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Department of Economics
Kenneth Taylor Hall 426
1280 Main Street West
Hamilton, Ontario, Canada
L8S 4M4

<http://www.mcmaster.ca/economics/>

The Unprecedented Fall in U.S. Revolving Credit^{*}

Gajendran Raveendranathan[†] Georgios Stefanidis[‡]

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Abstract

Revolving credit in the U.S. declined drastically in the last decade after several years of upward trending growth. We show that the Ability to Pay provision of the Credit CARD Act of 2009, which places restrictions on credit card limits, accounts for this decline. Extending a model of revolving credit to analyze this policy, we account for changes in credit statistics by income and age. Although the goal was consumer protection, the policy has led to welfare losses. Even consumers with time inconsistent preferences who could benefit from tighter credit constraints are worse off. An alternative policy considered by policymakers—an interest rate cap—improves welfare.

Keywords: revolving credit, credit limits, Ability to Pay, Credit CARD Act
JEL classification: E21, E44, E65, G28, G50

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[†]McMaster University. E-mail: raveeg1@mcmaster.ca

[‡]York University. E-mail: stefa107@yorku.ca

1 Introduction

The decade succeeding the Credit CARD Act of 2009 and the Great Recession saw an unprecedented decline in revolving credit (mainly credit card debt). By 2019, revolving credit to disposable income declined to 70 percent of its 2008 level. The background to this decline was three decades of consistent growth and a stabilization in the 2000s. We argue that the Ability to Pay provision of the Credit CARD Act of 2009, which imposes restrictions on credit card limits, accounts for this decline. We extend a model of revolving credit lines with a search friction in the credit card market to analyze this policy. We show that the policy change accounts for changes in credit statistics by income and age and changes in aggregate credit statistics. The stated intention of the provision was consumer protection. Through the lens of our model, we show that the policy has resulted in ubiquitous welfare losses. We further investigate these welfare losses by considering agents with time inconsistent preferences who stand to benefit from credit limit restrictions. The provision does not even benefit such agents. Finally, we consider an alternative policy debated by policy makers—an interest rate cap. We show that such a policy improves consumer welfare.

We begin our analysis by documenting empirical patterns concurrent with the fall in credit. Using triennial survey data from the Survey of Consumer Finances, we first show that credit limits followed a very similar pattern to revolving credit. In particular, the (cross-sectional) average credit card limit increased from less than 35 percent to more than 55 percent of disposable income per capita between 1989 and 2007.¹ By 2016, it decreased to 38 percent of disposable income per capita. We also find that the decrease in credit and limits were ubiquitous across all income levels and ages. Furthermore, the decrease was largest for the middle-high income consumers and young-middle age consumers.

Our paper attributes these patterns to the Ability to Pay provision. This is a provision of the Credit CARD Act of 2009 that requires credit card issuers to evaluate consumers' ability to make minimum payments assuming full utilization of the credit line. To comply, issuers modified their approval procedures known as underwriting tests. The Consumer Financial Protection Bureau (CFPB), which surveys issuers to prepare *The Consumer Credit Card Market Report* for Congress, found that issuers incorporated thresholds for debt obligations to income and/or thresholds for residual income in their underwriting tests. As a result, 4.7 percent of applications failed the Ability to Pay underwriting test and were denied credit cards in 2013-14. Furthermore, the same report finds that the number of denied credit line increases due to Ability to Pay were more than the actual number of credit line increases in the same period. Although there is evidence for the

¹The average credit card limit refers to the cross-sectional average of total borrowing limits on credit cards reported by households.

provision’s impact, the CFPB in its 2019 Consumer Credit Card Market Report states that Ability to Pay has not been studied like the other Credit CARD Act provisions. The main contribution of our paper is to extend a model of revolving credit lines to study this provision, evaluate its impact on the credit card market, and quantify implications for consumer welfare.

Our model of revolving credit lines with a search friction in the credit card market builds on [Mateos-Planas and Ríos-Rull \(2013\)](#) and [Raveendranathan \(2020\)](#). In these papers, credit card contracts are long-term defaultable credit lines specified by a credit limit and interest rate. To analyze the policy, we incorporate credit limit increases and on-the-credit-search into our model. These features are important to analyze the Ability to Pay provision because it applies to credit limit increases and credit card issuances. Furthermore, we consider agents with time inconsistent preferences in the form of quasi-hyperbolic discounting as in [Nakajima \(2012, 2017\)](#). Such preferences give rise to a motive for credit limit restrictions. In particular, agents with time inconsistent preferences may benefit from limit restrictions since they constrain their “future selves” from over borrowing.

For our benchmark economy, we assume consumers without hyperbolic discounting. This is our preferred setup because it best accounts for credit data by income. However, when analyzing welfare, we also consider the implications for consumers with hyperbolic discounting. We calibrate our pre-policy model to the 2004 U.S. economy and show that it accounts for non-targeted credit statistics by income and age. Subsequently, we introduce the Ability to Pay provision into our model. We model Ability to Pay as a constraint on the lender’s problem. In particular, the credit card limit to expected earnings has to be below a threshold when the lender issues a credit card or increases the credit limit. This constraint captures the modifications made to underwriting tests by issuers for compliance. We refer to the threshold as the Ability to Pay threshold. We calibrate this threshold to target the observed decline in average credit card limits. The calibrated model accounts for non-targeted changes in credit statistics by income and age, discussed above. The model also accounts for changes in aggregate credit statistics associated with default risk and credit access.

Having shown that our model accounts for a multitude of empirical patterns, we analyze welfare implications of the policy taking transition dynamics into account. The provision leads to welfare losses in our benchmark model. The impact is felt most by middle-high income consumers and young-middle age consumers. The losses for middle-high income consumers are equivalent to a one-time transfer worth 0.3-0.4 percent of disposable income per capita. The losses for young-middle age groups are equivalent to a one-time transfer worth 0.7 percent of disposable income per capita. The total welfare losses of the policy are equivalent to a one-time transfer worth 0.25 percent of total disposable income. To put the total losses in context, they are equivalent to 53 percent of

losses consumers would face if we were to shutdown the credit card market. As mentioned above, two novel features of our model are on-the-credit-search and credit limit increases. If one ignores these features, the welfare losses of the policy are almost zero.

The stated intention of the policy was to protect consumers. Therefore, we also consider a framework where there is greater scope for consumers to benefit from government protection. In particular, we incorporate consumers with quasi-hyperbolic discounting. As mentioned above, such consumers may benefit from constraints on credit limits. For this analysis, we consider hyperbolic discount factors in the range used in [Laibson, Repetto, and Tobacman \(2007\)](#) and [Nakajima \(2017\)](#). Furthermore, we re-calibrate the models with quasi-hyperbolic consumers to match the same set of target moments. Although the magnitudes are smaller, the policy still leads to welfare losses.

After showing that the Ability to Pay provision leads to welfare losses, we turn to an alternative policy: an interest rate cap. A potential benefit of an interest rate cap is that it can limit the degree of credit card firms' market power. In our model, market power manifests as a result of two ingredients. First, we have introduced search frictions in the credit card market. Second, credit card firms set the terms of the credit card contract. A rate cap benefits consumers by lowering interest rates. There are two major costs associated with a rate cap. First, as a result of a rate cap, credit card firms become less profitable. Due to this reduction in profitability, credit card firms send fewer offers, which makes it harder for consumers to acquire a credit card. Second, with lower interest rates, credit card firms may find it optimal to reduce credit card limits. We find that an interest rate cap of 7.41 percentage points over the risk-free rate maximizes total welfare. The average spread in the data is 11.48 percentage points. Hence, this policy would require the average credit card interest rate to decrease by approximately four percentage points. Although low income consumers pay higher interest rates, high income consumers benefit the most from a rate cap. This is because high income consumers have lower credit card utilization rates (credit/limit). That is, they are less constrained. Therefore, they can respond by borrowing substantially more compared to low income consumers.

The fall in revolving credit coincides with other regulatory changes and the Great Recession. Using our model, we rule them out as potential explanations. One of the provisions of the CARD Act is that credit card issuers cannot increase interest rates on existing balances, with some exceptions. Comparing a model where the credit card issuers choose between commitment and no commitment to interest rates (pre-policy) with one where credit card issuers commit to interest rates (post-policy), we find that commitment leads to lower levels of credit among low income consumers. This implication is at odds with the data.

The Great Recession of 2007 led to the largest and most persistent drop in output in the post World War II U.S. economy. We analyze the transition dynamics of an unexpected large drop in average earnings. We find that in the initial years, credit and

limits (normalized by income) increase, which is at odds with the data. The magnitudes of the changes after ten years are negligible.

The BAPCPA (2005) has made filing for bankruptcy more stringent. For example, it prevents households above median income from filing for bankruptcy. A consequence of this stringency is increased administrative burden, which has led to higher bankruptcy fees (Albanesi and Nosal, 2020). Analyzing comparative statics with respect to the cost of default (stigma), we find that an increase in the default cost leads to higher credit and credit limits, which goes against the data. A lower cost of default increases the charge-off rate, which also goes against the data. Finally, we rule out substitution to other forms of consumer credit.

Related literature Our paper contributes to three strands of the literature: the literature on quantitative models of consumer credit, the literature that analyzes various provisions of the Credit CARD Act of 2009, and the literature on consumer credit and behavioral consumers.

The standard models of consumer credit build on the seminal work of Chatterjee and Eyingor (2016) and Livshits, MacGee, and Tertilt (2007). In these models, credit card contracts are bond price schedules issued by perfectly competitive lenders. A recent strand of the literature has modified these models to incorporate revolving credit lines, search frictions, and imperfect competition. Examples include, but are not limited to Drozd and Nosal (2008), Mateos-Planas and Ríos-Rull (2013), Herkenhoff and Raveendranathan (2019), Braxton, Herkenhoff, and Phillips (2019), and Raveendranathan (2020). We make a theoretical contribution to this literature by modifying a model of revolving credit lines with a search friction to study the Ability to Pay provision. In particular, we analyze a model where lenders increase credit limits in periods after a match and issue credit cards to all consumers.

Our paper contributes to the literature that studies various provisions of the Credit CARD Act of 2009. Other provisions of the CARD Act restricted over limit fees and interest rate hikes on existing balances. Agarwal et al. (2015) analyze regulatory limits on over limit fees. In particular, they compare consumer credit cards, which were subject to the CARD Act, with small business credit cards, which were not subject to the CARD Act. Nelson (2020) and Mateos-Planas and Ríos-Rull (2013) study the impact of restricting credit card interest rate hikes. We study the impact of the Ability to Pay provision.

Our study also contributes to the literature on consumer credit and behavioral consumers. In particular, Nakajima (2012, 2017) and Exler, Livshits, MacGee, and Tertilt (2018) focus on over-borrowing by consumers with temptation and cross-subsidization of interest rates between rational and over-optimistic consumers. In these studies, consumers with temptation or over optimism are not exploited by credit card issuers. This is because credit card issuers are assumed to be perfectly competitive. We incorporate

lender market power and long-term relationships in our study to allow for such exploitation. With these modifications, we study welfare implications of both Ability to Pay and an interest rate cap.

