Credit Shocks and Financial Literacy Accumulation

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Abstract

Does interest rate uncertainty induce financial literacy investment? I construct a novel dataset using the American Life Panel and find that households acquire financial literacy when credit tightens. I use the dataset to calibrate a life cycle model with financial literacy investment and borrowing uncertainty. When borrowing rates are less persistent, young households invest more in financial literacy to insure against future borrowing constraints. A financial literacy subsidy of about $83 a year over ten-years increases returns on savings by 0.06 percentage points and increases the welfare for low-income, highly leveraged households by 1.2–1.4%.

Introduction

Each year, households pay dearly for mistakes they make budgeting their finances. Everything from credit fees to mortgage mismanagement can cost households tens of thousands of dollars. Economists have promoted financial literacy as a skill to avoid financial errors but it remains low worldwide. The 2014 S&P Global FinLit Survey found that only a third of adults could correctly answer 75% of a financial literacy test. If financial literacy is valuable, what accounts for this low level?

Financial literacy is partly a *choice*. A rational individual may be financially ignorant, if the cost of acquiring financial literacy is too high. However, the benefits of financial literacy vary with circumstances. People in economic distress often find that the benefits outweigh the costs: individuals are more likely to retain financial education when they are bankrupt (Wiener et al. 2005).

I document that borrowing uncertainty encourages individual to acquire financial literacy. Using a novel dataset constructed from the American Life Panel (ALP), I calibrate a life cycle model with financial literacy investment and borrowing uncertainty. I find that such uncertainty induces people to invest in financial literacy in order to better deal with future credit constraints. I show that policies that make borrowing easier, such as an interest rate cap, discourage financial literacy investment and lead to lower retirement wealth. If instead individuals have financial literacy investment subsidized, they increase their return on savings and increase their retirement wealth.

The ALP is a probability-based panel that allows independent researchers to sample from their panel's pool and merge any survey in their archive.[1] This feature allows me to build a unique dataset with a time-varying index of financial literacy: a set of 12 questions that test an individual's knowledge of finance, taxation and retirement planning. I merge

[1] I also utilize data from the FDIC and Survey of Consumer Finance, but the unique measure of financial literacy is constructed using the ALP.

this index with bank-level data from the FDIC to estimate the effect of a proxy for credit tightness—the local average loan-reserve ratio— on change in financial literacy.

I find that a percentage point change in credit tightness is associated with a change in financial literacy a quarter standard-deviation above the average change. Furthermore, older individuals invest less on average. 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 to benefit from financial literacy.

Using the implications from the regression analysis, I calibrate a life cycle model with financial literacy choice and borrowing uncertainty to the ALP. The model is able to replicate the life cycle profile of financial literacy investment. For model validation, I demonstrate that the model can also match age-cohort borrowing percentages in the Survey of Consumer Finance 2010.

I evaluate the partial contributions of various features of my model. When individuals cannot borrow, they increase their savings and financial literacy. However, welfare falls because individuals do not have an alternative consumption smoothing instrument. On the other hand, when individuals cannot invest in financial literacy, they borrow more but arrive at retirement with less wealth. The experiment demonstrates the complementary functions of borrowing and financial literacy investment over the life cycle. Borrowing lets individuals consume earlier in their lives and when they are hit with a negative income shock. Financial literacy allows individuals to insure against negative shocks and increase their return on wealth.

I investigate the transition from net borrower to net saver by exploring the effect of different levels of borrowing rate persistence on household decisions. When borrowing rates are very persistent, households transition less frequently because they expect to either have low borrowing interest rates for life or for borrowing to remain costly. Compared to the baseline, only households with high income and high borrowing rates invest

more in financial literacy because they trade-off borrowing with financial literacy investment as a means to smooth consumption. On the other hand, when borrowing rates are less persistent, individuals save more and invest in financial literacy more on average out of precaution.

Financial literacy has been a 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 in 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 savings from the lower borrowing rates are not funneled into greater savings or financial literacy investment.

On the other hand, a subsidy program has a more direct effect. For a subsidy which covers 10% of the cost of a financial literacy investment, the average return on savings is increased by 0.06 percentage points from the baseline case and welfare increases by 0.12% from the baseline. Low-income and highly-leveraged individuals benefit the most from the subsidy (increase in welfare by 1.2–1.4%) , suggesting that a better way to improve welfare may be to subsidize low-income individuals, especially those in debt.[2]

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.

[2]Some studies have found financial education to be less effective with low-income recipients (e.g. Kaiser and Menkhoff (2017)) but it is also possible that financial literacy interventions did not cover a sufficient amount of the cost to induce participants in the intervention to retain the education.

1 Literature Review

My work builds most immediately on that of Lusardi, Michaud and Mitchell (2017) and Jappelli and Padula (2013).[3] These papers treat financial literacy accumulation as a choice and demonstrate the reasons why individuals could be "rationally financially ignorant" (Lusardi, Michaud and Mitchell 2017).

Jappelli and Padula (2013) build an intertemporal consumption model with financial literacy investment. They treat financial literacy as a stock that raises the return on savings. They test the implications of their model and show that countries with generous social security programs have lower financial literacy levels. This implies that financial literacy can be a precautionary investment because social security programs lower the variance of consumption.[4]

On the other hand, negative financial experiences can encourage financial literacy investment. In a survey of 143 countries, Klapper, Lusardi and Van Oudheusden (2015) find that respondents from nations that had experienced hyperinflation episodes scored higher than the world on the inflation-related financial literacy questions.[5] Similarly, Wiener et al. (2005) find that bankrupt individuals retain financial education better than non-bankrupt individuals.

The effect of idiosyncratic shocks in determining financial literacy investment was explored in detail by Lusardi, Michaud and Mitchell (2017). The authors augment the standard life cycle model with a financial literacy choice, out-of-pocket costs, mortality risk and a risky asset. They find that initial endowments of financial literacy do little to explain life cycle wealth because individuals face different marginal utilities of consump-

[3]Previous research has also observed the relationship between financial literacy and credit outcomes. See Lusardi and Scheresberg (2013),and Lusardi and Tufano (2015)

[4]In a different setting, Hsu (2016) shows that married individuals can be discouraged from acquiring financial literacy if they are married to a financially literate spouse.

[5]In particular, respondents from Argentina, Georgia, Bosnia and Herzegovina, and Peru.

tion over their lives and at the cross-section.[6] Lusardi, Michaud and Mitchell (2017) note that financial literacy acts as a form but absent from their model is the ability to borrow. This research raises a further question—if borrowing constraints encourage precautionary saving (Deaton 1989), then how could borrowing constraints influence financial literacy?

While financial education has been demonstrated to affect financial behavior (Fernandes, Lynch and Netemeyer 2014), research has found it to be less effective for financially vulnerable segments of the population (Kaiser and Menkhoff 2017). It is unclear why this is the case, especially since financial literacy should be beneficial to all groups, not just households involved in "sophisticated" financial activities. For example, Klapper, Lusardi and Panos (2013) found that financially literate individuals were more likely to have a savings available during the Great Recession. This suggests that if measures were taken to provide financial literacy prior to the Great Recession, the welfare cost would have been lower.

2 Regional 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 (Foster 2014; Mottola and Kieffer 2017). The American Life Panel includes surveys that are both regularly fielded to the panel (e.g. the Survey of Consumer Payment Choice, Health and Retirement Survey) as well as one-time fielded surveys.

[6] Lusardi, Michaud and Mitchell (2017) show in counterfactual exercises that wealth at the time of retirement would be 41 percent lower and 30 percent lower for college and high school graduates respectively without endogenous financial literacy accumulation

Financial Literacy Measure

Lusardi and Mitchell (2014) describe financial literacy as a person's "ability to process economic information and make informed decisions about financial planning, wealth accumulation, debt and pensions." A measure of financial literacy should capture the full spectrum of knowledge related to financial literacy.

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.[7] The financial literacy measure is the sum of financial literacy questions correctly answered by an individual in a year. 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).

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

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 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).[8]

As a measure of internal consistency, I calculate the Cronbach Alpha for the twelve questions and find the score to be 0.73. This suggests the measure of financial literacy is acceptable and the score for my index is comparable to other studies of financial literacy.[9]

I perform a simple principal components analysis with the 12 questions and report the "Uniqueness" or 1-Communality of each question in table **??**. Communality is the proportion of variance for each question that can be explained by the predicted factor. No question has more than 30% of its variance explained by the predicted factor, so 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.[10] 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.

Figure 1 plots out the life cycle profile for percentage of questions answered correctly

[8]For example, retirement planning has turned away from defined benefit plans towards defined contribution (Fisch Hasler and Lusardi 2019).

[9]See Hung et al. 2009, Murphy et al. 2013.

[10]The closest paper to this is Jappelli (2010), but he uses a subjective measure of financial literacy: Business owners are asked to evaluate on a 0–10 scale the statement, "Economic literacy among the population is generally high."

by age.[11] Individuals accumulate financial literacy over their lifetime but the rate of accumulation decreases after age 50. Eventually, the levels decline after age 73. 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. In figure 2, I plot the total percentage correct with the percentage of retirement questions correct. Retirement knowledge is low early in life but increases rapidly as households approach retirement.

Table 10 reports the liquid net worth and proportion of each age-cohort with negative liquid wealth. I further divide the age-cohorts into high financial literacy ($\geq$75% correct) and low financial literacy (75).[12] High financial literacy households have a lower percentage of their cohort with negative net worth and the accumulate a greater amount of liquid wealth for every age but 30–40.

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).[13] 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, Za-

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

[12] This threshold was chosen based on the threshold used by Klapper, Lusardi and Van Van Oudheusden (2015).

[13] Banks will increase loan loss provisions as a result of both past due payments and expected losses (Agénor and Zilberman 2015)

man and Thomson 2017).[14] As a robustness check, Table 12 in the Appendix, reports a simple regression of state mortgage rates on state averaged loan-reserve-to-total-loan reserve ratios. A one-percentage point increase in loan-reserve-to-total reserves ratio is positively associated with a .07–.09 percentage point increase in mortgage rates in a state.

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.[15] 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.[16]

3 Empirical Methodology

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

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

[14] Balasubramanyan, Zaman and Thomson (2017) measure the change in lending standards as the fraction of core loans that loan officers report had tightening credit standards in the Senior Loans Officer Opinion Survey (SLOOS). For more on this variable's construction, see Bassett et al. (2014).

