Improved Matching, Directed Search, and Bargaining in the Credit Card Market

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Abstract

I build a model of revolving credit in which consumers face idiosyncratic earnings risk, and credit card firms target consumers with credit offers. Upon a match, they bargain over borrowing limits and borrowing interest rates — fixed for the duration of the match. Using the model, I show that improved matching between consumers and credit card firms quantitatively accounts for the rise in revolving credit and consumer bankruptcies in the U.S. I also provide empirical evidence consistent with the key features in my model: directed search and bargaining. The lifetime consumption gains from improved matching are substantially large (3.55 percent).

Keywords: revolving credit, consumer bankruptcy, matching, directed search, bargaining
JEL classification: E20, G20

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1 Introduction

The U.S. economy has experienced an unprecedented increase in revolving credit and consumer bankruptcies since the 1970s. Revolving credit refers to credit with a pre-arranged limit, mainly credit card loans. Consumer bankruptcy refers to a Chapter 7 filing that discharges personal debt. Between 1970 and 2004, revolving credit to disposable income increased from 0.57 to 8.72 percent. During the same period, annual consumer bankruptcies per working-age person increased from 0.10 to 0.57 percent. This rise in revolving credit and consumer bankruptcies was followed by a bankruptcy policy reform in 2005 (BAPCPA) that made it harder to file for bankruptcy, discussed in more detail below.

In this paper, using a model that features search and bargaining in the credit card market, I show that *improved matching* between consumers and credit card firms quantitatively accounts for the rise in revolving credit and consumer bankruptcies in the United States. The idea behind improved matching is that, due to the digital and IT revolution, it has become relatively easier for consumers to find credit card firms and vice versa. For example, Livshits, MacGee, and Tèrtilt (2016) discuss the evolution of the credit card industry in detail and provide empirical evidence for such efficiency gains. To quantitatively study the explanation of improved matching, I build a model of revolving credit with persistent idiosyncratic earnings risk, and a search friction between consumers and credit card firms. Consumers without credit access save and passively wait for credit offers. I assume that credit card firms send credit offers only to these consumers. Upon a match, the credit card firm and the consumer bargain over both a borrowing limit and a borrowing interest rate, which are fixed for the duration of the match. The consumer (now with credit access) may borrow subject to the borrowing limit and the borrowing interest rate or save subject to the saving interest rate. The match ends when the consumer defaults or chooses to search for a new credit card.

In this model, an efficiency parameter determines the mass of matches formed for a given mass of consumers without credit access and a given mass of credit offers. I refer to this parameter as the matching efficiency. I increase the matching efficiency from 1970 to 2004 — the earliest year for which data are available and the last year before the reform — to match the rise in the population with credit cards. I refer to this increase in the matching efficiency as improved matching. The model-generated transition leads to a revolving credit to disposable income of 7.44 percent (compared to 8.72 percent in the data) and to annual consumer bankruptcies per working-age person of 0.45 percent (compared to 0.57 percent in the data). Furthermore, the increase in the matching efficiency is consistent with other facts: the rise in the charge-off rate (percent of credit card debt written-off); almost no change in the (cross-sectional) average spread (credit card interest rate - risk-free rate); and the increase in the population with interest assessed credit card debt.

Two features in my model are key for the increase in the matching efficiency to account for the rise in revolving credit and consumer bankruptcies. First, credit card firms target consumer with credit offers conditional on the consumers' idiosyncratic state, such as age, assets, and earnings (directed search). This implies that credit card firms can send more credit offers to consumers who are more profitable and fewer credit offers to consumers who are less profitable. Second, consumers and credit card firms bargain over the credit card contract. The contract specifies a borrowing limit and a borrowing interest rate — fixed for the duration of the match. This implies that default risk in all future periods is taken into account during the period of bargaining. However, after the bargaining period, the terms of the credit card contract are not affected by changes in earnings or debt levels. I also provide empirical evidence consistent with these two features. For example, with directed search, the model matches the distribution of population with credit cards by age. With bargaining, the model is consistent with the fact that the difference between the average borrowing interest rate of those with credit card debt and those without credit card debt is small.

The increase in the matching efficiency has strong implications for the welfare gains to consumers. For example, gains measured by consumption-equivalent variation for a consumer under the veil of ignorance is 3.55 percent. That is, an unborn consumer requires a lifetime increase in consumption of 3.55 percent to be as well off without an increase in the matching efficiency. Previous papers that have studied the rise in revolving credit and consumer bankruptcies, such as Athreya, Tam, and Young (2012), Livshits, MacGee, and Tèrtilt (2010), Sánchez (2017), and Herkenhoff (2017), have estimated welfare gains that range from 0.03 to 0.57 percent. One reason for the difference between their estimates and mine is the explanation itself. With improved matching, consumers entering the economy are better off because they have a higher probability of credit access. However, not all consumers entering the economy are better off with alternative explanations. For example, Athreya, Tam, and Young (2012) and Sánchez (2017) study the role of improvements in information about consumers that is available to credit card firms. With more information, the cost of borrowing may increase for risky consumers, which makes them worse off. Another reason for the difference is the way credit card contracts are determined. As mentioned above, in my model, default risk in all future periods is taken into account during the bargaining period. After that, the borrowing limit and borrowing interest rate are fixed until the match is broken. In the papers mentioned above, there is no borrowing limit or borrowing interest rate. Instead, there is a bond price schedule (Eaton and Gersovitz, 1981). The consumer issues debt in every period, and the bond price is discounted by the next period's probability of default. In this case, the bond price might be sensitive to fluctuations in persistent earnings or debt levels.

As pointed out above, the rise in revolving credit and consumer bankruptcies was followed by a bankruptcy policy reform in 2005 (BAPCPA). In particular, the reform introduced a median income test whereby those above the state's median income cannot file for bankruptcy without passing a means test. Previous work by Chatterjee et al. (2006) and Athreya et al. (2014) assumes a perfectly a competitive credit card market in the analysis of stricter bankruptcy policies such as the BAPCPA. However, Ausubel (1991) provides empirical evidence for the failure of competition in the credit card market. I add to this literature by analyzing how the welfare implications of stricter bankruptcy policies vary depending on the level of competition in the credit card market — captured by the credit card firm's bargaining power in the model. In particular, I study the following three policies: 1) credit card market exclusion; 2) bankruptcy fees; and 3) earnings tests. Credit card market exclusion excludes the consumer who defaults from receiving credit offers. A bankruptcy fee is a payment during the default period. The earnings test does not allow those above an earnings threshold to default. The earnings test is a tractable version of the median income test from the 2005 reform (earnings include only labor earnings, whereas income includes both labor and investment earnings).

In my model, while stricter bankruptcy policies increase the cost of default, they also increase commitment to repay debt. Hence, they may benefit the consumer through higher probabilities of credit access, higher borrowing limits, and lower borrowing interest rates. The main finding from these policy experiments is that the credit card firm's bargaining power dampens the consumer's welfare gains (or amplifies welfare losses). For example, when the credit card firm has more bargaining power, the introduction of credit card market exclusion leads to small welfare gains to the consumer; and the introduction of a bankruptcy fee leads to large welfare losses to the consumer. The reason for this result is that when the credit card firm has more bargaining power, to avoid losses, it bargains for a lower borrowing limit. With a lower borrowing limit, the consumer is more committed to repaying debt. Hence, the benefits of stricter bankruptcy policies are smaller.

The policy experiment of credit card market exclusion deserves further discussion. Previous work by Athreya (2001, 2004), Chatterjee et al. (2006), and Livshits, MacGee, and Tèrtilt (2007, 2010) does not distinguish between credit access and credit card market exclusion. That is, consumers who default are excluded from the credit card market for an exogenously specified period of time. However, in the U.S., there is no explicit policy of credit card market exclusion. For example, Cohen-Cole, Duygan-Bump, and Montoriol-Garriga (2009) document that 75 percent of individuals have access to revolving credit within 18 months of filing for bankruptcy. My policy analysis contributes to this literature as well, by distinguishing between credit access and credit card market exclusion; and highlighting the welfare gains from introducing the latter.

Finally, the quantitative effects of earnings tests are small (even if consumers above ten percent of the labor earnings distribution are not allowed to default). This result is consistent with the median income test from the 2005 policy reform. For example, using data from the

Survey of Consumer Finances, I document that borrowing by those above the median income was unaffected from 2004 to 2007.

