Regulating Consumer Credit with Over-Optimistic Borrowers*

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– Preliminary –

Abstract

We quantitatively analyze consumer credit markets with behavioral consumers and default. Our model incorporates over-optimistic and rational borrower types into a standard incomplete markets with consumer bankruptcy framework. Lenders price credit endogenously, forming beliefs – type scores – about borrowers' types. Since over-optimistic borrowers incorrectly believe they have rational beliefs, lenders do not need to take strategic behavior into account when updating type scores. We find that the partial pooling of over-optimistic with rational borrowers results in spill-overs across types via interest rates, with over-optimists being cross-subsidized by rational consumers who have lower default rates. Higher interest rates lower the average debt level of realists compared to a world without over-optimists. Due to overestimating their ability to repay, over-optimists borrow too much. We evaluate three policies to address these frictions: reducing the cost of default, educating over-optimists about their true type, and increasing borrowing cost. Of the three, only the lower default costs improve the welfare of over-optimists. However, rational consumers are made worse off by that policy.

Keywords: Credit Cards, Endogenous Financial Contracts, Overoptimism, Bankruptcy.

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1 Introduction

The growth of consumer credit since the 1970s has motivated debate over whether and how to regulate consumer credit products. Crystallized by the 2008 Financial Crisis, this has resulted in the creation of the Consumer Financial Protection Bureau (CFPB) as part of the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 with a mandate to regulate credit products. The ensuing policy debate has centered around whether borrowers' cognitive biases create the need for active regulation — beyond requiring the disclosure of relevant information when making financial decisions — that can limit harmful borrowing decisions (Bar-Gill and Warren 2008; Campbell 2016). In particular, advocates of new regulations have argued that regulation should prevent households from over-borrowing and ending up "trapped in debt."[1]

A common view is that these "behavioral" consumers are "exploited" by the credit industry – for example through strategic pricing, – and that regulation is needed to protect these consumers (Campbell 2016). This line of thinking has been picked up in a recent theoretical IO literature (Heidhues and Koszegi 2010; Heidhues and Koszegi 2015; Eliaz and Spiegler 2006). Several papers show that under some conditions, behavioral (sometimes called naive) debtors pay more for the same product than informed rational debtors. The extra fees (or higher interest rates) benefit either the intermediary directly, or in models with competitive banking, the rational debtors benefit through lower prices. For example, Heidhues and Koszegi (2015) argue that lenders can take advantage of borrowers that underestimate their future impatience. These borrowers backload repayments and thus incur penalties that they did not anticipate ex-ante. However, none of these papers feature default in equilibrium. This is potentially important both because risk based pricing is a justification for higher pricing for some consumers, and since high default rates are cited as a concern in the policy debate.

In this paper, we quantitatively analyze unsecured consumer credit markets with behavioral consumers and default. Specifically, we introduce over-optimistic borrowers into an otherwise standard incomplete markets economy with unsecured debt and equilibrium default. Lenders price credit endogenously based on beliefs about a borrower's type. We study how the updating of these beliefs over a borrower's life impacts the interest rates at which they borrow, and show that spill-overs between rational and over-optimistic borrowers may arise.

[1] Senator Chris Dodd, U.S. Senate, Congressional Record, 155, S5314 (2009).

The key theoretical novelty is to incorporate "behavioral" consumers into incomplete markets models with consumer bankruptcy (Chatterjee et al. 2007; Livshits, MacGee, and Tertilt 2007). We model behavioral consumers via over-optimistic beliefs for two reasons. First, we show that this gives rise to a tractable model of type-scoring and partial pooling of behavioral and non-behavioral consumers. Second, substantial work has documented that some consumers are over-optimistic about future income (Arabsheibani et al. 2000; Dawson and Henley 2012; Balasuriya and Vasileva 2014), survival (Puri and Robinson 2007), the time it takes to complete everyday tasks (Buehler, Griffin, and Ross 1994), and that they generally underestimate the probability of experiencing negative events (Weinstein 1980).[2] Gathergood (2012) found that U.K. consumers reporting financial difficulties were more likely to endure unforeseen expenditures.

Motivated by these findings, we consider two alternative forms of over-optimism in our model. The first we refer to as income over-optimism, as behavioural consumers place too high (low) a probability on positive (negative) transitory income shocks. The second we term expense over-optimism, as consumers believe they face a lower probability of being hit by an expense shock than their true risk.[3] Since our model assumes over-optimists believe they face the same risks as rational consumers, our behavioral consumers differ from realists in both being more prone to shocks *and* they are not aware of the higher risk they face. While conceptually these are distinct features (and we decompose results for each channel), in practice they often come hand in hand. For example, a literature on impulse buying has documented that some people are particularly prone to unanticipated impulse purchases (Beatty and Ferrell 1998; Verplanken and Sato 2011), resulting in these impulse buyers facing higher risk which they but are not aware of. In our framework, impulse buyers can be interpreted as over-optimistic about their expense risk. Another context in which proneness to shocks appears coupled with over-optimism is among the self-employed. While they face more risks than wage earners, the self-employed have been found to be more over-optimistic than the average population (Åstebro 2003; Arabsheibani et al. 2000).

Our model is an incomplete-market economy with bankruptcy populated by finitely lived heterogeneous agents who are subject to idiosyncratic earnings and unforeseen expenditures which we term "expense shocks". Households decide on how much to

[2]Using a British household survey, Dawson and Henley (2012) find that 30% are over-optimistic about future income, while Arabsheibani et al. (2000) show that entrepreneurs are more over-optimistic than employees. Balasuriya and Vasileva (2014) find that over-optimists save less for retirement.

[3]An alternative interpretation is they have limited financial literacy in that they do not fully understand their expected future financial position.

borrow or save, and whether to file for bankruptcy. There are two types of households: realists who hold correct beliefs over the uncertainty they face, and over-optimists that think of themselves as realists (and – conditional on their state – behave as realists) but actually face systematically higher risk. If households do not default, they can borrow or save in a one-period bond that is priced in a perfectly competitive debt market.

While financial intermediaries observe household earnings, age and current debt or asset positions, they cannot directly observe whether a household is an over optimist or realist. Since financial intermediaries observe income and expense shock realizations and form beliefs on the probability that a household is a realist. We refer to these beliefs as type scores. In equilibrium, lending interest rates depend on current income, age, the amount borrowed and the type score. This results in the endogenous pooling of over-optimists with realist borrowers with the same type score. Since over-optimists believe they are realists, both types behave identically and there is no way for lenders to design screening contracts. As consumers age, lenders update their beliefs about a borrower's type based on observed realizations of her idiosyncratic uncertainty. The model thus gives rise to a tractable theory of type scoring.

The equilibrium allocation in our model generates spill-overs between rational and over-optimistic borrowers. Since over-optimists default more often, cross-subsidization through the interest rate goes from rational to behavioral consumers. If the fraction of over-optimists rises in our economy, the average borrowing interest rate goes up and both types borrow less and default less at an individual level. However, aggregate debt and aggregate bankruptcies increase due to a composition effect: when increasing the fraction of over-optimists, the economy is composed of more risky households that borrow and default more.

Although over-optimists benefit from the cross-subsidization, from a paternalistic point of view, over-optimistic debtors borrow too much and default too late.[4] This arises because over-optimistic consumers have too optimistic views about the future and hence, rather than defaulting right away, they expect to repay their debt in the future. However, over-optimists are systematically surprised by more future bad realizations, and end up unable to get out of debt.

To address these inefficiencies, we explore several potential policy interventions. First, we reduce the cost of default, inducing over-optimistic people to default earlier. Second,

[4]Paternalistic welfare weights the future using the true probabilities rather than over-optimistic beliefs.

we investigate "financial literacy education" where we inform people about their true type, inducing them to internalize the true probabilities into their beliefs. Third, we explore the implications of making borrowing more costly through increased regulatory requirements or a proportional transactions tax. This should reduce over-borrowing. For all policies, we investigate how they impact behavioral and rational people individually and what the aggregate implications are.

These policy experiments provide interesting insights into the winners and losers from credit regulation. First, reducing default costs indeed makes over-optimists better off. However, this comes at the cost of making rational people worse off. Second, financial literacy education backfires in the sense that precisely over-optimists will be made worse off by facing their true, higher than expected, exposure to risk. Rational people in fact benefit from the policy because they are no longer pooled with the high-risk over-optimists. Thus, some of the voiced concern about naive consumers could be driven by self-interested (rational) policy-makers not wanting to cross-subsidize over-optimists. Third, increasing transactions costs does reduce both debt levels and bankruptcy filing rates, but does not improve the welfare of either group of borrowers.