We contribute to the various studies that have analyzed trends in U.S. revolving credit since the 1970s. More specifically, the literature has studied in great detail the stark increase between the 1970s and the early 2000s. [Athreya, Tam, and Young \(2012\)](#), [Narajabad \(2012\)](#), and [Sánchez \(2018\)](#) attribute the rise in revolving credit to improved information about consumers through adoption of credit scoring by lenders. [Drozd and Nosal \(2008\)](#) and [Herkenhoff \(2019\)](#) attribute the rise in revolving credit to greater access to credit cards resulting from the IT revolution. [Livshits, MacGee, and Tertilt \(2016\)](#) argue that both improved information and increased access to credit cards jointly account for the rise in revolving credit and associated empirical patterns. Our paper is the first to study the potential causes of the fall in revolving credit. Furthermore, we focus on an explanation based on policy rather than technological advances.

2 Data

We use annual aggregate U.S. consumer credit data from the Federal Reserve Board G19 data set. In particular, we focus on outstanding revolving credit (mainly credit card debt). The left panel of Figure 1 plots the time series for this variable as a percent of total U.S. disposable income. Three major patterns emerge from the time series. First, revolving credit to disposable income increased consistently from the 1970s until the early 2000s (0.5 percent in 1970 to almost 8 percent in the 2000s). As discussed above, several papers have argued that the observed rise was driven by lower fixed costs for lenders in accessing different markets and improved information about consumers. Second, revolving credit to disposable income stabilized in the early-late 2000s. This is the period in which there was a boom (often termed over-leveraging) in the mortgage and home equity line of credit markets (refer to Figure 29c in Appendix B.2). However, we do not observe a similar pattern for revolving credit, which was mostly flat until 2009. Third, revolving credit to disposable income declined after 2009. By 2019, it decreased to 5.6 percent of disposable income (70 percent of its 2008 level). Furthermore, there has been no recovery.²

We document a similar pattern for credit card limits using triennial data from the Survey of Consumer Finances (SCF). We normalize the (cross-sectional) average credit card limit in our sample by the disposable income per capita. The right panel of Figure

²Appendix B.2 shows that there has been a decline whether we measure total revolving credit or total unsecured credit. Unsecured credit is the sum of revolving credit and personal loans, an alternative measure used by [Livshits, MacGee, and Tertilt \(2010\)](#). It measures total uncollateralized consumer credit. Appendix B.2 also shows that there has not been any substitution into other forms of consumer credit.

1 plots the time series for this variable. It increased from 35 percent to more than 55 percent of disposable income per capita between 1989 and 2007. By 2016, it decreased to 38 percent of disposable income per capita (70 percent of its 2007 level). External sources corroborate the fall in credit limits. *The Consumer Credit Card Market Report (2017)* prepared by the Consumer Financial Protection Bureau shows that the total credit line on open credit card accounts decreased from 34 to 24 percent of total disposable income between 2005 and 2017 (Figure 5, page 36). Summarizing, in the last decade, the U.S saw an unprecedented fall in both revolving credit and credit card limits.

Figure 1: Total revolving credit and average credit card limits

Notes: The left panel plots total revolving credit as a percent of disposable income between 1970 and 2019 (data sources: Federal Reserve Board G19, Bureau of Economic Analysis, and authors' calculations). The right panel plots the (cross-sectional) average credit card limit per debtor as a percent of disposable income per capita between 1989 and 2016 (data sources: Survey of Consumer Finances, Bureau of Economic Analysis, World Bank WDI, and authors' calculations). The average credit card limit refers to the cross-sectional average of total borrowing limits on credit cards reported by households in the Survey of Consumer Finances.

The SCF allows us to investigate how different income and age groups experienced the drastic changes in the revolving credit market. We separate the 2004 and 2016 SCF cohorts into 5 quintiles by reported household income. The top left panel of Figure 2 is a bar chart of the change in average credit to disposable income per capita in each quintile between 2004 and 2016. The top right panel is a bar chart of the change in average credit limits to disposable income per capita in each quintile between 2004 and 2016. We emphasize the following two patterns. First, the declines in credit and limits were ubiquitous. Second, the declines were largest for the middle-high income quintiles.³

³We also externally corroborate this pattern. *The Consumer Credit Card Market 2017* report shows the decline in credit by credit scores. Figure 17 (page 47) shows that prime and near prime consumers experienced the largest drop in credit compared to subprime consumers. This is consistent with our finding that middle-high income quintiles experienced the largest drop in credit since these consumers are more likely to have higher credit scores.

We then separate the 2004 and 2016 SCF cohorts by age. The bottom left panel of Figure 2 plots the change in average credit to disposable income per capita for each age group between 2004 and 2016. The bottom right panel plots the change in average credit limits to disposable income per capita for each age group between 2004 and 2016. We emphasize the following two patterns. First, the declines in credit and limits were ubiquitous in all ages. Second, the declines in credit were largest for young-middle age consumers.

Figure 2: Change in revolving credit and credit card limits by income and age (2004-2016)

Notes: The top left panel plots the percentage point change in the (cross-sectional) average credit to disposable income per capita between 1998 and 2016 by income quintile (data sources: Survey of Consumer Finances, Bureau of Economic Analysis, World Bank WDI, and authors' calculations). The top right panel plots the percentage point change in the (cross-sectional) average credit card limit per debtor to disposable income per capita between 1998 and 2016 by income quintile (data sources: Survey of Consumer Finances, Bureau of Economic Analysis, World Bank WDI, and authors' calculations). The bottom panels plot the analogous changes by age.

Ability to Pay: The Credit CARD Act of 2009 is a federal statute intended to limit the scope of predatory behavior by credit card providers. We focus on the Ability

to Pay provision.⁴ This provision requires credit card companies to screen consumers more thoroughly when issuing new credit cards or increasing credit limits on existing accounts. Credit card companies have to establish that consumers can make minimum periodic payments. In particular, they must consider consumers' ability to make minimum payments assuming full utilization of the credit line.

We draw from *The Consumer Credit Market Report* (2015 and 2017) to inform our discussion of Ability to Pay. These are biennial reports prepared by the Consumer Financial Protection Bureau (CFPB) for Congress. These reports highlight procedures implemented by credit card issuers to comply with Ability to Pay. They also provide data showing that Ability to Pay has led to fewer credit card issuances and fewer credit limit increases. To comply, credit card issuers modified their approval procedures, known as underwriting tests. In particular, they included a threshold for debt obligations to income and/or a threshold for income the consumer will have after paying debt obligations (pages 144-145, 2015 report). If a borrower fails this underwriting test, they are not issued a credit card or an increase in their credit limit.

The reports find that 4.7 percent of all credit card applications in 2013 and 2014 were denied due to Ability to Pay (page 104, 2015 report). The reported denial rate comes with an important caveat. In particular, it is not known whether denied applicants would have subsequently failed other underwriting tests. Ideally, one would want to know the number of applications that would have been successful had it not been for the Ability to Pay underwriting test. However, this statistic is not available.

To mitigate this concern, the reports compare rejection rates due to Ability to Pay between super-prime borrowers (FICO scores ≥ 720) and deep sub-prime borrowers (FICO scores ≤ 579). Super-prime borrowers are less likely to be rejected for other reasons compared to deep subprime borrowers. That is, deep sub-prime borrowers are more likely to have failed other underwriting tests. For super-prime borrowers in 2016, more than 15 percent of rejected applications were due to Ability to Pay (Figure 14, page 129, 2017 report). The same statistic for deep sub-prime borrowers was less than 3 percent. We view these statistics as a better indicator of the extent to which Ability to Pay impacted denial rates.

Ability to Pay has also led to fewer credit limit increases. There were more credit limit increases denied due to Ability to Pay than credit limit increases issued in 2013 and 2014 (Figure 28, page 116, 2015 report). Given these facts, we propose a model of revolving credit where lenders issue credit cards to all consumers and increase credit limits over time. In this framework, we introduce Ability to Pay as a constraint on the lender's problem to capture the modifications to issuers' underwriting tests. This constraint will require the credit limit to expected income ratio to not exceed a parameter: the Ability

⁴The provision in its entirety can be found here <https://www.consumerfinance.gov/policy-compliance/rulemaking/regulations/1026/2018-06-01/51/>

to Pay threshold.

3 Model

Our model economy extends [Mateos-Planas and Ríos-Rull \(2013\)](#) and [Raveendranathan \(2020\)](#) to analyze the policy discussed above. Novel features in our model are on-the-credit-search and credit limit increases. We analyze a small open economy with overlapping generations of consumers and credit card firms. Furthermore, we assume a search friction in the credit card market. The consumers face idiosyncratic earnings shocks and extreme value type 1 shocks over default and repayment. They maximize lifetime utility by making decisions on consumption, savings/borrowing, and default/repayment. Credit card firms maximize ex-ante profits by making the discrete decision whether to send credit offers. We assume a fixed cost of sending offers. Upon matching with a consumer, the credit card firm maximizes ex-post profits by choosing the terms of the credit card contract. The main difference from [Mateos-Planas and Ríos-Rull \(2013\)](#) and [Raveendranathan \(2020\)](#) is in our modeling of credit card contracts. The lender commits to the borrowing premium, which captures the interest rate margin on credit cards over the index rate. However, the lender does not commit to the limit.⁵ After a match, the lender is allowed to increase the limit or keep it the same, but not decrease it. This assumption is motivated by the strategy followed by credit card firms where they initially issue accounts with low limits and increase them over time.⁶

Consumers live up to J periods with j denoting their age. Consumers of age j survive to $j + 1$ with probability ψ_j . She supplies labor inelastically until retirement. In retirement, she does not work, but receives Social Security. The idiosyncratic productivity of a consumer consists of a permanent component θ_i , a persistent $AR(1)$ component $\eta_{i,j}$, and a transitory *iid* component $\gamma_{i,j}$. Earning states are summarized in $\epsilon = (\theta, \eta, \gamma)$. Working age earnings for this individual are denoted $y_{j,\epsilon}$. They are given by $(1 - \tau)\theta\eta\gamma\nu_j$, where τ is the Social Security tax rate and ν_j is the deterministic life cycle productivity. Retirement age earnings are given by Social Security SS_θ , where the Social Security is a function of the permanent component θ . The consumer also faces extreme value type 1 shocks ζ^R and ζ^D over repayment and default, respectively. These extreme value type 1 shocks capture un-modeled defaults resulting from health care bills, divorce, and

⁵Before the CARD Act of 2009, lenders were not prohibited from increasing interest rates on existing credit card balances. However, we show that the model with commitment to the interest rate better accounts for credit by income in the data. We explore this further in Section 7.1.

⁶Decreases in credit card limits are rare. For example, on average less than 1 percent of accounts experience a credit line decrease every quarter (Figure 52, page 154, [Consumer Credit Market \(2017\)](#)). We have analyzed the case where the lender could decrease the limit or decrease it to current debt levels as in [Mateos-Planas and Ríos-Rull \(2013\)](#). In these cases, the model generates too few defaults compared to the data. Later, we analyze the case where the lender commits to limits as in [Raveendranathan \(2020\)](#). We show that the policy has a significantly muted effect on welfare.

lawsuits.⁷ Debt is denoted as b .

Credit standing determines whether consumers have access to revolving credit, that is, a credit card. The terms of a credit card are summarized by the credit card limit $\bar{b}$ and credit card borrowing premium τ_q . These terms may differ between consumers.

To summarize, a consumer's idiosyncratic state with a credit card is age, debt/asset level, the vector of productivity components, and credit card terms $(j, b, \epsilon, \bar{b}, \tau_q)$. A consumer without credit access cannot borrow, but may save. Her idiosyncratic state is age, level of assets, and productivity components (j, b, ϵ) .