Related literature

This paper builds on Drozd and Nosal (2008) and Herkenhoff (2017). Drozd and Nosal (2008) incorporate a search friction between consumers and credit card firms into the standard framework of credit card markets from Chatterjee et al. (2006) and Livshits, MacGee, and Tèrtilt (2007). They assume that credit card firms compete for customers by sending credit offers with pre-specified borrowing limits and borrowing interest rates, and they study the qualitative implications of a decrease in the cost of sending credit offers. Herkenhoff (2017) incorporates directed search into a standard model of credit card markets, but assumes an exogenous Eaton and Gersovitz (1981) type of bond price schedule. I incorporate directed search from Drozd and Nosal (2008) and Herkenhoff (2017); and build on them by allowing for the credit card firm and the consumer to bargain over both the borrowing limit and the borrowing interest rate — fixed for the duration of the match.

This paper is also related to the literature that evaluates alternative explanations for the rise in revolving credit and consumer bankruptcies. Athreya (2004) and Livshits, MacGee, and Tèrtilt (2010) argue that a decrease in the stigma associated with bankruptcy and a decrease in the lending fee can jointly account for the rise in revolving credit and consumer bankruptcies. Narajabad (2012), Athreya, Tam, and Young (2012), and Sánchez (2017) study explanations based on information frictions. Livshits, MacGee, and Tèrtilt (2016) study both information frictions and fixed-cost-based explanations in a two-period stylized model. I also use my framework to study these alternative explanations. I show that while they lead to an increase in revolving credit and consumer bankruptcies, they cannot account for the increase in the population with credit cards. For example, in the quantitative exercise, improvements in information about consumers available to credit cards firms leads to a decrease in the population with credit cards. This is because, with more information, credit card firms send fewer (or zero) credit offers to consumers who are less (or not) profitable. Increased competition in the credit card industry, captured by consumers' higher bargaining power, decreases the profits to the credit card firm. This decrease leads to fewer credit offers and a decline in the population with credit cards.

The paper proceeds as follows. Section 2 describes the benchmark model. Section 3 discusses the calibration of the benchmark model. Section 4 for discusses the results from the increase in the matching efficiency. Section 5 evaluates alternative explanations for the rise in revolving credit and consumer bankruptcies. Section 6 analyzes the welfare implications of the policy experiments discussed above. Section 7 concludes.

2 Benchmark Model

A small open economy consists of overlapping generations of consumers and credit card firms. Consumers face persistent idiosyncratic earnings risk, supply inelastic labor, and maximize lifetime utility. Credit card firms target consumers with credit offers. Upon a match, they bargain over the credit card contract. The next two subsections discuss the consumer's problem and the credit card firm's problem; the third subsection discusses the credit card contract.

2.1 Consumer's problem

There are two types of consumers: those without credit access (credit cards) and those with credit access. The idiosyncratic state of a consumer without credit access is (j,b,ε), where j is the age of the consumer; b is the level of assets $(b<0)$; and ε is the idiosyncratic productivity. The idiosyncratic state of a consumer with credit access is $(j,b,\varepsilon,\bar{b},r_b)$, where j,b, and ε are the same as above, and $\bar{b}$ and r_b are the borrowing limit and the borrowing interest rate, respectively.

Consumers without credit access save at a saving interest rate r and passively wait for credit offers. I assume that credit card firms send credit offers only to these consumers. Furthermore, I assume directed search, which allows credit card firms to perfectly observe and send credit offers conditional on the idiosyncratic state of these consumers $(j,b,\varepsilon) \in [\boldsymbol{J} \times \mathbb{R}_{\leq 0} \times E]$. Let $p_t(j,b,\varepsilon)$ denote the probability of credit access in period t for a consumer in submarket (j,b,ε). The probability of credit access is given by the following equation:

$$\overbrace{p_t(j,b,\varepsilon)}^{prob\ cred\ access} = \frac{\overbrace{M[u_t(j,b,\varepsilon),v_t(j,b,\varepsilon)]}^{mass\ of\ matches}}{\underbrace{u_t(j,b,\varepsilon)}_{mass\ of\ consumers}},$$

where $u_t(j,b,\varepsilon)$ is the mass of consumers without credit access; $v_t(j,b,\varepsilon)$ is the mass of credit offers; and $M(u,v)$ is the matching function. The probability of credit access is the mass of matches normalized by the mass of consumers.

Let $V_t^N(j,b,\varepsilon)$ denote the value of no credit access and $V_t^C(j,b,\varepsilon,\bar{b},r_b)$ denote the value of credit access. The value of no credit access is given by the following equation:

$$
\begin{aligned}
V_t^N(j,b,\varepsilon) = \max_{c,b'}\ & U(c) + \beta\psi_j E_{\varepsilon'|\varepsilon}\Big[\overbrace{(1-p_{t+1}(j+1,b',\varepsilon'))}^{\text{prob no cred access}}\overbrace{V_{t+1}^N(j+1,b',\varepsilon')}^{\text{val no cred access}} + \\
& \underbrace{p_{t+1}(j+1,b',\varepsilon')}_{\text{prob cred access}}\underbrace{V_{t+1}^C(j+1,b',\varepsilon',\bar{b}_{t+1}(j+1,b',\varepsilon'),r_{b,t+1}(j+1,b',\varepsilon'))}_{\text{val cred access}}\Big] \\
& s.t. \\
& c + (1+r)b = \varepsilon + b' \\
& c \geq 0 \\
& b' \leq 0.
\end{aligned}
$$

The consumer without credit access chooses consumption ($c \geq 0$) and assets ($b' \leq 0$) to maximize lifetime utility. The expected probability of credit access for this consumer is $E_{\varepsilon'|\varepsilon}p_{t+1}(j+1,b',\varepsilon')$. If this consumer gains credit access, then the consumer and the credit card firm will bargain over the borrowing limit, $\bar{b}_{t+1}(j+1,b',\varepsilon')$, and borrowing interest rate, $r_{b,t+1}(j+1,b',\varepsilon')$, which will determine the value of credit access in the next period, $V_{t+1}^C(j+1,b',\varepsilon',\bar{b}_{t+1}(j+1,b',\varepsilon'),r_{b,t+1}(j+1,b',\varepsilon'))$. Therefore, the consumer also takes into account how the choice of b' affects the probability of credit access, the borrowing limit, the borrowing interest rate, and the value of credit access in the next period. This leads to a discussion of the consumer's problem with credit access.

The value of credit access is the maximum of the value of repayment, $V_t^R(j,b,\varepsilon,\bar{b},r_b)$, and the value of default, $V_t^D(j,\varepsilon)$. That is,

$$
V_t^C(j,b,\varepsilon,\bar{b},r_b) = \max_{d_f\in\{0,1\}}\ (1-d_f)V_t^R(j,b,\varepsilon,\bar{b},r_b) + d_f V_t^D(j,\varepsilon),
$$

where $d_f \in \{0,1\}$ is the discrete choice to repay or default. If the consumer chooses to repay, then he makes another discrete choice of whether to keep the credit card or to search for new credit cards. Therefore, the value of repayment is the maximum of the value of repaying and keeping the credit card, $V_t^{R_K}(j,b,\varepsilon,\bar{b},r_b)$, and the value of repaying and searching for new credit cards $V_t^{R_S}(j,b,\varepsilon,r_b)$. That is,

$$
V_t^R(j,b,\varepsilon,\bar{b},r_b) = \max_{d_k\in\{0,1\}}\ (1-d_k)V_t^{R_S}(j,b,\varepsilon,r_b) + d_k V_t^{R_K}(j,b,\varepsilon,\bar{b},r_b),
$$

where $d_k \in \{0,1\}$ is the discrete choice to repay and search for new credit cards or to repay and keep the credit card. The value of repaying and keeping the credit card is given by the following equation:

$$
\begin{aligned}
V_t^{R_K}(j,b,\varepsilon,\bar{b},r_b) = \max_{c,b'} \; & U(c)+\beta\psi_j E_{\varepsilon'|\varepsilon} V_{t+1}^C(j+1,b',\varepsilon',\bar{b},r_b) \\
& s.t. \\
& c+(1+r_b)b = \varepsilon + b' \qquad if \quad b>0 \\
& c+(1+r)b = \varepsilon + b' \qquad if \quad b\leq 0 \\
& c \geq 0 \\
& b' \leq \begin{cases} \bar{b} & \text{if } j<J. \\ 0 & \text{if } j=J. \end{cases}
\end{aligned}
$$

In this case, the consumer may borrow subject to the borrowing limit $\bar{b}$ and borrowing interest rate r_b, or save subject to the saving interest rate r.