Despite broad evidence on behavioral traits in consumers, surprisingly little work has incorporated behavioural borrowers into models of consumer debt that explicitly allow for default. Two exceptions are Laibson, Tobacman, and Repetto (2000) and Nakajima (2012, 2017) who each examine self-control problems – Laibson, Tobacman, and Repetto (2000) analyze hyperbolic discounters while Nakajima (2012, 2017) uses "temptation preferences" based on Gul and Pesendorfer (2001) – and thus conceptually quite different from the over-optimists considered in our paper. Laibson, Tobacman, and Repetto (2000) and Nakajima (2012) are positive analyses not concerned with policy implications. The only other paper that analyzes the policy implications of introducing behavioral consumers into a consumer bankruptcy model is Nakajima (2017), which also finds contrasting views among the borrowers regarding bankruptcy reform. In Nakajima (2017), lowering default costs increases the welfare of behavioral borrowers since tighter borrowing constraints limit the temptation these borrowers are exposed to. Our proposed mechanism is complementary as (the paternalistic planner on behalf of) the over-optimistic borrowers benefit both from better ex-post insurance afforded by the more generous bankruptcy regime and from the tighter ex-ante borrowing constraints limiting over-borrowing. We show that if lenders cannot directly distinguish between behavioural and realist consumers, that rational types are made worse off by reducing

default costs. Moreover, unlike Nakajima (2017), in our income over-optimism experiments we find that that lower default costs can make behavioural consumers worse off. Moreover, models with self-control problems have, by design, nothing to say about financial literacy education.

Although our model features lenders who are better informed than borrowers about the risk of default, our structure differs from one common definition of predatory lending. Bond, Musto, and Yilmaz (2009) define a *predatory loan* as one which a borrower would decline if they had the same information as the lender. Depending on each household's type score, borrowing in our model pools borrowers with correct beliefs about future default risk with borrowers who incorrectly share the same beliefs. But – contrary to Bond, Musto, and Yilmaz (2009) – over-optimists are aware of and agree with their type score as it is simply a function of realized past shocks. They are ignorant about their fundamentally higher risk and just think of themselves as being unlucky and thus pooled with worse risks. As a result, they agree to the loan contract offered to them. Even more strikingly, if one was to resolve their ignorance, over-optimists would understand that their loan contracts have been subsidized by rational types and be more than happy to accept those contracts.

The remainder of the paper is organized as follows. We outline our model and calibration in Section 2. Section 3 reports the main quantitative results on how type scores evolve over the life cycle and how the presence of over-optimists impacts credit markets. Section 4 analyzes how policies making default easier, financial literacy education to a tax on borrowing affect behavioral and rational types. Finally, Section 5 concludes.

1.1 Bankruptcy and Consumer Financial Protection

The rise in consumer credit and the number of household experiencing challenges in meeting their debt payments has sparked renewed debate over consumer financial protection. This debate has sparked not only a closer look at bankruptcy rules, but also at broader regulations of consumer lending.

A core element of consumer financial protection is the option to discharge debt. In the U.S., households can choose between Chapter 7 and Chapter 13 when filing for bankruptcy protection.[5] When a household's Chapter 7 bankruptcy filing is accepted,

[5]Mecham (2004) provides an in-depth description of U.S. bankruptcy law.

creditors lose any claims towards the bankrupt's future income in exchange for assets above a certain exemption level are seized. As a consequence of the 2015 Bankruptcy Abuse and Consumer Protection Act, Chapter 7 is now means-tested.[6] After declaring Chapter 7 bankruptcy, consumers are exempt from re-filing for six years. Total filing cost comprise court fees and legal fees and range from roughly $1,000 to $1,700 (Sullivan, Warren, and Westbrook 2000). The court also demands a full list of creditors, outstanding debt, available assets, regular cost of living and the details on a debtor's income. Typical Chapter 7 bankruptcies rulings take four months till completion.

Regulation of consumer lending has struggled with the trade-off between limiting the terms of financial products (e.g., usury law) and mandating disclosure (Zywicki 2013). The post financial crisis period has seen a shift towards more prescriptive legislative reforms, as evidenced by the creation of Consumer Financial Protection Bureau (CFPB) and the Credit Card Accountability Responsibility and Disclosure Act of 2009 (CARD Act). Proponents of that regulation regularly argued that some consumers were over-borrowing due to behavioral biases, or that less-sophisticated borrowers were exploited by sophisticated lenders. From a paternalistic point of view, these frictions allow for potential welfare gains from regulation. In the following section we develop a framework to analyze several reforms in the presence of borrowers that exhibit behavioral biases.

2 Model Environment

The model incorporates over-optimistic consumers and type-scoring by lenders into an otherwise standard incomplete-markets heterogeneous-agent life-cycle economy with defaultable one-period debt. The economy is populated by measure 1 of J-period lived consumers who face idiosyncratic income and expense shocks. A fraction $\lambda \in (0, 1)$ of households have over-optimistic beliefs about the idiosyncratic uncertainty they face, while $(1 - \lambda)$ have realistic (correct) beliefs. To make the role of over-optimism more transparent, we assume both types of consumers have identical beliefs over the distribution of income and expense shocks. However, over-optimistic consumers face higher probabilities of expense and adverse transitory income realizations than they believe, and thus higher risk than the realists.

[6] Roughly 70% of bankrupts file under Chapter 7. Chapter 13 – the other option – is not present in our model.

Markets are incomplete as the only financial instruments are one-period bonds. We examine a small open economy, where the risk free interest rate is exogenous.[7] Since households can declare Chapter 7 bankruptcy, debt is partially state-contingent.

Debt is priced endogenously by competitive lenders who observe a history of consumer's income and expense shocks. While lenders know the fraction of the population, λ, that are over-optimists, they cannot observe a consumer's type directly. Thus, lenders form beliefs over borrowers' types, which we term *type scores*, and update these beliefs each period based on a consumer's realized income and expense shocks. The bond price schedule offered to a consumer reflects the expected default risk, and is thus influenced by the type score.

The model timing sees consumer productivity and expense shocks realized at the beginning of the period. Lenders update their type score. Then, consumers decide whether to file for bankruptcy, and if they do not file, how much to borrow or save.

2.1 Households

Consumers maximize expected discounted life-time utility, $\mathbb{E}^B \sum_{j=1}^{J} \beta^{j-1} u\left(\frac{c_j^B}{n_j}\right)$, where β denotes the discount factor, and consumption c_j is adjusted by household size n_j at age j. $B \in \{R, O\}$ denotes a households type, rational ($B = R$) or over-optimistic ($B = O$). Consumer types differ in the distribution of shocks they face, but not in their beliefs regarding the distribution. Realists' beliefs coincide with the true distribution they face. Over-optimists believe they face the same distribution of uncertainty as realists, but actually face a distribution with more downside risk. Borrowers' beliefs are not updated as consumers age, so that over-optimists interpret bad realizations simply as continued bad luck.

Labor income at age j for consumer type B is the product of age-dependent labor productivity and productivity shocks:

$$y_j = \overline{e}_j z_j \eta_j, \tag{2.1}$$

[7]This paper focuses on unsecured debt. Given that unsecured debt is a small share of total debt in the United States, the assumption that this has little effect on the risk free rate of return is a reasonable approximation. More importantly, it reduces the computational burden which allows us to track type scores over the life-cycle.

where $\overline{e}_j$ is deterministic labor productivity, z_j is a persistent auto-regressive earnings shock, and η_j is a transitory earnings shock.

Households face unforeseen expenses that we capture by expense shocks $\kappa \geq 0$, drawn from a finite set $K = \{0, \kappa_1, ..., \kappa_N\}$ with independently and identically (within type) distributed probabilities $\{\pi_0^B, ...\pi_N^B\}$. An expense shocks alters a household's net asset position.[8]

Rational households have correct beliefs over future income and expenditure shocks:

$$\mathbb{E}^R(x'|x) = \mathbb{E}(x'|x), \tag{2.2}$$

where x is any random variable, x' is next period's realization and $\mathbb{E}$ is the true mean. Over-optimists believe that they face the same income and expense shocks as realists.

$$\mathbb{E}^O x^O = \mathbb{E} x^R, \tag{2.3}$$

As a result, an over-optimist will make the same decision as a realist conditional on the state. However, over-optimists face systematically higher risk than realists, so that $\mathbb{E}\kappa^O > \mathbb{E}\kappa^R$ and/or $\mathbb{E}\eta^O < \mathbb{E}\eta^R$.

