4.5	27.5	-1.5
Low-Income, Retirement	6.7	64	3.04

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).

Table 10.C: Percent change in decisions by Group - Doubled Variance ($\sigma_\nu^2 = .272$)

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	–0.03	0.85	–.03
Low-Income, Young	0.03	0	–.135
Retirement	0.01	0.004	.001
Low-Income, Retirement	0.02	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.

3 Effect of Interest Rate Cap

For my first policy experiment, I will evaluate the effect of an interest rate cap. In May 2019, legislation was proposed in congress to cap credit card interest rates at 15 %.[14] Empirical research has found that individuals with low financial literacy tend to borrow at higher interest rates (Huston 2012; Lusardi and 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

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

Table 11.A: Interest Rate Cap

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

	Savings Return (%)		Savings ($)		Debt-to-Income		Δ Welfare from Base %
	41–51	63–73	41–51	63–73	41–51	63–73	
No Cap	3.77	3.78	67212	90227	.07	.03	0
Interest Cap = $r_{bt}^{max} = 15\%$							
$\zeta(r_{bt}) = 0$	3.77	3.78	67079	90227	.07	.04	0.014
$\zeta(r_{bt}) = 10\%$	3.77	3.78	68545	90235	.05	.08	–0.1
W/o Financial Literacy							
$\zeta(r_{bt}) = 0$	2	2	66751	89770	.07	.04	–0.9
$\zeta(r_{bt}) = .10\%$	2	2	68217	89804	.05	.08	–1.0

Notes: Baseline $r_{bt}^{max} = 22\%$.

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. Therefore, 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.

I augment equation 11 to include a measure of credit rationing. The new equation becomes:

$$X_t - p\ell_{t+1} - s_{t+1}\mathbb{1}\{s_{t+1} \geq 0\} - (1 - \zeta(r_{b,t}))s_{t+1}\mathbb{1}\{s_{t+1} < 0\} \quad , \tag{15}$$

where $\zeta(r_{b,t})$ is the probability of being denied credit.

Table 11.A reports the results of the interest rate cap, both with and without rationing.[15] The effect of the interest rate cap on financial literacy, for both rationing and non-rationing cases, is very slight: individuals slightly decrease their financial literacy when borrowers do not ration (table 11.B) and slightly increase their financial literacy when borrowers ration (table 11.C). This is consistent with the results of the variance exercise in table 10.A because the cap is implicitly a decrease in the variance of the borrowing rate. Furthermore, individuals save about $200 less with the interest rate cap but when borrowers begin rationing credit, they save about $600 more when they are young for precautionary reasons. Tables 11.B and 11.C report the breakdown of the results by several cohorts. The group that gains the most with the cap but loses the most with the rationing is the low-income, young group, whereas the retirement age group is almost completely indifferent to the policy.

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

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	–0.01	–0.04	0.04
Low-Income, Young	0	–.01	0.14
Retirement	–0.01	–0.002	0
Low-Income, Retirement	–0.01	–0.01	.002

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).

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

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

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	–0.03	1.9	–.05
Low-Income, Young	0	0.08	–.07
Retirement	0.01	0.001	-.001
Low-Income, Retirement	0.01	0.004	0

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).

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 report 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.