The value of repaying and searching for new credit cards, $V_t^{R_S}(j,b,\varepsilon,r_b)$, is equal to the value of no credit access, $V_t^N(j,b,\varepsilon)$, if the consumer has no debt. That is, $b\leq 0$. However, if the consumer has debt, then he has to repay the debt with the given borrowing interest rate r_b. In that case, the consumer's problem is the same as the problem without credit access, except for the current-period budget constraint given by the following equation:

$$c+(1+r_b)b = \varepsilon + b'.$$

Instead of repaying, suppose that the consumer chooses to default. Then, the value of default is given by the following equation:

$$
\begin{aligned}
V_t^D(j,\varepsilon) = & U(\varepsilon)-\chi+\beta\psi_j E_{\varepsilon'|\varepsilon}\Big[\overbrace{(1-p_{t+1}(j+1,0,\varepsilon'))}^{prob\ no\ cred\ access}\overbrace{V_{t+1}^N(j+1,0,\varepsilon')}^{val\ no\ cred\ access}+ \\
& \underbrace{p_{t+1}(j+1,0,\varepsilon')}_{prob\ cred\ access}\underbrace{V_{t+1}^C(j+1,0,\varepsilon',\bar{b}_{t+1}(j+1,0,\varepsilon'),r_{b,t+1}(j+1,0,\varepsilon'))}_{val\ cred\ access}\Big].
\end{aligned}
$$

In this case, the consumer just consumes the labor earnings ($c=\varepsilon$) and is not allowed to save or borrow during the default period ($b'=0$); a default cost χ, referred to as stigma, is incurred only during the default period; and the consumer loses credit access. The assumption of $b'=0$ during the default period is the same as in Chatterjee et al. (2006). It reduces the computational burden. Results are not sensitive to this assumption because consumers who default have high levels of debt and low earnings. Hence, they will not save much even if given the choice.

2.2 Credit card firm's problem

Let $\Pi_t(j,b,\varepsilon,\bar{b},r_b)$ denote the profits to the credit card firm matched with a consumer of age j, debt (or assets) b, productivity ε, borrowing limit $\bar{b}$, and borrowing interest rate r_b. Let $s=(j,b,\varepsilon,\bar{b},r_b)$. Given the policy functions of a consumer with credit access, the profits are the present value of expected flows of borrowing and repayment, calculated as follows:

$$\Pi_t(s) = \overbrace{(1-d_f(s))}^{no\ default}\overbrace{(1+r_b)\max[b,0]}^{repayment} + \overbrace{d_k(s)}^{continue\ match}\Bigg[\overbrace{-\max[b'(s),0]}^{borrowing} + \underbrace{\psi_j\frac{E_{\varepsilon'|\varepsilon}\Pi_{t+1}(j+1,b'(s),\varepsilon',\bar{b},r_b)}{1+r}}_{continuation\ value}\Bigg].$$

If the consumer chooses to repay, $d_f(s)=0$, and if she holds debt, $b>0$, then $(1+r_b)b$ is the current-period inflow for the credit card firm. If the consumer chooses to continue the match, $d_k(s)=1$, and if she chooses to borrow, $b'(s)>0$, then $b'(s)$ is the current-period outflow for the credit card firm. $\psi_j\frac{E_{\varepsilon'|\varepsilon}\Pi_{t+1}(j+1,b'(s),\varepsilon',\bar{b},r_b)}{1+r}$ is the discounted expected continuation value of profits. The credit card firm makes a profit (or loss) only when the consumer borrows.

I assume that credit card firms incur a fixed cost κ to send one credit offer to one submarket (j,b,ε). The zero-profit conditions equate the cost of sending one credit offer to the expected profits in a submarket (j,b,ε). They are characterized by the following equation:

$$\kappa = \frac{M(u_t(j,b,\varepsilon),v_t(j,b,\varepsilon))}{v_t(j,b,\varepsilon)}\Pi_t(j,b,\varepsilon,\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon)),$$

for all $(j,b,\varepsilon)\in[\boldsymbol{J}\times\mathbb{R}_{\leq 0}\times E]$. $\frac{M(u_t(j,b,\varepsilon),v_t(j,b,\varepsilon))}{v_t(j,b,\varepsilon)}$ is the credit card firm's probability of matching with a consumer in the given submarket. $\Pi_t(j,b,\varepsilon,\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon))$ are the profits conditional on a match.

2.3 Bargaining between the consumer and the credit card firm

Upon a match, the consumer and the credit card firm bargain over the credit card contract, which specifies a borrowing limit, $\bar{b}(j,b,\varepsilon)$, and a borrowing interest rate, $r_b(j,b,\varepsilon)$. The borrowing limit and the borrowing interest rate are a function of (j,b,ε) only during the period of the match. Subsequently, the borrowing limit and the borrowing interest rate are fixed for the lifetime of the match. Given age, assets, and productivity, the borrowing limit $\bar{b}_t(j,b,\varepsilon)$ and the borrowing interest rate $r_{b,t}(j,b,\varepsilon)$, are chosen to maximize the total match surplus, as follows:

$$\max_{\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon)} \overbrace{[V_t^C(j,b,\varepsilon,\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon))-V_t^N(j,b,\varepsilon)]}^{consumer's\ surplus}{}^{\mu}\,\overbrace{[\Pi_t(j,b,\varepsilon,\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon))]}^{credit\ card\ firm's\ surplus}{}^{1-\mu}$$

$$\begin{aligned}
& s.t. \\
& \Pi_t(j,b,\varepsilon,\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon)) \geq 0 \\
& V_t^C(j,b,\varepsilon,\bar{b}_t(j,b,\varepsilon),r_{b,t}(j,b,\varepsilon)) - V_t^N(j,b,\varepsilon) \geq 0,
\end{aligned}$$

where μ is the consumer's bargaining power.

2.4 Functional forms

I assume a CRRA utility function given by,

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

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

$$M(u,v) = A_t^{\alpha} u^{\alpha} v^{1-\alpha},$$

where A_t is the matching efficiency and α is the consumer's matching share. Given a Cobb-Douglas matching function, the probability of credit access is not bounded above. In the numerical exercises, this probability is capped at one. I use a Cobb-Douglas matching function because it leads to an analytical solution for the probability of credit access, which simplifies the analysis.

2.5 Equilibrium definition

Given a sequence of matching efficiencies $\{A_t\}_{t=1}^{\infty}$, the interest rate r, and initial conditions for the distribution of agents $\Omega_1(\cdot)$, an equilibrium is a sequence of value and policy functions for consumers with credit access $\{V_t^C(\cdot), c_t(\cdot), b_t'(\cdot), d_{f,t}(\cdot), d_{k,t}(\cdot)\}_{t=1}^{\infty}$; a sequence of value and policy functions for consumers without credit access $\{V_t^C(\cdot), c_t(\cdot), b_t'(\cdot)\}_{t=1}^{\infty}$; a sequence of probabilities for credit access $\{p_t(\cdot)\}_{t=1}^{\infty}$; a sequence of borrowing limits and borrowing interest rates $\{\bar{b}_t(\cdot), r_{b,t}(\cdot)\}_{t=1}^{\infty}$; and a sequence of measures $\{\Omega_t(\cdot)\}_{t=1}^{\infty}$ such that, for all t, the following hold:

- Given prices, the value functions and policy functions satisfy the consumer's problem;
- zero-profit conditions hold for credit offers;
- the borrowing limits and borrowing interest rates solve the bargaining problem; and

- the law of motion for $\Omega_t(\cdot)$ is consistent with the policy functions, probabilities of credit access, borrowing limits, borrowing interest rates, and the exogenous earnings process.

3 Calibration

Table 1 shows the parameters determined outside of the model. The cost of sending one credit offer to one submarket, κ, is normalized to an arbitrarily small number. This is because, in this model, there is a one-to-one mapping between a decrease in the cost of sending one credit offer and an increase in the matching efficiency. We can see this in the equation for the probability of credit access in a submarket, backed out from the zero-profit condition for credit offers:

$$p(j,b,\varepsilon) = A\left[\frac{\Pi(j,b,\varepsilon,\bar{b}(j,b,\varepsilon),r_b(j,b,\varepsilon))}{\kappa}\right]^{(1-\alpha)/\alpha}.$$

Suppose that the matching efficiency, A, increases to $(1+g)A$. That is equivalent to the fixed cost of sending credit offers, κ, decreasing to $\dfrac{\kappa}{(1+g)^{\alpha/(1-\alpha)}}$ for $\alpha \in (0,1)$. Therefore, κ is normalized to a small number, and the matching efficiency will be calibrated to match the rise in the population with credit cards from 1970 to 2004.