2.1.1 Bankruptcy

Consumers can file for bankruptcy. Filing for bankruptcy discharges the households debt so a filer enters the following period with zero debt. To proxy for six years of exclusion from bankruptcy, bankrupts cannot file for bankruptcy in consecutive periods.

Filers must repay a fraction γ of their income when they declare bankruptcy. This captures the good faith effort required from borrowers to repay their debt as well as filing fees and legal fees. Since a filer cannot borrow or save, consumption of a filer is $(1-\gamma)y_j$.[9] Bankrupts suffer a utility cost of filing, χ, which captures other costs (e.g, "stigma") associated with filing for bankruptcy.

[8] The associated probabilities carry a superscript B (while the shock sizes do not) because over-optimists will face higher expense risk (but the support of expense shocks remains the same).

[9] We do not allow bankrupts to save as assets are seized to repay creditors

2.2 Financial Intermediaries

Financial intermediaries are competitive and can borrow and save at the exogenous risk free rate r^s. They offer each borrower a one-period bond price schedule. The face value to be repaid next period is d'.[10] Due to bankruptcy, repayment is (partially) state contingent. Intermediaries take into account expected losses from default when determining the bond price schedule $q(d', \cdot)$. Specifically, this price schedule depends explicitly on the borrower's age j, current realization of the persistent income state z, the amount d' being borrowed, and the lenders' perception of the borrower's risk type B. The latter is summarized by a *type score* s.[11]

Type Scores are the probabilities that intermediaries attach to a household being rational. Although intermediaries cannot observe a household's type directly (i.e., realist or over-optimist), they can observe the history of realizations of transitory income shocks η and expense shocks κ, as well as the age j. Type score s summarizes the lenders' beliefs about a borrower's type. The type scores are updated using Bayes' rule. A household that starts a period with type score s and experiences shock realizations (η, κ) will have the type score updated to

$$s'(\eta, \kappa, s) = \frac{s\mathrm{Pr}^R(\eta, \kappa)}{s\mathrm{Pr}^R(\eta, \kappa) + (1-s)\mathrm{Pr}^O(\eta, \kappa)}, \tag{2.4}$$

All households enter the economy with (prior) type score $s_0 = 1 - \lambda$.

Since over-optimistic households do not learn their own type and believe they face the same risks as realists, households' choices do not convey any additional information about the household's type. The decision rules of an over-optimistic consumer, conditional on a household state (which includes the type score) and bond price, are the same as those of rational households. Since over-optimists face a higher probability of receiving an expense shock, by observing expenditure shock realizations lenders can update their beliefs of a household's types.[12]

[10] In our setting, savings are simply denoted as negative debts, i.e. $d' < 0$.

[11] The current realization of persistent income z is informative about future income and thus predictive of future default risk. Since the transitory shock η and the expense shock κ are idiosyncratic, their current value is not directly informative of future default risk. In standard models, loan prices do not depend on the realizations of these shocks. However, in our proposed model, the realizations of κ and η are informative about the borrower's underlying type, and thus affect prices by affecting the type score.

[12] Since both types of agents are ignorant about their fundamental differences, they do not choose to

Conditional on the probability that a household is rational (s), intermediaries accurately forecast the borrower's default probability, $\theta(d', z, j, s)$, and price the loan accordingly.

2.3 Equilibrium

Lenders earn zero expected profits on each loan. Conditional on observable characteristics (persistent labor income z and age j) as well as a household's type score (s), bond prices are determined by the default probability of a household and the risk-free rate. Free entry implies that there is no cross-subsidization of interest rates between contracts for consumers with different observable characteristics. If a borrower defaults, banks receive a fraction $\gamma y/(d' + \kappa)$ of the original loan from a required repayment which is proportionally allocated to outstanding loans and unpaid expenses.

The zero profit condition implies a bond price schedule of

$$q^{ub}(d', z, j, s) = (1 - \theta(d', z, j, s))\overline{q}^b + \theta(d', z, j, s)E(\frac{\gamma y}{d' + \kappa'})\overline{q}^b, \tag{2.5}$$

where $\overline{q}^b = \frac{1}{1+r^s+\tau}$ is the hypothetical price of a save bond.

In the numerical solution of the model, the interest rate is restricted by a ceiling $\bar{r}$ which yields the *equilibrium bond price*

$$q^b(d', z, j, s) = \begin{cases} q^{ub}(d', z, j, s) & \text{if } q^{ub}(d', z, j, s) \geqslant \frac{1}{1+\bar{r}} \\ 0 & \text{otherwise.} \end{cases} \tag{2.6}$$

Consumers take the equilibrium bond price schedule as given. The households' optimization problem is summarized by a value function V which is the value of not defaulting, while $\overline{V}$ is the value of filing for bankruptcy. Since bankruptcy cannot be declared in successive periods, we define the value of informal default, W, when not eligible for bankruptcy.[13] With an informal default, the same fraction of income is garnished as in bankruptcy and the debt is rolled over at a fixed interest rate r^r. All value

signal their type by separating in equilibrium. Hence, there can only be a (partial) pooling equilibrium.

[13]Informal default addresses the possibility of an empty budget set for a consumer that is ineligible for bankruptcy but draws a large expense shock. The only debt held in this case stems from an expense shock. This option is rarely used in our simulations.

functions depend on whether beliefs are rational or over-optimistic, $B \in \{R, O\}$:

$$V_j^B(d, z, \eta, \kappa, s) = \max_{c,d'} \left[u\left(\frac{c}{n_j}\right) + \beta \mathbb{E}^B \max\left\{ V_{j+1}^B(d', z', \eta', \kappa', s'), \overline{V}_{j+1}^B(z', \eta', s') \right\} \right] \quad (2.7)$$
$$\text{s.t. } c + d + \kappa \leqslant y_j^B + q^b(d', z, j, s) d'$$

$$\overline{V}_j^B(z, \eta, s) = u\left(\frac{c}{n_j}\right) - \chi + \beta \mathbb{E}^B \max\left\{ V_{j+1}^B(0, z', \eta', \kappa', s'), W_{j+1}^B(z', \eta', \kappa', s') \right\} \quad (2.8)$$
$$\text{s.t. } c = (1-\gamma) y_j^B$$

$$W_j^B(z, \eta, \kappa, s) = u\left(\frac{c}{n_j}\right) - \chi + \beta \mathbb{E}^B \max\left\{ V_{j+1}^B(d', z', \eta', \kappa', s'), \overline{V}_{j+1}^B(z', \eta', s') \right\} \quad (2.9)$$
$$\text{s.t. } c = (1-\gamma) y_j^B, \qquad d' = (\kappa - \gamma \bar{e}_j z \eta)(1 + r^r).$$

An equilibrium is a set of value functions, optimal decision rules for consumption $c^B(\cdot)$ and default $n^B(\cdot)$ for consumers, default probabilities $\theta(\cdot)$, and bond prices $q^b(\cdot)$, such that households optimize (equations (2.7)-(2.9)), and bond prices satisfy the intermediaries' problem (zero profit condition in equation (2.6)), taking the default probabilities as given. To solve numerically we iterate backwards on the value functions.

2.4 Benchmark Calibration

We calibrate to a benchmark with no over-optimistic households (i.e., $\lambda = 0$). This approach is consistent with our objective of showing how varying the fraction of behavioral consumers in the population impact credit markets. In addition, it allows us to use the established approach of Livshits, MacGee, and Tertilt (2010), who calibrate a similar model to the US economy in 1995-1999.

Consumers enter the economy at age 20 and live for 54 years, modelled in 18 three year periods. For the first 15 periods, consumers face stochastic (labor) income. During the last three periods, households receive non-stochastic retirement benefits. The felicity function is $u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$. The consumers (annual) discount factor is set to $\beta = 0.94$, and the coefficient of relative risk aversion to $\sigma = 2$. To proxy household size over the life-cycle, we use the equivalence units n_j from Livshits, MacGee, and Tertilt (2007).