Consumers with and without credit cards search for new credit cards. Search is assumed to be targeted. That is, credit card firms tailor credit offers to consumers on the basis of their idiosyncratic state variables except the transitory component γ .⁸ Consumers without credit access can search in submarket (j, b, θ, η) . They receive a credit offer with probability $p^S(j, b, \theta, \eta)$. This probability is determined by the following equation:

$$p^S(j, b, \theta, \eta) = \frac{M(u^S(j, b, \theta, \eta), v^S(j, b, \theta, \eta))}{u^S(j, b, \theta, \eta)}, \quad (1)$$

where $u^S(j, b, \theta, \eta)$ is the mass of consumers in submarket (j, b, θ, η) without credit access, $v^S(j, b, \theta, \eta)$ is the mass of credit card firms making credit offers in submarket (j, b, θ, η) , and $M(u, v)$ is the matching function. That is, $M(u, v)$ determines the mass of successful matches when the mass of consumers looking for a credit card is u and the mass of credit card firms making offers is v . Therefore, the right hand side of equation 1 represents the fraction of successful matches in submarket (j, b, θ, η) receiving a credit offer.

Consumers with a credit card have access to submarket $(j, b, \theta, \eta, \bar{b}, \tau_q)$. Their probability of credit access $p^C(j, b, \theta, \eta, \bar{b}, \tau_q)$ is computed analogously to that in equation 1:

$$p^C(j, b, \theta, \eta, \bar{b}, \tau_q) = \frac{M(u^C(j, b, \theta, \eta, \bar{b}, \tau_q), v^C(j, b, \theta, \eta, \bar{b}, \tau_q))}{u^C(j, b, \theta, \eta, \bar{b}, \tau_q)}. \quad (2)$$

This probability, in addition to the idiosyncratic states of equation 1, also depends on current credit card terms $(\bar{b}, \tau_q)$.

⁷Other papers that use extreme value type 1 shocks in models with consumer credit are [Auclert and Mitman \(2018\)](#), [Herkenhoff and Raveendranathan \(2019\)](#), [Chatterjee et al. \(2016\)](#), and [Raveendranathan \(2020\)](#). The main benefit of using extreme value type 1 shocks is that it makes default a probability function rather than a discrete choice function, adding smoothness to the CC issuer's ex-post profit function. In Appendix A.4, we show that our results are not sensitive to these shocks.

⁸The implicit assumption is that the offer is sent before the transitory earnings realization. This assumption is similar to [Mateos-Planas and Ríos-Rull \(2013\)](#) where they assume the lender doesn't observe the consumer's default cost and switching cost. This assumption adds smoothness to the lender's ex-post profit function.

3.1 Credit card firms

The mass of credit card firms sending offers to each submarket is pinned down by the zero-profit condition for each submarket. That is, cost κ of sending a credit offer is equated to the expected profits to be made in that submarket. As a result, all submarkets yield zero expected profits to credit card firms. The zero profit condition for new card holders is:

$$\kappa = \frac{M\left(u^S(j, b, \theta, \eta), v^S(j, b, \theta, \eta)\right)}{v^S(j, b, \theta, \eta)} \Pi^S(j, b, \theta, \eta), \quad (3)$$

and for current card holders is:

$$\kappa = \frac{M\left(u^C(j, b, \theta, \eta, \bar{b}, \tau_q), v^C(j, b, \theta, \eta, \bar{b}, \tau_q)\right)}{v^C(j, b, \theta, \eta, \bar{b}, \tau_q)} \Pi^C(j, b, \theta, \eta, \bar{b}, \tau_q). \quad (4)$$

Both expressions feature M/v , the credit card firm's probability of matching with a consumer, and Π , the ex-post profits upon a match which we specify next.

Upon match with a new cardholder, the credit card firm chooses the credit card contract that specifies a credit card limit $\bar{b}$ and a credit card borrowing premium τ_q . The terms are specific to consumers' idiosyncratic state (j, b, θ, η) . The credit card contract is chosen as follows:

$$\Pi^S(j, b, \theta, \eta) = \max_{\bar{b}^S, \tau_q^S} \left\{ E_\gamma \Pi(j, b, \epsilon, \bar{b}^S, \tau_q^S) \right\}, \quad (5)$$

subject to

$$E_\gamma W^C(j, b, \epsilon, \bar{b}^S, \tau_q^S) \geq E_\gamma W^S(j, b, \epsilon)$$

$$\phi E_{\epsilon'|\theta, \eta} [y_{j+1, \epsilon'}] \geq \bar{b}^S$$

where Π without the superscript, characterized below, denotes the profits to a credit card firm whose customer has idiosyncratic state (j, b, ϵ) and credit card contract $(\bar{b}^S, \tau_q^S)$. As discussed above, credit card firms decide on the credit card terms before observing consumers' transitory earnings component. The optimal contract for submarket (j, b, θ, η) is denoted $(\bar{b}^S(j, b, \theta, \eta), \tau_q^S(j, b, \theta, \eta))$. The first constraint is the participation constraint of new cardholders. It imposes that they have to benefit by accepting the credit card firm's offer. Their payoff W^S is determined in section 3.2. The second constraint is the Ability to Pay constraint and is only active when this policy is in place. It requires that the limit at issuance must be less than ϕ fraction of expected earnings.

The next problem we consider is that of a credit card firm newly matched with a current cardholder. A credit card firm in this position must offer the consumer a credit card contract preferable to the existing one.⁹ It makes a balance transfer of any outstanding

⁹The incumbent credit card firm cannot make a competing offer after the consumer is matched with

debt b to the incumbent credit card company. The problem it solves is:

$$\Pi^C(j, b, \theta, \eta, \bar{b}, \tau_q) = \max_{\bar{b}^C, \tau_q^C} \left\{ E_\gamma \Pi(j, b, \theta, \eta, \gamma, \bar{b}^C, \tau_q^C) \right\} - \max\{b, 0\}, \quad (6)$$

subject to

$$\begin{aligned} E_\gamma W^C(j, b, \epsilon, \bar{b}^C, \tau_q^C) &\geq E_\gamma W^C(j, b, \epsilon, \bar{b}^I(j, b, \theta, \eta, \bar{b}, \tau_q), \tau_q) \\ \phi E_{\epsilon'|\theta, \eta}[y_{j+1, \epsilon'}] &\geq \bar{b}^C \end{aligned}$$

The problem of the credit card firm matched with current cardholders has two differences to the one matched with new cardholders in equation 5. First, the credit card firm assumes any consumer debt, $\max\{b, 0\}$. Second, the new offer has to be an improvement for the consumer relative to staying with the incumbent, where $\bar{b}^I$ is the limit chosen by the incumbent.

Finally, the incumbent credit card firm may only increase the credit limit and has committed to the premium.¹⁰ The value function for this stage is:

$$\Pi^I(j, b, \theta, \eta, \bar{b}, \tau_q) = \max_{\bar{b}^I \geq \bar{b}} \left\{ E_\gamma \Pi(j, b, \theta, \eta, \gamma, \bar{b}^I, \tau_q) \right\} \quad (7)$$

subject to

$$\phi E_{\epsilon'|\theta, \eta}[y_{j+1, \epsilon'}] \geq \bar{b}^I \text{ if } \bar{b}^I > \bar{b}$$

The incumbent credit card firm can increase the credit limit $\bar{b}^I$ while making sure to satisfy the Ability to Pay constraint. It can also keep the same credit limit even if it does not satisfy the Ability to Pay constraint. The constraint requires that if the incumbent lender is increasing the limit, it must be less than or equal to ϕ fraction of earnings. This is consistent with policy, which only applies to issuances and limit increases.

Finally, we characterize the credit card firms' payoff taking credit card terms as given. In particular, once credit card firms have chosen the limit and borrowing premium, $(\bar{b}, \tau_q)$,

a new credit card firm. However, at the stage where they set the limit and/or premium, they can tailor their offer so that it is not lucrative for other credit card firms to poach their client.

¹⁰An exception is the retirement period. During the retirement period, we allow incumbent lender to choose a limit that is weakly greater than the current debt level. This choice best fits the empirical default by age distribution. Results are not sensitive to this assumption.

their profits are determined as follows:

$$\Pi(j, b, \epsilon, \bar{b}, \tau_q) = \left((1 - d) * \left(\max\{b, 0\} - \max\{b', 0\}(q_j(\tau_q) + \tau_c) + \frac{\psi_j E_{\epsilon'|\epsilon} [p_{o'=0} \Pi^I(j + 1, b', \theta', \eta', \bar{b}, \tau_q) + p_{o'=1} \max\{b', 0\}] }{1 + r} \right) \right) \quad (8)$$

where

$$p_{o'=0} = 1 - p^C(j + 1, b', \theta', \eta', \bar{b}, \tau_q),$$

$$p_{o'=1} = p^C(j + 1, b', \theta', \eta', \bar{b}, \tau_q),$$

$$b' = b'(j, b, \epsilon, \bar{b}, \tau_q),$$

$$d = d(j, b, \epsilon, \bar{b}, \tau_q),$$

where consumer's default d and borrowing b' policy functions are determined in section 3.2. Assuming the consumer repays, which happens with probability $1 - d$, and holds debt, $b > 0$, b is the current-period inflow for the credit card firm. If the consumer borrows, $b' > 0$, then $b'(q_j(\tau_q) + \tau_c)$ is the current-period outflow for the credit card firm, where $q_j(\tau_q)$ is the price of borrowing (described below) and τ_c is the transaction cost. The last term is the expected continuation value of the match discounted by the conditional survival probability ψ_j and the risk-free rate r . The credit card firm's continuation value depends crucially on whether the consumer receives a competing offer, $p_{o'=1}$, or not, $p_{o'=0}$. A competing offer results in the credit card firm retrieving any debt, $\max\{b', 0\}$, but losing the customer. In absence of a competing offer, the credit card firm maintains its contract with the consumer. The payoff to the credit card firm in this case is that of the incumbent credit card firm, Π^I .

The price of borrowing, denoted q_j , depends on the borrowing premium, τ_q as well as the age of the agent, j . It is specified as:

$$q_j(\tau_q) = \frac{\psi_j}{1 + r + \tau_q}, \quad (9)$$

where r is the risk free interest rate and τ_q is the lending/borrowing premium, set to zero for saving. This takes into account the possibility of consumer death, in which case the banks keeps the consumer's assets.

3.2 Consumers

Consumers are assumed to have quasi-hyperbolic preferences. Value functions without a tilde denote the payoff for consumers who discount the future periods with the hyperbolic discount factor $(\beta\delta, \beta\delta^2, \beta\delta^3, \dots, \beta\delta^J)$. These consumers are the ones making all decisions. In contrast, value functions with a tilde are associated with consumers

who discount the future only with the exponential discount factor $(\delta, \delta^2, \delta^3, \dots, \delta^J)$. These consumers do not make decisions. However, they are aware that decisions in the future will be made by a hyperbolic discounter. In this sense, consumers have sophisticated preferences.