Table 1: **Parameters determined outside of the model**

Parameter		Description	Value
Credit market			
κ	Cost of sending a credit offer	Normalization	1e-6
μ	Consumer's bargaining power	Firm has more bargaining power	0.100
General			
σ	Risk aversion		2
r	Interest rate	Gourinchas and Parker (2002)	0.034
Earning process			
ρ_ε	Persistence	Guvenen, Ozkan, and Song (2014)	0.953
σ^2_ε	Variance persistent component	Guvenen, Ozkan, and Song (2014)	0.060
Age-specific			
J	Maximum age	Working age, 20 to 64	45
ψ_j	Conditional survival probability		$1_{\{j=1,..,J-1\}}$, $0_{\{j=J\}}$

The bargaining power of the consumer, μ, is set to 0.1, which implies that the credit card firm has most of the bargaining power. This assumption is consistent with findings from

Ausubel (1991), who provides evidence for the failure of competition in the credit card market. In Section 5, I discuss the results for different values of μ.

A period is assumed to be one year. The interest rate is set to 0.034, following Gourinchas and Parker (2002). The idiosyncratic productivity ε is assumed to follow a log $AR(1)$ process given by $\log \varepsilon' = \rho_\varepsilon \log \varepsilon + \eta'$. The innovation η' is assumed to be iid normal with mean zero and variance σ_η^2. This process is parameterized using estimates from Guvenen, Ozkan, and Song (2014) and discretized using Rouwenhorst (1995) with 24 grid points.

The maximum age J is set to 45. This implies that consumers enter the economy at age 20 and die with a conditional probability of one at age 64. The survival probability from 20-63 is set to one.

The five remaining parameters are the matching efficiency for the initial steady state A_{1970}, the matching efficiency for the final steady state A_{2004}, the consumer's matching share α, the discount rate β, and the stigma χ. These are presented in Table 2. The matching efficiency for the initial and final steady states are calibrated to match the population with credit cards in 1970 and 2004, respectively.

Table 2: **Parameters determined jointly in equilibrium**

Parameter		**Target** (unit = percent)	**Value**
A_{1970}	Matching efficiency (1970)	Pop. with credit cards 1970 = 18.46	0.00002
A_{2004}	Matching efficiency (2004)	Pop. with credit cards 2004 = 71.47	0.00269
α	Consumer's matching share	Pop. with credit cards, ages 20-29 2004 = 57.76	0.56945
β	Discount rate	Pop. with credit card debt 2004 = 30.16	0.91089
χ	Stigma	Charge-off rate 2004 = 4.97	15

α is the consumer's share in the matching function, and $(1-\alpha)$ is the credit card firm's share. $(1-\alpha)$ determines the extent to which the mass of credit offers impacts the mass of matches in a submarket. Hence, it determines the rate at which a profitable consumer gains credit access. This can also be seen in the above equation for the probability of credit access. α is calibrated to match the population with credit cards from ages 20-29 in 2004 — the rate at which young consumers gain credit access.

The discount rate is calibrated to match the population with interest assessed credit card debt in 2004. In the model, all consumers with credit card debt pay interest, but in the data, that is not the case. However, I restrict the analysis to consumers who pay interest on their credit card debt (Appendix A has a detailed discussion of credit card payment patterns in the data). The estimate for the discount rate is consistent with the range estimated in papers with heterogeneous agents and idiosyncratic earnings risk, such as Castañeda, Díaz-Giménez, and Ríos-Rull (2003), Chatterjee et al. (2006), and Brüggemann (2017).

For the transition, I increase the matching efficiency linearly from 1970 to 2004, as shown in Figure 1. It is reasonable to terminate the increase in the matching efficiency in 2004 because after that year, the population with credit cards has ceased to increase. This can be seen in Figure 2, which shows the rise in the population with credit cards for the period from 1970 to 2016 for both model and data. The model does well in generating the observed increase in the population with credit cards. However, it cannot match the final level observed in the data because, in the model, consumers with zero-profitability will never gain credit access.

Figure 1: **Exogenous deterministic path for matching efficiency** (A_t)

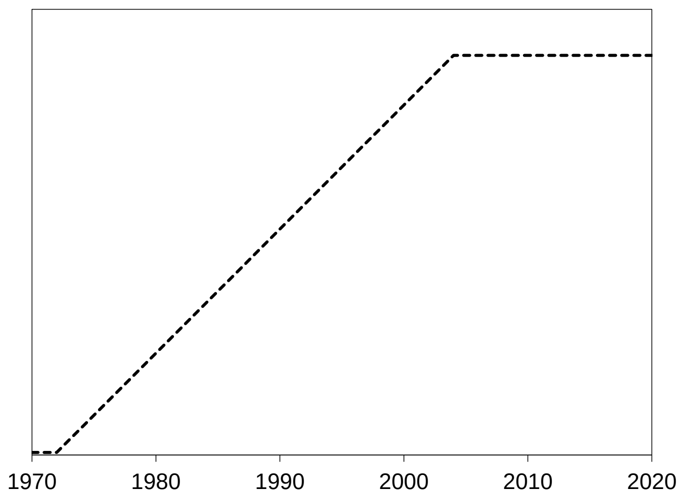
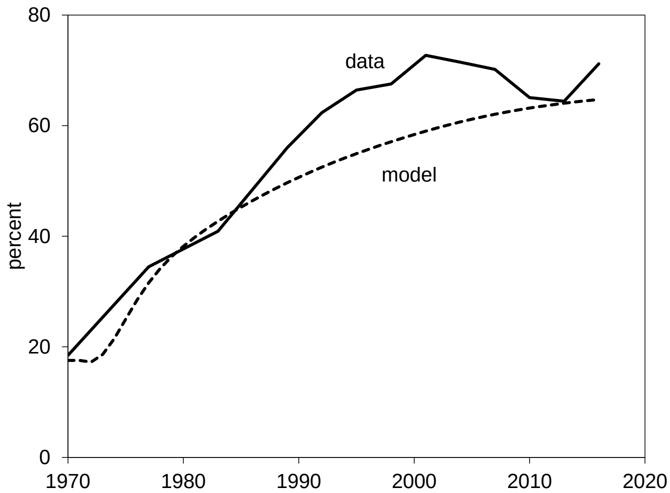


Figure 2: **Population with credit cards**



4 Results

This section compares results from the increase in the matching efficiency with the data. Figure 3 shows that the increase in the matching efficiency accounts for most of the rise in revolving credit and consumer bankruptcies in the U.S. between 1970 and 2004.

Figure 3: **Revolving credit and consumer bankruptcies**

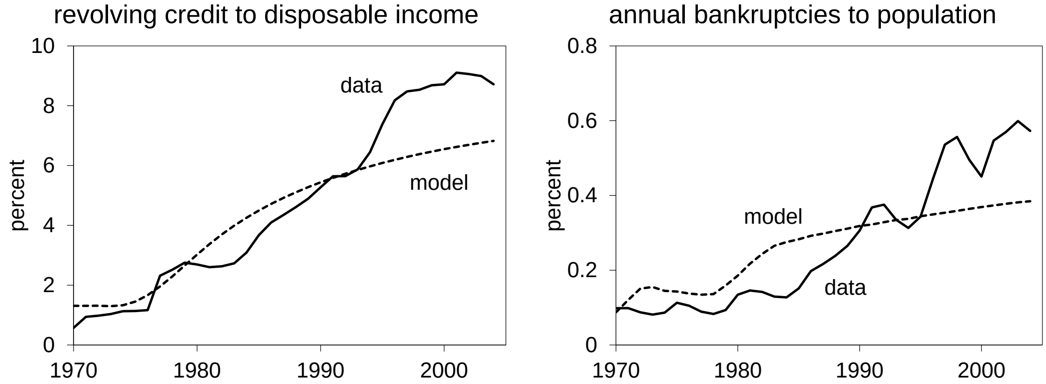


Table 3 compares the percentage point change from the initial to the final steady state in the benchmark model with data from 1970 to 2004 for variables related to the credit card market. The increase in the matching efficiency is consistent with the rise in the population with credit card debt and the charge-off rate. However, it understates the observed increase in the charge-off rate. We see a small change in the (cross-sectional) average spread, as observed in the data. Finally, the increase in the matching efficiency does not generate the observed increase in the standard deviation of spreads. The subsequent subsections discuss the results in more detail.