Livshits, MacGee, and Tertilt (2007) parameterized the expense shocks to U.S. estimates of medical expenses, divorces and unplanned parenthood. The support of expense shocks K has three elements: $\kappa \in K = \{0, \kappa_1, \kappa_2\}$. The smaller shock (divorces

and unplanned parenthood) is 26.4% of average (three year) income. The large medical shock corresponds to 82.18% of average endowment. The probabilities $[\pi_1, \pi_2]$ of these shocks realizing are 7.1% and 0.46%, respectively.[14] Livshits, MacGee, and Tertilt (2003) contains a more detailed account of the expense shock parameterization.

We represent the persistent shock as a five state Markov process. The parameters of this process map into an auto-correlation $\rho_z = 0.95$ and a variance $\sigma_z^2 = 0.043$. For the transitory shock, we assume that 10% of households are hit with a positive or negative realization each period. Then, the support of the shock is set to match the variance $\sigma_\eta^2 = 0.043$. Each retiree receives a deterministic pension of 20% of average income in the economy, plus receive 35% of their last persistent income realization before retirement.

We set the interest rate on savings to the annual value of 3.44%, and the transaction cost of lending, τ so that the risk-free borrowing interest rate is 6% annual, The rate at which informally defaulted debt is rolled over (r^r) is fixed at 20% per year.

In our baseline, we follow Livshits, MacGee, and Tertilt (2010) and set the utility cost of declaring bankruptcy to $\chi = 0$ and the garnishment rate γ to 31.9% (Nakajima (2017) calibration is similar at 34%).[15] This implies that there are no dead weight costs of bankruptcy, as the cost imposed on filers is transferred to lenders. We set a rather loose interest rate ceiling at 100% annually.[16]

2.5 Welfare Measures

Since over-optimists have distorted beliefs about the risks they face, their expected value at birth does not correspond to the value that a planner would attach to their life or the value that over-optimists would expect were they educated about their bias. Over-optimistic beliefs weigh positive outcomes too heavily and vice versa. Consequently, over-optimists' expectations do not correspond to the average outcomes of over-optimistic individuals or – since over-optimists are not aware of their own presence – to average outcomes of all types in the economy. In order to compare the welfare of over-optimists being born into one of our experiments, we introduce a welfare measure that is not distorted by biased expectations.

[14] Expense shocks are assumed to only hit working-age households.

[15] See Livshits, MacGee, and Tertilt (2010) for a discussion of how to interpret this cost.

[16] This value is larger than implied by current usury laws. However, official legal ceilings can be avoided. See Livshits, MacGee, and Tertilt (2010) for a more detailed discussion. Numerically, the ceiling does not have strong effects as it rarely binds for borrowers.

We define *realized welfare* $\mathcal{V}^O$ as the welfare that over-optimists would expect if they used the correct rational expectations but still behaved ignorantly over their whole life:

$$\mathcal{V}_1^O(0,z,\eta,\kappa,s) = u\left(\frac{c_1^O}{n_1}\right) + \beta \mathbb{E}^O \max\left\{\mathcal{V}_2^O(d',z',\eta',\kappa',s'), \overline{\mathcal{V}_2^O}(z',\eta',s')\right\}, \tag{2.10}$$

where c^O and d' are the optimal consumption and borrowing choices (of both realists and over-optimists). These policies solve the household problem in equations (2.7)-(2.9). Note that while behavior is unchanged, expected values are formed using rational expectations $\mathbb{E}^O$.

The expected *realized welfare* $\mathcal{V}$ of being born into a certain economy is simply the average of *realized welfare* $\mathcal{V}_1^O$ weighted by the ergodic distribution of newborns, μ:

$$\mathcal{V} = \sum_{z,\eta,\kappa} \mathcal{V}_1^O(0,z,\eta,\kappa,s'(\eta,\kappa,\lambda))\ \mu(z,\eta,\kappa). \tag{2.11}$$

3 Quantitative Analysis with Over-optimistic Borrowers

Our experiments consider two alternatives sources of over-optimism: transitory income shocks or expense shocks. In both cases, over-optimists believe they face the same income and expense risk as realists. While there is evidence pointing to the presence of non-sophisticated consumers, there is no consensus as to which bias is most important or the fraction of consumers in the US whose behavior is not rational. Thus, the following analysis is intended to illustrate the effects of introducing over-optimistic households without taking a stand on how large the actual fraction might be. Consequently, we introduce a range of plausible measures of over-optimists, and evaluate the effects of these different measures in Section 3.3. When we turn to policy analysis in Section 4, we fix the measure of over-optimistic households in the economy at $\lambda = 0.2$.

To highlight the effects of over-optimism in the transitory income case, we set the probabilities that over-optimists receive negative (positive) transitory income shocks to 0.15 (0.05). As we target the same economy average transitory shocks as Livshits, MacGee, and Tertilt (2010) (summarized in the first two rows of Table 1), we set the transitory shock probabilities for realists so as to match an economy average probability of positive (negative) transitory shocks of 10 (10) percent. As a result, both realists

and over-optimists believe that the probability of positive (negative) transitory income shock is 0.0875 (0.1125).

For the expense over-optimism experiments, we scale up the probability that an over-optimist receives an expense shock by ψ: $[\pi_1^R, \pi_2^R] = \psi[\pi_1, \pi_2]$. This implies that the probability of not receiving any expense shock is decreased one-for-one with the increased probability of receiving a shock.[17] We set the degree of overoptimism to $\psi = 2$ so as to equalize the welfare of behavioural consumers in the economy with expense to that of income.[18]

Table 1: Over-Optimism Paramerization

	Income		**Expense**	
Aggregate	η	$[0.6, 1, 1.6]$	$[\kappa_1, \kappa_2]$	$[0.264, 0.8218]$
	$Pr(\eta)$	$[10\%, 80\%, 10\%]$	$[Pr(\kappa_1), Pr(\kappa_2)]$	$[7.1\%, 0.46\%]$
Behavioral	$Pr(\eta)$	$[15\%, 80\%, 5\%]$	$[Pr(\kappa_1), Pr(\kappa_2)]$	$[21\%, 0.46\%]$
Rational	$Pr(\eta)$	$[8.75\%, 80\%, 11.25\%]$	$[Pr(\kappa_1), Pr(\kappa_2)]$	$[3.6\%, 0.46\%]$

Our numerical experiments yield several key insights. First, over-optimism with respect to transitory income shocks results in behavioral consumers over-borrowing – that is, they borrow more than they would if they were made aware of the risk they faced. Although this is consistent with the intuition of many, it runs counter to the arguments of Hynes (2004) that behavioural consumers could under-borrow since they place too high a probability on repaying debt. Surprisingly, over-optimism leads consumers to file for bankruptcy *less often* than if they knew their true type (had accurate perception of the risks they are facing). Their over-optimistic expectations of future income generate both a greater desire to borrow and an excess probability weight on being able to repay loans in the future (which yields greater willingness to roll-over loans rather than defaulting right away).

Not surprisingly, over-optimists borrow more than realists, default more frequently, and pay on average higher interest rates.[19] In the case of over-optimism regarding in-

[17] In order to keep average risk in the economy constant, we proportionally decrease expense shock probabilities of realists: $[\pi_1^R, \pi_2^R] = [\pi_1, \pi_2](1 - \lambda\psi)/(1 - \lambda)$.

[18] We ran several experiments with lower ψ and found the same basic forces to be at work. While quantitatively smaller, the effects of lower degrees of overoptimism exhibit the same qualitative features.

[19] While over-optimists file for bankruptcy more often than realists, they still file "not often enough" relative to their decisions if made aware of their true risk exposures.

come, the higher levels of borrowing, bankruptcies and borrowing interest rates are driven almost entirely by the higher risk profile of over-optimists, and not by the cross-subsidization from the realists. However, welfare is significantly impacted by the cross-subsidization arising from pooling the two types of borrowers (within any given type-score bin).