[15] 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.

[16] As a measure of credit availability, Cooper, Luengo-Prado and Olivei (2016) use a bank's level of non-performing real estate loans. I find that the loan-loss reserve ratio is preferable to nonperforming loans in my context, because the former is an *ex ante* measure of credit risk whereas the latter is an *ex post* measure (Jesus and Gabriel 2006). While these two measures are related, bank managers discretion also plays a part in the final loan loss provisioning (Walland and Koch 2000; Lobo and Yang 2001).

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 economic conditions (such as the US inflation rate) but also retest effects. All learning requires some degree of memorization but if the change in financial literacy is only the result of rote memorization, then the inclusion of year dummies should render the main effect's coefficient statistically insignificant.

Table 7 reports the summary statistics for the variables of interest. In general, 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 during this period and that there may be variation that explains this distribution. Loan Reserve provisioning is also increasing as banks hold reserves during this period of high borrowing risk.

Table 9 lists the correlation matrix for an extended set of variables. The Loan Reserve Ratio (LRR) is positively correlated with financial literacy, expectations of increasing borrowing rates and income; the ratio is negatively associated with home ownership. This makes sense as reserves are being stored 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, table 11 reports the results from the basic regression. A percentage point change in $\Delta LoanReserve_{jt}$ is associated with a change in financial literacy a quarter of a standard deviation above the average change. This translates to a 0.3 increase in financial

literacy score on average. 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

Figures 1 and 2 show that the growth rate of financial literacy is declining over the life cycle. To estimate the life cycle effect, I re-run equation 1 but add quadratic and interaction terms. The augmented regression becomes:

$$\Delta FinancialLiteracy_{ijt} = \alpha_i + \beta_1 \Delta LoanReserve_{jt} + \beta_2 \overline{Age^2}_{ijt} + \beta_3 \Delta LoanReserve_{jt} \times \overline{Age}_{ijt} + \beta_4 \Delta LoanReserve_{jt} \times \overline{Age^2}_{ijt} + \gamma \Delta X_{ijt} + \delta_t + \Delta \varepsilon_{ijt}$$

Column 2 in table 11 reports the results with the addition of the quadratic age term.[17] I find that the quadratic term, β_2, is negative and statistically significant. This is a 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.

MSA Heterogeneity

To further understand the conditions behind the empirical result, I average observations over the MSA-level and run the regression at the MSA-level, as follows:

$$\Delta \overline{FinancialLiteracy}_{jt} = \alpha_j + \beta_1 \Delta LoanReserve_{jt} + \gamma \overline{X}_{jt} \delta_t + \Delta \bar{\varepsilon}_{jt} \quad , \tag{2}$$

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

where $\Delta\overline{FinancialLiteracy}_{jt}$ is the average change for households in MSA j from year t to $t-1$. The fixed effect, α_j, is at the MSA-level and captures the MSA-specific trend. Therefore, β_1 captures the deviations from the MSA-specific trend. I sum up the the deviations from the MSA-level trend and graph the top and bottom three MSA's in figure 3. The areas with the greatest predicted fall in financial literacy are primarily regions that did not see a run-up in housing prices as much as the rest of the country. For example, the foreclosure rate in Buffalo was about half the nation's average when the housing bubble burst (Abel and Deitz 2010). On the other hand, the MSA's with the greatest predicted change in financial literacy occur in places that saw a large decline in housing prices after the housing bubble burst (e.g. Orlando).

Life Cycle Model

In this section, I will develop a model of financial literacy investment under borrowing uncertainty. My model draws from Jappelli and Padula (2013) and Lusardi, Michaud and Mitchell (2017).[18] The stochastic borrowing interest rate is most closely related to Ludvigson (1998) and Fulford (2011).[19]

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:

[18] To my knowledge, the work of Lusardi, Michaud and Mitchell (2017) is the only other heterogeneous agent model with endogenous financial literacy accumulation.

[19] Their models have a stochastic borrowing constraint rather than a stochastic interest rate. A stochastic interest rate is chosen in my context in order to better link the model to the motivating regression.

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

In every period t, individuals receive income y. This is made up of three parts. First, individuals inelastically supply one unit of labor each period and earn a wage w that 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:

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

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

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:

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

This return is paid at the beginning of period t for the stock of financial literacy accumulated up to that period, Φ_t. The intuition for treating the stock of financial literacy as the determinant of the interest rate follows from the observed relationship between financial literacy and savings assets.[20] Explanations for the relationship include making less fiduciary mistakes (Lusardi and Tufano 2009); knowledge of savings instruments' returns

[20]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)

(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^s_{base} is a base interest rate so that individuals with zero financial literacy still receive a positive return to saving.

The structure of the production function follows from previous empirical work that has found diminishing returns to financial literacy education. Both Cole el al. (2011) and Fort et al. (2016) find that financial literacy interventions are less effective for higher educated individuals. This is likely because higher-educated individuals tend to already have high financial literacy (Lusardi et al. 2010), so that the benefit to additional financial literacy investment is lower than it is for less educated individuals. A life cycle profile has also been observed in terms of financial literacy accumulation and depreciation. Older individuals tend to have at least accumulated some financial literacy from experience (Eberhardt et al. 2019), so they likely face a diminishing marginal benefit to an additional unit of financial literacy.[21]

Following Jappelli and Padula (2013), I will allow individuals to accumulate and de-accumulate financial literacy.[22]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.[23] I designate $\delta \in (0,1)$ the depreciation rate of the financial literacy stock. Since financial knowledge is often conflated with financial liter-

[21]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.

[22]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.

[23]I make this assumption in order to more realistically match financial literacy life cycle profile. Decreases in financial literacy tend to be due to either cognitive decline or obsolescence of financial information.

acy (Huston 2010), the depreciation of financial literacy stock may appear to convey the simple forgetting of financial concepts.[24] However, the depreciation of financial literacy can be understood as not just the decay of financial knowledge, but also the obsolescence of an existing stock of financial literacy in the face of innovations in financial products (Lusardi, Michaud and Mitchell 2017).

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

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

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

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

Borrowing

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

$$s_{t+1} \ \geq \ \sum_{t}^{J} \frac{-y_{min}}{1+r_b^{max}} = \overline{b_{t+1}} \quad , \tag{8}$$

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.[25]

[24] In a meta-analysis of 71 studies on financial literacy, Sandra Huston (2010) find that 47% of the selected studies use financial literacy and financial knowledge in a synonymous fashion. When she restricts the sample to articles including both phrases, three-fourths use financial literacy and financial knowledge interchangeably.

[25] If agents borrow up to the bound, they will have no savings and may draw the lowest income shock

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

$$r_{b,t} = \rho_r r_{b,t-1} + \nu_t \quad , \tag{9}$$

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.

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:

$$X_t = y_t + (1 + r(\Phi_t))s_t \mathbb{1}\{s_t \geq 0\} + (1 + r_{b,t})s_t \mathbb{1}\{s_t < 0\} \quad . \tag{10}$$

Their borrowing, consumption and financial literacy decisions are conditioned by the current states and their knowledge of the income and credit interest rate processes. 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

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.

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:

$$s_{t+1} = X_t - c_t - p\ell_{t+1} \tag{11}$$

Consumer Problem

Combining the savings path (11), the financial literacy path (6), the income process (4) and the credit interest rate process (9), 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

$$s_{t+1} = (1 + r(\Phi_t))s_t \mathbb{1}\{s_t \geq 0\} + (1 + r_{b,t})s_t \mathbb{1}\{s_t < 0\} + y_t - c_t - p\ell_{t+1} \tag{12}$$

$$\ell_{t+1} \geq 0 \tag{13}$$

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.

In the following section, I will run through the details of the model's calibration before showing a series of discrete choice graphs demonstrating the model's mechanics.

Calibration

Due to a low level of observations for individuals 18–29 in my dataset, the initial distribution begins with t = 2 or with members of sample in the age range of 30–40. Therefore, the model period t is representative of 10-years.

The initial distribution for financial literacy and liquid assets 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 cali-

brated 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.[26]

Following Lusardi, Michaud and Mitchell (2017), I set the cost of financial literacy to .06 in order to approximate financial literacy to $ 500 dollars a year.[27] model is normalized to $83000, .06 of $83000 is $4980 or about 500 dollars per year

I calibrate three 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 declines in financial literacy.

The model is solved using a grid search method with 156 saving asset grid points, with 80 of the saving asset grid points being negative, 1 being zero and the rest positive asset grid points. For financial literacy, I use 15 literacy grid points. For the shocks, I use 5 income shock grid points and 4 interest rate shock grid points.

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

[27] My

Model Calibration

Table 1: 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	0.84	Income Persistence
σ^2_ε	0.225	Income Shock Std.
ρ_r	0.707	Borrow Rate Persistence
σ^2_ν	0.136	Borrow Rate Std.
α	.313	Investment Elasticity
δ	0.14	Depreciation Rate
A	0.042	Savings Productivity

The parameter calibration is tabulated in table 1. The initial distribution's normalized average financial literacy is 0.7 and this implies that the average person receives a return of about 1.057 over 10-years. The calibrated rate of depreciation is 0.14 or about 1.4% per year.

Table 2 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 0.12. 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.

Table 2: 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} (%)	5.3	3.7	-2.1	-2.2
Untargeted: Negative Liquid Net Worth				
$Borrowing^{Data}$(%)	18.4	15	10.7	7.2
$Borrowing^{Model}$(%)	21	17.2	1.6	0.1

Liquid Net Worth: liquid assets- credit card debt.

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.[28] 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.

1 Counterfactual Experiments

Ex-Ante Welfare Measure

As a measure of ex-ante welfare, I will calculate the compensating equivalent variation (CEV) to compare each counter-factual with the baseline. This measure calculates how much an agent's consumption must increase or decrease at every age and for every pos-

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

sible contingency in order to make them indifferent between the compared cases. Given the state space, $\Omega \{s_t, \Phi_t, y_t, \hat{r}_{bt}\}$, and using a CRRA utility functional form, I can express the ex-ante welfare effect of the counter-factual as follows:

$$CEV = [\frac{\int V^{counter}(\Omega)d(\Omega)}{\int V^{baseline}(\Omega)d(\Omega)}]^{\frac{1}{1-\gamma}} \quad , \tag{14}$$

where $V^{counter}$ and $V^{baseline}$ are the values for the counter-factual and baseline, respectively, at state Ω with probability density $d(\Omega)$. The segment of the population I will be considering in the welfare analysis will be the initial age cohort in my sample of 30-to-40 year-olds.