Table 3: **Model vs data**

Variable (unit = percentage point change, 1970 - 2004)	**Data**	**Model**
Revolving credit to disposable income	7.98	6.14
Annual bankruptcies to population	0.49	0.37
Population with credit card debt	24.72	22.13
Charge-off rate	3.96	0.97
Spread: (cross-sectional) average	0.37	−0.64
Spread: (cross-sectional) standard deviation	3.13	−0.28

4.1 Directed search

This subsection discusses the extent to which directed search is important for the increase in the matching efficiency to quantitatively account for the rise in revolving credit and consumer bankruptcies. Directed search allows credit card firms to target consumers with credit offers conditional on their individual characteristics (in the model: age, debt, and earnings). To further discuss the importance of directed search, focus on the probability of credit access, given by the following equation:

$$p(j,b,\varepsilon) = A\left[\frac{\Pi(j,b,\varepsilon,\bar{b}(j,b,\varepsilon),r_b(j,b,\varepsilon))}{\kappa}\right]^{(1-\alpha)/\alpha}.$$

The probability of credit access is a function of the matching efficiency A, the profitability $\Pi(j,b,\varepsilon,\bar{b}(j,b,\varepsilon),r_b(j,b,\varepsilon))$, and the fixed cost of sending one credit offer κ. α dictates the extent of directed search. For example, with a low α, a profitable consumer will have a higher probability of credit access. α is equal to 0.57 in the benchmark model. Suppose instead, that $\alpha = 1$. Then, $p(j,b,\varepsilon) = A$ for all consumers, except for those with zero-profitability. For consumers with zero-profitability, the probability of credit access is not defined when $\alpha = 1$; therefore, I assume that $p(j,b,\varepsilon) = A$. Then, the probability of credit access is exogenous and the same across all consumers. That is, there is no directed search.

In Table 4, I compare the level of revolving credit and consumer bankruptcies from the final steady state of the benchmark model (which has directed search) with those from the model where $\alpha = 1$ (which has no directed search). Furthermore, the matching efficiency is re-calibrated to match the population with credit cards in 2004 for the case without directed search. We see that the model without directed search significantly understates the level of revolving credit and consumer bankruptcies. The reason is that in the model without directed search, credit card firms do not take consumers' profitability into account when sending credit offers. Hence, relative to the benchmark model, they send too many credit offers to consumers who are less profitable and too few credit offers to consumers who are more profitable.

Table 4: **Benchmark (directed search) vs No directed search**

Variable (unit = percent)	**Benchmark**	**No directed search**
Revolving credit to disposable income	7.45	2.11
Annual bankruptcies to population	0.45	0.15

This leads to the question of who is a profitable consumer. Figure 4 shows the profits to the credit card firm matched with a 20-year-old who has a very low, low, and median earnings shock in the benchmark final steady state. First, we see that profits decrease with assets. This is because a consumer with more assets is less likely to borrow. Second, with respect to earnings, a consumer with a low earnings shock is more profitable than a consumer with a very low earnings shock or a median earnings shock. This is because a consumer who has a very low earnings shock is more likely to default, whereas a consumer who has a median earnings shock is not as likely to borrow. Therefore, the most profitable consumers are those with low assets and with an earnings shock that is not so low that they are risky, but also not so high that they are not likely to borrow.

Figure 4: **Profits by earnings shock**

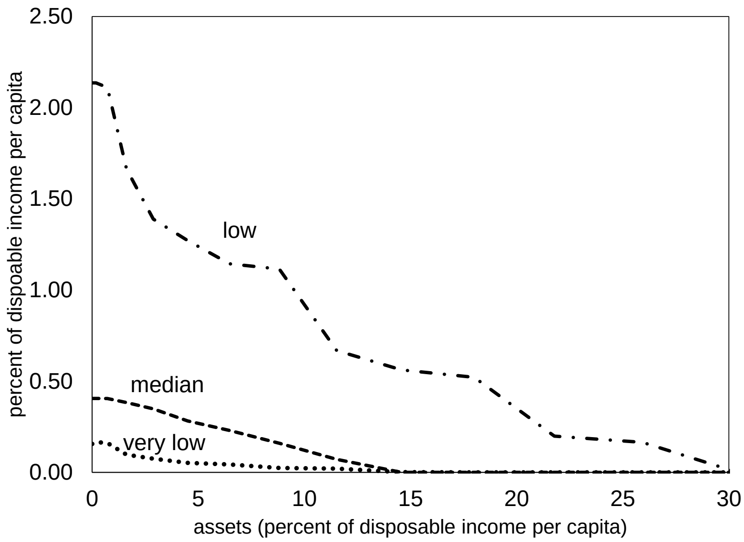
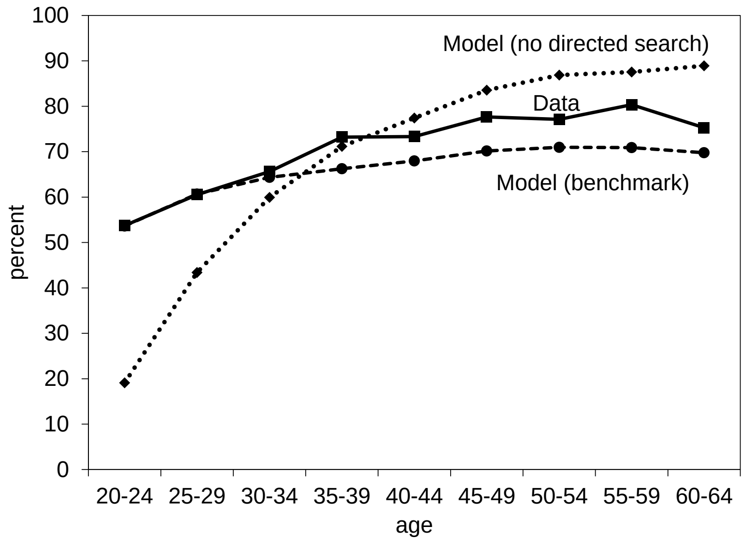


Figure 5 provides empirical evidence for directed search. It compares the distribution of the population with credit cards by age between the data, the benchmark model, and the model without directed search. We see that the benchmark model matches the data, but the model without directed search does not. The reason is that, in the benchmark model, credit card firms target young consumers, and they immediately gain credit access. In the case without directed search, young consumers gain credit access at a constant rate $(p = A = 0.07)$, which is much slower than the rate in the data.

Figure 5: **Evidence for directed search: population with credit cards by age in 2004**



4.2 Bargaining

This subsection discusses the extent to which the credit card contract assumed in the benchmark model is important for the increase in the matching efficiency to quantitatively account for the rise in revolving credit and consumer bankruptcies. In the benchmark economy, the borrowing limit and borrowing interest rate are determined during the period of the match, and are fixed for the duration of the match. To quantify the importance of this type of contract, I compare the benchmark model with the standard model of competitive pricing of revolving credit (Chatterjee et al., 2006; Livshits, MacGee, and Tèrtilt, 2007). In the standard model of competitive pricing of revolving credit, the consumers face the following bond price schedule:

$$q(j,\varepsilon,b') = \frac{\psi_j E_{\varepsilon'|\varepsilon}(1-d_f(j+1,b',\varepsilon'))}{1+r}.$$

Every period, the consumer issues debt where the price schedule $q(j,\varepsilon,b')$ is discounted by the conditional survival probability ψ_j, the expected probability of default $E_{\varepsilon'|\varepsilon}d_f(j+1,b',\varepsilon')$, and the risk-free interest rate r. In this case, the bond price might decrease (higher cost of borrowing) with increased borrowing (higher b') or decreased earnings (lower ε) because the consumer might be more likely to default. In the benchmark model, default risk in all future periods is taken into account during the bargaining period. However, after the bargaining period, increased borrowing or decreased earnings do not affect the terms of the contract.

In Table 5, I compare the level of revolving credit and consumer bankruptcies from the final steady state of the benchmark model (which has bargaining) with those from the standard model of competitive pricing of revolving credit (which has no bargaining). For the case of standard competitive pricing, I report results for three different levels of stigma (χ). The first case assumes that stigma is the same as in the benchmark economy; the second case decreases stigma to 30 percent of the benchmark case; and the third case increases stigma to 170 percent of the benchmark case. All other parameters are assumed to be the same.

Table 5: **Benchmark (bargaining) vs standard competitive pricing (no bargaining)**

Variable (unit = percent)	**Benchmark**	**Standard competitive pricing**		
		$\chi_{benchmark}$	$0.3\chi_{benchmark}$	$1.7\chi_{benchmark}$
Revolving credit to disposable income	7.45	3.31	1.51	3.81
Annual bankruptcies to population	0.45	0.20	0.47	0.10

In the case where stigma is equal to the benchmark value, $\chi_{benchmark}$, the model with standard competitive pricing leads to revolving credit and consumer bankruptcies that are less than half of those in the benchmark model. When the default cost stigma is decreased to $0.3\chi_{benchmark}$, the standard competitive pricing model does a better job of accounting for the number of consumer bankruptcies, but leads to a further decrease in revolving credit. If χ is increased to $1.7\chi_{benchmark}$, the standard competitive pricing model leads to more revolving credit, but it cannot account for the number of consumer bankruptcies. Therefore, the credit card contract assumed in the benchmark model is key to account for both the level of revolving credit and consumer bankruptcies.