Realist borrowers in the model are affected by the presence of behavioral borrowers. These spillover effects are not limited to the mis-pricing of debt due to pooling of behavioral and realistic borrowers as the presence of behavioral agents inhibits the realists' ability to smooth consumption. Transitory shocks, which would be easily smoothed in a model with no behavioral agents, have persistent affects in our model and are harder (more expensive) to borrow against. Whereas in the standard model transitory shocks do not affect debt prices, in our model with behavioral agents, these transitory shock have informational content, and thus affect both type-scores and, consequently, debt prices. Thus, borrowers face increased interest rates exactly when they need to borrow.[20]

Some of the quantitative implications of our model are sensitive to the nature of over-optimism. While "over-borrowing" and filing "too little, too late" are quantitatively large under income-shock confusion, these mistakes are not as quantitatively important under expense-shock over-optimism. On the other hand, cross-subsidization is more important quantitatively in the latter case. The nature of over-optimism also critically affects some of the policy prescriptions. For example, tighter bankruptcy regulation (modeled as higher γ in the model) increases the realized welfare of over-optimists when their confusion concerns the income shocks, but lowers that welfare when over-optimism is about the expense shocks (realists in our parameterization always prefer higher γ). All of this is discussed in details in the following subsections.

3.1 Type Scoring

Type scores summarize the probability that lenders attach to a certain household being a realist. Conditional on these scores, lenders quote their credit prices. As discussed in Section 2.2, intermediaries update type scores by observing the realized value of shocks as households age.

[20] Athreya, Tam, and Young (2009) point out this price effect for *persistent* shocks in a standard model of unsecured debt markets. The presence of the behavioral agents in our model leads to this price effect appearing even for *transitory* shocks (and would amplify the price effect for persistent shocks, if those were subject to over-optimism as well).

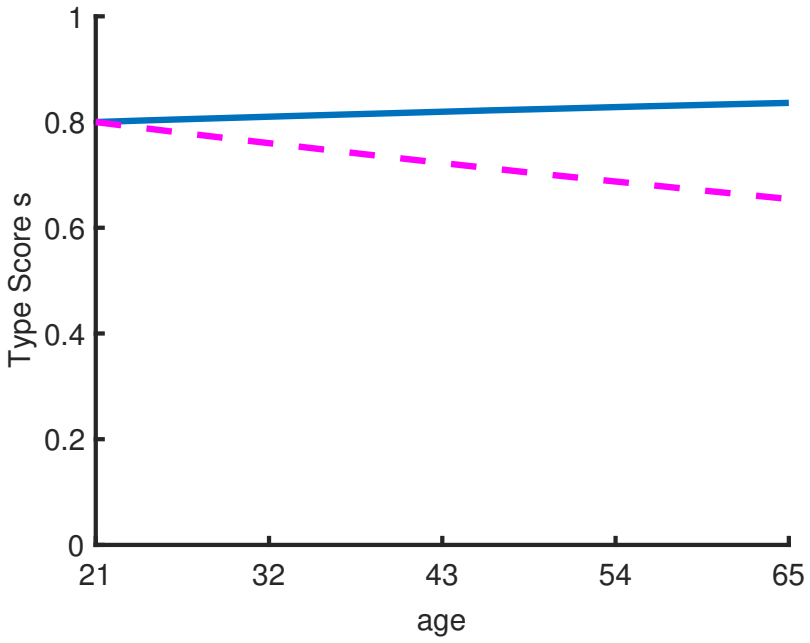
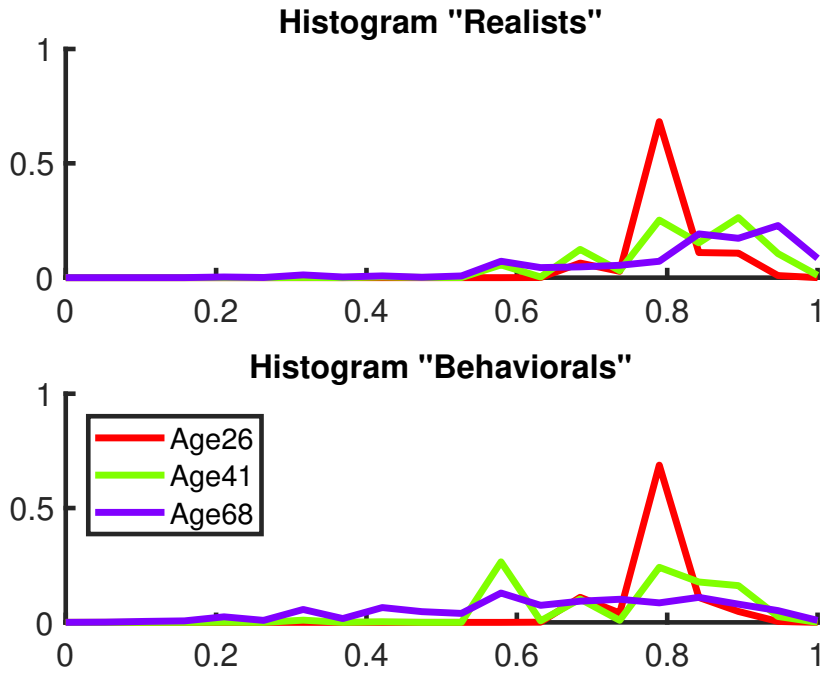


Figure 1: Evolution of Type Scores, over-optimists vs. realists, averages

To illustrate how this information is incorporated into individual type scores, Figure 1 plots average type scores by type over the life-cycle. Type scores monotonically increase with age as long as the person is not hit by an adverse income or expense shock. As soon as an adverse shock hits, the score drops (for both realists and over-optimists). The two types only differ in the underlying probability of these adverse shocks. Over-optimists face them more often and hence their scores are more likely to decline over time. Even so,a lucky over-optimist's score can remain high for their entire life, while the score for an unlucky realist can decline dramatically as they age.On average though, the type scores of over-optimists decline with age, while realists' type scores increase. This life-cycle pattern is illustrated in Figure 1, where the solid line gives the average score for realists while the dashed line gives the average score for over-optimists.

Another way of looking at this is to compare the distribution of scores over the life cycle. Figure 3.1 depicts the distribution of type scores at two different ages. At the age of 26, intermediaries have only observed households for a few periods. Accordingly, most households have not yet incurred adverse shocks. Their type scores increase to slightly above the initial value of 0.8. Those households hit by an adverse shock are more likely to be over-optimistic, hence there is a small mass around a type score of 0.65.



As households age, different people experience very different sequences of shocks realizations. Thus, the distribution of type scores becomes much more disperse as a cohort ages. Accordingly, interest rates for borrowers becomes more disperse with age. Less pooling of type scores later in life implies less cross-subsidization in interest rates across types, too. Early in life, the type score distribution of over-optimists nearly coincides with that of realists. This is no longer true for older households. For older cohorts, the distribution of over-optimists is clearly to the left of the distribution of realists. However, even for older consumers there is still substantial pooling of types.

3.2 Over-Optimism Regarding Income Shocks

We first examine the implications of over-optimism regarding transitory income shocks, with over-optimists facing a higher (lower) probability of negative (positive) transitory income shocks than they believe.

The first column of Table 2 reports several key averages for over-optimists and realists. Over-optimists have higher average debt to income ratios and filings rates than realists. This higher risk results in higher average borrowing rates, with the average rate for over-optimists roughly 190 basis points higher than that of realists. Although over-optimist filing rates are roughly 40 % (0.32/0.79) higher than those of realists, filing

rates per borrower are only 10 % higher. This reflects the role of the extensive margin, as roughly a third of over-optimists in the economy borrow each period compared to just over a quarter of realists.