2 Experiment 1: Contribution of Model Features

In this first experiment, I analyze the relative contribution of each feature in my model by shutting down the mechanism and comparing it to the baseline model.

A person's marginal utility of consumption may vary over their lifetime due to various shocks. To highlight the contribution of different consumption smoothing options, I run a series counter-factuals with certain key features of the model shut down to highlight their partial contributions.

Th first distinction of my model from previous work on financial literacy is the inclusion of borrowing. In column 2, I report several outcomes of my model when households cannot borrow. On average, financial literacy does not change as much as savings. Ex-ante welfare for the average 30–40 year-old falls by about 0.53%. This is because younger individuals cannot borrow to smooth consumption but are instead compelled to either save or consume their cash. Figure 15 shows the contour plots for low/high income and borrowing rate groups. The individuals with the greatest welfare loss have low income and low savings because they have the greatest demand for borrowing.

Table 3: Shut Down Model Features

	Baseline	No Borrow	No Invest	No Borrow/Invest
Return for Avg. Lit (%) - Age 41	5.81	5.81	2	2
Return for Avg. Lit (%) - Age 63	5.83	5.83	2	2
$\frac{Wealth}{Income}$ - Age 41	1.17	1.17	1.15	1.15
$\frac{Wealth}{Income}$- Age 63	1.79	1.79	1.68	1.68
Δ Welfare From Baseline (%)	0	–0.53	–1.7	–2.3

In the next column, I allow borrowing but instead shut down financial literacy investment. Compared to the baseline model, the average individual has lower wealth-to-income at ages 41 and 63 because they cannot alternatively smooth consumption with financial literacy. This is because individuals borrow more and cannot raise the return on their savings to increase their wealth. As a result, retirement wealth-to-income falls by 6% and welfare by 1.7%. Figure 16 shows the welfare contour plots for the no literacy model. In this scenario, it is the wealthier individuals who face a greater loss in welfare. In the last column I shut down both financial literacy investment and borrowing. This is equivalent to a standard one-asset life cycle model. The welfare loss is approximately the sum of welfare loss for each of the preceding counterfactuals.

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 individuals stock of financial literacy grows, the opportunity cost to borrowing increases because financial literacy raises their return on savings. Thus, households transition from being net borrowers to net savers.

In the next exercise, I will explore how borrowing uncertainty influences the transition from net borrower to net saver.

Shock Persistence

To investigate the effect of borrowing expectations on financial literacy investment, I explore a series of counterfactuals where the persistence to the borrowing interest rate is varied. When individuals borrow, they do not know the real value that they will have to pay back in the next period. A high persistence, ρ_r, leads individuals to put great weight on current interest rates. For example, an individual who sees low interest rates will expect borrowing to remain cheap over their lives and may choose to be a net borrower for a longer period of their lifetime than under a less persistent regime.

On average, an increase in the interest rate persistence leads to a welfare improvement by 2.8%. The average return on savings decreases by about .04 percentage points for individuals at retirement and this leads to an average fall in wealth-to-income by about 25%. In other words, individuals invest less in financial literacy and save less. High shock persistence stratifies the market to a great degree and I plot out the welfare distribution in figure 17. Individuals who borrow at a low interest rate benefit the most from the increase in persistence because they expect to face low interest rates over their lifetimes. This also explains why the welfare gain is slightly less for high financial literacy individuals because they are already planning to borrow less than low financial literacy households.

On the other hand, individuals who face high interest rates suffer a large welfare loss, although it is partly attenuated when individuals have high financial literacy (top right contour plot). These households trade-off borrowing with financial literacy investment as a form of consumption smoothing. The low income group (top left corner) does not have the resources to invest in financial literacy and cannot ameliorate the welfare loss in the same way.

Table 4: Interest Rate - Persistence

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

	Return for Avg. Lit (%)		Wealth-to-Income		Debt-to-Income		Δ Welfare from Base %
Age	41	63	41	63	41	63	
$\rho_r = .7037.$	5.81	5.83	1.17	1.79	.09	.06	0
Change in Persistence							
$\rho_r = 0.8796$	5.80	5.79	1.04	1.33	.07	.04	2.8
$\rho_r = 0.5278$	5.83	5.82	1.27	2.05	0.1	0.05	–0.3
W/o Financial Literacy							
$\rho_r = 0.8796$	2.00	2.00	.99	1.24	.07	.04	1.2
$\rho_r = 0.5278$	2.00	2.00	1.23	1.97	.14	.05	–2

Notes: Baseline is $\rho_r = .7037$.

The result for the low persistence case has an opposite distribution of welfare gains. High interest rate borrowers benefit compared to the baseline because they expect interest rates to fall in the future.

Financial literacy investment and borrowing increase for young individuals compared to the baseline case— this happens for two reasons. Individuals who are in a low interest repayment state expect interest rates to increase in the future. They invest in financial literacy rather than borrow to raise their savings and be able to insure against shocks in the future with their savings rather than relying on borrowing. Individuals in a high interest repayment state believe that interest rates will be lower in the future. They borrow because they believe the repayment will be more cheap in the future.

I run the same persistence scenarios without financial literacy investment and find that in general, individuals have less wealth at each age and borrow more. The welfare loss is greatest for the low persistence case compared to the model when financial literacy investment is possible. This suggests that financial literacy plays a role in insuring against borrowing uncertainty. The extra welfare loss is not just due to losing the ability to raise returns on savings but also the precautionary benefit of financial literacy investment.

These exercises have shown that financial literacy is acquired when individuals are in distress or expect future difficulties. However, policymakers interested in raising the financial literacy of their countries 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 Policy Experiments

Effect of Interest Rate Cap

For my first policy experiment, I will test the effect of an interest rate cap. In May 2019, legislation was proposed in congress to cap credit card interest rates at 15 %.[29]

This policy will benefit high-interest rate borrowers by allowing them to pay lower interest rates on loans that they draw. However, 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 costs of credit risk.

I augment equation 10 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. Greer (1974) estimates that a percentage point increase in the loan rate ceiling leads to increase in loans extended by eight persons for every 1000 persons. Using the estimates from Greer (1974), I will consider two scenarios of credit rationing: one where $\zeta(r_{b,t}) = 2\%$ and one where $\zeta(r_{b,t}) = 8\%$. Lenders can discriminate based on credit history, so the the credit rationing parameter is a function of the interest rate state.

When credit rationing is low, the interest cap is welfare improving. Individuals benefit from lower borrowing interest rates and they take advantage by borrowing more when they are young; the debt-to-income ratio increases for young individuals by 10%. However, if the rationing is too high (e.g. $\zeta = .08$), then the interest rate cap leads to a slight decrease in welfare.

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

Table 5: Interest Rate Cap

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

	Avg. Lit Return (%)		Wealth-to-Income		Debt-to-Income		Δ Welfare from Base %
	41–51	63–73	41–51	63–73	41–51	63–73	
No Cap	5.81	5.83	1.2	1.8	.09	.06	0
Interest Cap = $r_{bt}^{max} = 15\%$							
$\zeta(r_{bt}) = .02$	5.81	5.83	1.2	1.8	0.1	.06	0.014
$\zeta(r_{bt}) = .08$	5.81	5.83	1.2	1.8	.08	.05	-0.07
W/o Financial Literacy							
$\zeta(r_{bt}) = .02$	2	2	1.2	1.7	.1	.06	–1.7
$\zeta(r_{bt}) = .08$	2	2	1.2	1.7	.08	.05	–1.8

Notes: Baseline $r_{bt}^{max} = 25\%$.

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.[30] However, 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).[31] 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 a financial literacy subsidy. In order to account for these different conclusions, I will compare a general subsidy with various targeted subsidies aimed at specific cohorts.

The first subsidy, which covers 10% of the cost leads to about a .12% increase in welfare from the baseline. Individuals on average receive nearly 0.06 percentage points higher return on savings with 10% subsidy. Since all subsidy programs raise the savings interest rate for the listed ages, it is likely that the welfare increase in being driven primarily by returns on savings and not just lower investment cost. This is further supported by the fact that the wealth-to-income ratio is similar to the no subsidy case for all policies at both ages listed. A higher return allows agents to more efficiently smooth between periods so that they can reach their target wealth in future periods but give up less in the present than they would have to in the baseline case. Increasing the subsidy to cover 30% of the cost of financial literacy increases the return on savings by nearly 0.2 percentage points

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

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

Table 6: Subsidy Program

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

	Avg. Lit Return (%)		Wealth-to-Income		Debt-to-Income		Δ Welfare from Baseline %
Age	41	63	41	63	41	63	
No Subsidy	5.81	5.83	1.2	1.8	.09	.06	0
Full Population							
τ= .1	5.87	5.85	1.2	1.8	0.09	0.06	.12
$\tau = .3$	6.03	6	1.21	1.81	.09	0.06	.36

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

and more than doubles the welfare gain.

Figure 19 shows the welfare distribution. For three of the four cases, welfare is improved the greatest for individuals with high leverage and moderate levels of financial literacy.[32]

Below that level, the subsidy is not great enough to induce a significant increase in financial literacy investment. Above a moderate level of financial literacy, the subsidy still improves welfare but the decline in the marginal return leads to a diminishing effect. The subsidy provides the greatest welfare improvement for the low-income groups (left column). Because interest rates are persistent, the low income, low borrowing rate group, expect to be able to pay off their debt and reap the benefits of the financial literacy subsidy in the coming periods. The high income groups benefit as well but less so, because they already have the resources to make the financial literacy investment.

4 Discussion

My paper demonstrates that early life borrowing experience has an effect on financial literacy accumulation and latter life outcomes. A similar result has been observed in recent work. Brown, Cookson and Heimer 2019 found that borrowers who grew up on a tribal court reservation without access to finance had lower credit scores and were 2-4 percentage points more likely to have delinquent loans.

