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How important is variability in consumer credit limits?

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Abstract

This paper demonstrates that credit limit variability is a crucial aspect of the consumption, savings, and debt decisions of households in the United States. While typical models of intertemporal consumption fix the credit limit, variable credit limits create a reason for households to hold both high interest debts and low interest savings at the same time since the savings act as insurance. This approach can explain the credit card puzzle: why around a third of households in the U.S. hold both debt and liquid savings at the same time. Unlike other approaches it is consistent with observed changes over time. It also offers an important new channel for financial system uncertainty to affect household decisions. One of the largest “assets” in the portfolio of U.S. households is their ability to borrow. Increased uncertainty about credit limits reduces the value of this asset, and so has effects similar to a decline in wealth.

JEL classification: E21, D91, D14
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1 Introduction

Consumers in the United States face credit limits that vary substantially and unexpectedly over time. The credit limits of 42% of households in the U.S. fell by more than $1000 between 2007 and 2009, while 40% had credit limits that increased by more that $1000. While that may have been a more volatile period than normal, the evidence suggests that reductions and increases in credit limits are relatively common.¹

This paper demonstrates that variable credit limits matter. They are crucial to understanding both the decisions that consumers make about savings and credit, and to understanding how financial uncertainty can affect consumer decisions. While the typical model of consumption over time assumes that credit limits are fixed, I allow the credit limit to vary unexpectedly. Sometimes consumers can borrow more, sometimes less, and this relatively minor change affects consumer decisions substantially.

The key modeling insight in this paper is to consider the ability to borrow as one of a portfolio of assets that households use to smooth consumption. The value of that asset then depends on whether it will be available when needed. Savings in a bank or under a mattress can be used in an emergency. The ability to borrow is much less certain: a lost wallet, identity theft, or the uncertainties of dealing with a large company which can alter the line of credit at any time, all mean that it is possible to lose access to credit unexpectedly. If consumers face uninsurable income or consumption shocks—times when their income goes down significantly or their need to spend goes up—the risk of not being able to borrow when times are bad creates a reason to hold cash, even while carrying expensive debt, as a precaution against not being able to borrow. The cash acts

¹ The 2009 panel of the Survey of Consumer Finances 2009 records credit limits from the 2007 and 2009. A web survey by Consumer Action in 2008, found that out of 1069 respondents 17.5% had a credit limit cut at one time or another, and 10% had credit limits reduced in 2008 (Consumer Action, 2008). While the survey is far from scientific, it does suggest that having ones credit limit cut is not uncommon. An earlier report in 2007 by the same group found that even during the boom years of consumer credit, three quarters of major banks had a policy of reducing credit limits for changes in credit scores or other reasons (Consumer Action, 2007). Credit reports often contain errors (Hunt, 2002) which can result in unexpected reduced credit limits for some people even when credit is generally increasing. For other examples of unexpected credit cuts see “Consumers Squeezed As Issuers Slash Credit Card Limits” in Forbes.com (Asher Hawkins, April 8 2010) or just after the 2008 financial crisis “Credit Card Companies Slash Credit Limits” in The Wall Street Journal (Shelly Banjo, January 5, 2009).
as an insurance policy, so that even in the worst case when the consumer cannot borrow, she can still consume something.\(^2\)

This approach has two important implications. First, it explains the so-called “credit card puzzle.” Around a third of households in the United States carry both large revolving credit card debt at high rates of interest and hold liquid assets which pay low or no interest. As suggested by Gross and Souleles (2002), such behavior seems to be very odd: Why not pay off the debt which costs 14\% interest, with the bank account which yields close to zero? The costs of not doing so are meaningfully large, although also not a huge burden; for those that carry both credit card debt and liquid savings, the interest on the debt which could be paid off devours around 0.6\% of monthly income.\(^3\) Moreover, holding both debt and savings at the same time seems to be common among the poor all over the world (Collins et al., 2009, p.49). There have been a number of other explanations to the puzzle (Bertaut, Haliassos, and Reiter, 2009; Laibson, Repetto, and Tobacman, 2000; Lehnert and Maki, 2002; Telyukova and Wright, 2008) that I discuss in section 2. While each may explain part of the puzzle for some households, these explanations either focus on a different puzzle or are not consistent with the evidence on savings and debt behavior over time.

The model establishes that a stochastic debt limit gives consumers a motive to keep both cash and debt at the same time, but whether or not a sizable fraction of the population does so depends on preferences, the disposable income process, and the risk of losing access to borrowing. I show that for a wide range of reasonable preference parameters, it is easy to match the fraction of people who keep both positive debt and savings even for low probabilities of losing access to credit. Some heterogeneity in preferences or risks is necessary to get a significant fraction of the population to be willing to borrow while holding no savings, while a different group borrows and saves at the

\(^2\)See Carroll (2001) for a view of the development of and evidence behind precautionary models. A few of the key papers in a large buffer stock and precautionary savings literature are: Schechtman and Escudero (1977), Deaton (1991), and Carroll (1997). Fulford (2011) examines the short and long-term consequences of a permanent change in the liquidity constraint. Ludvigson (1999) examines stochastic debt limits, although explicitly restricts the analysis to exclude borrowing and saving at the same time, suggesting that to do so is a “challenging direction” for research (p. 436).

\(^3\)These calculations are made using the Federal Reserve 2007 Survey of Consumer Finances. See the section on the SCF for more detail. Zinman (2007a) examines the distribution of costs of the credit card puzzle or those who “borrow high and lend low” and finds that few households pay more than $10 a month.
same time. Holding no savings leaves open the risk that the consumer will not be able to borrow
and will have no savings at a time when marginal utility is high, and so is quite risky. Only those
who face low risks or do not care much about them are willing to spend much time with no savings.
Allowing for two populations with different preferences, the model matches the joint distribution
of savings and debt.