Table 6 presents evidence consistent with the credit card contract assumed in the benchmark model. Recall that in the benchmark model, when the consumer and the credit card firm bargain over the credit card contract, the consumer has no debt. Subsequently, the borrowing interest rate or the borrowing limit do not change after the consumer starts to accumulate debt. Table 6 shows that the difference in the average borrowing interest rate between debtors and savers (in the cross-section) is small — in both the model and data.

Table 6: **Evidence for bargaining**

Variable (unit = percentage points)	**Data**	**Model**
Avg interest rate debtors - avg interest rate savers	0.71	0.24

4.3 Charge-off rate and (cross-sectional) average spread

This subsection discusses the rise in the charge-off rate and the small decrease in the (cross-sectional) average spread observed in the benchmark model. There are two reasons for the rise in the charge-off rate. First, the increase in the matching efficiency increases the consumer's outside option: the value of searching for a new credit card. This allows the consumer to bargain for a higher borrowing limit (Table 7). Second, the increase in the matching efficiency leads to a change in the distribution of consumers with credit cards. Table 7 shows that in the initial steady state, the majority of consumers with credit cards were those with lower earnings (quintile 1). In the final steady state, there is an increase in the proportion of credit card holding consumers with higher earnings (quintiles 2-5). These consumers with higher earnings are relatively safer, and, therefore, they bargain for higher borrowing limits. Higher borrowing limits allow for higher debt accumulation. Given a strictly concave utility function, repayment is more costly with higher debt. This leads to a higher number of defaults. Therefore, a higher percent of debt is written off, which is the rise in the charge-off rate. For the same two reasons, there is also a decrease in the (cross-sectional) average spread. However, quantitatively, the decrease is small.

Table 7: **Credit card holders by earnings, average borrowing limits, and average debt**

Variable	**Benchmark Initial steady state**	**Benchmark Final steady state**
Credit card holders by earnings		
(unit = percent)		
Quintile 1	34.82	28.46
Quintile 2	34.31	36.38
Quintile 3	13.04	14.40
Quintile 4	13.85	15.89
Quintile 5	3.98	4.87
Average borrowing limit $_{debtor}$	0.24	0.36
Average debt $_{debtor}$	0.16	0.25

4.4 Welfare gains

This section shows that the increase in the matching efficiency leads to large welfare gains. It also shows that directed search and bargaining are key features for the increase in the matching efficiency to generate the large welfare gains. I use consumption-equivalent variation (CEV) to measure welfare. CEV calculates the lifetime growth in consumption in the initial steady state that would make the unborn consumer indifferent between the initial and final steady states. In Appendix A, I derive the welfare measure, taking into account the utility cost (stigma) associated with default.

Table 8 compares welfare gains estimated from the benchmark model, the model without directed search (Section 4.1), and the model with standard competitive pricing of revolving credit (Section 4.2). In the benchmark case, the initial and final steady states are the economies with a matching efficiency of A_{1970} and A_{2004}, respectively. An unborn consumer requires a lifetime consumption growth of 3.55 percent to be as well off without the increase in the matching efficiency. For the cases without directed search and with standard competitive pricing of revolving credit, I assume an initial steady state with zero revolving credit — this gives an upper bound for the welfare estimates from these two cases. Even then, the welfare gains are substantially larger in the benchmark case. For example, with standard competitive pricing, $0.3\chi_{bennchmark}$ accounts for most of the bankruptcies observed in 2004. It leads to lifetime consumption gains of 0.56 percent, which is close to the 0.57 percent estimate from Livshits, MacGee, and Tèrtilt (2010).

Table 8: **Comparison of welfare gains**

Variable (unit = percent)	**Benchmark**	**No directed search**	**Standard competitive pricing** $\chi_{benchmark}$	$0.3\chi_{benchmark}$	$1.7\chi_{benchmark}$
Initial steady state (1970)					
Revolving credit to disposable income	1.31	0	0	0	0
Annual bankruptcies to population	0.09	0	0	0	0
Final steady state (2004)					
Revolving credit to disposable income	7.45	2.11	3.31	1.51	3.81
Annual bankruptcies to population	0.45	0.15	0.20	0.47	0.10
Welfare gains					
CEV	3.55	1.04	1.48	0.56	2.01

4.5 Controlling welfare gains for substitution

The previous section focused only on revolving credit and ignored substitution between different forms of personal credit. This section controls the benchmark welfare estimate for substitution from non-revolving personal loans to revolving credit.

As documented in Livshits, MacGee, and Tèrtilt (2010), some of the rise in revolving credit was associated with a decrease in non-revolving personal loans. This can be seen in Figure 6, which shows that while there was an increase in revolving credit, there was also a decrease in non-revolving personal loans. Following Livshits, MacGee, and Tèrtilt (2010), I refer to the sum of revolving credit and non-revolving personal loans as unsecured credit. In 1970, most unsecured credit took the form of non-revolving personal loans. By 2004, most unsecured credit was revolving credit. The sum of revolving credit and non-revolving personal loans (unsecured credit) increased only from the early 1980s. Given this substitution, the welfare estimate from the increase in the matching efficiency might be overstated.

Figure 6: **Revolving credit, non-revolving personal loans, and unsecured credit**

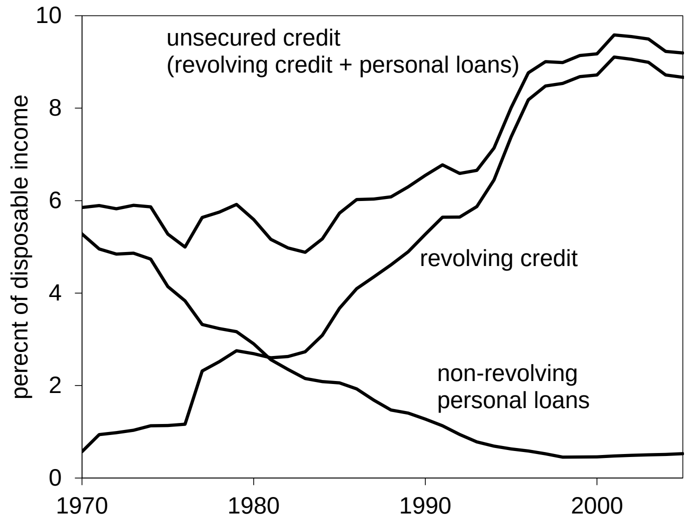


Table 9: **Controlling welfare gains for substitution**

Variable (unit = percent)	**Value**
Initial steady state = standard competitive pricing	
Revolving credit to disposable income	3.31
Annual bankruptcies to population	0.20
Final steady state = benchmark	
Revolving credit to disposable income	7.45
Annual bankruptcies to population	0.45
Welfare gains	
CEV	2.78

To control for this substitution, suppose that the initial steady state is the economy with standard competitive pricing ($\chi_{benchmark}$). This can be interpreted as the 1970 economy with mainly non-revolving personal loans. Let the final steady state be the benchmark economy. This can be interpreted as the 2004 economy with mainly revolving credit. Table 9 shows that even after controlling for substitution, the welfare gains from the increase in the matching efficiency are large (2.78 percent).

5 Alternative explanations

This section uses the benchmark model to analyze the implications of two alternative explanations for the rise in revolving credit and consumer bankruptcies: 1) improvements in information about consumers and 2) increased competition in the credit card industry.

5.1 Improvements in information about consumers

This subsection compares a full private information economy with the benchmark economy, which assumes perfect information. For the full private information case, I assume that the credit card firm does not observe the consumer's idiosyncratic state. In that case, the credit card firm chooses the same borrowing limit and the same borrowing interest rate for all consumers to maximize the expected profits computed over the distribution of consumers without credit access, given by the following equation:

$$\Pi^* = \max_{\bar{b}, r_b} \; E_{j,b,\varepsilon} \Pi(j, b, \varepsilon, \bar{b}, r_b).$$

Given Π^*, the probability of credit access is identical across all consumers, and is computed as follows:

$$p* = A \left[\frac{\Pi^*}{\kappa} \right]^{(1-\alpha)/\alpha}.$$

Table 10 compares the results from the economy with full private information to those from the benchmark economy, which assumes perfect information (all the parameters are the same in both cases). We see that while improvements in information lead to a rise in revolving credit and consumer bankruptcies, it also leads to a decrease in the population with credit cards. The intuition for this result is that with perfect information, the credit card firm will send fewer (or zero) credit offers to consumers who are less (or not) profitable.