One potential avenue of future research would be to identify heterogeneity in the types of financial literacy knowledge. Wagner and Walstad (2019) found that financial education has a greater influence on long-term behaviors (e.g. retirement planning) but short-term behaviors (e.g. paying a bill on time) respond more to negative feedback mechanisms. In the current model, financial literacy captures all the outcomes but certain behavioral aspects, such as rational inattention, may play an independent role and

[32] Darker shades means greater welfare gain.

influence financial literacy accumulation. For example, augmenting this model or a related kind with rational inattention might help to explain . Kim, Mauer and Mitchell (2017).[33]

Another potential future research path would be to develop a general equilibrium model using this financial literacy structure in order to capture. To my knowledge, the closest work that has been done by Padula and Pettinicchi (2013), who developed a model of financial education in a general equilibrium model. Their model mainly focused on a discrete choice offered to households to participate in a financial education program that increased the precision of their signal on their risky asset. However, there are features in my model that would change certain standard outcomes in a general equilibrium model. For example, financial literacy, by increasing the propensity to save in general, may lead to a fall in the equilibrium interest rate.[34] As a consequence, borrowing may increase as well instability associated with higher leverage. On the other hand, my model also implies that an increase in borrowing interest rate uncertainty may encourage financial literacy investment and so may be a stabilizing feature in a general equilibrium model with a financial sector.

5 Conclusion

In this paper, I developed a model of endogenous financial literacy accumulation to explore how borrowing interest rate and income shocks over the life cycle influence financial literacy decisions. I found that what has the greatest effect on the decision to invest in financial literacy is an agent's expectation about the cost to borrowing that they will face in coming periods. When agents expect to be credit constrained, they shift their resources towards investing in financial literacy as an alternative way to smooth consump-

[33] Both John Gathergood and Olivia Mitchell, authors in the papers listed, also have research with respect to financial literacy. See Gathergood (2012) and Lusardi, Michaud and Mitchell (2017).

[34] Meaning saving of riskless assets as well.

tion over one's life. 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 a financial investment continues to reap benefits 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 when it targets low-income and credit-constrained households. The implication of these two policy experiments is that any monetary policy that reduces constraints to borrowing should be coupled with a target financial education policy.

Lusardi, Michaud and Mitchell (2017) conclude that financial education programs offered early in life may not lead to behavioral changes if individuals are already at their optimal financial literacy levels. Rather, the authors emphasize the importance of *endogenous* financial literacy accumulation for explaining life cycle outcomes, because individuals face different income shocks over their life cycle. My model extends this insight by allowing my model's individuals to borrow but face uncertainty about the borrowing interest rate. Borrowing provides an alternative means for insuring against income shocks but the uncertainty regarding the borrowing interest rate influence's an individual's decision to invest in financial literacy. Policymakers interested in improving the financial literacy of their citizens will find these results most fruitful.

Appendix

Table 7: Summary Statistics

Variable	**Mean**	**Median**	**Std Dev.**
$\Delta FinancialLiteracy_{ijt}$	.17	0	1.1
$\Delta Log(Income_{ijt})$ (percentage)	.01	0	.28
$\Delta LoanReserve_{cj}$ (pct. points)	.01	-.03	.42
Age_{ijt}	57	56	12

Table 8: 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 9: Correlation Matrix

Variables	LRR	FinLit	Increase Int. Exp	Log(Income)	Age	Own Home
LRR	1					
FinLit	0.0456*	1				
Increase Int. Exp	0.0970*	0.0174	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

Table 10: Liquid Net Worth over Life Cycle

Age	30–40	41–51	52–62	63–73	74–84
High Financial Literacy (≥75%)					
Liquid Net Worth	22058	79169	216467	292886	326336
Net Borrower (%)	5	9	5	4	0
Low Financial Literacy (75%)					
Liquid Net Worth	69228	41473	57120	151644	65731
Net Borrower (%)	15	25	18	3.3	18

Liquid Net Worth is liquid wealth minus credit card debt
Net Borrower is percentage of cohort that has negative liquid net worth

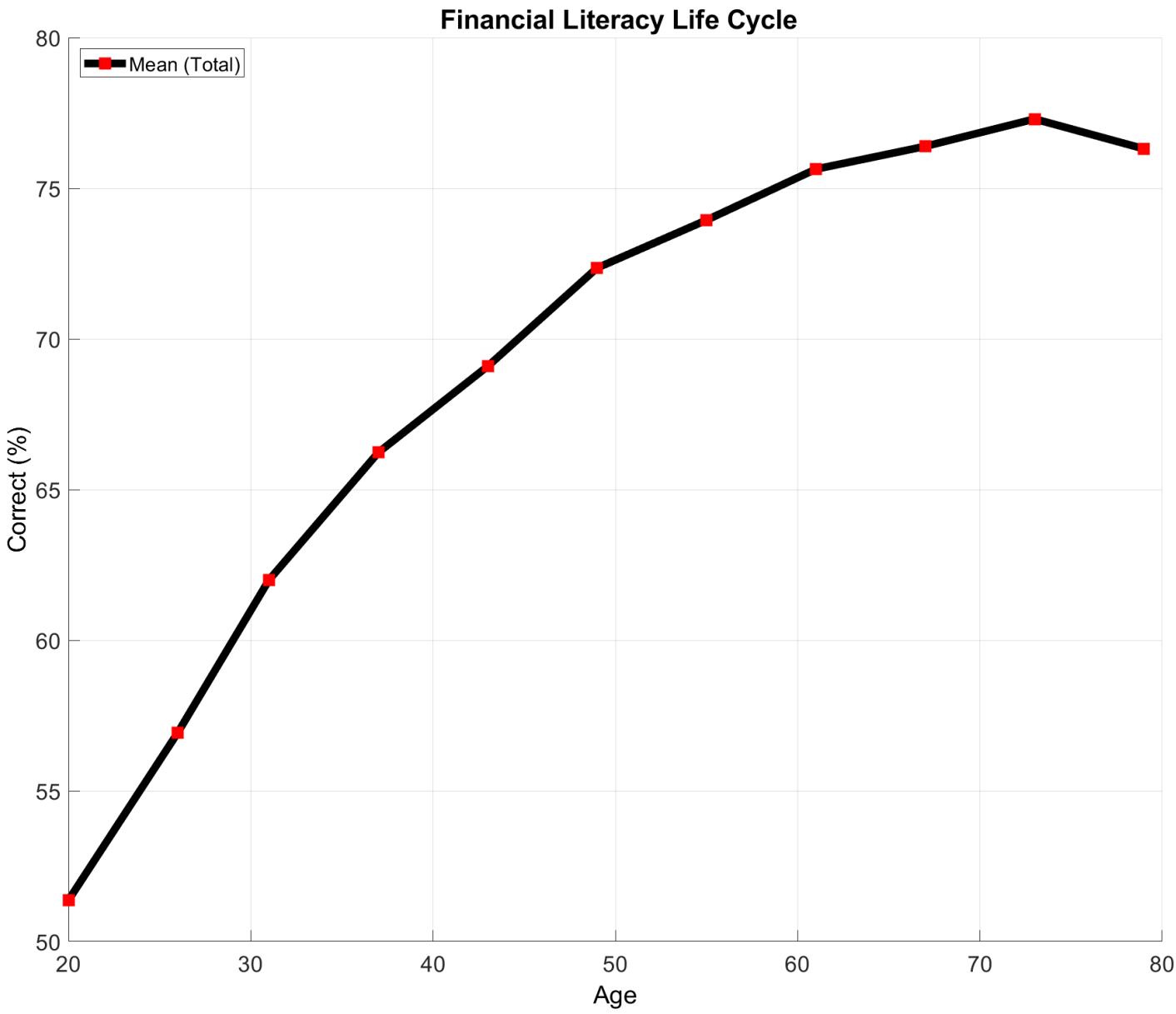

Financial Literacy Life Cycle
Mean (Total)
Correct (%)
Age
80
75
70
65
60
55
50
20
30
40
50
60
70
80

Figure 1

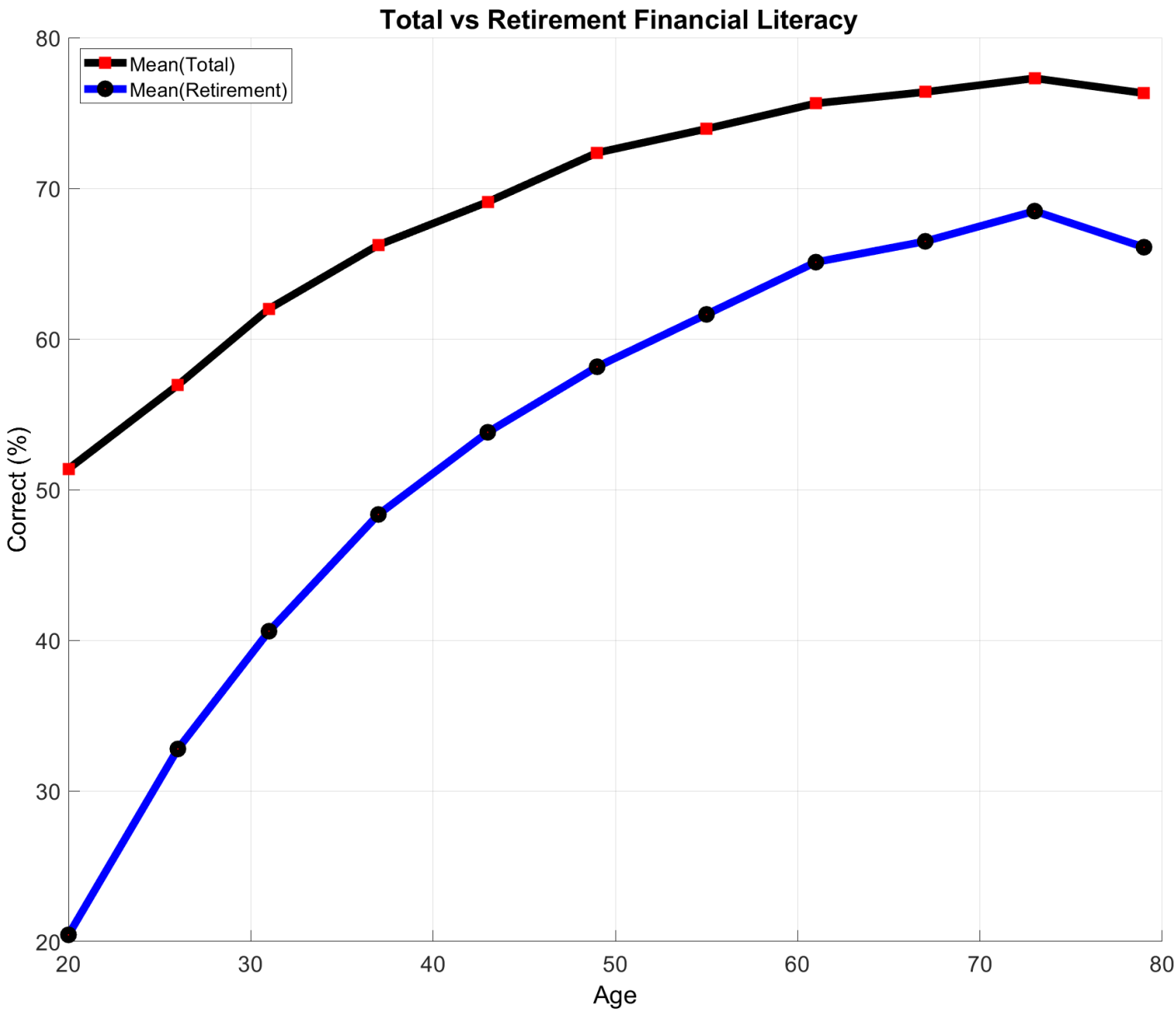

Total vs Retirement Financial Literacy
Mean(Total)
Mean(Retirement)
Correct (%)
Age
80
70
60
50
40
30
20
20
30
40
50
60
70
80

Figure 2

Table 11: Financial Literacy Change

Variables	I	II	III	IV
$\Delta LoanReserve_{jt}$	.27**	.27**	.3**	.33**
	(.13)	(.13)	(.12)	(.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
$Adj\ R^2$	0.0152	0.0202	0.0224	0.0230

[1]Standard errors in parentheses, clustered at MSA level.
[2]Year and Individual fixed-effects in all specifications.