This approach to explaining the credit card puzzle has important implications for regulation of
consumer credit. There is increasing regulatory attention over consumer uses of credit both at the
state and federal level with the new Consumer Financial Protection Board. Yet it is impossible to
design good regulations and informational campaigns without understanding why and how con-
sumers use credit. Moreover, focusing on the price of credit may miss that the most important
welfare issue is the variability of credit and credit rationing.

The second implication of allowing credit limits to vary is what happens during times of fi-
nancial crisis. Credit makes up approximately two thirds of the resources available for immediate
consumption of the average household. It is thus the most important factor in determining the
short-term budget constraint of households. Financial uncertainty such as during the financial cri-
isis of 2008 in which commercial banks reduced credit limits overall by more than a quarter, and
cut many consumers off entirely (see section 5.1), can have large consequences for consumption
and saving purely from increasing the uncertainty around credit. Higher uncertainty about whether
credit will be available in the future means that the credit households already have becomes less
valuable. Without any change in income or employment, I show that an increase in credit limit
uncertainty by itself can cause a large immediate decrease in consumption as consumers save more
in an attempt to build up additional insurance. The change comes not just from those who are

4For example, the fourth of five tips for “Getting the most from your credit card” in the consumer information
section of the Federal Reserve Board of Governors website suggests “If you can’t pay your balance in full each month,
try to pay as much of the total as you can. Over time, you’ll pay less in interest charges–money that you will be
able to spend on other things, and you’ll pay off your balance sooner” (http://www.federalreserve.gov/
consumerinfo/fivetips_creditcard.htm, accessed 7 May 2010). If consumers keep liquid savings as a
precautionary measure while borrowing to fund current consumption, then telling them to pay down expensive credit is
bad advice, even if well intentioned. Interestingly, the financial gurus appear to understand risk. Dave Ramsey’s seven
steps to financial peace suggests building a $10000 emergency fund first, then paying off debt as step two (Ramsey,
2010). That advice follows the clear hierarchy of payments shown in the model as wealth increases, see section 3.3.
borrowing. Since credit makes up a large fraction of the available resources for all groups, even
of those who currently hold no debts want to have additional savings: they have just become ef-
effectively much less wealthy. The actual reduction in credit can be small since the effect comes
from the diminished value of credit as a way to smooth consumption. While those who borrow and
save at the same time tend to be poorer (although not the poorest), the credit and debt decisions of
these consumers are thus central to understanding the the impact of financial uncertainty and crises.
Firms which use credit to help maintain a buffer of inventory or employment to meet unexpected
demand will also adjust. In precautionary models changes in credit can have large and long-term
consequences for consumption (Fulford, 2011; Guerrieri and Lorenzoni, 2011). When precaution
is important, this paper shows that the uncertainty surrounding credit may be just as important as
the amount of credit.

This paper is organized as follows. First, I discuss other possible explanations for the credit
card puzzle and show that they are generally inconsistent with the available data. I then present
an intertemporal consumption model which allows the consumer to hold both debt and savings at
the same time. With certain credit limits I show that no optimizing consumer ever holds both debt
and savings, but with a stochastic credit limit an optimizing consumer might. The next section
asks whether for reasonable parameters the approach can generate a significant fraction of the
population saving and borrowing at the same time. It can, but some preference heterogeneity is
necessary to explain the joint distribution of savings and debt. Before concluding, 5 examines the
comparative dynamics following an increase in the probability of losing access to borrowing, and

2 Alternative explanations of the credit card puzzle

There have been a number of other proposed solutions to the credit card puzzle. Each of them
may be a motive for some households, but the evidence suggests that the explanation for most

5The buffer-stock theory of inventory is closely related to the consumer’s problem (Deaton, 1991; Deaton and
Laroque, 1992). Credit constraints can cause fluctuations in inventories (Kashyap, Lamont, and Stein, 1994).
household lies somewhere else. The most obvious, although least interesting, is that the puzzle is a mere accounting issue: wages or salary may be deposited directly in the bank before being used to pay down debt. Then at its extreme, if wages are paid the day after the due date on a credit card statement, there could be large balances for the entire month even though all available cash is used to pay down the credit balance every month. Even allowing for a month of gross total household income to be kept in liquid accounts, however, Gross and Souleles (2002) find that more than one third of credit card borrowers keep more than this amount. Section 4.1 further explores the effects of different assumptions about timing in the data, and shows that even allowing for large accounting issues a substantial fraction of consumers must be borrowing and saving at the same time. While it is possible that some households are simply making mistakes, the costs of doing so are large enough to be noticeable: my estimates suggest that for those who are both borrowing and saving the cost is around 0.6% of monthly household income; (Zinman, 2007b) finds somewhat smaller, but still non-trivial, costs.

The most compelling explanations are based on transaction uncertainty and so rely on similar precautionary preferences to this paper. Telyukova and Wright (2008) suggest that the credit card debt puzzle is just a new version of a much older question: why do people hold money, which pays no interest and may have a negative return in the presence of inflation, when they could earn a positive return in the bank? They propose a model in which some transactions cannot be paid for with credit, since they take place anonymously and so must be settled on the spot. While some consumption items that are generally paid in cash such as rent are predictable, others such as emergency visits from the plumber, are not. The unpredictability of cash needs encourages consumers to keep cash, even while they maintain credit card debt. A similar approach is used by Masters and Rodríguez-Reyes (2005) to explain why countries with similar levels of technology can have very different credit card use and acceptance rates.