Table 10: **Full private information to perfection information (benchmark)**

Variable (unit = percent)	**Full private information**	**Perfect information (Benchmark)**
Population with credit cards	99.13	66.12
Revolving credit to disposable income	2.45	7.45
Annual bankruptcies to population	0.20	0.45
Population with credit card debt	23.48	30.22
Charge-off rate	1.46	3.30
Spread: (cross-sectional) average	2.30	3.55
Spread: (cross-sectional) standard deviation	0.00	0.76

5.2 Increased competition in the credit card industry

This subsection compares an economy with low competition in the credit card industry to one with high competition in the credit card industry. The benchmark economy assumes that the consumer's bargaining power μ is equal to 0.1; hence, that is considered as the economy with low competition. For the economy with high competition, the consumer's bargaining power is increased to 0.5.

The results are presented in Table 11. We see that while the increase in the consumer's bargaining power leads to a rise in revolving credit and consumer bankruptcies, it also leads to a decrease in the population with credit cards. The intuition for this result is that when the consumer has more bargaining power, she can bargain for higher borrowing limits and lower borrowing interest rates. This decreases the credit card firm's profitability, and, therefore, the credit card firm will send fewer credit offers, thus leading to a decrease in the population with credit cards.

Table 11: **Low competition (benchmark) to high competition**

Variable (unit = percent)	**Low competition, $\mu = 0.1$ (Benchmark)**	**High competition, $\mu = 0.5$**
Population with credit cards	66.12	55.09
Revolving credit to disposable income	7.45	8.93
Annual bankruptcies to population	0.45	0.49
Population with credit card debt	30.22	32.23
Charge-off rate	3.30	3.08
Spread: (cross-sectional) average	3.55	3.07
Spread: (cross-sectional) standard deviation	0.76	0.69

6 Policy experiments

This section analyzes how the welfare implications of stricter bankruptcy policies vary depending on the level of competition in the credit card market — captured by the consumer's bargaining power. To do that, I introduce two bankruptcy policies under two scenarios. The two policies are credit card market exclusion and bankruptcy fees (Appendix A contains the analysis of a third policy - earnings tests). Credit card market exclusion excludes the consumer who defaults from receiving credit offers for a specified period of time, and a bankruptcy fee is a payment during the default period. The first scenario sets the consumer's bargaining power to 0.1, which is also the value assumed in the benchmark economy (low competition). The second scenario sets the consumer's bargaining power to 0.5 (high competition). In the model, both policies increase the cost of default. Their potential benefits are higher probabilities of credit access, higher borrowing limits, and lower borrowing interest rates due to the increased commitment to repay debt.

6.1 Credit card market exclusion

Credit card market exclusion is incorporated into the benchmark model as follows. Let p^{Ex} denote the probability of credit card market exclusion upon default. If the duration of credit card market exclusion is x years, then $p^{Ex} = 1 - 1/x$. Furthermore, let $V^{Ex}(j,b,\varepsilon)$ denote the value of credit card market exclusion. It is characterized by the following equation:

$$V^{Ex}(j,b,\varepsilon) = \max_{c,b'} \; U(c) + \beta\psi_j E_{\varepsilon'|\varepsilon}\Bigg[\overbrace{(1-p^{Ex})}^{prob\ inclusion} \; \big[\overbrace{(1-p(j+1,b',\varepsilon'))}^{prob\ no\ cred\ access}\overbrace{V^N(j+1,b',\varepsilon')}^{val\ no\ cred\ access} +$$

$$\underbrace{p(j+1,b',\varepsilon')}_{prob\ cred\ access}\underbrace{V^C(j+1,b',\varepsilon',\bar{b}(j+1,b',\varepsilon'),r_b(j+1,b',\varepsilon'))}_{val\ cred\ access}\big] + \underbrace{p^{Ex}}_{prob\ exclusion} \; \underbrace{V^{Ex}(j+1,b',\varepsilon')}_{val\ market\ exclusion}\Bigg],$$

where the constraints are the same as those faced by a consumer without credit access. The value of default is given by the following equation:

$$V^D(j,\varepsilon) = U(\varepsilon) - \chi + \beta\psi_j E_{\varepsilon'|\varepsilon}\Bigg[\overbrace{(1-p^{Ex})}^{prob\ inclusion} \; \big[\overbrace{(1-p(j+1,0,\varepsilon'))}^{prob\ no\ cred\ access}\overbrace{V^N(j+1,0,\varepsilon')}^{val\ no\ cred\ access} +$$

$$\underbrace{p(j+1,0,\varepsilon')}_{prob\ cred\ access}\underbrace{V^C(j+1,0,\varepsilon',\bar{b}(j+1,0,\varepsilon'),r_b(j+1,0,\varepsilon'))}_{val\ cred\ access}\big] + \underbrace{p^{Ex}}_{prob\ exclusion} \; \underbrace{V^{Ex}(j+1,0,\varepsilon')}_{val\ market\ exclusion}\Bigg].$$

Table 12 compares the results of introducing credit card market exclusion under the two scenarios (consumer's bargaining power of 0.1 and 0.5). In Table 12 and Table 13, all units are in percent except for the unit of the average borrowing limit, which is in units of the numeraire. We see that the welfare gains to the consumer are small when the consumer's bargaining power is 0.1 (low competition), compared to when the consumer's bargaining power is 0.5 (high competition). The reason for this result is that when the credit card firm has more bargaining power, to avoid losses, it bargains for a lower borrowing limit relative to the case when it has less bargaining power (0.36 vs 0.39). In the second case, where the credit card firm has less bargaining power and the consumer has a higher borrowing limit, the commitment to repay debt is weaker. Hence, the benefits of credit card market exclusion, which makes default costly, are larger.

Table 12: **Implications of credit card market exclusion**

Variable (unit = percent)	**Benchmark** 0 years	**Credit card market exclusion** 2 years	4 years	8 years
Consumer's bargaining power = 0.1				
Revolving credit to disposable income	7.45	7.44	7.25	7.65
Annual bankruptcies to population	0.45	0.44	0.42	0.42
Average borrowing limit $_{debtor}$	0.36	0.37	0.37	0.40
Average spread $_{debtor}$	3.55	3.59	3.53	3.49
Welfare: CEV	-	0.01	0.06	0.21
Consumer's bargaining power = 0.5				
Revolving credit to disposable income	8.93	9.01	9.15	9.34
Annual bankruptcies to population	0.49	0.48	0.46	0.44
Average borrowing limit $_{debtor}$	0.39	0.40	0.42	0.43
Average spread $_{debtor}$	3.07	3.05	3.04	2.95
Welfare: CEV	-	0.08	0.22	0.47

6.2 Bankruptcy fee

This section studies the implications of introducing a bankruptcy fee under the same two scenarios discussed in the previous section. Suppose that the fee for bankruptcy is ϕ. Then, the value of default is identical to that in the benchmark economy, except that $c = \varepsilon - \phi$ instead of $c = \varepsilon$ during the default period. Table 13 compares the results of introducing a bankruptcy fee under the same two scenarios discussed above. The introduction of a bankruptcy fee leads to significant welfare losses in both cases. Consistent with results from the previous section, we see that the welfare losses are smaller when the consumer has more bargaining power.

Table 13: **Implications of bankruptcy fees**

Variable (unit = percent)	**Benchmark** 0	**Fee (percent of disp. inc. pc)** 1.5	3.0	4.5
Consumer's bargaining power = 0.1				
Revolving credit to disposable income	7.45	2.61	2.82	2.82
Annual bankruptcies to population	0.45	0.03	0.00	0.00
Average borrowing limit $_{debtor}$	0.36	0.14	0.15	0.15
Average spread $_{debtor}$	3.55	1.14	0.93	0.93
Welfare: CEV	-	−2.19	−2.08	−2.08
Consumer's bargaining power = 0.5				
Revolving credit to disposable income	8.93	3.05	3.32	3.32
Annual bankruptcies to population	0.49	0.04	0.00	0.00
Average borrowing limit $_{debtor}$	0.39	0.14	0.17	0.17
Average spread $_{debtor}$	3.07	0.55	0.27	0.27
Welfare: CEV	-	−1.89	−1.69	−1.69

7 Conclusion and future research

In this paper, I build a quantitative model of revolving credit with earnings risk that features a search friction between consumers and credit card firms. Using this model, I show that improved matching — calibrated to match the rise in the population with credit cards — accounts for the rise in revolving credit and consumer bankruptcies in the U.S. from 1970 to 2004. I also provide empirical evidence consistent with two key features in my model: directed search and bargaining. Finally, the welfare gains from improved matching are substantially larger than those previously estimated by alternative explanations for the rise in revolving credit and consumer bankruptcies.

I also use the calibrated model to analyze how the level of competition in the credit card market (captured by the credit card firm's bargaining power) affects the welfare implications of introducing stricter bankruptcy policies, such as credit card market exclusion and bankruptcy fees. I show that the credit card firm's bargaining power dampens welfare gains (or amplifies losses).