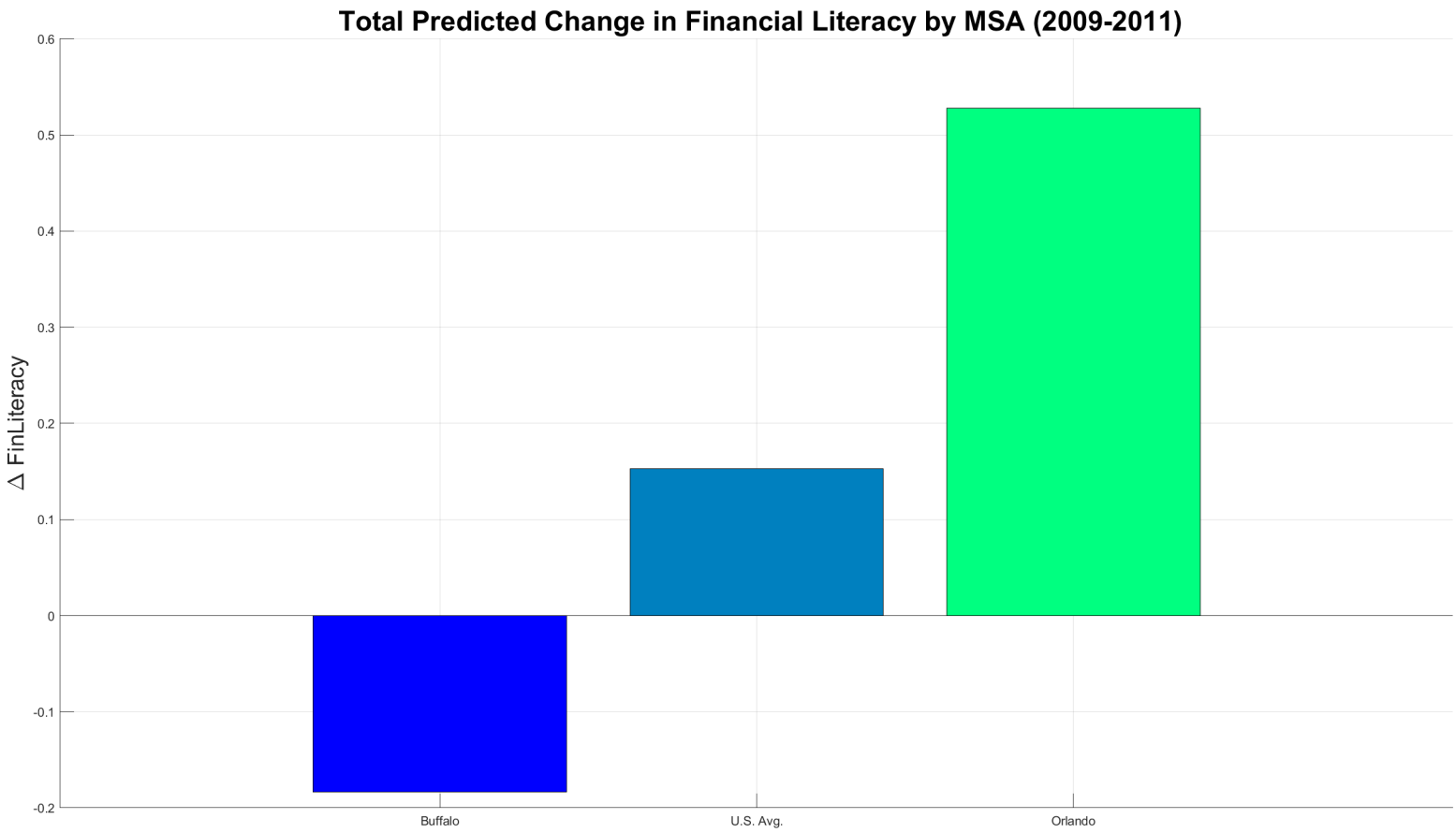


Figure 3

1 Additional Regression Tables

Table 12: 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

2 Additional Graphs

Comparative Statics

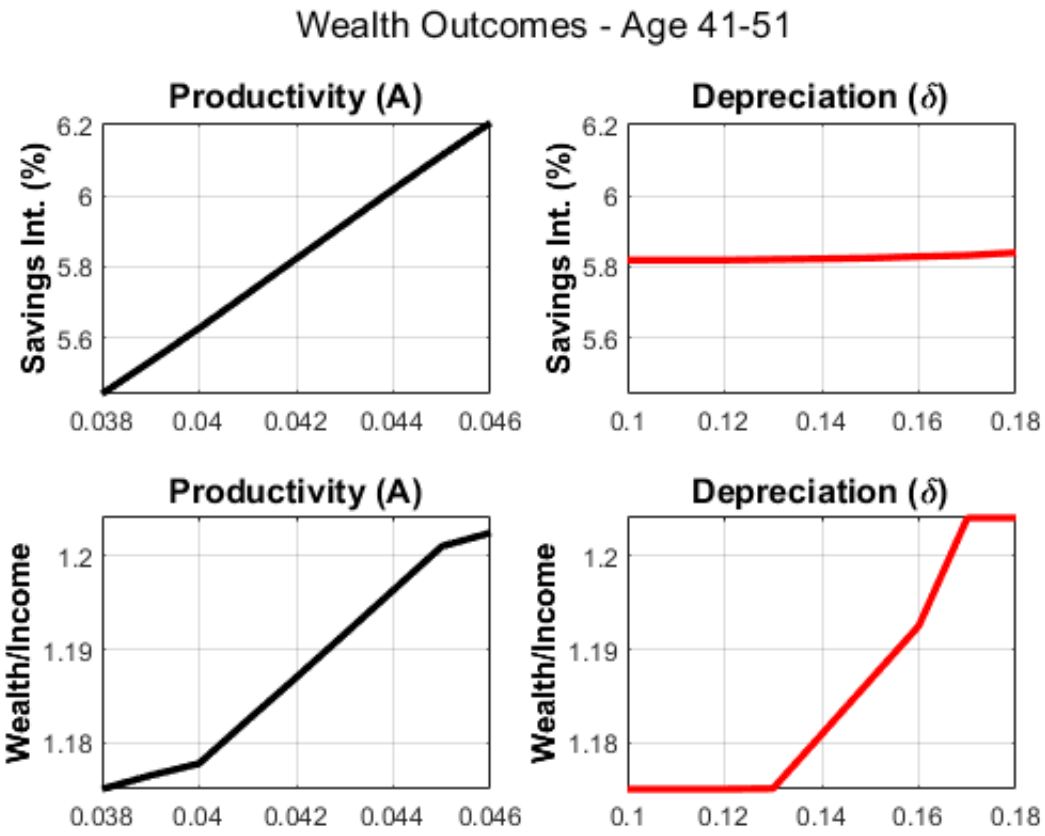


Figure 4

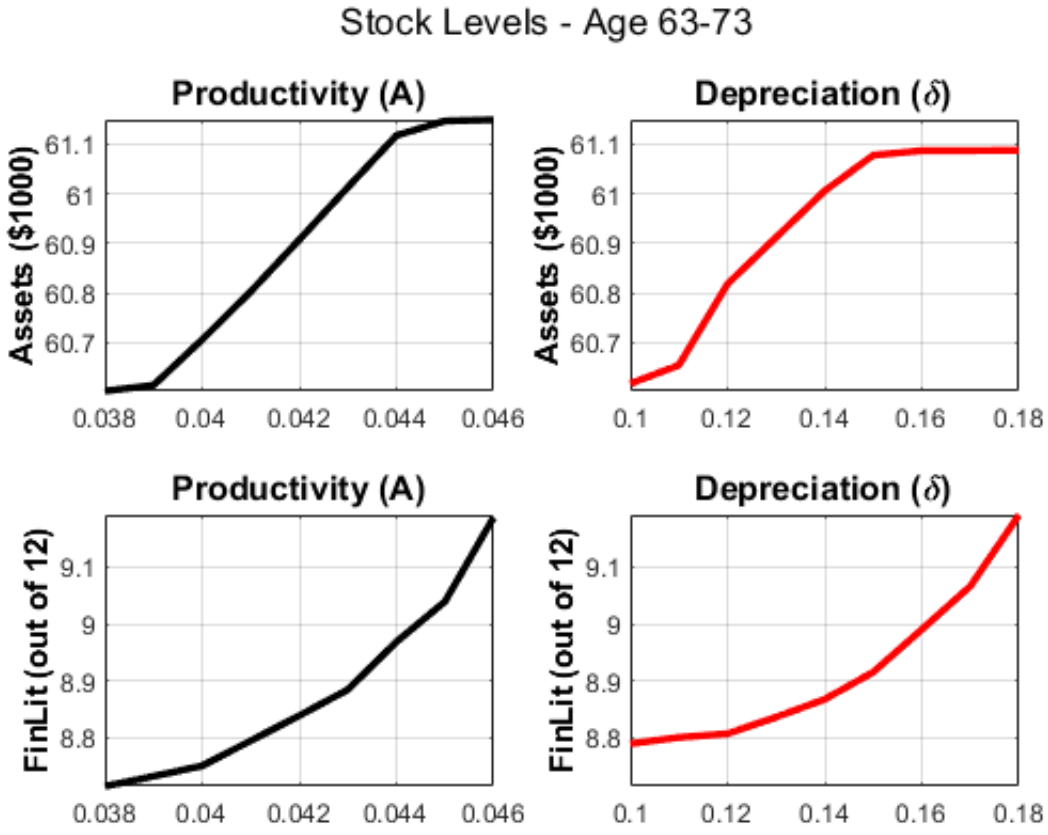

Stock Levels - Age 63-73
Productivity (A)
Depreciation (δ)
Assets ($1000)
61.1
61
60.9
60.8
60.7
0.038
0.04
0.042
0.044
0.046
0.1
0.12
0.14
0.16
0.18
Productivity (A)
Depreciation (δ)
FinLit (out of 12)
9.1
9
8.9
8.8

Figure 5

3 American Life Panel

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

Construction of financial literacy

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

Question 1 - Numeracy

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

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

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

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

Question 11 - Minimum Withdraw

Assets

2009

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

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

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

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

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

2010

Information on liquid is 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.[35] 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

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

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.[36]

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.[37]

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

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

[37]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).