Table 2: Decomposition Benchmark Transitory Income: Bias vs. Extra Risk

		Benchmark		
		biased pooled	biased not pooled	not biased not pooled
Debt-to-income	Rational	9.05%	9.08 %	9.08%
	Behavioral	13.16%	13.14%	9.05%
	Aggregate	9.88%	-	
Filings	Rational	0.79%	0.82%	0.82%
	Behavioral	1.11%	1.00%	0.86%
	Aggregate	0.86%	-	
Interest Rates	Rational	10.48%	11.16%	11.16%
	Behavioral	12.42%	10.09%	12.08%
	Aggregate	10.87%	-	
Filings per Borrower	Rational	3.01%	3.09%	3.09%
	Behavioral	3.36%	3.00%	3.19%
	Aggregate	%	-	
Borrowers	Rational	26.38%	26.35%	26.35%
	Behavioral	33.05%	33.28%	26.96%
	Aggregate	27.71%	-	

Behind the aggregates lie significant variations over the life-cycle. A key factor driving these life-cycle changes is that type scores become (on average) more accurate over the life cycle. This means that the fraction of realists that are pooled with over-optimists decline as with age (see Figure 1). This partially accounts for a fanning out of average borrowing interest rates for behavioural versus realists over the life cycle. The dispersion in average rates in Figure 2 also reflects the shift in the debt level of those borrowing. On average, over-optimists carry higher debt levels as they

What is it that behavioral consumers get wrong? To answer this, we compare the choices of over-optimists to those they would make if they were informed about the true probabilities they face and were not pooled with realists. The results of these experiments are reported in Table 2, column "not biased not pooled". Not surprisingly, over-optimistic consumers over-borrow, and their debt-to-income ratio is roughly 4 percentage points lower if they are made aware. This is driven by both a decline in the fraction of borrowers, from roughly 33% to 27%, and a fall in the average debt per borrower. Despite the lower debt-to-income when over-optimists are aware, their rate of filing per borrower falls relatively little. Surprisingly, being made aware results in a modest decline in the average borrowing rate of over-optimists of roughly 34 basis points.

Surprisingly, over-optimistic consumers actually file *less often* (i.e., have higher minimum debt level before filing) than they would if aware. In the benchmark experiment. an additional 1.08% of consumers would file if made aware of their true income process. Why do over-optimistic consumers file too late? The key factor is that they are over-optimistic about their future ability to repay debt. This leads them to prefer to smooth their current consumption by increasing their borrowing rather than filing for bankruptcy.

Figure 2: Average Borrowing Interest Rates, over-optimists vs. realists, 2 ages

To better identify the impact of partial pooling of over-optimists with realists, we simulate an economy comprised entirely of realists and one populated entirely by over-optimists. The results of these experiments are reported in Table 2, column "biased not pooled". When realists are no longer pooled with over-optimists, their average amount borrowed and filings rise slightly. These changes are largely a response to a rise in borrowing interest rates when realists are no longer pooled with over-optimists, which also

sees a small decline in the fraction of realists who borrow. Over-optimists in contrast see a fall in average borrowing interest rates when they are no longer pooled with realists. This reflects the opposing forces arising from over-optimism with regards to income. On the one hand, since over-optimists file too late, their default rate is relatively low given the shocks they receive. Working in the other direction, over-optimists over-borrow which results in some acquiring large debts that drive defaults later in life.

The results indicate that more-informed lenders need not result in predatory lending. We follow Bond, Musto, and Yilmaz (2009) and define a "predatory loan" as *one that a borrower would decline if they had same information as the lender.* Over-optimists are more likely than realists to consider themselves unlucky and their type score unfair. However, if made aware, over-optimists would recognize their contract was actually subsidized by rational types. Hence, they would be more than happy to accept such contracts.

3.3 Expense-shock Over-optimism

We now examine how over-optimism regarding the probability of expense shocks impacts the economy. Our experiments show that expense over-optimism has a smaller impact than income over-optimism on borrowers decision when to file. However, cross-subsidization via pooling is relatively more important.

The benchmark economy populated only by realists yields an average borrowing interest rate of 11.1%, a filing rate of 0.75% and a debt-to-income ratio of 9.1%.[21] Table 3 shows how things change once over-optimists are added. In the table we vary the fraction of over-optimists from 0 to 100 percent. The first thing to note is that the average interest rate increases in the fraction of over-optimists. The average interest rate rises for two reasons. First, over-optimists default more and hence, as they comprise a larger fraction of the population, the average interest rate goes up through a simple composition effect. Secondly, conditional on type score, lenders cannot tell realists and optimists apart and hence pool them into the same contract. This means that the interest rate for realists also rises. This effect is sizable. In a world with 50% over-optimists, realists face an interest rate of 13.3% which is more than two percentage points higher than a world without over-optimists.

The higher interest rate discourages borrowing. The debt-income ratio of realists, in a world with 50% over-optimists, is 7.9% versus 9.1% in a world with only realists. Since

[21] Our calibration of income and expense shocks differ from the Income shock case.

Table 3: Debt, Interest rates, Bankruptcy and Welfare

	Fraction of Over-optimists λ					
	0	0.1	0.2	0.3	0.5	1
Debt-to-income						
Realists	9.05%	8.88%	8.69%	8.42%	7.92%	
Over-optimists		8.64%	8.40%	8.12%	7.68%	6.63%
Average		8.86%	8.63%	8.33%	7.80%	
Bankruptcy Filings						
Realists	0.75%	0.75%	0.75%	0.75%	0.75%	
Over-optimists		1.45%	1.45%	1.45%	1.45%	1.43%
Average		0.82%	0.89%	0.96%	1.10%	
Average Interest Rates						
Realists	11.12%	11.47%	11.82%	12.28%	13.28%	
Over-optimists		12.49%	13.01%	13.60%	14.80%	17.85%
Average		11.57%	12.06%	12.67%	14.03%	
Net Gains from Pooling						
Realists	BENCH	-0.06%	-0.13%	-0.20%	-0.34%	
Over-optimists		0.49%	0.54%	0.50%	0.36%	BENCH

over-optimists systematically face higher interest rates than realists, average debt in the economy falls by even more due to the composition effect – namely to 7.8% percent in a world with 50% over-optimists.

The default rate of realists and over-optimists is essentially constant in λ. However, due to the composition effect, average filing rates go up with λ – so that in a world with 50% over-optimists, the filing rate is almost 50% higher than in the fully rational world.

In terms of welfare, not surprisingly, realists' welfare monotonically declines in the fraction of over-optimists. They are hurt through the higher interest rates they face through pooling with people more default-prone than themselves, and there is nothing to gain from the presence of over-optimists. Relative to being by themselves, the realists lose -0.13% in consumption equivalent units if living in an economy with 20% over-optimists. The over-optimists, on the other hand, benefit from the presence of realists – using our paternalistic welfare concept.[22] Compared to living in a world with only other over-optimists, they gain 0.54% in terms of consumption equivalence units in our benchmark economy (with only 20% over-optimists).

By assumption, over-optimists face higher risks then they are aware of. To better understand the results, we decompose results into the effects of adding high risk people vs. over-optimistic people, that are both high risk but also have biased expectations. The decomposition results are summarized in Table 4. The last column is the benchmark economy – i.e. numbers are identical to those in Table 3 for $\lambda = 0.2$. The first column, on the other hand, gives results for an economy without any over-optimists (c.f. Table 3, $\lambda = 0$). Starting from a world without over-optimists and replacing 20% of the population with high risk people who are *not* biased (i.e. have correct expectations and hence are not pooled) implies a substantial rise in bankruptcy filings and the borrowing interest rate. This is due purely to a composition effect, as there is no interaction between the two types of consumers in column (2). Column (3) introduces biased beliefs while abstracting from pooling. Being over-optimistic makes the high risk people file less – as they hope to get into a better financial position down the road. Yet, average interest rates increase even further. This is because people default on larger loans (not shown). Finally, moving from column (3) to (4) we see the effect of pooling. By construction, the numbers for our low risk realists are identical across columns (1) through (3). In column (4), on the other hand, realists now face different (higher) interest rates as they are being partially pooled with high risk types. The higher interest rate leads them to borrow less

[22] See Section 2.5 for details.

Table 4: Decomposition

	Only low risk people	**Adding 20% high risk people**		
		not biased	biased	biased
		not pooled	not pooled	pooled
	(1)	(2)	(3)	(4)
Debt-to-income				
Low risk	9.05%	9.05%	9.05%	8.69%
High risk		8.72%	6.63%	8.40%
Average	9.05%	8.99%	8.57%	8.63%
Bankruptcy filings				
Low risk	0.75%	0.75%	0.75%	0.75%
High risk		1.53%	1.43%	1.45%
Average	0.75%	0.91%	0.88%	0.89%
Average interest rates				
Low risk	11.12%	11.12%	11.12%	11.82%
High risk		16.27%	17.85%	13.01%
Average	11.12%	12.15%	12.47%	12.06%

and accordingly default slightly less. The effect of pooling on the high risk people is the opposite. They face lower interest rates now and accordingly borrow more and file slightly more.