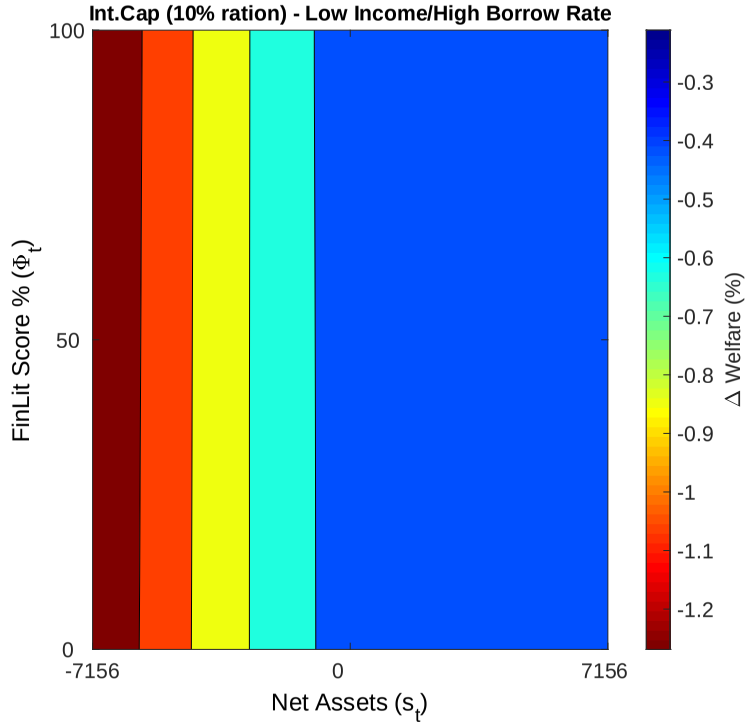
Figure 11.D plots out the distribution of welfare losses for four groups in a set of contour plots. The age-group shown is 30–40 year-olds (initial age). The x-axis represents the savings state and the y-axis is the financial literacy stock. The only group that is indifferent to the policy is the high-income, 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%.

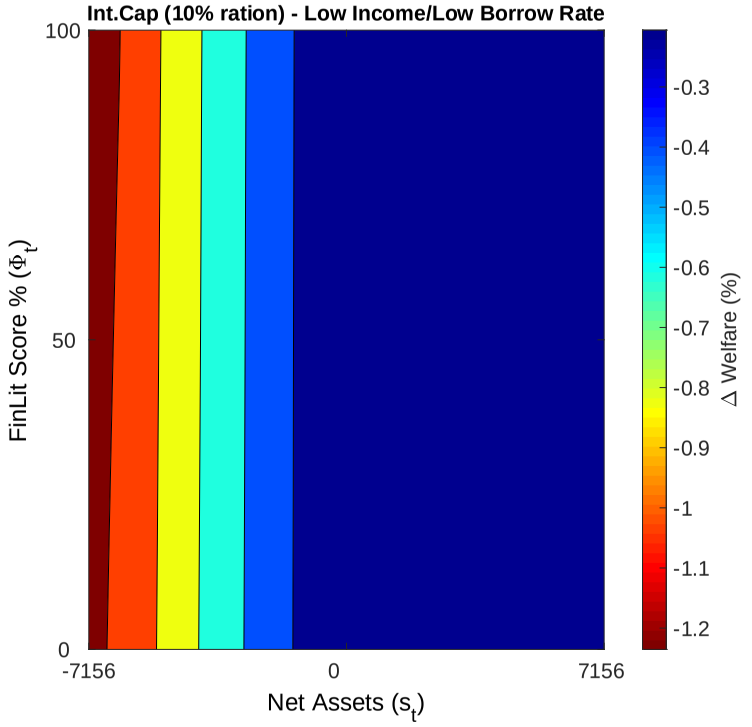
On the contrary, for the low-income groups, welfare slightly decreases as their stock of financial literacy is increasing. For this group, the wealth effect is dominant and the more financially literate individuals would like to borrow against future wealth, but face

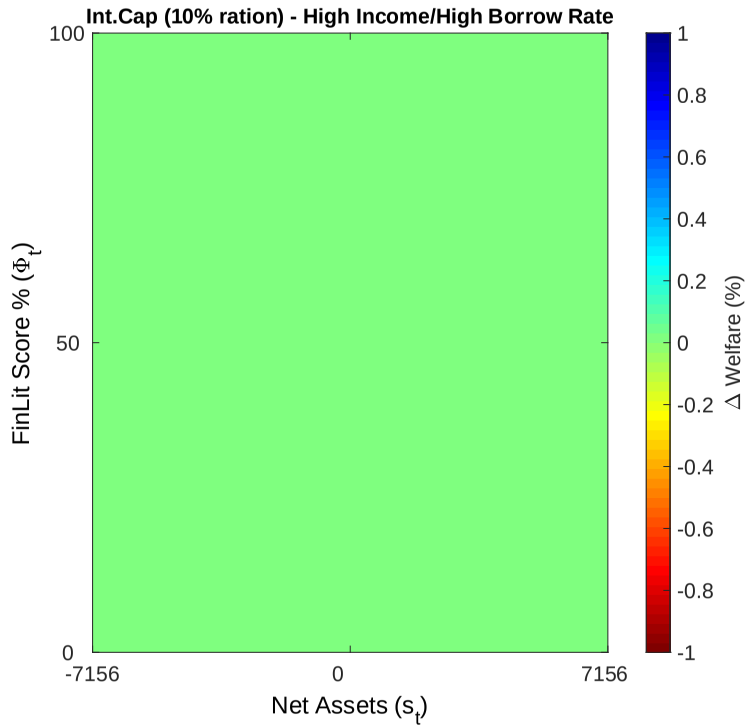
credit constraints.