The framework developed in this paper can be used to further understand the market for credit cards. With the bargaining structure in my model, the credit card firm is not allowed to adjust the borrowing limit or break the match after the first period. Ex-post, the credit card firm may want to adjust the borrowing limit or break the match to avoid further losses. However, ex-ante, this could impact bargaining during the period of the match. I also assume that the consumer has access to, at most, one credit card. The option of a second credit card may allow the consumer to borrow more. However, having the option of the second credit card can also affect the terms of the first credit card. Incorporating these features and understanding the impact constitutes a potential direction for future research.

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A Appendix

A.1 Earnings tests

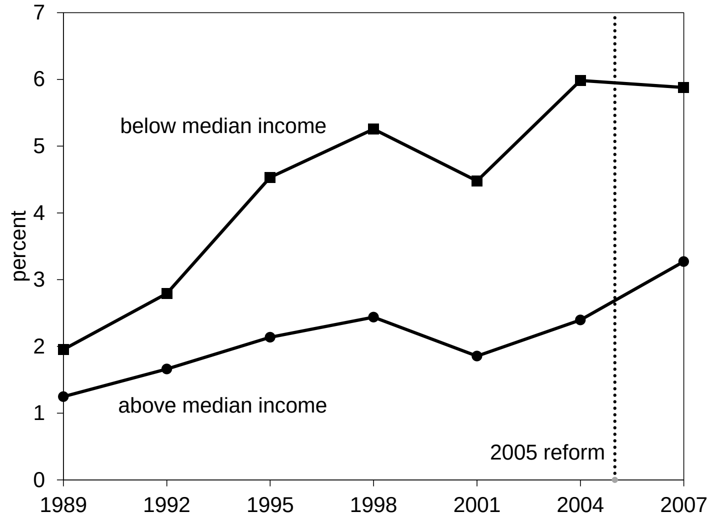
This sections analyzes the implications of earnings tests under the same two scenarios as in Section 6 (consumer's bargaining power = 0.1 and consumer's bargaining power = 0.5). An earnings test specifies an earnings threshold above which the consumer cannot file for bankruptcy. The quantitative effects are small even for a ten percent earnings threshold, as shown in Table 14.

Table 14: **Implications of earnings tests**

Variable (unit = percent)	**Benchmark**	**Earnings threshold** (percent of earnings distribution) 50	25	10
Consumer's bargaining power = 0.1				
Revolving credit to disposable income	7.45	7.47	7.46	7.46
Annual bankruptcies to population	0.45	0.45	0.45	0.41
Average borrowing limit $_{debtor}$	0.36	0.36	0.36	0.37
Average spread $_{debtor}$	3.55	3.54	3.55	3.52
Welfare: CEV	-	0.00	0.01	0.03
Consumer's bargaining power = 0.5				
Revolving credit to disposable income	8.93	8.98	8.99	8.98
Annual bankruptcies to population	0.49	0.49	0.49	0.45
Average borrowing limit $_{debtor}$	0.39	0.39	0.39	0.40
Average spread $_{debtor}$	3.07	3.07	3.07	2.92
Welfare: CEV	-	0.01	0.02	−0.08

The above results show that earnings tests have a quantitatively small effect on credit card borrowing. In the U.S., the 2005 policy reform (BAPCPA) introduced a median income test whereby those above the median income cannot file for bankruptcy without passing a means test. Figure 7 shows that the borrowing behavior by those above median income did not change from 2004 to 2007.

Figure 7: **Debt to income by income groups**



A.2 Credit card payment patterns

In reality, consumers use credit cards both as a borrowing device and as a convenient payment device. For the latter, they do not have to pay interest as long as the balances are paid off within a grace period. This section shows that debtors use credit cards mainly as a borrowing device.

Figure 8: **Payment patterns**

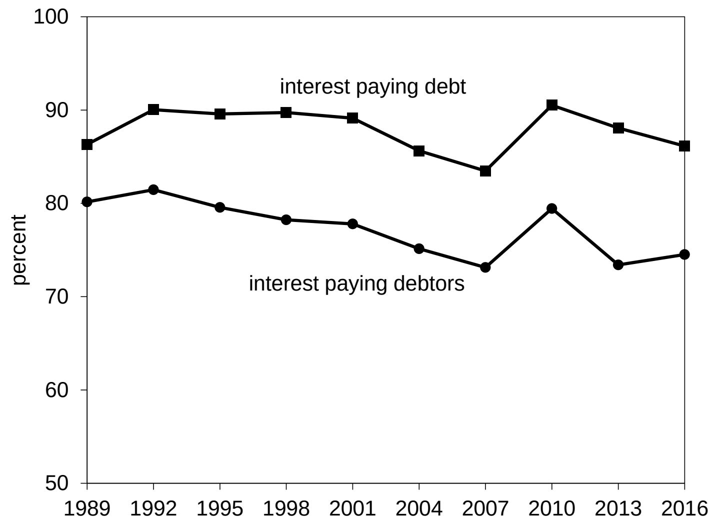


Figure 8 shows both the percent of debtors who pay interest on their credit cards and the percent of debt on which debtors pay interest. We see that almost 80 percent of debtors use the credit card as a borrowing device. We also see that on almost 90 percent of debt, debtors pay interest.

A.3 Welfare measure

Let $V_{in}(b_0)$ denote the expected discounted lifetime utility of entering the initial steady state with b_0. Then, $V_{in}(b_0)$ is characterized by the following equation:

$$V_{in}(b_0) = \sum_{j=1}^{J} E_{h_j} \beta^{j-1} \psi^{j-1} [U(c_{in}(h_j;b_0)) - d_{f,in}(h_j;b_0)\chi],$$

where E_{h_j} is the expectation over all possible sequences of shocks in age j; ψ^{j-1} is the unconditional survival probability for age j; $c_{in}(h_j;b_0)$ and $d_{f,in}(h_j;b_0)$ are the consumption and default decisions in the initial steady state given a sequence of shocks h_j and the initial condition b_0. Let $V_{fi}(b_0)$ denote an analogous value for the final steady state. Given a CRRA utility function and the stigma cost of default, consumption-equivalent variation (CEV) is characterized by the following equation:

$$CEV = \left[\frac{V_{fi}(0) + \sum_{j=1}^{J} E_{h_j} \beta^{j-1} \psi^{j-1} d_{f,in}(h_j;0)\chi}{V_{in}(0) + \sum_{j=1}^{J} E_{h_j} \beta^{j-1} \psi^{j-1} d_{f,in}(h_j;0)\chi} \right]^{1/(1-\sigma)} - 1.$$

A.4 Data sources

For the risk-free interest rate, I 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 rates data are from Ausubel (1991) for the period from 1971 to 1984 and from FRED for the period after 1984. Revolving credit data are from FRB G.19; non-revolving personal loans and unsecured credit were constructed following the methodology from Livshits, MacGee, and Tèrtilt (2010). Chapter 7 bankruptcy filings data are from McKinley (1997) for the period from 1970 to 1979 and from the American Bankruptcy Institute for the period after 1979. The Survey of Consumer Finances was used for the following data: population with credit cards, population with credit cards by age, population with interest assessed credit card debt, (cross-sectional) standard deviation of credit card interest rates, percent of debtors who pay interest on their credit cards, percent of debt on which debtors pay interest, credit card debt to income for those above and below median income.

A.5 Computation algorithm for stationary equilibrium

This section presents the algorithm used to solve for the stationary equilibrium. An analogous algorithm can be used for the transition. The algorithm for the perfect information case is as follows:

- Solve consumer problem for age J
- Use policy functions to calculate profits $\Pi(J, b, \varepsilon, \bar{b}, r_b)$
- Solve for $\bar{b}(J, b, \varepsilon)$ and $r_b(J, b, \varepsilon)$
- Calculate probabilities of credit access $p(J, b, \varepsilon)$
- Use backward induction from $j = J-1, .., 1$:
  - Solve consumer problem for age j given solution for $j+1$
  - Use policy function to calculate profits $\Pi(j, b, \varepsilon, \bar{b}, r_b)$
  - Solve for $\bar{b}(j, b, \varepsilon)$ and $r_b(j, b, \varepsilon)$
  - Calculate probabilities of credit access $p(j, b, \varepsilon)$
- Given policy functions, simulate, and solve for stationary distribution

The algorithm for the private information case is as follows:

- Guess $\bar{b}$, r_b, and $p*$
- Use backward induction to solve for value functions, policy functions, and profits
- Given policy functions, simulate, and solve for stationary distribution
- Choose $\bar{b}$, r_b, and $p*$ to maximize expected profits
- Update until convergence