Report data, I use *lnlsgr* as the total loans on a bank's balance sheet in year t.[38] For the loan loss allowance, I use *lnatres* as the loan loss allowance.

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

4 Model Features and Calibration

Construction of Weighted Borrowing and Saving Rates

In Figure 1, as well as in the results in the policy counter−factuals, I report a weighted borrowing and saving rate. The weighted savings rate is the weighted average return on savings received by individuals savings, whereas the weighted borrowing return is the weighted average interest rate paid for individuals who borrow. Since individuals decide to borrow, there is a realized borrowing rate that is endogenously determined. In order to calculate that rate, I do the following for each period t:

1. Calculate the total interest charged in period t e.g. $r_{b,t} \times$ amount borrowed$_t$
2. Calculate the total loan amount drawn in peirod t

Then the weighted rate is calculated as follows:

$$Weighted\ Borrowing\ Rate_t = \frac{Interest\ Factor_t}{Total\ Loan\ Amount_t} \tag{17}$$

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.

[38] 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.[39] The average interest rate is 14.6, with little variation across age cohorts.

5 Calibration of AR(1) process

Consider an AR(1) process as follows:

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

The mean for the AR(1) process 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.

Likewise, the variance 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 $\sqrt{\sigma_y^2}$ =σ_y.

To calibrate the AR(1) process, I perform the following procedure:

1. First, choose feasible values for ρ and σ_ε^2.

[39]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).

2. Simulate 1000

3. Calculate the mean and standard deviation using 19 and 20 respectively

4. Repeat until the mean−to−standard deviation ratio matches empricial data's mean−to−standard deviation ratio

6 Additional Results

Table 13: Additional Untargeted Moments

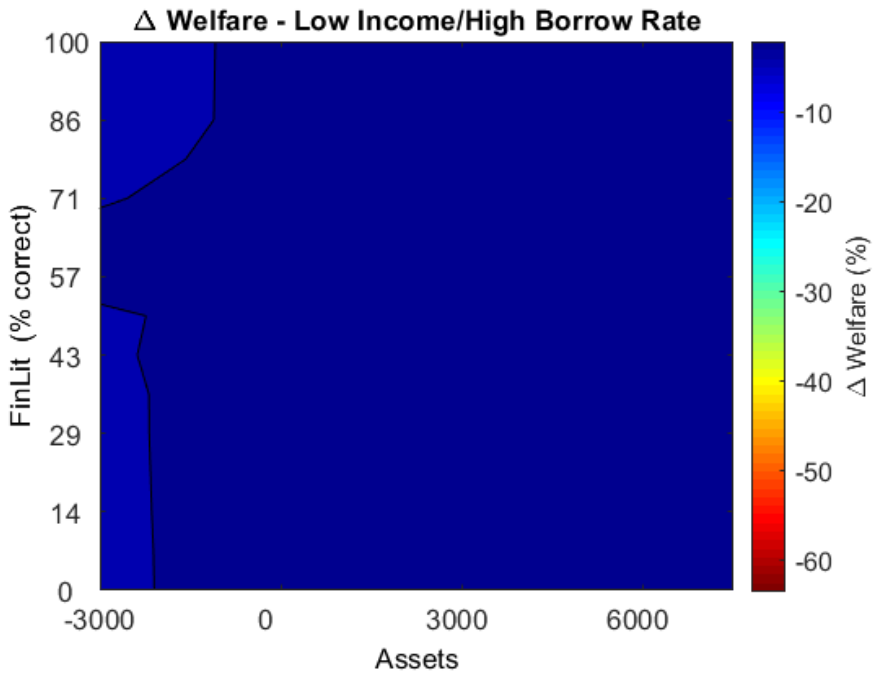
Age	41–51	52–62	63–73	74–84
Borrowing Interest Rate^{Data} (%)	14.5 (6.1)	14.8 (6)	14.5 (5.8)	14.6 (5.8)
Borrowing Interest Rate^{Model} (%)	18.1	17.2	16.3	19.5

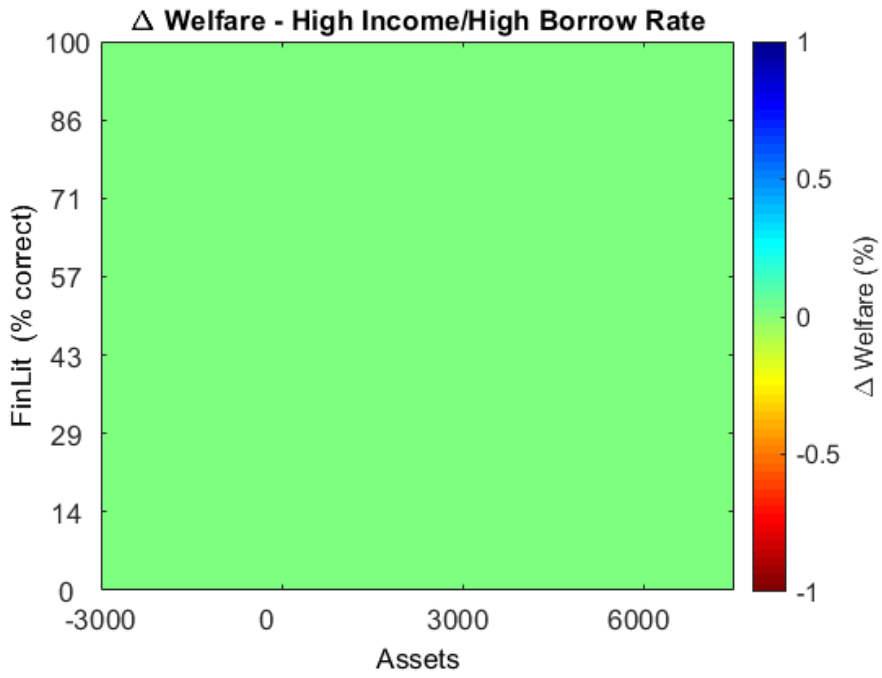
Standard Deviation in paraentheses.

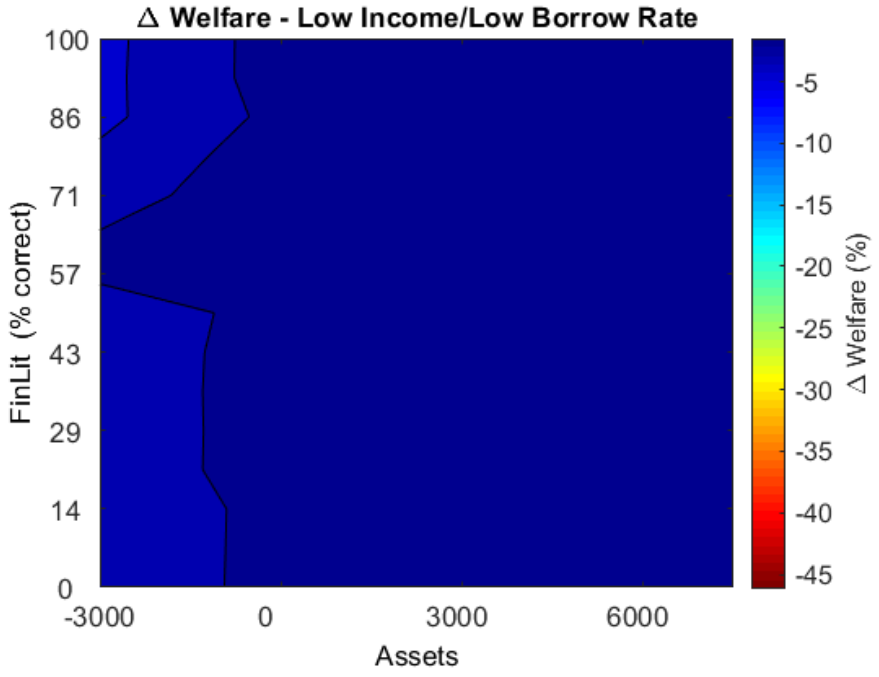
Table 14: Percent change in decisions by Group - No Borrow

	Δ Saving	Δ FinLit Invest	Δ Welfare from Base %
Young	0	-0.24	-0.2
Low Income, Young	0	0	-1.5
Old	0	0	-0.2
Low Income, Old	0	0	-0.4