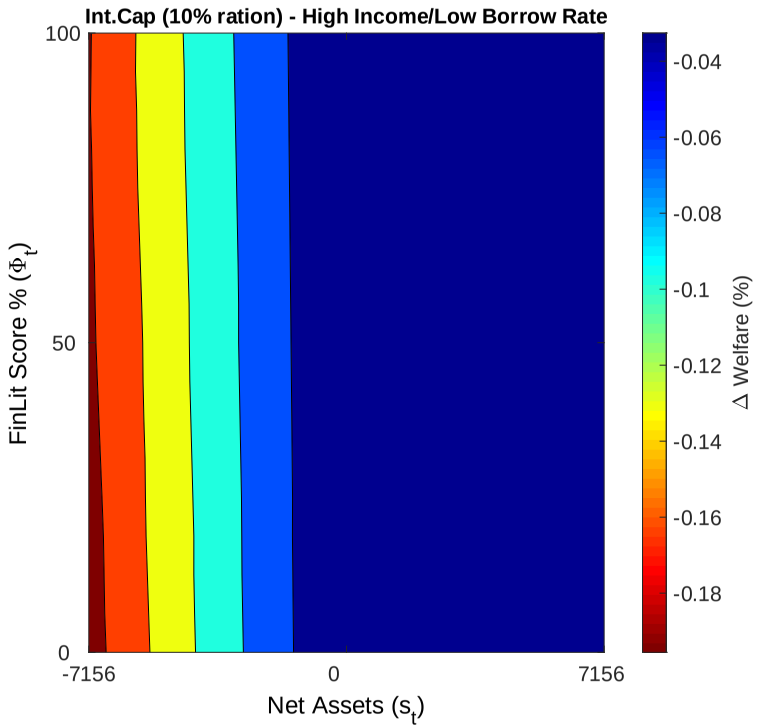
The effect of the interest rate cap is ambiguous. Individuals with low financial literacy and low-income would benefit from lower borrowing prices but credit rationing would harm them the most. A potentially better policy would be to improve their financial literacy and encourage them to shift towards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

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









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.[16] 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).[17] Since individuals in low-income cohorts may be more likely to be in a distressing financial situation, this counter-point would suggest that they be more receptive to financial literacy. 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 .03% 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 the wealth-to-income ratios remain 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.

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

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

Table 12.A: Subsidy Program

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

	Avg. Return (%)		Wealth-to-Income		Financial Literacy		Δ Welfare from Baseline %
Age	41	63	41	63	41	63	
No Subsidy	3.77	3.78	1.18	2.05	8.73	8.83	0
Full Population							
τ= .1	3.78	3.81	1.18	2.05	8.82	9	.03
$\tau = .3$	3.82	3.84	1.18	2.05	9.03	9.33	.2
Youth Subsidized Only							
τ= .1	3.78	3.79	1.18	2.05	8.8	8.86	.01
$\tau = .3$	3.81	3.8	1.18	2.05	9.0	9.0	.04

Notes: The subsidy τ covers p*τ of the cost of financial literacy.

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

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	1	0.01	0.06
Low-Income, Young	1	0	0.12
Retirement	1.6	0.01	0.04
Low-Income, Retirement	1.1	0.001	0.10

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).