Problem without credit card: A consumer without a credit card can either repay or default.¹¹ The value function to the hyperbolic consumer $(\beta\delta)$ before the realization of the extreme value shocks is:

$$W^S(j, b, \epsilon) = E_{\zeta^R, \zeta^D} \left[\max_{d^S \in \{0,1\}} d^S \left(V^D(j, \epsilon) + \zeta^D \right) + (1 - d^S) \left(V^S(j, b, \epsilon) + \zeta^R \right) \right]. \quad (10)$$

Once the taste shocks, (ζ^R, ζ^D) , have realized the consumer chooses between defaulting, $d^S = 1$, or repaying, $d^S = 0$. In both choices, the V term reflects the “modeled payoff,” specified below, and the ζ term reflects the non-modeled component affecting the default decision. The expectation is over extreme value shocks (ζ^R, ζ^D) .¹²

The value function to the consumer with an exponential discount factor who takes the default/repayment decisions of the hyperbolic consumer as given before the realization of the extreme value shocks is:¹³

$$\tilde{W}^S(j, b, \epsilon) = E_{\zeta^R, \zeta^D} \left[d^S(j, b, \epsilon) \left(\tilde{V}^D(j, \epsilon) + \zeta^D \right) + (1 - d^S(j, b, \epsilon)) \left(\tilde{V}^S(j, b, \epsilon) + \zeta^R \right) \right]. \quad (12)$$

The “modeled payoff” of repayment without credit access is the payoff of a consumer choosing consumption and saving to maximize lifetime utility subject to her budget and

¹¹These consumers do not hold debt in equilibrium. Since revolving credit is the only modeled debt, default at this stage will occur only due to extreme value taste shocks. In this case, default captures bankruptcy due to expense shocks such as healthcare bills, lawsuits, and divorce.

¹² The probability of default prior to realization of (ζ^R, ζ^D) takes the following form, standard in the discrete choice literature:

$$d^S(j, b, \epsilon) = \frac{\exp(\xi V^D(j, \epsilon))}{\exp(\xi V^D(j, \epsilon)) + \exp(\xi V^S(j, b, \epsilon))}, \quad (11)$$

where ξ is a scaling parameter that determines the variance of the extreme value shocks.

¹³The closed form solution to this expectations is:

$$\tilde{W}^S = \frac{1}{\xi} \left[\gamma_E + \log \left(e^{\xi V^D} + e^{\xi V^S} \right) \right] + \frac{1}{e^{\xi V^D} + e^{\xi V^S}} \left[\left(\tilde{V}^D - V^D \right) e^{\xi V^D} + \left(\tilde{V}^S - V^S \right) e^{\xi V^S} \right],$$

where γ_E is the Euler’s constant. The logarithm term corresponds to the closed form solution of equation 10. That is, the expected value for the hyperbolic agent. The remaining expressions correct this expectation to take into account the payoff of the exponential agent.

no borrowing constraint. This is given by the following equation:

$$V^S(j, b, \epsilon) = \max_{c \geq 0, b' \leq 0} \left\{ U(c) + \beta \delta \psi_j E_{\epsilon'|\epsilon} \left[p_{\sigma'=0} \tilde{W}^S(j+1, b', \epsilon') + p_{\sigma'=1} \tilde{W}^C(j+1, b', \epsilon', \bar{b}', \tau'_q) \right] \right\}$$

subject to

$$c + b = y_{j,\epsilon} + q_j(0)b', \quad (13)$$

where

$$\bar{b}' = \bar{b}^S(j+1, b', \theta, \eta'), \quad \tau'_q = \tau_q^S(j+1, b', \theta, \eta'),$$

$$p_{\sigma'=0} = 1 - p^S(j+1, b', \theta, \eta'),$$

$$p_{\sigma'=1} = p^S(j+1, b', \theta, \eta'),$$

where c is consumption, b' is next period debt/assets, $U(c)$ is the utility function, and $E_{\epsilon'|\epsilon}$ is the expectation operator over next period earnings shocks given current period earnings shocks. In the subsequent period, with probability $p_{\sigma'=0}$ the consumer does not receive a credit offer. The continuation value in this case is $\tilde{W}^S(j+1, b', \epsilon')$. With probability $p_{\sigma'=1}$ the consumer receives a credit offer and gains credit access. The payoff in this case is $\tilde{W}^C(j+1, b', \epsilon', \bar{b}', \tau'_q)$. This payoff, in addition to the usual state variables, depends on credit terms $(\bar{b}', \tau'_q)$. Continuation values anticipate future discount factor δ , but decisions being taken by the $\beta\delta$ consumer. Hence, they use the value functions with tilde. Next period's credit card limit $\bar{b}'$, credit card borrowing premium τ'_q , and probability of receiving an offer $p_{\sigma'=1}$ depend on the idiosyncratic state of the consumer. The credit card terms and probability of receiving an offer are determined in the credit card firm's problem discussed in Section 3.1.

As described above, the consumer with the exponential discount factor, who takes the decisions of the hyperbolic consumer (c and b') as given, has the following payoff:

$$\tilde{V}^S(j, b, \epsilon) = U(c) + \delta \psi_j E_{\epsilon'|\epsilon} \left[p_{\sigma'=0} \tilde{W}^S(j+1, b', \epsilon') + p_{\sigma'=1} \tilde{W}^C(j+1, b', \epsilon', \bar{b}', \tau'_q) \right]$$

subject to

$$c + b = y_{j,\epsilon} + q_j(0)b', \quad (14)$$

where

$$\bar{b}' = \bar{b}^S(j+1, b', \theta, \eta'), \quad \tau'_q = \tau_q^S(j+1, b', \theta, \eta'),$$

$$p_{\sigma'=0} = 1 - p^S(j+1, b', \theta, \eta'),$$

$$p_{\sigma'=1} = p^S(j+1, b', \theta, \eta').$$

The “modeled payoff” of default is given by the following equation for the $\beta\delta$ dis-

counting consumer:

$$V^D(j, \epsilon) = U(y_{j,\epsilon}) - \chi + \beta\delta\psi_j E_{\epsilon'|\epsilon} \left[p_{o'=0} \tilde{W}^S(j+1, 0, \epsilon') + p_{o'=1} \tilde{W}^C(j+1, 0, \epsilon', \bar{b}', \tau'_q) \right],$$

where

$$\begin{aligned} \bar{b}' &= \bar{b}^S(j+1, 0, \theta, \eta'), & \tau'_q &= \tau_q^S(j+1, 0, \theta, \eta'), \\ p_{o'=0} &= 1 - p^S(j+1, 0, \theta, \eta'), \\ p_{o'=1} &= p^S(j+1, 0, \theta, \eta'), \end{aligned}$$

where χ refers to a default cost (stigma of default). The defaulting consumer just consumes the earnings ($c = y_{j,\epsilon}$) and is not allowed to save or borrow during the default period ($b' = 0$). The default cost χ is incurred only during the default period. Next period's payoff is identical to that of a consumer without credit access. The equation for the δ discounting consumer is exactly the same as above without the β .

Problem with credit card: A consumer with access to revolving credit can either repay or default. Similarly to the previous section, the payoff when repaying or defaulting involves a modeled and a non-modeled component. The non-modeled payoff takes the form of extreme value shocks. The value function to the $\beta\delta$ discounting consumer before the realization the extreme value shocks is:

$$W^C(j, b, \epsilon, \bar{b}, \tau_q) = E_{\zeta^R, \zeta^D} \left[\max_{d^C \in \{0,1\}} d^C \left(V^D(j, \epsilon) + \zeta^D \right) + (1 - d^C) \left(V^C(j, b, \epsilon, \bar{b}, \tau_q) + \zeta^R \right) \right],$$

and for the δ discounting consumer it is:

$$\tilde{W}^C(j, b, \epsilon, \bar{b}, \tau_q) = E_{\zeta^R, \zeta^D} \left[d^C \left(\tilde{V}^D(j, \epsilon) + \zeta^D \right) + (1 - d^C) \left(\tilde{V}^C(j, b, \epsilon, \bar{b}, \tau_q) + \zeta^R \right) \right].$$

This leads to a probability of default function that is analogous to equation (11). The closed form solution of this expectation takes a similar form to the one discussed in the footnote to equation 12. The value of default is defined in equation (15).

Current credit card holders can borrow up to limit $\bar{b}$ at prices determined by the borrowing premium τ_q if they choose to repay. The “modeled payoff” of repayment for

the $\beta\delta$ discounting consumer is:

$$V^C(j, b, \epsilon, \bar{b}, \tau_q) = \max_{c \geq 0, b' \leq \bar{b}} \left\{ U(c) + \beta\delta\psi_j E_{\epsilon'|\epsilon} E_{o'} \tilde{W}^C(j+1, b', \epsilon', \bar{b}', \tau'_q) \right\} \quad (18)$$

subject to

$$c + b = y_{j,\epsilon} + \begin{cases} q_j(\tau_q)b' & \text{if } b' > 0 \\ q_j(0)b' & \text{if } b' \leq 0 \end{cases},$$

where

$$\bar{b}' = \begin{cases} \bar{b}^I(j+1, b', \theta, \eta', \bar{b}, \tau_q) & \text{if } o' = 0 \\ \bar{b}^C(j+1, b', \theta, \eta', \bar{b}, \tau_q) & \text{if } o' = 1, \end{cases} \quad \tau'_q = \begin{cases} \tau_q & \text{if } o' = 0 \\ \tau_q^C(j+1, b', \theta, \eta', \bar{b}, \tau_q) & \text{if } o' = 1, \end{cases}$$

$$p_{o'=0} = 1 - p^C(j+1, b', \theta, \eta', \bar{b}, \tau_q),$$

$$p_{o'=1} = p^C(j+1, b', \theta, \eta', \bar{b}, \tau_q).$$

The payoff for the δ discounting consumer is:

$$\tilde{V}^C(j, b, \epsilon, \bar{b}, \tau_q) = U(c) + \delta\psi_j E_{\epsilon'|\epsilon} E_{o'} \tilde{W}^C(j+1, b', \epsilon', \bar{b}', \tau'_q) \quad (19)$$

subject to

$$c + b = y_{j,\epsilon} + \begin{cases} q_j(\tau_q)b' & \text{if } b' > 0 \\ q_j(0)b' & \text{if } b' \leq 0 \end{cases},$$

where

$$\bar{b}' = \begin{cases} \bar{b}^I(j+1, b', \theta, \eta', \bar{b}, \tau_q) & \text{if } o' = 0 \\ \bar{b}^C(j+1, b', \theta, \eta', \bar{b}, \tau_q) & \text{if } o' = 1, \end{cases} \quad \tau'_q = \begin{cases} \tau_q & \text{if } o' = 0 \\ \tau_q^C(j+1, b', \theta, \eta', \bar{b}, \tau_q) & \text{if } o' = 1, \end{cases}$$

$$p_{o'=0} = 1 - p^C(j+1, b', \theta, \eta', \bar{b}, \tau_q),$$

$$p_{o'=1} = p^C(j+1, b', \theta, \eta', \bar{b}, \tau_q).$$

Subsequent period payoff $\tilde{W}^C$ shows that the consumer maintains access to credit. Next period's borrowing terms depend, among other things, on whether the consumer receives a new offer. If the consumer receives no new offers, $o' = 0$, the borrowing premium remains unchanged. In this case the incumbent bank may choose the credit limit $\bar{b}^I$. A new offer, $o' = 1$, leads to new limit and borrowing premium, $\bar{b}^C$ and τ_q^C . All these variables are specific to the submarket dictated by the consumer's state variables. They are determined in the credit card firm's problem discussed in detail in Section 3.1. Finally, the consumer incurs premium τ_q for borrowing and no premium for saving. Price q_j is specified in equation 9. In Appendix A.9, we define the equilibrium.