There are several problems with explanation that relies on merchant acceptance to explain why consumers might not pay off credit card balances with available cash. The first is that this approach explains a different puzzle: why anyone caries cash in the form of Federal Reserve bank
notes. Cash pays no interest and is dominated as a payment mechanism by credit cards which have limited liability if stolen, warranty protections, and often offer rewards of some sort. It makes sense that consumers still carry cash in their pockets, along with credit cards, on the chance that they will want to consume from a merchant who does not take a credit card.

Yet it seems that another explanation is needed to explain the portfolio decision of why such a large fraction of households carry positive balances in savings accounts, while also keeping revolving balances of credit. Table 1 shows how payment methods and the credit card puzzle have evolved over time. The fraction of households in the credit card puzzle has been approximately constant since 1992. During the same time the acceptance of credit cards and their use in transactions has increased substantially. While in 1992 few grocery stores accepted credit cards, now almost all do (Evans and Schmalensee, 2005). Electronic payments (whether credit or debit) grew from approximately 22% of non-cash transactions per person in 1995 to 67% of non-cash transaction in 2006. While it is more difficult to track cash transactions, the evidence suggests they have been falling (Gerdes, 2008). Moreover, the ability to get a cash advance on the credit card obviates any need to keep money in an savings account to pay merchants who will not accept credit. While cash advances are not often used compared to regular credit (they are more expensive, and represent about 0.8 percent of credit card value), Gerdes (2008) points out that they are likely used for emergencies since the average cash advance is much higher than the average ATM withdrawal. The checks sent by credit card companies to use for cash advances even suggest their use for emergencies. The credit card puzzle has held constant at the same time as the precautionary need based on transactions suggested by Telyukova and Wright (2008) has largely disappeared, which strongly suggests that another explanation is needed.

Trying to use the bankruptcy system, which protects some assets, may help explain the behavior of some borrowers (Lehnert and Maki, 2002). Yet the fraction of households borrowing and saving at the same time barely changed from 2004 to 2007 (see figure 1), despite the change in bankruptcy laws in 2005 which made it substantially harder to discharge personal debts while keeping other assets (DeLaurell and Rouse, 2006).
Self-control issues are a different possible explanation. Hyperbolic discounting can explain a separate puzzle: why credit card borrowers also hold illiquid assets as a self-control mechanism (Laibson, Repetto, and Tobacman, 2000), but has difficulty explaining the short-term portfolio decision of assets that are comparably liquid. Haliassos and Reiter (2007) and Bertaut, Haliassos, and Reiter (2009) propose a model in which one portion of the household, the accountant, attempts to control another part, the shopper, by limiting the credit line available. While such preferences could coexist within one person, they are more likely in a household which has to make joint decisions and so must reconcile potentially different preferences. While in the raw data discussed in section 4.1 married households are somewhat more likely to borrow and save at the same time, a simple logit analysis shown in table 2 that controls for other possible demographic differences such as age suggests that the likelihood of borrowing and saving at the same time is only slightly higher and statistically insignificant for households in which a spouse or partner is economically part of the household. Such self-control issues are unlikely to be a major explanation of the puzzle.

3 A model of consumer spending and debt

This section presents a basic model of intertemporal consumption and demonstrates that an optimizing household will never hold both debt and cash at the same time with a certain borrowing limit, but may do so with a stochastic limit. For simplicity, it does not include several extensions used in the simulations.

The model departs from the standard intertemporal consumption model in two ways: First, it allows debt and cash consumption to be separate and decided separately. That means that there are both two decisions variables and two states: debt and savings. In the standard model without a stochastic debt limit, debt and cash wealth can be collapsed into a single state “assets” or “wealth” and so do not have to be treated separately. Second, with a stochastic debt limit, it is possible for a consumer to have debts greater than her debt limit, since she may have borrowed under a previously higher limit. It is therefore necessary to specify what happens in this situation, which
never occurs in the standard model. For those above their debt limit, I assume that they must pay at least the interest on the debt every period, and may pay more than that, but do not have to. So debt, for those who are above their debt limit is non-increasing.

### 3.1 The basic model

A household dynasty or infinitely lived individual seeks to maximize:

$$\max_{\{c_t\}_{t=0}^{\infty}} E_0 \left[ \sum_{t=0}^{\infty} \beta^t u(c_w^t + c_b^t) \right]$$

where consumption in each time period is composed of two parts, consumption paid for with cash $c^w_t$ and consumption paid for with debt $c^b_t$. Utility does not depend on how the consumption was financed, only on how much there is, so consumption this period is $c_t = c^w_t + c^b_t$. At the start of each period a consumer receives stochastic labor income and the returns on cash wealth saved from the previous period both of which are immediately deposited. Cash wealth $w_t$ then evolves according to:

$$w_{t+1} = (1 + r_s)(w_t - c^w_t) + y_{t+1},$$

where disposable income in period $t + 1$ is $y_{t+1}$ with distribution $G(\cdot)$ whose support has a lower bound $y_l > 0$, and the safe rate of return on savings is $r_s > -1$. The consumer can never spend more cash than she has so that $c^w_t \leq w_t$, and so with $w_0 \geq y_l$ given, $w_t \geq y_l$ for all $t$.

Cash balances are necessarily positive because the consumer gets some sort of consumable resources each period, whether or not there is debt. This observation is the accounting explanation for the credit card debt puzzle: we should expect to see positive cash balances unless the timing of payments is such that wages can be paid directly into debt (if wages are garnished, for example). The real puzzle then is not whether the individual has positive cash holdings during the period, but whether she has cash savings from period to period that are positive $w_t - c^w_t > 0$, while at the same time

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6See Hartley (1996) for a model in which cash good and luxury goods (which can be bought using either cash or credit) enter utility separately. Consumers in that model, whose only uncertainty is whether luxury goods will be available, do not hold both credit card debt and and excess cash, which allows the value function to be reduced to a single state variable.
time carrying debts.