Table 12.C: Percent change in decisions by Group - Financial Subsidy for Youth Only

State	Δ FinLit Invest (%)	Δ Savings ($)	Δ Welfare (%)
Young (Age 30)	0.82	0.01	0.01
Low-Income, Young	0.33	0	0.01
Retirement	0.32	0.01	0
Low-Income, Retirement	0.34	0.001	0

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).

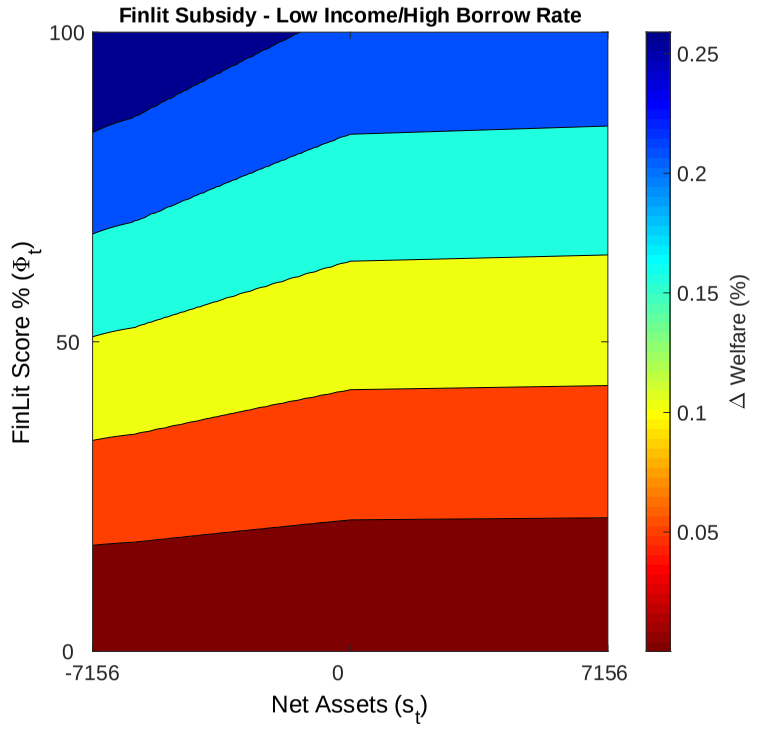
The long-term effect of a one-time subsidy is shown in the last two rows of table 12.A. In this policy, the subsidy is only offered for the initial age. Individuals see their average return increase by about 1 basis point at all ages. However, the welfare gain is much less. Comparing the welfare gains in tables 12.B and 12.C for the young groups, the one-time subsidy improves welfare and increases financial literacy for these groups noticeably less. The low-income group, for instance, sees a welfare gain of one-twelfth of the gain in the full subsidy and increases their financial literacy by about 70% less than

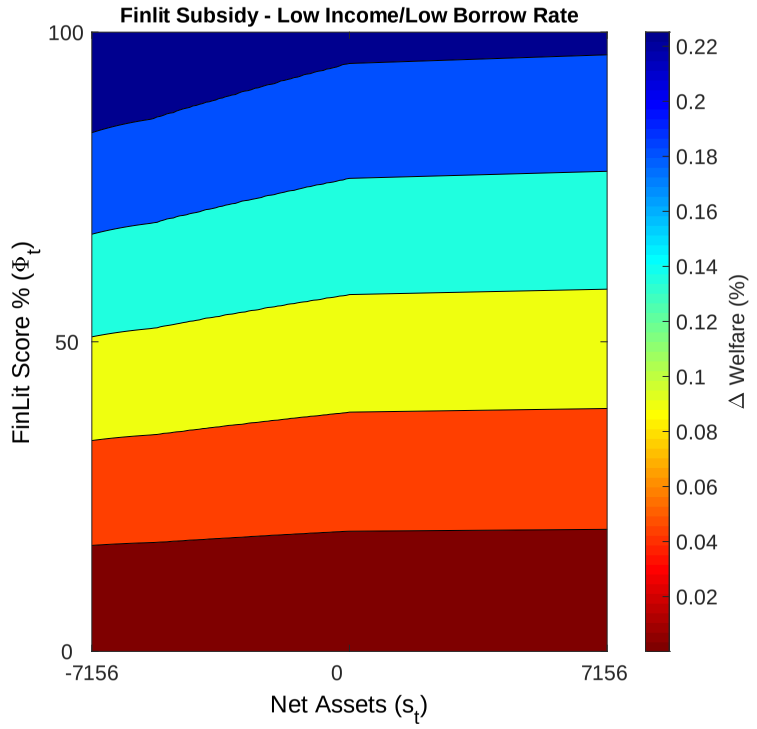
the full subsidy. This is because the low-income, young group have lower savings on average and the immediate benefit of the subsidy is relatively less. When the subsidy is offered for all ages, individuals take into account the value of literacy for when they will have accumulated savings. This highlights 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.