3.3 Functional forms

We assume a CRRA utility function given by,

$$U(c) = \frac{c^{1-\sigma}}{1-\sigma}, \quad (20)$$

where σ is the relative risk aversion. I assume a Cobb-Douglas matching function given by,

$$M(u, v) = \frac{uv}{[u^\zeta + v^\zeta]^{1/\zeta}}$$

where ζ is the matching elasticity, u is the mass of consumers, and v is the mass of credit offers.

Social Security replaces a fraction λ of the average earnings from ages 30-64 given the permanent component θ and the unconditional expected values of η and γ ($E(\eta)$ and $E(\gamma)$). The Social Security function is given by,

$$SS_\theta = \lambda \theta E(\eta) E(\gamma) \sum_{j=11}^{45} \nu_j / 35. \quad (21)$$

4 Calibration

We borrow many parameters from the literature and calibrate the remaining parameters by targeting key moments in the U.S. economy. For the pre-policy calibration, we set Ability to Pay threshold ϕ so that the constraint never binds. With the remaining calibration parameters, we target salient moments in the 2004 U.S. economy. This captures the period prior to the Credit CARD Act of 2009, the Great Recession, and BAPCPA (2005). For the post-policy calibration, the Ability to Pay threshold ϕ will be indirectly inferred.

Table 1 presents the parameters determined outside of the model equilibrium. The benchmark model is one with no hyperbolic discounting ($\beta = 1$).¹⁴ However, when analyzing welfare, we also consider the impact of the policy for consumers with hyperbolic discounting. The risk aversion parameter is set to 2, a standard choice in the literature. A period is assumed to be one year and the risk free rate is set to 0.0344 (Gourinchas and Parker, 2002).

Consumers of age 1 in our model correspond to 20-year-olds in the data. Maximum life-span, denoted J , is set to 60 years. Retirement age, denoted j_r , is set to 46 years. The maximum life span corresponds to the age of 79 in the data and retirement age corresponds to 65 in the data. Figure 3 plots the conditional survival probability ψ_j and

¹⁴This choice best fits the empirical credit by income distribution. In Appendix A.1, we discuss this further.

the deterministic life cycle productivity ν_j , estimated using data from the U.S. census and [Guvenen, Ozkan, and Song \(2014\)](#), respectively.

Table 1: Parameters determined outside of the model equilibrium

Parameter	Description		Value
General			
β	Temptation discount factor	Accounts for credit by income	1
σ	Risk aversion	Standard in macro literature	2
r	Interest rate	Gourinchas and Parker (2002)	0.0344
Earnings and expense process			
σ_θ^2	Variance permanent component	Storesletten, Telmer, and Yaron (2004)	0.244
σ_η^2	Variance persistent component		0.024
σ_γ^2	Variance transitory component		0.063
ρ_η	Persistence		0.977
Age-specific			
J	Maximum age	Life span, 20-79	60
j_r	Retirement age	Retire at 65	46
ψ_j	Conditional survival probability	U.S. census	Figure 3
ν_j	Life cycle productivity	Guvenen, Ozkan, and Song (2014)	Figure 3
Credit card market			
ζ	Matching elasticity	Herkenhoff (2019)	0.370
τ_c	Transaction cost	Agarwal et al. (2015)	0.034

The idiosyncratic productivity process includes permanent, persistent, and transitory components. The idiosyncratic persistent productivity η is assumed to follow a log $AR(1)$ process given by $\log \eta' = \rho_\eta \log \eta + v'$. The innovations for all three processes are assumed to be iid normal with mean zero and variances given by σ_θ^2 , σ_η^2 , and σ_γ^2 , respectively. This process is parameterized using estimates from [Storesletten, Telmer, and Yaron \(2004\)](#) and discretized using [Tauchen \(1986\)](#). We use 3, 13, and 7 grid points for the permanent, persistent, and transitory components, respectively.

The matching elasticity for the credit card market ζ is set to 0.37, following [Herkenhoff \(2019\)](#) and [Braxton, Herkenhoff, and Phillips \(2019\)](#). The transaction cost τ_c is set to 0.034, a direct estimate from the data ([Agarwal et al., 2015](#)).

The five remaining pre-policy parameters are cost of credit offer κ , exponential discount factor δ , stigma χ , scaling parameter for extreme value shocks ξ , and Social Security replacement rate λ . They are calibrated jointly to match five targets in the year 2004 presented in [Table 2](#). The cost of a credit offer is calibrated to match the population with credit cards in 2004 (71.58 percent). The exponential factor is calibrated to match the population with interest assessed credit card debt in 2004 (30.21 percent).¹⁵ Stigma

¹⁵The difference between the population with credit cards and the population with credit card debt is

Figure 3: Conditional survival probability and life cycle productivity

is calibrated to match the annual Chapter 7 bankruptcy rate in 2004 (0.38 percent of total population). Scaling parameter ξ is calibrated so that the fraction of “taste shocks” defaults matches the fraction of defaults due to health care bills, divorce, and lawsuits (44.81 percent). “Taste shocks” defaults are ones for which the Bellman value of repayment is greater than the Bellman value of default (false positives). Finally, Social Security replacement rate is calibrated to match average Social Security to disposable income per capita (29.57 percent).

Table 2: Parameters determined jointly in equilibrium

Parameter	Value	Target	Data	Model
Pre Ability to Pay		Year = 2004		
κ Cost of offer	0.002	Population with CC	71.58	71.47
δ Self-control discount factor	0.867	Population with CC debt	30.21	30.44
χ Stigma	2.786	Default rate	0.38	0.38
ξ Scaling parameter	5.814	Defaults: healthcare, divorce, lawsuits	44.81	44.93
λ Social Security replacement rate	0.238	Social Security to income pc	29.57	29.56
Post Ability to Pay		Year = 2016		
ϕ Ability to pay	0.308	Average limit to income pc (2016/2004)	70.71	70.92

The only post-policy parameter is the Ability to Pay threshold ϕ . We calibrate it to match the relative decline in the (cross-sectional) average credit card limits between 2004 and 2016. By 2016, the average credit card limit to disposable income per capita decreased to 70.71 percent of its 2004 level. Targeting this decline, the calibrated value of ϕ is 0.308. This implies that the credit card limit at issuance or limit increase must be less 30.8 percent of the individual’s expected earnings in our post-policy model.¹⁶

that the latter only includes consumers with a positive outstanding balance on their credit card.

¹⁶We calibrate the final steady state to match the decline in credit limits because calibrating the

5 Ability to Pay (ATP)

In this section, we first study the benchmark model without the Ability to Pay provision. Next, we introduce the Ability to Pay provision to the benchmark model. Finally, we analyze implications of the policy for consumer welfare.

5.1 Pre-ATP model

We begin our analysis of the pre-ATP calibration by presenting policy functions of some credit card firms. Figure 4 plots an example of the solution to the lender's problem by persistent and permanent earnings for a consumer with no assets and no credit card. The left panel of Figure 4 shows that consumers with high permanent or persistent earnings receive higher credit limits. The lender takes into account consumers' default risk. Higher income consumers can maintain higher debt levels while keeping the default probability low. Therefore, the lender offers higher income consumers higher credit limits.

Figure 4: Example solution to lender's problem pre-ATP

Notes: Figure 4 plots an example of the solution to the lender's problem by persistent and permanent earnings for a consumer with no assets and no credit card. The left panel plots the credit card limits as a percent of disposable income per capita. The middle plots credit card interest rates in percent. The right panel plots probabilities of credit access in percent. The x-axis is persistent earnings where the unit is percentile of persistent earnings. The red lines refer to consumers with a high permanent component of earnings. The blue lines refer to consumers with a low permanent component of earnings.

The middle panel of Figure 4 shows that consumers with low permanent earnings receive a credit card offer with a higher interest rate. The reasoning behind the higher interest rate is twofold. First, consumers with low permanent earnings are more likely to default. Therefore, just to break even lenders must charge a higher interest rate. Second, as studied in [Raveendranathan \(2020\)](#), lenders charge a higher premium because

model along the transition path is computationally very demanding. In Appendix A.3, we show that the transition converges quickly. Hence, our estimate for ϕ is not sensitive to calibrating to the final steady state. When we analyze welfare, we take transition dynamics into account.

of market power. Analyzing the implications across persistent earnings, we see that lower persistent earnings also lead to higher interest rates, except at the very top of the earnings distribution.

The right panel of Figure 4 shows that consumers with low permanent earnings are less likely to receive a credit offer. This is due to higher default risk and scale effects caused by lower average levels of borrowing. Consumers with lower persistent earnings have stronger borrowing incentives; however, they are more likely to default. Hence, they receive fewer credit offers. Consumers at the very top of the persistent earnings distribution have low incentives to borrow. Hence, they too receive fewer credit offers.

Figure 5: Credit statistics by income quintile: model (non-targeted) vs data (2004)

Notes: Figure 5 plots cross-sectional credit statistics by income quintile. The top left panel plots average credit per consumer normalized by disposable income per capita. The top right panel plots average credit card limit per debtor normalized by disposable income per capita. The bottom left panel plots average credit card interest rate per debtor in percent. The bottom right panel plots the population with credit cards in percent.

We next turn to analyzing the stationary equilibrium outcomes. Figure 5 shows that the benchmark model accounts for 2004 credit statistics by income. We divide consumers

into income quintiles and plot credit, credit card limits, credit card interest rates, and the population with credit cards in each quintile. The model captures the fact that consumers with higher income hold higher levels of outstanding credit, receive higher credit limits, lower interest rates, and are more likely to hold a credit card. The result that high income consumers hold more credit hinges in the permanent earnings component. In Appendix A.2, we show that without the permanent component of earnings, the model fails to account for credit among high income consumers.¹⁷

Figure 6: Credit statistics by age: model (non-targeted) vs data (2004)

Notes: Figure 6 plots cross-sectional credit statistics by age. The top left panel plots average credit per consumer normalized by disposable income per capita. The top right panel plots average credit card limit per debtor normalized by disposable income per capita. The bottom left panel plots average credit card interest rate per debtor in percent. The bottom right panel plots the population with credit cards in percent.

Figure 6 shows that the benchmark model also accounts for 2004 levels of credit statistics by age. The model captures the hump-shaped profile of credit, increasing credit limits, flat credit card interest rates, and increasing population with credit cards over the

¹⁷The model also accounts for credit card utilization (credit/limit) by income (Appendix A.5).

life cycle. The hump shaped profile of credit is explained by increasing life cycle earnings, impatience (low δ), and search frictions in borrowing. Furthermore, lenders being able to increase limits over time is key in accounting for increasing limits in early stages of the life cycle. Finally, commitment to borrowing premiums explains the flat interest rates over the life cycle. Overall, the model does well in accounting for non-targeted pre-ATP credit statistics by income and age.¹⁸

5.2 Post-ATP model

In this section, we analyze the benchmark model with the ATP provision. Recall that we introduce ATP as a constraint on the lenders' problem to capture modifications issuers made to their underwriting tests for compliance (discussed in more detail in Section 2). The constraint in our model requires that credit limit to expected earnings at issuance or limit increase must be weakly less than the ATP threshold parameter ϕ . First, we analyze the solution to the lender's problem. Second, we show that the model accounts for changes in credit statistics by income and age and changes in aggregate credit statistics.