The evolution of debt is simpler, but the constraints on the choices are more complex. Debt $b_t$ evolves according to

$$b_{t+1} = (1 + r_b)(b_t + c^b_t),$$  \hspace{1cm} (3)$$

where $r_b > 0$ is the borrowing interest rate. If $c^b_t > 0$, then the consumer charges on the credit card and so debt increases. If $c^b_t < 0$, the consumer paid off some debt. The transfer takes place at the time of consumption—negative debt consumption requires higher cash consumption to reach the same utility.

Note that if a consumer buys something with a credit card, then pays it off with cash in the same time period, this transaction is a cash purchase within the model. It is only debt that is carried from period to period that matters. The convenience or rewards of using a credit card to facilitate purchases are relatively obvious—and credit card companies charge merchants substantial amounts for this convenience to their customers. It it is only if those purchases are not paid off quickly that they represent debt and not a consolidated billing system.

I focus on the case where $r_b > r_s$ so that borrowing is more costly than savings. Under these circumstances the consumer might want to lend rather than borrow on the credit card. To keep this from happening the lower bound on the debt consumption is that it can only pay off current debt:

$$c^b_t \geq -b_t.$$ Then given $b_0 \geq 0$, that imples $b_t \geq 0$ for all $t$.

The upper bound on debt consumption has two parts. Debt consumption can be up to the available credit in the current period, as long as current debt is not above the debt limit. If current debt is greater than the debt limit, then the consumer must pay at least the interest on the current debt so the debt cannot grow. Then the full constraint on debt consumption is:

$$-b_t \leq c^b_t \leq \begin{cases} \frac{-r_b b_t}{1+r_b} & \text{if } b_t > B_t/(1 + r_b) \\ \frac{B_t}{1+r_b} - b_t & \text{if } b_t \leq B_t/(1 + r_b) \end{cases}$$  \hspace{1cm} (4)$$

where the debt limit $B_t \geq 0$. Note that the consumer can borrow only up to $B_t/(1 + r_b)$ which
ensures that $b_{t+1} \leq B_t$ next period. $B_t$ which is a limit on next period debt, is subscripted $t$ to make it clear that it is a constraint on behavior in $t$ and in the information set at $t$. How $B_t$ changes (or not) over time, and how that affects the household’s decisions are considered in the next two sections.

Define debt holdings at the end of the period $D_t = (b_t + c^b_t)$ and cash savings at the end of the period as $S_t = (w_t - c^w_t)$. Note that both are non-negative for all $t$. The credit card puzzle is then the observation that for large numbers of consumers $S_t > 0$ and $D_t > 0$ in the same period.

Following the Lagrange approach (Chow, 1997) is more straightforward for stating the consumer’s problem since the constraints are crucial. Given $w_0 > 0$, $B_t \geq 0$, and $b_0 \geq 0$ the consumer’s problem is:

$$
\max_{\{c_t\}_{t=0}^\infty} E_0 \left[ \sum_{t=0}^\infty \beta^t u(D_t - S - t + w_t - b_t) \right] \text{ subject to:}
$$

$$
\lambda^w_t: w_{t+1} = (1 + r_s)S_t + y_{t+1} \quad \lambda^b_t: b_{t+1} = (1 + r_b)D_t
$$

$$
\lambda^{D_0}_t: D_t \geq 0 \quad \lambda^S_t: S_t \geq 0 \quad \lambda^I_t: \max\{B_t/(1 + r_b), b_t/(1 + r_b)\} - D_t \geq 0
$$

where the $\lambda$’s have an attached complementary slackness constraint and are the multipliers from the associated Lagrange equation:

$$
\mathcal{L} = E_0 \left[ \sum_{t=0}^\infty \beta^t \left( u(D_t - S - t + w_t - b_t) + \lambda^w_t ((1 + r_s)S_t + y_{t+1} - w_{t+1}) \right) + \lambda^b_t (b_{t+1} - (1 + r_b)D_t) + \lambda^{D_0}_t D_t + \lambda^P_t \left( \max\{B_t/(1 + r_b), b_t/(1 + r_b)\} - D_t \right) + \lambda^S_t S_t \right].
$$

### 3.2 Fixed debt limit

This section shows the well known result that no optimizing consumer who can borrow this period ($b_t < B$) has both $S_t > 0$ and $D_t > 0$ at the same time if the debt limit is not stochastic so $B_t = B > 0$. The reason to show this result is that setting up the first order conditions makes it obvious how the problem change when $B_t$ is stochastic in the next section, and so it makes clear
why credit limit variability is so important.

If \( B_t = B \) for all \( t \) and \( b_0 \leq B \) then the constraint on \( D_t \) can be simplified to \( B/(1+r_b) - D_t \geq 0 \). This simplification is crucial for what follows, and I show the implications of what happens when it does not hold in the next section. Consider the decision at \( t \) following a sequence of feasible, although not necessarily optimal, decisions \( \{D_{\tau}, S_{\tau}\}_{\tau=0}^{t-1} \), so that \( w_t \geq y_t \) and \( 0 \leq b_t \leq B \). The first order necessary conditions are:

\[
\begin{align*}
  w_{t+1} &: \beta E_t[u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1})] - \lambda^w_t = 0 \\
  b_{t+1} &: \beta E_t[-u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1})] + \lambda^b_t = 0 \\
  D_t &: u'(D_t^* - S_t^* + w_t - b_t) - \lambda^b_t(1 + r_b) + \lambda^{D_0}_t - \lambda^D_t = 0 \\
  S_t &: -u'(D_t^* - S_t^* + w_t - b_t) + \lambda^S_t(1 + r_s) = 0 \\
  \lambda^{D_0}_t &: \lambda^{D_0}_t \geq 0, \; D_t \geq 0, \; \lambda^{D_0}_t D_t = 0 \\
  \lambda^D_t &: \lambda^D_t \geq 0, \; \lambda^D_t(D_t/(1+r_b) - D_t) \geq 0, \; \lambda^D_t(B/(1+r_b) - D_t) = 0 \\
  \lambda^S_t &: \lambda^S_t \geq 0, \; S_t \geq 0, \; \lambda^S_t S_t = 0
\end{align*}
\]

which include the inequality constraints, non-negativity constraints for the \( \lambda \)'s and complementary slackness conditions (as well as the accumulation equations which are the FOC’s for \( \lambda^w_t \) and \( \lambda^b_t \)).

Suppose \( D_t^* > 0 \) and \( S_t^* > 0 \). Then by the complementary slackness condition both \( \lambda^S_t = 0 \) and \( \lambda^{D_0}_t = 0 \), and so using the FOC’s for \( D_t \) and \( S_t \) gives:

\[
\lambda^b_t(1 + r_b) + \lambda^D_t = u'(D_t^* - S_t^* + w_t - b_t) = \lambda^S_t(1 + r_s)
\]

and substituting from the conditions for \( w_{t+1} \) and \( b_{t+1} \):

\[
(1+r_b)\beta E_t[-u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1})] + \lambda^D_t = (1+r_s)\beta E_t[u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1})]. \tag{5}
\]

Since marginal utility is positive, \( \lambda^D_t \geq 0 \) and \( (1+r_b) > (1+r_s) \), the equation above cannot
hold, and so both $D^*_t > 0$ and $S^*_t > 0$ cannot be optimal. So the optimal path does not include instances where the consumer both leaves cash to accumulate at the low interest rate, and debt which accumulates at the high interest rate in the same period.

The consumption and savings decisions for someone who can always borrow up to one month’s income are illustrated in figure 3. The first row shows the decisions made when entering the period with no debt, the second when entering the period with half a month’s income worth of debt. The left column shows the cash consumption and debt consumption decisions for a range of cash wealth, while the right column shows the corresponding debt and savings decisions $D_t$ and $S_t$ which leave cash wealth and debt for the next period. Debt and savings for the next period are never both positive as the right column shows. As cash wealth this period increases, the consumer uses some of that cash to consume more, and some of it to pay down debt, but never leaves cash to next period while there is debt to payoff. Eventually there is no more debt to pay off, and the consumer saves some cash for the next period. When there is more debt as in the second row of the figure, it takes more cash wealth to pay off the debt without sacrificing consumption and the transition from borrowing to saving occurs at a higher cash wealth level. The difference illustrates the common financial planner advice that paying down high cost debt is better than saving. That advice may not always be good as the next section demonstrates.

3.3 Stochastic debt limit

When the debt limit is stochastic so that $B_t$ is a $t$-measurable random variable whose support has a lower bound of 0, the optimal path may include both positive savings and debt. Intuitively with a stochastic debt limit, when times are bad it may make sense to use debt to consume now rather than cash, since next period times may be bad also, but then you have spent your cash and may not be able to borrow. Cash wealth acts as self-insurance, just as all wealth does in standard precautionary models. When $B_t$ is stochastic the decision to leave more debt for next period now affects not just how much debt the consumer has next period, but also the likelihood and marginal utility cost (given by the shadow price $\lambda^{D}_{t+1}$) of the debt limit binding in the next period. To simplify the
analysis, I restrict $B_t \in \{0, B\}$, so that the consumer can either borrow up to $B$ or not at all.

A stochastic debt limit means that the FOC for $b_{t+1}$ must include that the constraint on $D_{t+1}$ may bind, and so the decisions today affect the costs of the constraint binding in the next period. The FOC for $b_{t+1}$ now reads:

$$b_{t+1}: \beta E_t[-u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1}) + 1(b_{t+1}^* > B_{t+1})\lambda_{t+1}^D/(1 + r_b)] + \lambda_{t+1}^b = 0$$

where $1(b_{t+1}^* > B_{t+1})$ is a random variable which is 1 if $b_{t+1}^* > B_{t+1}$ and zero otherwise.\(^7\) Now equation 5 reads:

$$(1 + r_b)\beta E_t[u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1}) - \lambda_{t+1}^D/(1 + r_b)1(b_{t+1}^* > B_{t+1})] + \lambda_{t+1}^D = (1 + r_s)\beta E_t[u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1})]$$

and it is possible for $D_{t+1}^*$ and $S_{t+1}^*$ to both be positive at the same time without violating optimal behavior.