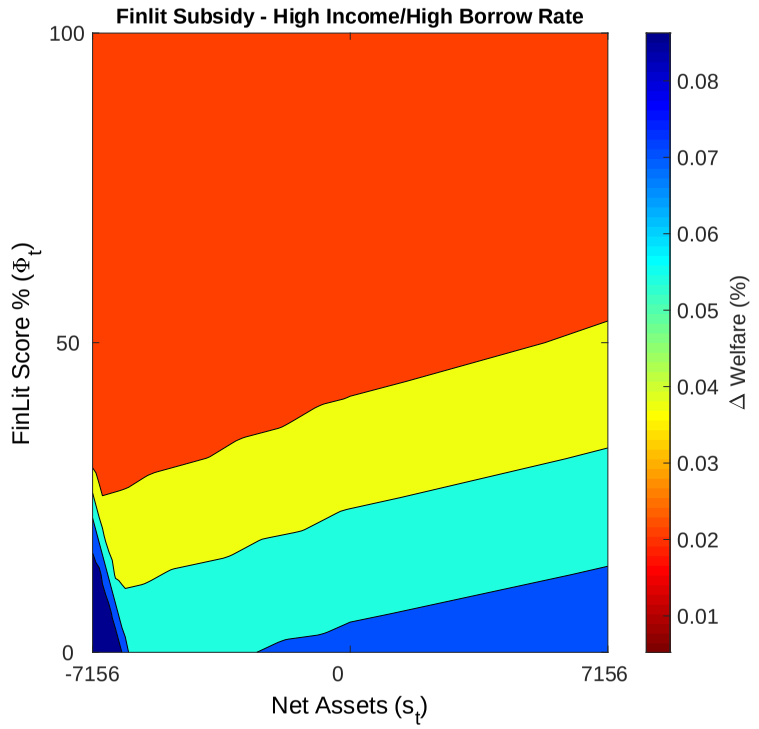
Figure 12.D shows the welfare distribution for the 10% subsidy. The greatest welfare gains are for low-income individuals, especially if they face high-borrowing rates and are leveraged. For this group, the financial literacy subsidy is more beneficial the greater the existing stock of financial literacy. 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.

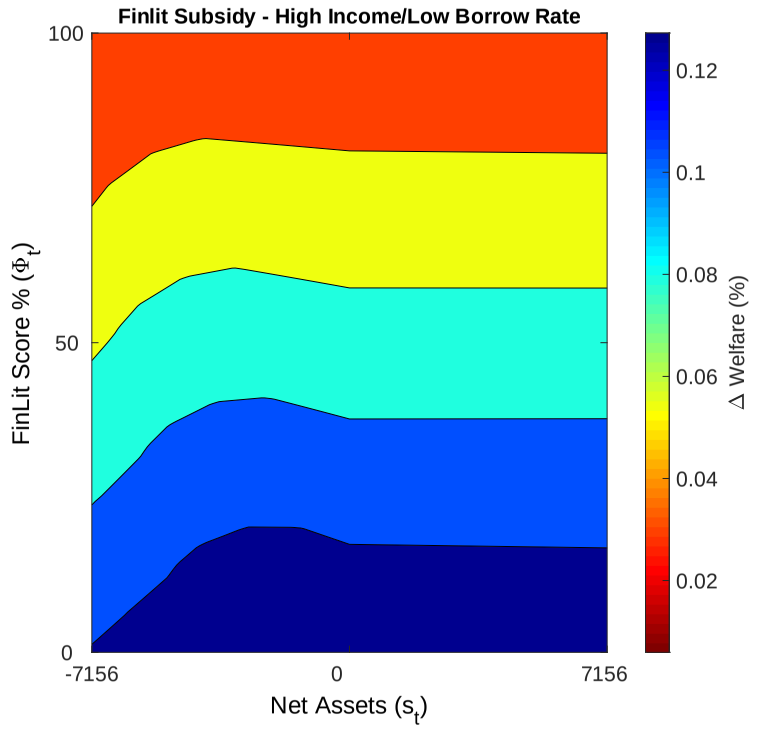
When individuals have high-income (lower two panels), the low financial literacy group benefits the most from the policy because they have a greater marginal return to financial literacy investment. In this case, it is the leveraged groups that benefit less from the subsidy because the high-income cohort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