Figure 7: Example of incumbent lender's credit card limits pre and post-ATP

Notes: Figure 7 plots an example of the solution to the incumbent lender's problem pre and post Ability to Pay by persistent and permanent earnings. The credit card limits are presented as a percent of disposable income per capita. The x-axis is persistent earnings where the unit is percentile of persistent earnings. The red lines refer to consumers with a high permanent component earnings. The blue lines refer to consumers with a low permanent component of earnings. The solid lines refer to the solution before Ability to Pay. The dashed lines refers to the solution after Ability to Pay.

Our model suggests that the ATP provision mostly impacted higher earnings consumers. Figure 7 plots the solution to the incumbent lender's problem pre-ATP and post-ATP for two permanent earnings values, with persistent earnings values on the x-axis. It shows that the limits decrease especially for consumers with high permanent

¹⁸The model also accounts for life cycle profiles of default rates and debtors (Appendix A.7). The model falls short only in accounting for the later stages of the life cycle, in particular, credit limits. Given that credit levels are low later in the life cycle, we don't view this shortcoming as a major concern.

earnings. The economic intuition is as follows. ATP imposes a restriction by requiring the lender to evaluate consumers' ability to pay assuming full utilization of the credit limit. This evaluation is required even if full utilization is less likely, which is the case for high income consumers. Hence, lenders are forced to issue lower limits for these consumers than they would have otherwise. In contrast, low earnings consumers regularly borrow to their credit limit. As a result, lenders were issuing tighter limits to such consumers even before ATP taking into account the higher likelihood of full utilization.

ATP not only leads to lower limits at issuance, but also fewer limit increases. For example, the fraction of accounts that experienced a limit increase in the pre-ATP benchmark model was 11 percent. After ATP, the fraction decreases to 8 percent. Hence, the model is consistent with the fact that ATP has led to fewer limit increases (discussed in Section 2).

In Figure 8, we show that the benchmark model accounts for changes in credit statistics by income. The left panel of Figure 8 plots the change in average credit by income quintile. The model captures the fact that the decrease in credit is concentrated among middle-high income quintiles. The right panel plots the change in average credit card limit by income quintile. Our mechanism suggests that higher earning individuals see a larger limit decline due to the policy. This is also true in the data.

Figure 8: Changes in credit statistics by income quintile: model (non-targeted) vs data (2004-2016)

Notes: Figure 8 plots changes in cross-sectional credit statistics by income quintile. The left panel plots the percentage point change in average credit per consumer to disposable income per capita. The right panel plots the percentage point change in average credit card limit per debtor to disposable income per capita.

In Figure 9, we show that the benchmark model accounts for changes in credit statistics by age. The left panel of Figure 9 plots the change in average credit by age. The right panel plots the change in average credit card limit by age. The model accounts for

the decrease concentrated among young-middle age consumers.

Figure 9: Changes in credit statistics by age: model (non-targeted) vs data (2004-2016)

Notes: Figure 9 plots changes in cross-sectional credit statistics by age. The left panel plots the percentage point change in average credit per consumer to disposable income per capita. The right panel plots the percentage point change in average credit card limit per debtor to disposable income per capita.

Table 3 compares levels and changes in aggregate statistics for the credit card market between the model and data pre-ATP and post-ATP. The model performs well in accounting for levels and changes in non-targeted credit statistics before and after ATP. The policy change in the model quantitatively accounts for the decline in credit (2.40 p.p. in model and 2.31 p.p. in data). Annual bankruptcies to population decrease by 0.12 p.p. in the model compared to 0.23 p.p. in the data. Charge-off rate decreases by 0.93 p.p. in the model compared to 2.14 p.p. in the data. Hence, the model accounts for lower levels of credit and default risk observed in the data.

Although magnitudes are small, the model also accounts for changes in the population with credit and the population with credit cards. The population with credit decreases by 3.10 p.p. in the model compared to 1.39 p.p. in the data. The population with credit cards decreases by 0.64 p.p. in the model compared to 0.22 p.p. in the data. Finally, the average spread (Average CC interest - Risk free) decreases by 0.19 p.p. in the model compared to an increase of 0.82 p.p. in the data. Although the spread in the model moves in the opposite direction of the one in the data, the magnitudes are small relative to their levels. That is, the average spreads are more than 10 percentage points in the model and data. To summarize, our benchmark model accounts for levels and changes in credit statistics by income and age and aggregate credit statistics.

Table 3: Ability to Pay: model vs data

Variable	Model pre-ATP (unit=percent)	Data 2004	Model post-ATP (unit=percent)	Data 2016	Model Change (unit=p.p.)	Data
Revolving credit to disp. inc.	6.36	7.93	3.96	5.62	-2.40	-2.31
Bankruptcies to population	0.38	0.38	0.27	0.15	-0.12	-0.23
Avg. CC limit to disp. inc. pc	40.45	53.84	28.69	38.15	-11.76	-15.70
Average CC interest - Risk free	11.17	11.48	10.97	12.30	-0.19	0.82
Charge-off rate	3.21	5.66	2.28	3.51	-0.93	-2.14
Population with credit	30.44	30.21	27.34	28.81	-3.10	-1.39
Population with credit cards	71.92	71.58	71.28	71.35	-0.64	-0.22

5.3 Welfare implications of ATP

In this section, we quantify the welfare implications of Ability to Pay for consumers by income and age. We compute welfare implications for the cohort of consumers in the pre-ATP stationary equilibrium taking transition dynamics into consideration. To measure welfare, we compute one-time equivalent transfers using the wealth equivalent variation (WEV). WEV is the minimum one-time transfer a consumer requires in the economy without ATP to be at least as well off as they would have been in the economy with ATP. For a consumer with a credit card, WEV is computed as follows:

$$\begin{aligned}
& \min_{WEV} \{WEV\} \\
& \text{subject to} \\
& W_{\text{No ATP}}^C(j, b - WEV, \epsilon, \bar{b}, \tau_q) \geq W_{\text{ATP}}^C(j, b, \epsilon, \bar{b}, \tau_q) \\
& b - WEV \leq \bar{b}.
\end{aligned}$$

where $W_{\text{No ATP}}^C(j, b - WEV, \epsilon, \bar{b}, \tau_q)$ is the consumer's payoff in the benchmark economy without ATP if the transfer is equal to WEV and $W_{\text{ATP}}^C(j, b, \epsilon, \bar{b}, \tau_q)$ is the consumer's payoff in the economy with ATP. WEV is computed analogously for a consumer without a credit card. A positive WEV implies that the consumer is better off in the economy with ATP compared to the economy without ATP. There are two benefits of using this measure of welfare. First, this measure allows for aggregation across heterogeneous consumers. Second, it takes into account that consumers re-optimize their decisions given the one-time transfer. Hence, if total transfers are positive, there exist lump sum transfers such that every consumer is weakly better off.

In the left panel of Figure 10, we plot the average transfers by income quintile resulting from ATP in the benchmark model (red bars). The policy leads to ubiquitous welfare losses. The consumers most hurt by ATP are those in the middle-high income quintile. Their losses are equivalent to a onetime transfer worth 0.3-0.4 percent of disposable

income per capita. This is consistent with implications discussed above where middle-high income consumers were the most affected by ATP in terms of credit. The right panel of Figure 10 plots average transfers by age resulting from ATP (red line). It shows that young-middle age consumers are hurt the most. The losses for some age groups are almost 0.7 percent of disposable income per capita.

If we aggregate the losses across all consumers, they are equal to 0.25 percent of total disposable income. To understand the magnitude of these losses, we compute the welfare losses of shutting down the credit card market. To shutdown the credit card market, we consider the case where $\phi = 0$. This would imply that there are no new credit card issuances or limit increases. However, current card holders will be able to keep their accounts with the given terms until default or death. If we shutdown the credit card market, the total welfare losses are 0.47 percent of total disposable income. Therefore, the losses from ATP are equivalent to 53 percent of losses of entirely shutting down the credit card market.

Figure 10: Welfare implications of Ability to Pay in benchmark model

Notes: Figure 10 plots welfare implications of introducing Ability to Pay by income quintile (left) and age (right). Red bars/lines refer to the benchmark model. Blue bars/lines refers to the model without limit increases or on-the-credit-search re-calibrated to match the set of moments presented in Table 1. Positive transfers indicate gains and negative transfers indicate losses. The one-time equivalent transfers are reported as a percent of disposable income per capita.

As mentioned above, two novel ingredients are key in accounting for the impact of the policy on welfare. First, lenders can increase the credit limit over time. Without this feature, the model does not capture the reduction in frequency of limit increases due to Ability to Pay. Second, lenders can send offers to consumers who already have a credit card (on-the-credit search). Without this feature, the model misses the fact that Ability to Pay impacts the current card holder when poached by a new lender. We quantify the importance of these two features by re-calibrating the model without them to match the

set of moments in Table 2. Without these two features the losses due to the policy change are almost zero (blue bars in the left panel and blue lines in the right panel of Figure 10).

Having quantified the welfare losses resulting from ATP, we decompose the sources in Figure 11. In particular, we focus on the level and volatility of consumption and the probability of default. We first depict the transition dynamics in the ratio of average consumption in the model with ATP to the same variable in the model without ATP. The left panel of Figure 11 plots this statistic for cohorts aged 20 and 30 when ATP comes into effect. The middle panel plots the analogous ratio for the coefficient of variation of consumption. Finally, the right panel is the analogous plot for the difference in default rates. The 20-year old cohort is worse off because of lower average consumption and higher volatility of consumption in the initial years of the transition. A similar pattern emerges for the 30-year old cohort. However, in addition to these losses, their default rate also increases along the transition path, leading to additional losses. Higher default rates are explained by the fact that they were heavily indebted in anticipation of credit limit increases. However, due to ATP, these anticipated limit increases never manifested.

Figure 11: Decomposing welfare losses in the benchmark model by age cohorts

Notes: Figure 11 decomposes sources of welfare losses in the benchmark model for two cohorts of consumers: consumers who are 20 years old and 30 years old at the time of the policy change (period 0). The left panel plots average consumption in the model with ATP divided by average consumption for the same cohort of consumers if there were no ATP. The middle panel plots the analogous ratio for the coefficient of variation of consumption. The right panel plots the difference between the default rates in the model with ATP and the model without ATP. The x-axes refer to the number of periods since the time of the policy change.

To summarize Ability to Pay leads to welfare losses in the benchmark model. Borrowing in this model was a result of idiosyncratic earnings risk, increasing life cycle earnings profile, and impatience due to a low exponential discount factor (δ). In Appendix A.6, we show that consumers are worse off even if ϕ takes different values other than the calibrated one (Figure 27). However, the goal of ATP was consumer protection. Therefore, we next investigate a framework where ATP may lead to welfare gains by disciplining consumers' from over borrowing. In particular, we allow for time inconsistent preferences

by introducing quasi-hyperbolic discounting.

For our analysis, we will assume that the consumers are sophisticated. That is, they are aware that their preferences are time inconsistent. Nakajima (2017), who studies consumer credit with quasi-hyperbolic discounting, uses a value of 0.7 for β based on a paper by Laibson, Repetto, and Tobacman (2007). Hence, we consider implications for values of β between 0.7 and 1.