Equation 6 also gives some insight into the behavior that leads to $D_{t+1}^*$ and $S_{t+1}^*$ both being positive. Rearranging equates the marginal costs to the marginal benefits of increasing both $D_t$ and $S_t$ and so entering the next period with (in expectation) both more debt and more savings:

$$(r_b - r_s)\beta E_t[u'(D_{t+1}^* - S_{t+1}^* + w_{t+1} - b_{t+1})] + \lambda_{t+1}^D = \beta E_t[1(b_{t+1}^* > B_{t+1})\lambda_{t+1}^D]$$

The price of higher debt and higher savings is the difference interest rates $(r_b - r_s)$ which means there will be lower cash next period with an expected marginal utility cost in the next period given by $(r_b - r_s)\beta E_t[u'(D_{t+1}^* - S_{t+1}^* + w_{t+1}^* - b_{t+1}^*)]$. Since holding less cash and more debt decreases cash wealth next period, marginal utility increases. Increasing both cash and debt leaves consumption unchanged, and so has no cost this period (as long as the debt constraint $\lambda_{t+1}^D$ is not

\(^7\)The assumption that $B_t \in \{0, B\}$ means that the decision about $D_t$ and so $b_{t+1}$ does not affect the distribution of $1(b_{t+1}^* > B_{t+1})$ since the restrictions on $D_t$ mean that $b_{t+1} \leq B$ for all $t$. So the simplification allows me to ignore that having more debt might make it more likely that the debt limit will bind by increasing the probability that $b_{t+1}^* > B_{t+1}$.
The right hand side gives the expected benefit in the next period increasing both cash and debt left to next period. It is the expected cost of the debt limit binding next period. When the debt limit binds, the household wants to consume more through debt, so the costs of the debt limit binding are high when marginal utility is high. If the period utility function displays a precautionary motive, $u''(\cdot) < 0$, then marginal utility is decreasing, although a borrowing constraint imposes a precautionary motive all by itself (Carroll and Kimball, 2001). When the debt limit binds, then consumption is determined by the amount of cash savings, so increasing both savings and debt reduces the cost of the debt limit binding since marginal utility is decreasing. So the cost of the debt limit binding tend to be high when marginal utility is high: with a bad shock (low $y_{t+1}$) and low cash wealth. In this case the costs of extra debt are small, while the benefits of increased cash-at-hand are large, and it is worth paying the carrying cost of a little extra debt to keep some cash as insurance.

The savings and debt decisions $D_t$ and $S_t$ for someone facing an uncertain debt limit next period are illustrated in figure 4. The risks and preferences are the same as in figure 3, except that the consumer may lose access to borrowing. The left column represents the savings and debt decisions when borrowing is possible in the current period, while the right shows the savings and debt decisions when borrowing is not possible in the current period. The first row shows the decisions made when entering the period with no debt, the second when entering the period with half a month’s income worth of debt. While in figure 3, $D_t$ and $S_t$ were never both positive, the uncertainty over borrowing allows $D_t$ and $S_t$ to both be positive at the same time. The easiest decisions are for those with no debt and who cannot borrow in the upper right plot. Then $D_t$ is necessarily zero, and $S_t$ is zero until there is enough cash wealth that the consumer wants to save for next period as in the standard consumption policy with liquidity constraints (Deaton, 1991). When borrowing is possible in the upper left plot, however, those with low cash this period choose to finance their consumption from borrowing, while keeping some cash in case they lose access to borrowing next period. Eventually they have enough cash to pay back the debt, so $D_t$ goes to zero,
and all additional transfers to the next period come from higher $S_t$. With higher debt in the lower left plot, the transition from paying off debt to active saving occurs at a higher wealth point.

With a variable debt limit, it is possible to have positive debt, but not to be able to borrow more, a situation illustrated by the bottom right plot. With a fixed debt limit, no feasible path which starts within the debt limit ever reaches such a situation, and so it can be safely ignored. With a variable debt limit, it is possible to have positive debt from the period before, and to have the borrowing limit decline so that adding to that debt is no longer possible. It is not optimal to use all available cash to pay back the debt, however, since then one might enter the next period still unable to borrow and with no cash. Instead, consumers choose to save and only start paying down debt once they reach a certain level of wealth. After the consumer reaches a certain level of insurance from saving cash for the next period, the consumer devotes all additional cash wealth to paying down the debt from the previous period. Once all of the debt is paid, the consumer adds to savings. This complicated policy leads to the multiple changes in direction in the lower right plot in figure 4.

From a household financial management point of view, when faced with variable credit limits, the first goal is to have some cash savings, and only then to pay down debt. It is only optimal to pay off the expensive debt once the household has sufficient cash savings to use in emergencies. As shown in figure 4 when very cash poor the household should actually use credit to fund consumption and so increase debt in order to build up cash savings.

For the consumption decisions shown in figure 4, there is a ergodic distribution of cash and debt in which 37% of consumers keep both positive cash and positive debt for the next period. Some additional assumptions are needed to assure that infinite accumulation is not in the optimal path (Clarida, 1987; Rabault, 2002; Schechtman and Escudero, 1977), but all of the simulations here meet those conditions.

While incomes and debt limits occasionally go down, consumer credit and incomes have generally been increasing. The analysis goes through, however, with underlying growth that increases incomes and debt limits at the same rate, together with the restriction of the period utility to show
constant relative risk aversion. Then the analysis proceeds in ratios (Carroll, 2004; Deaton, 1991): a low debt limit to income ratio next period means that it may be worth having both cash to income and debt to income positive this period. With growth the consumer keeps cash as a precaution against the debt to income ratio being low. Since growth tends to make consumers more impatient, it will tend to make borrowing more attractive, and so increase the proportion of the population which both borrows and saves at the same time. Ludvigson (1999) examines such a situation with stochastic debt limits, although explicitly limits the analysis to exclude borrowing and saving at the same time.

While rising incomes may not be especially important for monthly consumption and debt decisions, the same approach of examining ratios is useful for comparing a population with very different incomes. Under the same conditions, those with different permanent incomes will make the same choices in ratios: a person who has a high wealth to permanent income ratio will choose to consume the same fraction of income whether her permanent income is large or small. This property of the model allows me to compare the debt and savings decisions of those with both high and low incomes in a consistent manner by considering their decisions relative to their incomes.