Table 15: No Borrowing Contour Plots







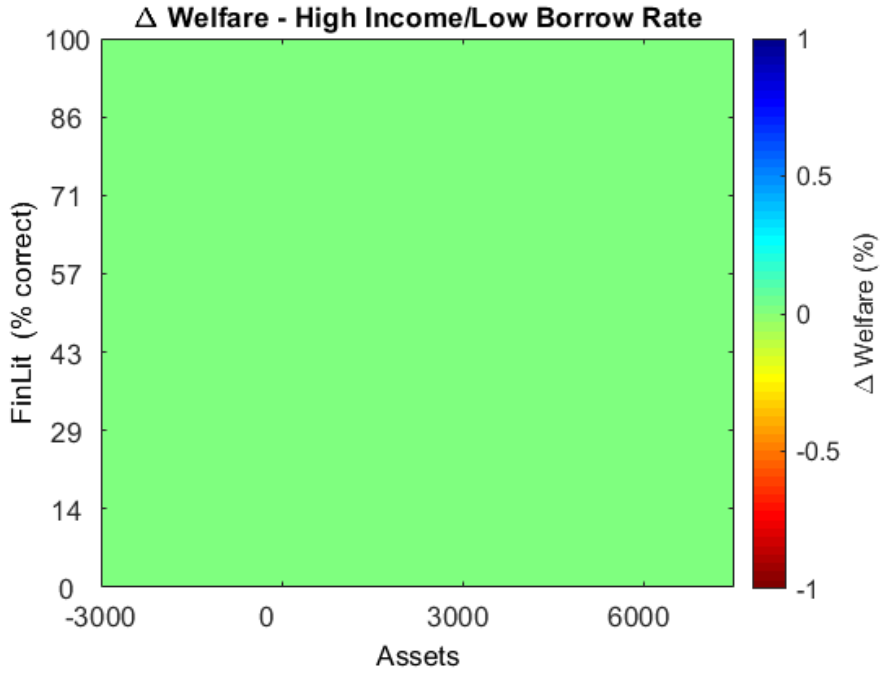


Table 16: No Literacy Contour Plots

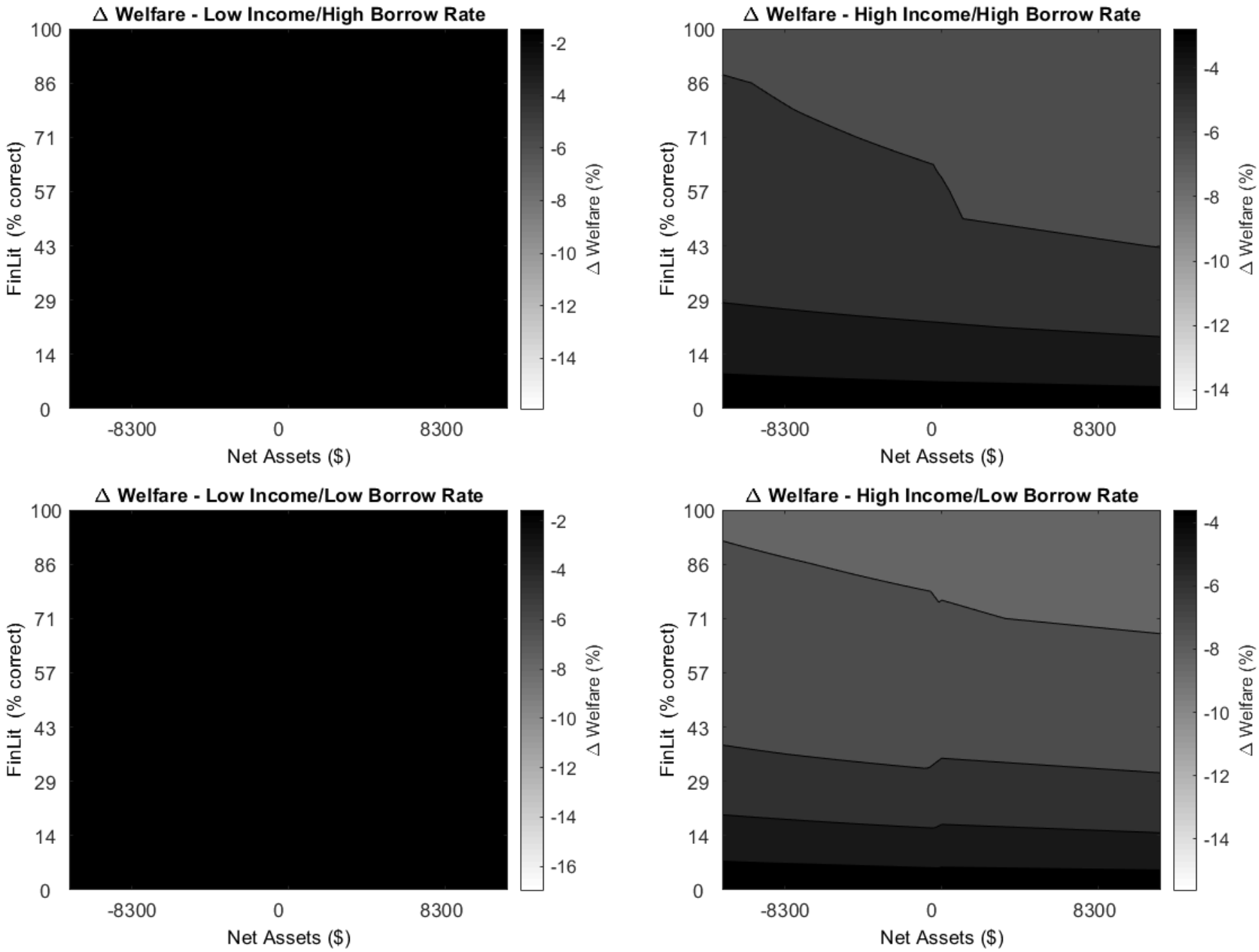
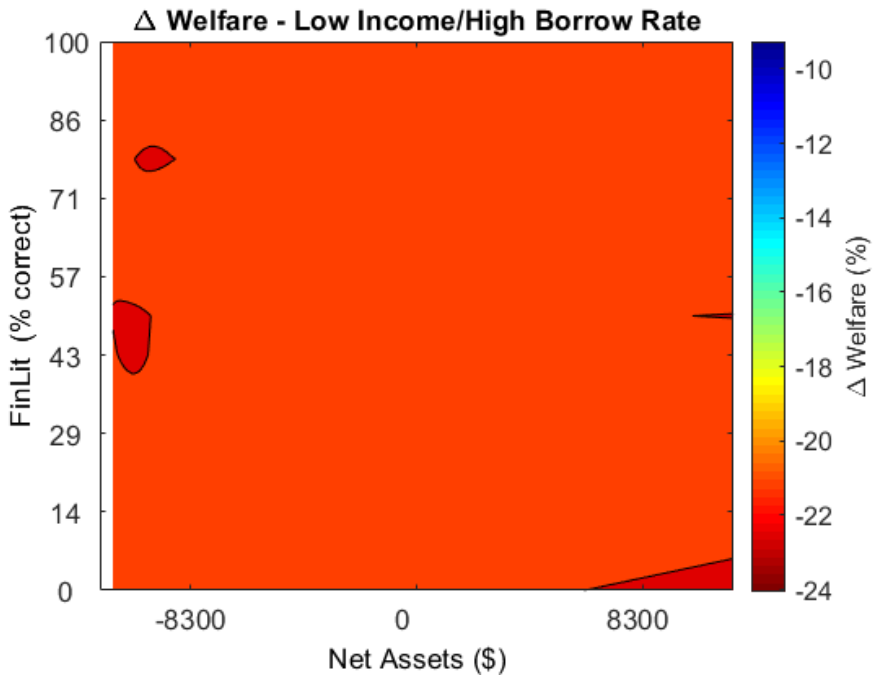
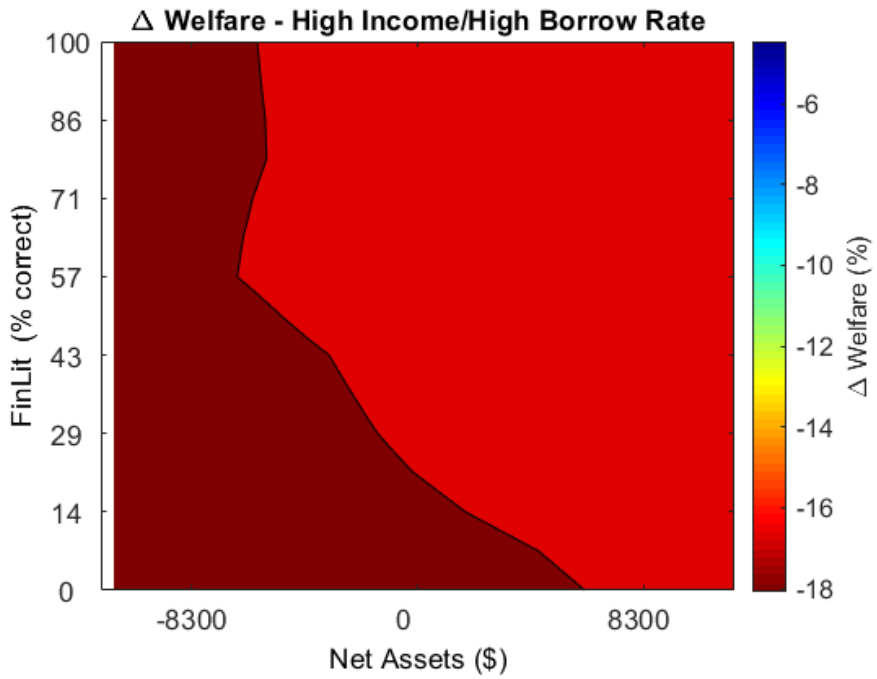
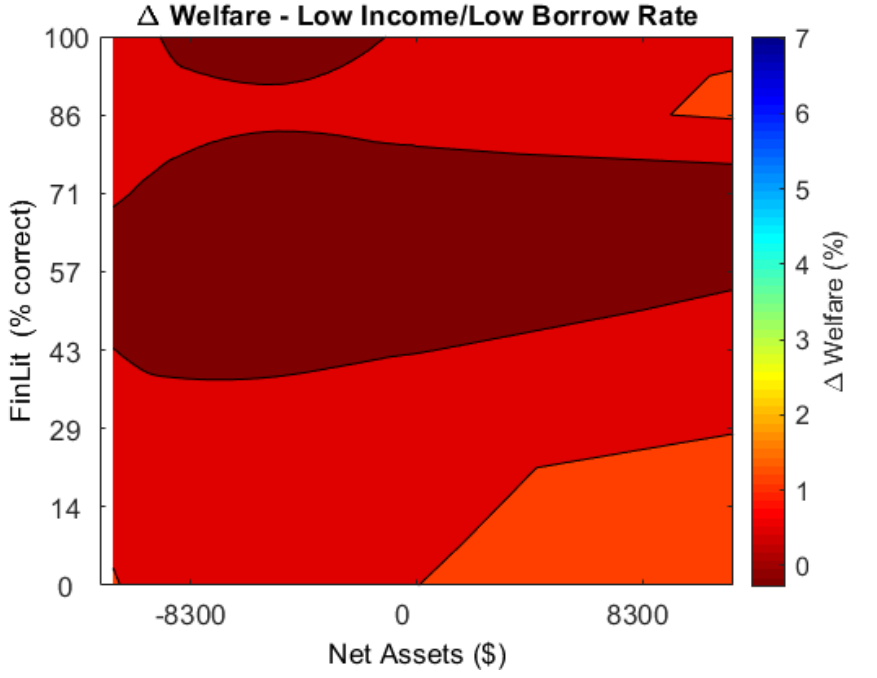