We re-calibrate the benchmark model to match the set of target moments in Table 2 for every β . Figure 12 plots the total welfare implications. Even though the magnitudes are smaller, Ability to Pay still leads to losses even with a hyperbolic discount factor as low as $\beta = 0.7$.¹⁹ In Appendix A.6, we show that the policy leads to welfare losses for other values of ϕ . Summarizing the main takeaway, the ATP provision leads to overall welfare losses with or without time hyperbolic discounting.

Figure 12: Welfare implications of Ability to Pay with quasi-hyperbolic discounting

Notes: Figure 12 plots welfare implications of introducing Ability to Pay. For each β , the model was re-calibrated. Positive transfers indicate average gains and negative transfers indicate average losses. The one-time equivalent transfers are reported as a percent of total disposable income.

6 Counterfactual interest rate cap

We have shown that, through the lens of our model, ATP leads to welfare losses. ATP is a policy that restricts quantities. An alternative, debated by policy makers, was a restriction on prices through an interest rate cap. In this section, we use our model to analyze the welfare implications of an interest rate cap. Lenders in our model have market power. This market power comes from the search friction in the credit card market and the fact that lenders pick the borrowing premium after a match. As a result,

¹⁹Even a discount factor of $\beta = 0.6$ leads to welfare losses.

an interest rate cap has the potential of increasing consumer welfare by limiting lenders' market power.

In our analysis, we impose a cap on the borrowing premium. Therefore, the cap places a restriction on the interest margin over the risk-free rate (the spread). To be consistent with the policy analysis from the previous section, we require that the cap applies only for new credit card issuances. That is, current accounts are not affected.

Figure 13: Trade offs of an interest rate cap

Notes: Figure 13 plots the trade offs of an interest rate cap. The x-axis refers to the maximum spread over the risk free rate. For example, a cap = 10 implies that the maximum spread over the risk-free rate is 10 percentage points. The top left panel plots the (cross-sectional) average spread per debtor. The top right panel plots the percent of population with credit cards. The bottom panel plots the (cross-sectional) average credit card limit per debtor.

We start by illustrating the trade-offs of a cap in our model. We focus on the effect of the cap on credit card interest rates, credit card limits, and probabilities of credit offers. Figure 13 illustrates the average values of these variables in our model for different cap levels. A rate cap of 10 implies that the maximum spread over the risk-free savings interest rate is 10 percentage points. As we go from right to left, the cap becomes tighter. As the cap becomes tighter, the left panel of Figure 13 shows that the spread decreases. This is the main benefit of the cap. The middle panel of Figure 13 shows that the population with credit cards decreases with a tighter cap. Less profits for the credit card firms lead to fewer credit offers. Lower credit access is one of the costs of the cap. The right panel of Figure 13 plots the average limit as a function of the cap. The resulting limit is not monotone. As the cap becomes tighter, initially the limit increases. As the cap restricts prices, lenders increase the limit to increase lending. However, as the cap becomes even tighter, the limit decreases. With a very tight cap, lenders are no longer compensated for default risk and they respond by tightening the limit. Hence, depending on the tightness of the cap, the credit limits may increase or decrease.

Figure 14 plots the total welfare gains (losses) for different levels of a rate cap in the benchmark model. The welfare implications are not monotone. As the cap becomes

Figure 14: Total welfare gains (losses) of an interest rate cap in benchmark model

tighter (right to left), consumers benefit. However, when the cap becomes too tight, consumers are hurt. The interest rate cap over the risk-free rate that maximizes total welfare is 7.41 percentage points. It leads to gains equivalent to a one-time transfer worth 0.12 percent of total disposable income. Recall that the losses of shutting down the credit card market were worth 0.47 percent of total disposable income. Hence, the gains from the optimal rate cap are worth 25 percent of losses consumers would face if we were to shutdown the credit card market.

Figure 15: Welfare implications of an interest rate cap in benchmark model

Figure 15 plots the welfare implications by income and age at the optimal rate cap. With respect to income, although low income consumers pay higher interest rates, the high income consumers benefit the most. This is because high income consumers have lower credit card utilization rates (refer to Appendix A.5 for utilization rates by income). Hence, they can respond to lower interest rates by substantially increasing their borrowing

compared to low income consumers. With respect to age, young consumers benefit the most.

Figure 16 plots the optimal rate cap (left panel) and total welfare gains (right panel) in the re-calibrated models with quasi-hyperbolic discounting. The optimal rate cap hardly changes for β between 0.8 and 1. For higher levels of hyperbolic discounting ($\beta = .7$), the optimal cap is lower. The right panel shows that the total welfare gains are almost the same across these models. Hence, an interest rate cap delivers welfare gains with and without hyperbolic discounting consumers.

Figure 16: Total welfare gains of an interest rate cap with quasi-hyperbolic discounting

7 Ruling out alternative explanations

The fall in revolving credit coincided with several regulatory changes and the Great Recession in the U.S. economy. In this section, we rule out these alternative explanations. We also justify why we chose the model with lender commitment to borrowing premiums as the benchmark economy.

7.1 Restrictions on credit card interest rate increases

The CARD Act of 2009 prohibited credit card issuers from increasing interest rates on existing balances, with some exceptions.²⁰ To analyze the implications of these restrictions, we perform the following numerical experiment. We modify the benchmark model by allowing lenders to choose between offering credit cards with and without commitment to borrowing premiums when matched with a consumer. For the contract without

²⁰Exceptions include increases due to a variable indexed interest rate, end of a promotional rate period, and late payments.

commitment, the incumbent lender chooses both the borrowing premium and the limit at the beginning of every period. The contract with commitment is the same as in the benchmark economy. In both cases, we maintain that the incumbent lender could only weakly increase the limit. We re-calibrate this model to match the set of target moments from Table 2. In the post-policy economy lenders are forced to choose the contract with commitment to the interest rate. This restriction mimics the CARD Act of 2009 provision that limits interest rate hikes.

The left panel of Figure 17 plots average credit by income quintile for the pre-policy model. In this case, the model does not even qualitatively account for credit by income. This is the main reason we chose the benchmark model to be the one with commitment to borrowing premiums.

The right panel of Figure 17 plots the change in average credit by income quintile after imposing commitment for interest rates. In this case, the model leads to lower credit. However, the decrease is concentrated among low income consumers, which is at odds with the data. Therefore, we conclude that the restriction on interest rate increases did not play a significant role in driving the fall in revolving credit.²¹

Figure 17: Credit by income quintile (pre-policy level and post-policy change)

The remainder of this section discusses the economic intuition for the results. The

²¹This numerical experiment complements related work by [Mateos-Planas and Ríos-Rull \(2013\)](#), who compare a model where the lender commits to the interest rate with one where the lender does not commit to interest rates. In their exercise, the level of credit does not change. There are three key differences between their model and ours. First we allow the lender to issue both contracts with and without commitment to borrowing premiums in the pre-policy model. They allow the lender to issue only contracts without commitment in the pre-policy model. Second we consider a richer earnings process (13 grid points for the persistent component, 7 grid points for the transitory component, and 3 grid points for the permanent component) whereas they consider an earnings process with two grid points. Third, in our model, the lender picks the terms of the contract in all periods. In their model, the consumer picks the term of the contract at issuance and the lender picks the terms of the contract in subsequent periods.

left panel of Figure 18 plots the percent of commitment and no commitment credit card contracts by income quintile. For consumers with higher income levels, lenders prefer to offer credit cards with commitment to the interest rate. Furthermore, for most accounts (more than 80 percent), lenders prefer to commit to the interest rate.

The right panel of Figure 18 illustrates the key mechanism. We plot the interest rate chosen by the incumbent lender for any given value of current debt for two values of persistent earnings. The lender charges a higher interest rate for heavily indebted consumers with high persistent earnings. This is because a consumer with high earnings is more likely to repay. The potential of an interest rate hike prevents high earning consumers from borrowing. Hence, for most high income consumers, the lender is better off committing to the interest rate.

The right panel of Figure 18 also shows that the lender charges heavily indebted low earnings consumers a lower interest rate. This is because a consumer with low earnings is more likely to default. Lowering the interest rate allows the lender to reduce default risk. Hence, for some low income consumers, the lender is better off without commitment. Consequently, a policy that imposes commitment eliminates contracts without commitment, which are concentrated among low income consumers. This leads to a fall in credit among low income consumers.

Figure 18: Credit card contracts and interest rates without commitment

7.2 Persistent effects of the Great Recession

The Great Recession of 2007 led to the largest and most persistent drop in output in post World War II U.S. economy (de-trended output per working age person decreased by 7.5 percent). In our benchmark model, we analyze a transition with a permanent drop in average earnings of 7.5 percent. Figure 19 plots the transition path for credit to income

and average credit to disposable income per capita. We see that both credit and credit card limits (normalized by income) increase in the short run. This is because income falls more than credit. The changes after 10 years are negligible. Hence, the persistent effects of the Great Recession fail to account for the fall in credit and credit limits in the last decade.

Figure 19: Great Recession: 7.5 percent permanent drop in earnings

7.3 Changes in the cost of bankruptcy

The BAPCPA (2005) made filing for bankruptcy more stringent. For example, it prevents households above median income from filing for bankruptcy. A consequence of this stringency is increased administrative burden, which has led to higher bankruptcy fees ([Albanesi and Nosal , 2020](#)). In this section, we show that increased cost of bankruptcy captured through higher stigma (χ) fails to account for the fall in revolving credit and credit limits.

Figure 20 plots comparative statics with respect to stigma for total revolving credit, average credit limits, and charge-off rate. It shows that a rise in the cost of bankruptcy, which increases commitment to repay by the consumer, leads to higher revolving credit and credit limits. Hence, the implications of a rise in the cost of bankruptcy cannot even qualitatively account for observed empirical patterns in the last decade. Also note that a decrease in the cost of bankruptcy decreases credit and credit limits as observed in the data. However, it leads to a higher charge-off rate, which is at odds with the data.

Figure 20: Comparative statics with respect to stigma (χ)

8 Conclusion

Revolving credit to disposable income declined drastically in the last decade. By 2019 it had decreased to 70 percent of its 2008 level. This drastic decline came on the heels of decades of growth. In this paper, we argued that the Ability to Pay provision of the Credit CARD Act of 2009 accounts for this decline. This provision requires lenders to evaluate consumers' ability to make minimum payments at the credit limit when issuing credit cards or increasing credit limits.

We extended a model of revolving credit lines with a search friction in the credit card market to analyze this policy. Novel features in our model are credit limit increases and on-the-credit-search. Calibrating the model to target the observed decline in average credit limits during this time period, we accounted for non-targeted levels and changes in credit statistics by income and age.

The intention of the provision was to protect consumers. Instead, the model suggests that it leads to a ubiquitous welfare loss. This is especially true for middle-high income consumers and young-middle age consumers. Furthermore, we incorporated consumers with time inconsistent preferences who could benefit from tighter credit constraints. We found that even such agents cannot benefit from a constraint on credit limits like the one imposed by the Ability to Pay provision.

Having shown that the Ability to Pay provision has no scope for welfare improvement, we used our model to study an alternative policy considered by policymakers: an interest rate cap. We found that such a price restriction improves welfare through its impact on the market power of credit card issuers.

Finally, we ruled out concurrent events and policy changes that took place in the late 2000s such as controls on interest rate hikes imposed by the Credit CARD Act, the

Great Recession of 2007, and increased cost of bankruptcy due to the BAPCPA (2005) as potential causes for the decline in revolving credit.