4 Fitting the model to data

Allowing the debt limit to be stochastic means that positive debt and positive savings at the same time is possible for an optimizing consumer. Whether anyone decides to hold both debt and savings at the same time, however, depends on preferences, relative returns, and the distribution of shocks. This section shows that for empirically relevant parameters it is possible to explain much if not all of the credit card puzzle. It then explores what combinations of parameters are needed to explain the entire puzzle.

4.1 Survey of Consumer Finances

The 2007 Survey of Consumer Finances (SCF) asks questions about assets, debts, and income of a representative sample of 4422 U.S. (see Bucks et al. (2009) for a description of the 2007 SCF and
changes between 2004 and 2007). 73% (survey weighted) of households had credit cards. Of the remaining 27%, around half did not apply for credit in the previous five years, one quarter applied and were rejected, and one quarter applied and were accepted. The analysis concentrates on those currently with credit cards.

In the SCF, 97% of households with a revolving credit card balance also held liquid assets. Yet the near universal holding of liquid assets is most likely an accounting artifact. The questions from the survey ask for the credit card balance after the household made the last payment; and for the household’s holdings of liquid assets as of the time of the survey—which may be frequently interpreted as of the last statement.

Figure 2 helps illustrate the complexity of finding the correct accounting timing. In both panels (a) is the amount left over after any payment on the credit card bill but before income or any consumption. The model timing has income coming at the beginning of the period, then the consumption, savings, and debt decisions at the end. In reality, income may come at any time during the month, and may even come at multiple times, and consumption need not take place at the same time that the credit card bill is paid, or all at once. We may, for example, observe (b) which includes credit card puzzle savings as well as income instead of (a). So Gross and Souleles (2002) calculate (a) by subtracting monthly income from liquid savings, an approach Telyukova and Wright (2008) suggest is conservative, since we might be observing credit card puzzle savings and income minus some consumption (c), and so underestimate the extent of the credit card puzzle. Yet if there is expected consumption after the credit card bill is due, but before the consumer expects to get income, then even liquid savings minus income may overstate the amount by which consumers hold positive savings.

To deal with this timing issue, I examine savings accounts and checking accounts separately. Both are very liquid in the sense that for most savings accounts the balance can be shifted to a checking account easily, or sometimes payments can come directly from the savings account.\footnote{In order to determine appropriate reserve requirements, Federal Reserve regulation D limits the number of ACH transactions of a savings account to no more than six per month (or statement cycle, see \url{http://www.federalreserve.gov/bankinforeg/reglisting.htm} but does permit transfers from one account to another by the same depositor at the same institution, or withdrawals by mail, in person, by telephone, or at the ATM.}
Savings accounts offer slightly higher interest, with slightly less liquidity. Because the interest differential is typically small, there is little reason to transfer money from checking to savings if that money will be used to pay off a credit card balance in the same month. I therefore include all of reported balances in a savings account as part of credit card puzzle savings. In addition, some portion of a checking account may be held even as the consumer rolls over credit card debt. If income is directly deposited, then the checking account includes monthly income at some point in the month.

Several approaches to measuring credit card puzzle savings and dividing the surveyed population are shown in table 1. The table divides the population into four groups: those with positive savings and positive debt, those with positive debt and no savings, those with positive saving and no debt, and those with no debt and no savings. Below the fraction in each group, I show the mean debt and savings to income ratios for each group, as well as the mean log saving and debt, and the carrying cost of the extra debt that could be paid off with liquid savings. The debt and savings to income ratios are normalized by dividing by one twelfth of normal yearly income.

Different assumptions about accounting change the fraction with positive debt and positive savings dramatically, but the credit card puzzle never goes away. Between 24% and 59% of households fall into the credit card puzzle. Subtracting monthly income has a large effect on the fraction of households who hold no savings at all. Depending on the approach between 1.7% and 36% of households had debt but no liquid savings, while between 0.5% and 14.6% held neither debt or savings. Which end of the range depends on how much of the checking account is left after paying the credit card bill: none or all. My preferred approach is in column two: including checking balances only if they are greater than income, which gives a relatively conservative 41.4% of households with positive debt and liquid savings, and around 18.8% with debt and no savings. The joint histogram of savings and debt corresponding to column two is shown in panel A of figure 7.

The exact extent of the credit card puzzle is thus somewhat uncertain. I therefore put less

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9The histogram is for the unweighted distribution. The SCF overweights high income earners in its sampling. While the analysis divides out income, and high income earners do both borrow and save at the same time, they are somewhat less likely to do so.
emphasis on the parameters which give the best fit to the SCF, since these depend heavily on the
data assumptions, and much more emphasis on whether the model can explain a wide range.

4.2 Approximating the consumer’s decisions

While the model is a relatively straightforward variation of a standard infinite horizon consumption
model, approximating the consumer’s decisions for a given set of preferences and parameters is
very difficult. There are two reasons for the difficulty. The first is the standard curse of dimension-
ality: there are two continuous state variables and two continuous decisions which are functions
of both state variables. The added dimensionality makes the calculations more computationally
intensive.

The dimension of the problem is compounded by a problem of scaling: in the short term the
decision of how much to consume in total is much more important for utility that the portfolio
decision of how that consumption should be financed. The problem is similar to trying to find
the highest point on a knifed edged ridge which falls off steeply on either side and slopes only
gently along the top of the ridge. The best way would be just to walk along the ridge and find the
highest point, but dimensionality means that it is only possible to approximate at set grid points
with functional form approximations in between. Since a wrong step means disaster, it is very
easy to not find the optimum. In addition, along the threshold between regime changes (moving
from zero to positive for any decision) the second derivative of the value function is not necessarily
continuous. The scaling and discontinuity problem mean that optimization methods that rely on the
second derivative—most practically useful methods—are often badly behaved, with wide swings
between decisions, and frequent non-convergence. I use a hybrid approach which relies on a
Newton solver initially, but then switches to a much slower derivative free method for the states that
resist convergence. Appendix A discusses the complexities of finding the consumption functions
for a given set of preferences, debt limit, and income processes.