Summing up, adding over-optimists (i.e. high risk people with biased expectations) to the model (i.e. comparing columns 1 and 3) increases bankruptcy filings and interest rates – predominantly because more risky people were added. The effect of adding biased expectations and pooling (i.e. comparing columns 2 and 4) is a small decrease in the interest rate, a decrease in debt and somewhat lower filing rates.

4 Policy Analysis

An ongoing policy debate asks whether credit market regulation could improve outcomes in the presence of behavioural consumers. We use our model to evaluate three types of policies:

1. Vary the cost of bankruptcy;
2. Financial literacy education that reveals behavioral consumers true risk processes;
3. Increase in the cost of lending.

Each of these policies feature potential channels to address the distortions created by behavioural borrowers. Since behavioral borrowers in our model file too late, a fall in the cost of bankruptcy could potentially help offset this distortion. Since behavioral consumers make financial mistakes, informing them – and lenders – of their true risk type should directly address this distortion.[23] Finally, since behavioral consumers over-borrow, an increase in the cost of borrowing may be called for.

We find that not only do some of these policies differentially impact realists versus behavioural types, but the nature of over-optimism can impact the welfare implications of these policy options. For example, an increase in the cost of bankruptcy (modeled as higher γ) increases the realized welfare of behavioural consumers with income over-optimism but lowers welfare with expense over-optimism (realists in our parameterization always prefer higher γ). Interestingly, while financial literacy increases welfare of realists, it lowers welfare for over-optimists. This seemingly counterintuitive result is due to financial literacy revealing a borrowers type to lenders, which ends the pooling of over-optimists with realists. This ends the cross-subsidization of over-optimists borrowing interest rates, which drives the welfare gains of realists and the losses of oer-optimists. Finally, increasing the cost of borrowing is effective in reducing debt, but is welfare decreasing as the negative effect on borrowing to smooth shocks dominates the reduction on over-borrowing by over-optimists.

[23] An obvious caveat is that this policy may be neither easy nor practical to implement. One should interpret our experiments as indicating the potential value to even investigate how to achieve this outcome.

4.1 Lower Cost of Default

In our model, over-optimists default too little. A potential policy to address this problem is to make default less costly. Since, conditional on type score, over-optimists are indistinguishable from realists, we consider a policy that makes default less costly for everyone.

The results from lowering the repayment requirement γ from the benchmark 32% to 10% of period income for expense shock over-optimism are reported in Table 5. Making default less costly doubles the default rate of over-optimists from 1.5% to 3%. Easier default makes debt less sustainable in equilibrium, as lenders anticipate higher default rates and adjust interest rates accordingly. As a result, average borrowing interest rates jump from 13% to 30%. Higher borrowing cost reduce the debt-to-income ratio for over-optimists from 8.4% to 1.9%. Even though interest rates increase significantly, over-optimists like this policy. Their welfare increases by half a percentage point in consumption equivalence units.

However, this policy adversely affects realists. When moving to $\gamma = 0.1$, realists lose more than over-optimists gain in consumption equivalence units. The reason is that they are also subject to significant interest rate increases – their rates increase from 12 to 29%. The interest rate hike is fueled by two factors – realists default more themselves (bankruptcy filings increase from 0.75% to 1.9%) and they are partially pooled with over-optimists that default more, too. Accordingly, realists hold less debt in equilibrium: their debt-to-income falls from 8.7% to 2.0%.

We repeat this thought experiment for the income over-optimism case (see Table 6). While the impact of varying bankruptcy costs on filings, debt and interest rates are qualitatively similar to that of expense over-optimism, the welfare effects differ. With income over-optimism, a fall in bankruptcy costs now leaves both over-optimists and realists worse off. Moreover, both over-optimists and realists see their welfare increase of the costs of filings are increased.

The finding that with income over-optimism behavioural consumers are harmed by lower bankruptcy costs is the opposite of Nakajima (2017). Hefinds that borrowers with self-control problems benefit from lower garnishment (they prefer the resulting tighter borrowing constraints).

These experiments offer limited support to policies which reduce the cost of bankruptcy. With expense over-optimism, lowering default costs can be welfare improving for over-

Table 5: Varying Repayment Requirements in Bankruptcy with Expense Shocks

Garnishment Rates γ (Benchmark $\gamma = 0.319$)				
	0.1	0.2	0.319	0.5
Debt-to-income				
Realists	1.98%	4.65%	8.69%	14.43%
Over-optimists	1.85%	4.39%	8.40%	14.97%
Average	1.95%	4.60%	8.63%	14.54%
Bankruptcy filings				
Realists	1.90%	1.48%	0.75%	0.29%
Over-optimists	2.98%	2.43%	1.45%	0.65%
Average	2.11%	1.67%	0.89%	0.36%
Average interest rates				
Realists	28.90%	24.70%	11.82%	7.22%
Over-optimists	29.90%	27.12%	13.01%	7.40%
Average	29.09%	25.17%	12.06%	7.26%
Paternalistic Welfare Change (% CEV)				
Realists	- 0.55%	- 0.21%		0.26%
Over-optimists	0.50%	0.32%		- 0.51%
Average	- 0.34%	- 0.10%		0.10%

Table 6: Varying Bankruptcy Repayment Requirements with Income Over-Optimism

		$\gamma = 0.2$	BM (0.32)	$\gamma = 0.5$
Bankruptcy filings	Realistic	1.42%	0.79%	0.31%
	Behavioral	2.10%	1.11%	0.44%
Interest rates	Realistic	20.16%	10.48%	7.06%
	Behavioral	24.41%	12.42%	7.23%
Debt-to-income	Realistic	4.98%	9.05%	14.78%
	Behavioral	7.32%	13.16%	21.78%
Paternalistic Welfare	Realistic	-0.16%		0.22%
	Behavioral	-0.15%		0.17%
Financial Mistakes	Filing too late	1.12%	1.07%	0.41%
	Overborrowing	7.42%	3.89%	0.39%

optimists, but has ambiguous net effects on welfare when intermediaries cannot fully tell the types apart as realists lose in welfare terms. With income over-optimism, the implications are starker, as both over-optimists and realists see their welfare decline with a reduction in bankrpucty costs.

4.2 Financial Literacy Education

One common argument in favor of increased regulation of consumer credit is that "sellers of credit products have learned to exploit the lack of information and cognitive limitations of consumers" (Bar-Gill and Warren 2008). Indeed, there is evidence that consumers do not fully understand financial products (which we term a lack of financial literacy). 63% of Americans display a significant lack of financial literacy in the FINRA National Capability Study.[24] Furthermore, only 53% of Americans count as financially literate according to Standard and Poor's Global Financial Literacy Survey.[25]

It is generally argued that financial literacy education would improve financial outcomes and welfare of behavioral consumers.[26] It is thought to prevent exploitation of

[24] A lack of financial literacy is defined as passing three or less out of five basic questions. See `http://www.usfinancialcapability.org/results.php?region=US#financial-knowlege`

[25] See `http://gflec.org/initiatives/sp-global-finlit-survey/` for more details.

[26] However, Miller et al. (2015) offers a negative view on the effectiveness of existing financial literacy

behavioral people who – armed with more knowledge – would better protect themselves against financial mistakes or against being exploited of by the financial industry.

Since in our model, over-optimists are misinformed about their future risks, one might think that educating them about their true risks could improve outcomes. We now explore what happens in the model if agents were perfectly informed about their true expense risks. We assume this means over-optimists are perfectly identified to themselves *and* to lenders.[27] As before, we focus on a paternalistic measure of welfare. However, since misinformation changes the expected utility of agents also by changing beliefs, in this section we also report how perceived welfare (including the potentially distorted beliefs) changes.

In Table 7 we report the results of this experiment with expense over-optimism. Better informed over-optimists file for bankruptcy more often. Understanding their higher risk, they now realize that getting out of debt in the future is not so likely. Consequently, for high enough levels of debt, they decide to file for bankruptcy earlier and thus obtain partial insurance against the risk they face. Their filing rate goes up from 1.45% to 1.53% per annum.

Expecting higher write-offs, lenders raise interest rates by more than three percentage points. This increase is further amplified since over-optimists are now perfectly identified and thus do not profit from cross-subsidization anymore.

Despite higher interest rates, over-optimists take on more debt. When facing more frequent expenditure shocks that force over-optimists into bankruptcy, they borrow in order to front-load consumption because they now understand that the probability of repayment is lower than for realists.