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A Model Appendix

A.1 Quasi-hyperbolic discounting and credit by income

Figure 21 plots credit by income quintile for different levels of hyperbolic discounting. For each case, the model was re-calibrated to match the same target moments presented in Table 1. We see that with more hyperbolic discounting (lower β), credit decreases at the highest income quintile. Consequently, credit starts to decrease with income for higher levels of hyperbolic discounting. This pattern is at odds with the data, where credit is increasing with income. Hence, our benchmark model assumes no hyperbolic discounting.

Figure 21: Credit by income quintile

A.2 Credit by income without permanent component

Figure 22 compares average credit to disposable income per capita between pre-policy benchmark economy and pre-policy benchmark economy without variation in permanent earnings θ . It shows that variation in permanent earnings is an important feature of the model to account for credit among high income quintiles.

Figure 22: Credit by income quintile

A.3 Transition dynamics of ATP in benchmark model

Figure 23 plots the transition path for total credit to disposable income and average credit limits to disposable income per capita in the benchmark model. The transition converges quickly to the final steady state. This is because in our model, most of the consumers that take on credit are young-middle age.

Figure 23: Transition dynamics of introducing ATP to benchmark model

A.4 Robustness to taste shocks over default

This section shows that results are not sensitive to the calibrated extreme value type 1 shocks over default and repayment in the benchmark model. For this exercise, we set the scaling parameter ξ to 5000, which leads to almost zero non-modeled defaults. Furthermore, we re-calibrate the model to match the set of target moments in Table 2 except the fraction of defaults due to healthcare bills, lawsuits, and divorce. Figure 24 plots the changes in credit statistics by income quintile. Figure 25 plots the welfare implications by income and age.

Figure 24: Changes in credit statistics by income quintile: model (non-targeted) vs data (2004-2016)

Figure 25: Welfare implications of Ability to Pay in model without extreme value type 1 shocks

A.5 Credit card utilization rates by income in benchmark model

Figure 26 plots credit card utilization (credit/limit) by income quintile. The left panel plots the percent of population that utilizes more than 25 percent of its credit limit. The right panel plots the percent of population that utilizes more than 75 percent of its credit limit. The model does well in accounting for utilization across income, especially for the higher quintiles.

Figure 26: Credit card utilization by income quintile: model (non-targeted) vs data (2004)

A.6 Comparative statics with ATP

Figure 27 plots the welfare implications for different parameters of ϕ . The red line refers to the benchmark model with $\beta = 1$, the blue line refers to the model re-calibrated with $\beta = 0.9$, the black line refers to the model re-calibrated with $\beta = 0.7$. The x-axis is the value of the threshold parameter ϕ in units of the percent of the calibrated value for each β . Overall, the policy leads to welfare losses.

Figure 27: Total welfare implications of Ability to Pay

A.7 Default rate and population with credit by age in benchmark model

Figure 28 plots the life cycle profile of the population with credit card debt and default rates in the pre-policy benchmark model and 2004 SCF data. The model accounts for the hump shaped profiles. The spike in default rates in the model is due to retirement.

Figure 28: Debtors and default rate by age: model (non-targeted) vs data (2004)

A.8 Computation algorithm

- Solve consumer's problem in the last period (age J).
 - Use policy functions to calculate ex-post profits for age J
 - Solve incumbent credit card firm's problem for age J
 - Solve lender's problem with new card holder for age J
 - Solve lender's problem with current card holder for age J
 - Calculate probabilities of credit access for age J
- Use backward induction from $j = J - 1, \dots, 1$:
 - Solve consumer's problem for age j
 - Use policy functions to calculate ex-post profits for age j
 - Solve incumbent credit card firm's problem for age j
 - Solve lender's problem with new card holder for age j
 - Solve lender's problem with current card holder for age j
 - Calculate probabilities of credit access for age j
- Given policy functions, simulate and solve for equilibrium

A.9 Equilibrium

For ease of exposition, we define stationary equilibrium. For the transition, the value functions, policy functions, and distributions include a time subscript. Given the risk free rate r , a stationary equilibrium consists of consumer value functions $V^S(j, b, \epsilon)$, $\tilde{V}^S(j, b, \epsilon)$, $W^S(j, b, \epsilon)$, $\tilde{W}^S(j, b, \epsilon)$, $V^D(j, \epsilon)$, $\tilde{V}^D(j, \epsilon)$, $V^C(j, b, \epsilon, \bar{b}, \tau_q)$, $\tilde{V}^C(j, b, \epsilon, \bar{b}, \tau_q)$, $W^C(j, b, \epsilon, \bar{b}, \tau_q)$, and $\tilde{W}^C(j, b, \epsilon, \bar{b}, \tau_q)$, consumer policy functions without a credit card $d(j, b, \epsilon)$, $c(j, b, \epsilon)$, and $b'(j, b, \epsilon)$, consumer policy functions with a credit card $d(j, b, \epsilon, \bar{b}, \tau_q)$, $c(j, b, \epsilon, \bar{b}, \tau_q)$, and $b'(j, b, \epsilon, \bar{b}, \tau_q)$, credit card firm profit functions $\Pi^S(j, b, \theta, \eta)$, $\Pi^C(j, b, \theta, \eta, \bar{b}, \tau_q)$, $\Pi^I(j, b, \theta, \eta, \bar{b}, \tau_q)$, and $\Pi(j, b, \epsilon, \bar{b}, \tau_q)$, credit card firm policy functions $\bar{b}^S(j, b, \theta, \eta)$, $\tau_q^S(j, b, \theta, \eta)$, $\bar{b}^C(j, b, \theta, \eta, \bar{b}, \tau_q)$, $\tau_q^C(j, b, \theta, \eta, \bar{b}, \tau_q)$, and $\bar{b}^I(j, b, \theta, \eta, \bar{b}, \tau_q)$, mass of consumers $u^S(j, b, \theta, \eta)$ and $u^C(j, b, \theta, \eta, \bar{b}, \tau_q)$, mass of credit card firms $v^S(j, b, \theta, \eta)$ and $v^C(j, b, \theta, \eta, \bar{b}, \tau_q)$, and probabilities $p^S(j, b, \theta, \eta)$ and $p^C(j, b, \theta, \eta, \bar{b}, \tau_q)$ such that:

- policy functions $\bar{b}^S(j, b, \theta, \eta)$ and $\tau_q^S(j, b, \theta, \eta)$, solve the credit card firms problem for consumers without a credit card in (5) with resulting profit function $\Pi^S(j, b, \theta, \eta)$ as defined in (5);
- policy functions $\bar{b}^C(j, b, \theta, \eta, \bar{b}, \tau_q)$ and $\tau_q^C(j, b, \theta, \eta, \bar{b}, \tau_q)$, solve the credit card firm's problem for consumers with a credit card in (6) with resulting profit function $\Pi^C(j, b, \theta, \eta, \bar{b}, \tau_q)$ as defined in (6);
- policy function $\bar{b}^I(j, b, \theta, \eta, \bar{b}, \tau_q)$, solves the incumbent credit card firm's problem for consumers with a credit card in (7) with resulting profit function $\Pi^I(j, b, \theta, \eta, \bar{b}, \tau_q)$ as defined in (7);
- profit function $\Pi(j, b, \epsilon, \bar{b}, \tau_q)$ satisfies equation (8)
- the zero-profit conditions hold for credit offers in (3) and (4);
- policy functions $d(j, b, \epsilon)$, $c(j, b, \epsilon)$, and $b'(j, b, \epsilon)$, solve the consumer's problem without credit card in (10) and (13) with resulting value functions $W^S(j, b, \epsilon)$, $\tilde{W}^S(j, b, \epsilon)$, $V^S(j, b, \epsilon)$, $\tilde{V}^S(j, b, \epsilon)$, and as defined in (10), (12), (13), and (14) respectively;
- policy functions $d(j, b, \epsilon, \bar{b}, \tau_q)$, $c(j, b, \epsilon, \bar{b}, \tau_q)$, and $b'(j, b, \epsilon, \bar{b}, \tau_q)$, solve the consumer's problem with credit card in (16) and (18) with resulting value functions $W^C(j, b, \epsilon, \bar{b}, \tau_q)$, $\tilde{W}^C(j, b, \epsilon, \bar{b}, \tau_q)$, $V^C(j, b, \epsilon, \bar{b}, \tau_q)$, and $\tilde{V}^C(j, b, \epsilon, \bar{b}, \tau_q)$ as defined in (16), (17), (18), and (19) respectively;
- Value functions $V^D(j, \epsilon)$ and $\tilde{V}^D(j, \epsilon)$ satisfy (15) and (??) respectively
- Matching probabilities $p^S(j, b, \theta, \eta)$ and $p^C(j, b, \theta, \eta, \bar{b}, \tau_q)$ satisfy (1) and (2)
- the tax rate balances the social security budget; and
- the distribution of consumers are invariant given the policy functions, probability of credit access function, credit card limit function, credit card interest rate function, and the earnings process.

B Data Appendix

B.1 Sources

For the risk-free interest rate, we use annual returns on the 3-month treasury bill from the Federal Reserve Economic Data (FRED). The average credit card interest rate data are from FRB G.19. Credit card charge-off rate data are from FRED. Revolving credit data are from FRB G.19. Chapter 7 bankruptcy filings data are from the American Bankruptcy Institute. Estimates for bankruptcies by age were taken from [Fisher \(2017\)](#).

The Survey of Consumer Finances was used for the following data: population with credit cards (total, by age, by income), population with interest assessed credit card debt (total, by age, by income), interest assessed credit card debt by age and income, average borrowing limit (total, by age, by income), (cross-sectional) average credit card interest rate by age and income, and percent of interest assessed debt. In the SCF, credit card debt is under reported (refer to [Zinman \(2009\)](#) and [Exler and Tertilt \(2020\)](#) for a detailed discussion). Hence, we scale average credit in the SCF such that it matches average credit from the FRB G19 series.

2001-2004 averages and 2016-2019 averages were used to calculate levels and percentage point changes for aggregate credit statistics (if the data was available for the four year period).

B.2 Other forms of consumer credit

In this subsection, we show that the fall in revolving credit has not been substituted by the rise in other forms of credit. Figure 29 plots revolving credit, personal loans (e.g. home equity line of credit), non-revolving consumer credit such as motor vehicle loans and education loans. The rise in revolving credit between 1970 and the 2000s was associated with substitution away from personal loans. However, the fall in revolving credit in the last decade has not been substituted by a rise in personal loans. Motor vehicle loans, which fell during the recession has been recovering back to trend. The rise in education loans precedes the fall in revolving credit. The magnitudes of changes in other forms of non-revolving credit are small.

Figure 29: Other forms of consumer credit

Notes: The left panel plots total outstanding revolving credit, personal credit, and unsecured credit (revolving+personal) as a percent of disposable income between 1970 and 2018 (data sources: Federal Reserve Board G19, Bureau of Economic Analysis, and authors' calculations). Personal loans were constructed following methodology used in [Livshits, MacGee, and Tertilt \(2010\)](#). The middle panel plots components of non-revolving credit such as outstanding motor vehicle loans and outstanding education loans as a percent of disposal income (data sources: Federal Reserve Board G19, Bureau of Economic Analysis, and authors' calculations). The right panel plots outstanding mortgages and outstanding home equity line of credit as a percent of disposable income (data sources: FRED, Bureau of Economic Analysis, and authors' calculations)