Table 17: High Persistence Contour Plots







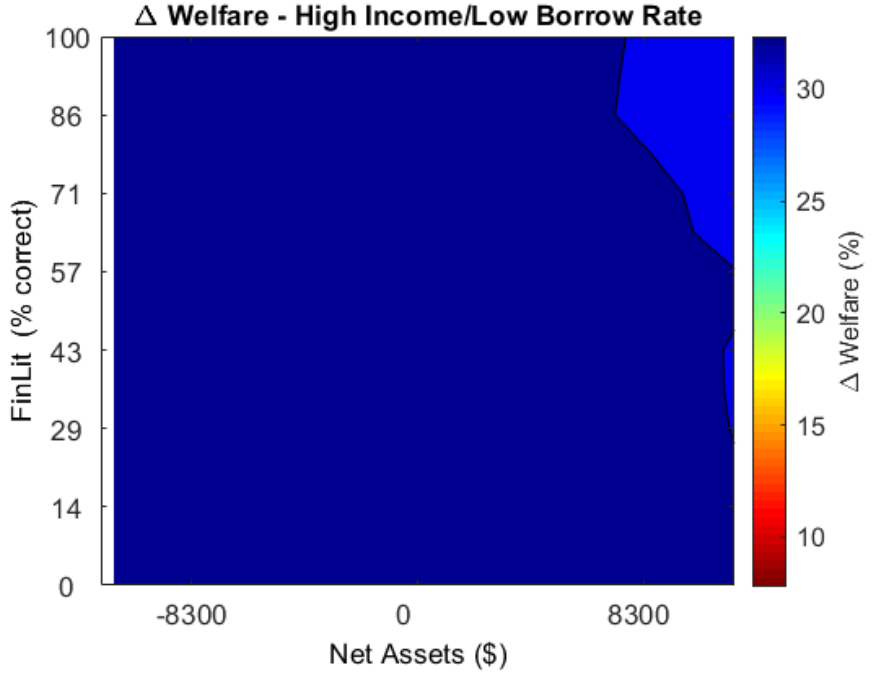


Table 18: Low Persistence Contour Plots

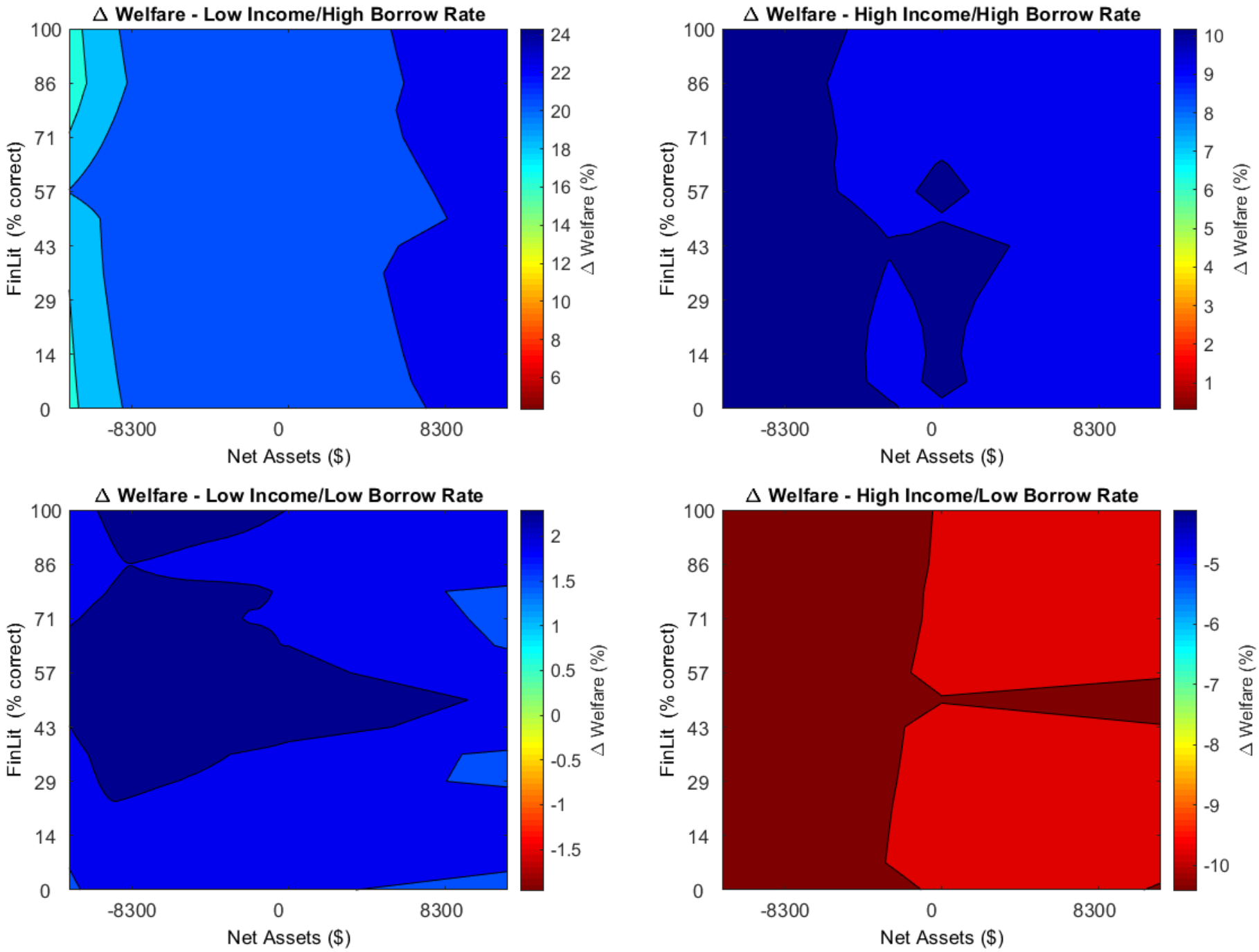
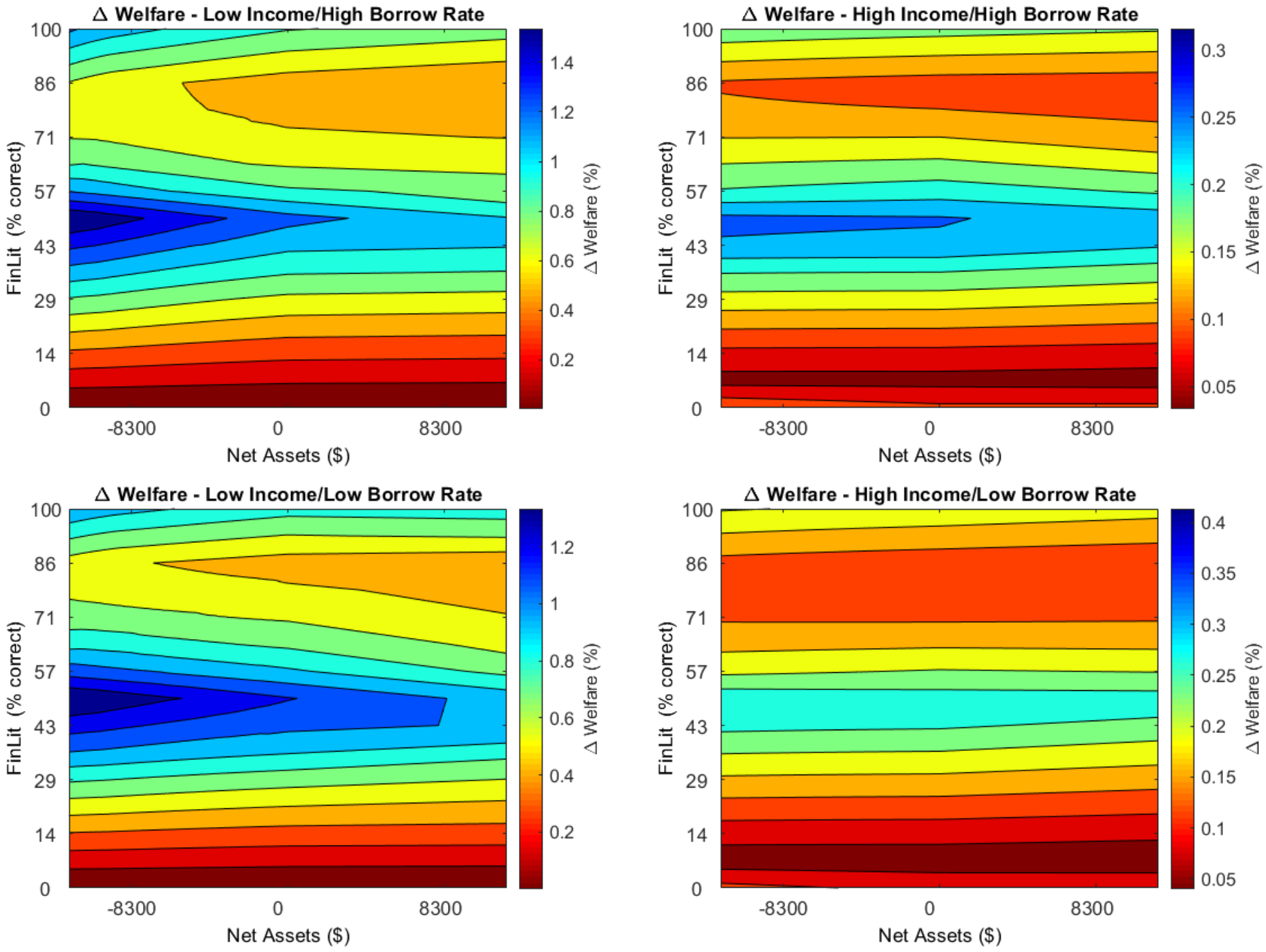


Table 19: 10% financial literacy subsidy



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