For consumers who are over-optimistic with respect to expense shocks, the impact of financial education is the opposite of what is often argued: they borrow and file *even more after being educated*. At the same time, they do worse in welfare terms. Since by assumption lenders are perfectly informed about borrower types after financial literacy education has taken place, pooling no longer occurs. This means over-optimists no longer benefit from cross-subsidization and face higher interest rates (16.3% instead of

efforts to lower defaults. This argument is supported by our findings – bankruptcy rates increase in response to financial literacy education.

[27] It should be noted that it is unclear how such a policy could be implemented. In our set-up neither consumers nor lenders know who is an over-optimist. In such a world it is hard to think of an omniscient government that knows each consumer's type. In this section we abstract from implementation and simply ask what would happen if such a policy was somehow feasible.

Table 7: Increasing Financial Literacy

	Expense Over-optimism		**Income Over-optimism**	
	Benchmark	Financial Literacy	Benchmark	Financial Literacy
Debt-to-income				
Realists	8.69%	9.05%	9.05 %	9.08%
Over-optimists	8.40%	8.72%	13.16%	9.05%
Bankruptcy filings				
Realists	0.75%	0.75%	0.79%	0.82%
Over-optimists	1.45%	1.53%	1.11%	0.86%
Average interest rates				
Realists	11.82%	11.12%	10.48%	11.16%
Over-optimists	13.01%	16.27%	12.42%	12.08%
Paternalistic Welfare Change (% CEV)				
Realists		0.13%		0.01%
Over-optimists		– 0.36%		-0.18%
Perceived Welfare Change (% CEV)				
Realists		0.13%		
Over-optimists		– 2.65%		

13% previously). Thus, welfare declines by 0.36% in consumption equivalence units – using a paternalistic welfare measure. When asking them whether they liked the education (i.e. using their upward biased perceived welfare as a benchmark), they believe they lost even more in welfare terms (2.65%).

Turning to the realists, the picture is quite different. The education campaign does not affect them directly, of course, as they always held correct beliefs about their risk. However, the policy removes the cross-subsidization which reduces the average interest rate for realists (from 11.8 to 11.1 percent). Equipped with better credit terms, they borrow more. Realists marginally gain in welfare terms – 0.13% in consumption equivalence units.

The two right columns in Table 7 report the effects of financial literacy with income over-optimism. As with expense over-optimism, realists benefit from this policy, but my relatively less. Behavioural consumers are worse off, but the welfare loss is less than with expense over-optimism. This points to the relatively smaller effects of cross-subsidization via interest rates with income over-optimism compared to expense over-optimism.

4.3 Higher Borrowing Costs

In the current policy debate, one central argument for regulating the credit market is to preempt "over-borrowing." There are many policies aimed at reducing the incentives to borrow, ranging from limiting roll-over of short term loans, restricting the amount of simultaneous loans, introducing cool-off periods, increasing underwriting requirements, and introducing centralized loan databases.

One indisputable outcome of many forms of consumer financial regulation is that it increases the costs of lending. Higher cost of lending translate into higher interest rates which – independent of the specificities of the law – hamper borrowing. If individuals make financial mistakes such as "over-borrowing," higher cost of lending might actually be beneficial if they discourage borrowing and reduce financial mistakes.

Since over-optimists in our model consistently commit financial mistakes, making borrowing more costly might create welfare gains in our framework. In this section, we explore the effects of increasing the proportional costs of creating loans, τ. Lending

Table 8: Higher Borrowing Cost

$r^S + \tau$	$= 6\%$	$= 7\%$	$= 8\%$
Debt-to-income			
Realists	8.69%	7.14%	5.86%
Over-optimists	8.40%	6.96%	5.80%
Average	8.63%	7.10%	5.85%
Bankruptcy filings			
Realists	0.75%	0.73%	0.71%
Over-optimists	1.45%	1.42%	1.38%
Average	0.89%	0.87%	0.85%
Average interest rates			
Realists	11.82%	13.84%	16.03%
Over-optimists	13.01%	15.31%	17.62%
Average	12.06%	14.13%	16.35%
Paternalistic Welfare Change (in % CEV)			
Realists		– 0.39%	– 0.73%
Over-optimists		– 0.46%	– 0.85%
Average		– 0.41%	– 0.75%

cost could increase due to a higher regulatory burden or due to the introduction of a proportional transaction tax. In any case, we assume these costs to be fully wasteful.

Table 8 depicts the results of increasing the borrowing cost by one and two percentage points with expense over-optimism. This implies risk-free lending rates of 7% and 8% relative to the benchmark of 6% per annum. As borrowing costs go up, people borrow less. Interestingly, the average interest rate goes up by more than the increase in transactions costs – even though bankruptcy filings slightly drop. This over-proportional increase is due to people defaulting on larger loans. While the average debt/income ratio falls, the distribution of loans across people changes significantly (not shown in the table): as transaction costs increase, people at the margin who were previously borrowing small amounts stop borrowing altogether. Meanwhile, people who need larger loans now borrow even more because they roll over at higher interest rates. The composition of loans thus comprises less small lower-risk loans and more large higher-risk loans. Lenders expect higher write-offs and average interest rates rise by more than the increase in borrowing cost.

Not surprisingly, realists dislike the increase in borrowing cost as they do not over-borrow and thus do not gain from restricted (or more expensive) access to debt. Surprisingly though, the welfare loss is even larger for over-optimists. It seems that higher borrowing cost discourage default because fewer people borrow to begin with. However, discouraging default amplifies the financial mistakes that over-optimists commit since they already filed for bankruptcy too little in our benchmark. As a result, over-optimists fare even worse than realists when borrowing costs are increased.

Table 9 reports the results of increasing the transactions costs by 1 percentage point for the income over-optimism case. The qualitative results are similar to that of expense over-optimism discussed above. Policies that seek to reduce over-borrowing by increasing the costs of lending can reduce borrowing and bankruptcies, but leave both realist and behavioural consumers worse off. Moreover, the increase in the cost of carrying debt results in borrowers defaulting at lower debt-to-income thresholds, which results in higher filings per borrower.

Table 9: Higher Borrowing Cost with Income Over-Optimism

		Benchmark	1% tax
Average interest rates	Rational	10.48%	12.28%
	Behavioral	12.42%	14.59%
Debt-to-income	Rational	9.05%	7.51%
	Behavioral	13.16%	11.14%
Bankruptcy filings	Rational	0.79%	0.75%
	Behavioral	1.11%	1.08%
Paternalistic Welfare	Rational		-0.41%
	Behavioral		-0.44%

5 Conclusion

In this paper, we quantitatively analyze consumer credit markets with behavioral consumers and default. To that end, we introduce over-optimistic borrowers into an economy with unsecured debt and equilibrium default. Households are subject to idiosyncratic earnings and expense shocks. Rational households hold correct beliefs about the future while over-optimistic households think of themselves as realists but actually face systematically higher expense risk. Lenders price credit endogenously but cannot directly distinguish household types. By observing income and expense shock realizations they form type scores (i.e. beliefs about the probability of a household being rational). In equilibrium, spill-overs arise between rational and over-optimistic borrowers with the same type score. Because over-optimists default particularly often, cross-subsidization goes from rational to behavioral consumers.

When more over-optimists populate our economy, the average interest rate goes up. Both types borrow less and default less on an individual level. However, aggregate debt and aggregate bankruptcies increase due to a composition effect: when increasing the fraction of over-optimists, the economy is composed of more risky households that borrow and default more. Due to overestimating their ability to repay, over-optimists borrow too much and default too late compared with the paternalistic benchmark.

To address these inefficiencies, we explore three potential policy reforms. First, we reduce default cost, inducing over-optimistic people to default earlier. While this increases

over-optimistic welfare, rational people suffer from tighter borrowing limits they face. Second, we investigate financial literacy education where we inform consumers and lenders about the true types. Over-optimists are be made worse off by facing their true, higher than expected, exposure to risk. Furthermore, they do not benefit from cross-subsidization anymore. Rational people on the other hand benefit from the policy because they are no longer pooled with the high-risk over-optimists. Linking to the current policy debate, some of the voiced concern about naive consumers could be driven by self-interested (rational) policy-makers not wanting to cross-subsidize behavioral borrowers. Third, we explore the implications of making borrowing more costly in order to reduce over-borrowing. However, both groups are made worse off by facing significantly higher interest rates.

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