Table 12.D: 10% Financial Literacy Subsidy









5 Conclusion

In this paper, I developed a model of endogenous financial literacy accumulation to explore how borrowing interest rate shocks over the life cycle influence financial literacy decisions. I found that an agent's expectation about the cost of borrowing had the greatest effect on financial literacy accumulation. When agents expect credit to be costly, 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. This matters because financial literacy persists over the rest of a person's life cycle. While this insight is important for understanding the potential consequences of a public policy, it does not offer a positive prescription. Therefore, I show that a financial literacy subsidy can improve welfare, especially for low-income, leveraged households, but an interest rate cap may adversely affect this same group. The implication of these two policy experiments is that any monetary policy that reduces the cost of borrowing should be coupled with a target 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.

Appendix

1 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.

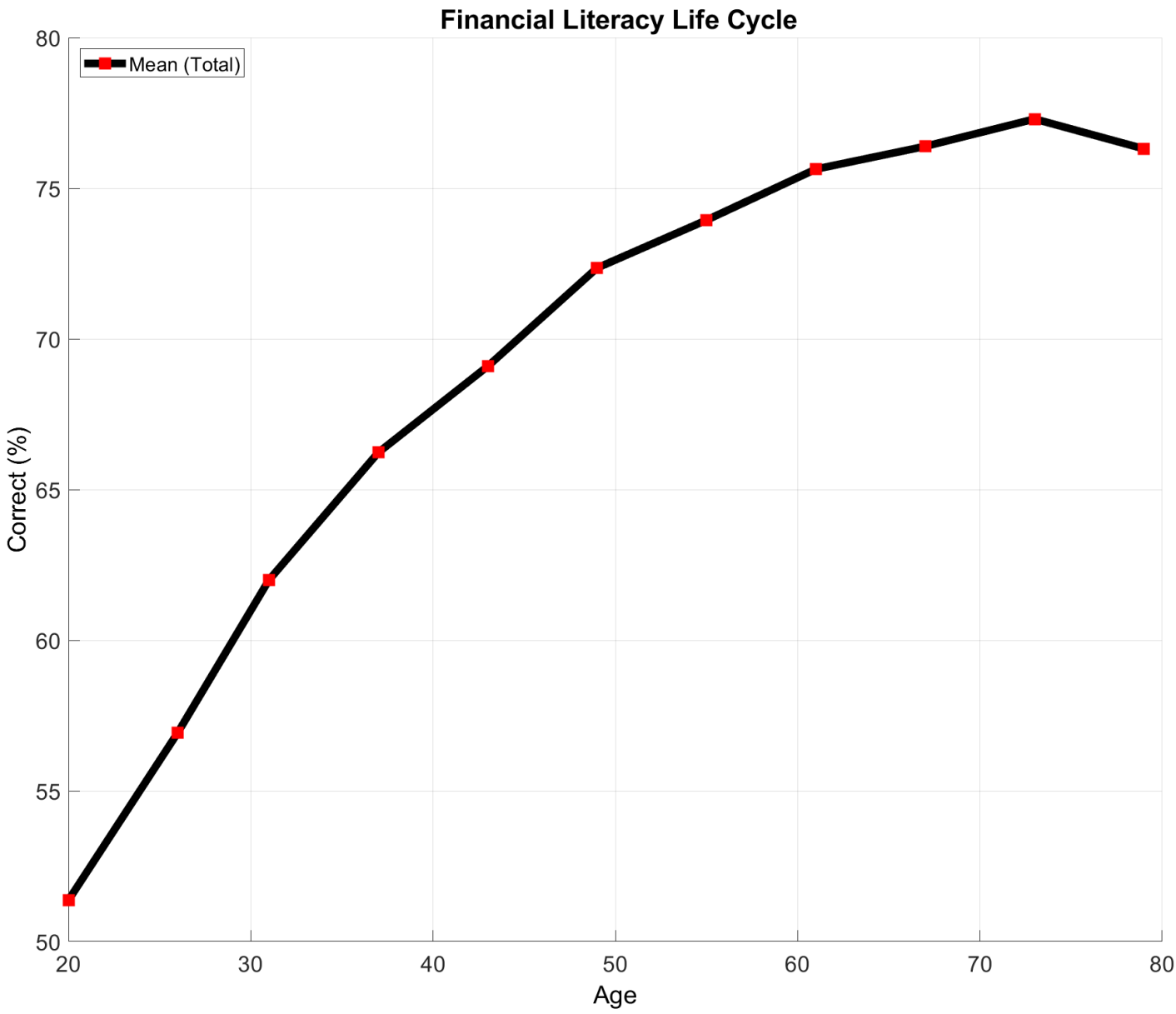

Financial Literacy Life Cycle
Mean (Total)
Correct (%)
Age
80
75
70
65
60
55
50
20
30
40
50
60
70
80

Figure 1

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.

Data Construction

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

Question 1 - Numeracy

"Suppose you had $100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow: more than $102, exactly $102, less than $102?"

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

"Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?"

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

Question 4 -Risk Diversification

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

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

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

Question 5 - Money Illusion

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

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

Question 6 - Inheritance

Question 10 - IRA taxation

Question 10 asks

"Which of the following statements are true?

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

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.

Both are true

Don't know

Question 11 - Minimum Withdraw

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.[18] 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

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.[19]

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 [Sam-

[18]The variable label says "fill for city nearest to R zip code," where R means respondent.
[19]This applies only to survey 36, which was in field form 2008 to 2013.

ple2]") 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.[20]

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 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.[21] For the loan loss allowance, I use *lnatres* as the loan loss allowance.

$$LoanReserveRatio_{jt} = \frac{Loan\ Loss\ Allowance_{jt}}{Total\ Loans_{jt}} \times 100 \tag{16}$$

[20] 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).

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

3 Model Features and Calibration

Construction of Saving 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 peirod t

Then the weighted rate is calculated as follows:

$$Saving\ Return_t = \frac{Interest\ Factor_t}{Total\ Saving\ Amount_t} \tag{17}$$

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.

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.[22] The average interest rate is 14.6, with little variation across age cohorts.

[22]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).

4 Calibration of AR(1) income process

Consider an AR(1) process as follows:

$$y_t = \rho y_{t-1} + \varepsilon_t \tag{18}$$

The mean for a discrete random variable is calculated as follows:

$$E(y) = \sum_{i=1}^{N} P(y_i) y_i \tag{19}$$

where $P(y_i)$ is the probability mass for value y_i.

The variance for a discrete random variable is calculated as follows

$$\sigma_y^2 = \sum_{i=1}^{N} P(y_i)(y_i - E(y))^2 \tag{20}$$

Taking the square root, the standard deviation is $\sqrt{\sigma_y^2} = \sigma_y$.

To calibrate the AR(1) process, I normalize the sample data to the mean income of the youngest age-cohort (83020.83) and normalize the model's initial age-earnings profile to one.

1. First, guess feasible values for ρ and σ_ε^2.
2. Simulate 1000 grid points.
3. Calculate the mean and standard deviation using 19 and 20.
4. Repeat until the mean-to-standard deviation ratio of the stationary AR(1) process matches standardized ratio in the sample data.

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