With the consumption functions for a given set of parameters, it is possible to find how a
community of people with those preferences facing those income and debt shocks would behave.
As long as preferences are such that no one wants to save indefinitely, the community will have an ergodic distribution of wealth, debt and consumption. I approximate that distribution by taking a large population of individuals, and endowing them with an initial state of wealth and debt. With the consumption function, each individual decides how much to consume using debt and cash, which determines how much is saved and left in debt for the next period. I then draw a new realization from the debt limit and income process for each person, and proceed to the next period and next set of decisions. The initial states cease to matter after a sufficiently large number of periods.

4.3 What preferences and risks can generate the credit card puzzle?

Preferences and the income and debt limit process interact in complex ways in this model. In this section, I model the income process in a very simple way which makes the interactions clear and shows that it is easy to a large fraction of the population to save and borrow at the same time for empirically reasonable parameters. I show many variations both to understand how different preferences and risks affect the decisions, and also to demonstrate that the model’s ability to generate savings and debt decisions similar to the data is not sensitive to small changes in parameters.

Consumers are faced with unexpected disposable income shocks: every so often they face some unexpected emergency which absorbs some fraction of income, but does not add to utility. For example, a car accident or one time medical emergency may require a large fraction of disposable income. For short term consumption decisions, such as how much to spend in a month, such unexpected variations in available funds from income are relatively more important than longer term shocks to income. I consider unemployment and serial correlation in disposable income shocks in a later section.

To keep the simulations tractable I model the disposable income process to a two state i.i.d. process: with probability $\pi_{\text{low}}$ the disposable income is $y_{\text{low}}$, and is one otherwise. Similarly the debt limit varies between two states: with probability $\pi_{B}$ the consumer is unable to borrow, otherwise $B_t = B$. I assume preferences display constant relative risk aversion, with the coefficient of
relative risk aversion $\gamma$.

While I will allow preference parameters and difficult to observe parameters to vary, many of
the prices and limits are observable. I set the interest rate earned on savings $r_s = 0.4\%$, and the
interest paid on debt $r_b = 14.22\%$.\(^{10}\) I set the maximum debt limit $B = 2$, implying that the
maximum that any consumer can borrow is 2 times monthly income. The median debt limit as a
proportion of monthly income in the 2007 SCF is 2.12. There are some very large credit limits
which push up the mean, but for the 94% of households with credit limits below 12 times monthly
income the mean is 2.74.\(^{11}\)

To understand how different parameters affect savings and debt decisions figures 5 and 6 show
the fraction of the simulated population that holds both debt and savings at the same time, the
fraction that holds only debt (and so has no savings), mean log savings and debt. Figure 5 shows
different preferences towards risk, while 6 show different discount rates. The axis of each graph
varies the disposable income left in the bad state, and so varies the costs of not being able to
borrow. I fix the probability of a bad state $\pi_{low}$ at 1/12, so that the bad event happens on average
once a year.\(^{12}\) Allowing the probability of the bad state to vary has a similar effect to varying the
income in the bad state and so I do not show it separately. I set the probability of losing access to
borrowing in a given month at 1%. The probability of losing access to borrowing acts mostly to
shift the curves right or left, and so is similar to changes in risk aversion. I show what happens

\(^{10}\)The average interest paid on a no-frills Wells Fargo savings account was 0.15% in 2006 (the year the SCF was
in the field), while it was 0.615% for a Bank of America account with a minimum deposit of $20,000. The average
interest earned is somewhere between. The the average credit card interest rate reported in the SCF is 14.22% while
it was 14.73% based on Federal Reserve series G19, Commercial Bank Interest Rate on Credit Card Plans NSA. The
CPI was 2.5% in 2006 according to the Bureau of Labor Statistics. I do not adjust the interest rates for inflation.

\(^{11}\)These calculations do not take into account survey weighting. The mean with survey weighting of those under 12
is 3.3. Dividing by income creates a problem when income is measured with error or is not a good approximation of
permanent income. The outliers for credit limits appear to come from very low reported incomes.

\(^{12}\)Is a 1 in 12 probability of a bad event that costs a substantial portion of monthly disposable income reasonable?
According to the National Highway Safety Administration there were just over 6 million car accidents in 2007 (Na-
tional Highway Traffic Safety Administration, 2009), while there were 112 million households in 2007 (Kreider and
Elliott, 2009), implying that there was on average slightly more than one car accident for every 20 households in 2007.
There were 2.4 million deaths from all causes, which suggests that on the order of 2% of households had to pay for
a funeral (see Center for Disease Control http://www.cdc.gov/nchs/fastats/deaths.htm, accessed 2
May 2010). In addition, there are many large consumption events which allow for some planning beforehand, but
are unexpected sufficiently long in advance. For example, one may learn about weddings, births, and moving from
one residence to another many months before hand, but until the information is revealed they are probabilistic events
which add to the uncertainty of disposable income in the future.
following a change in the probability of losing access in section 5.

Figures 5 and 6 illustrate that it does not require unreasonable beliefs about the risk of losing access to credit to generate a population that is willing to hold debt and save at the same time in fractions similar to the SCF. The fraction of those who hold both debt and savings at the same time jumps from close to zero to between 0.25 and 0.5 rapidly as the income in the bad state declines. For many parameter values, over a wide range of preferences, a small risk of losing access to credit results in a substantial fraction of the population holding both liquid savings and debt at the same time.

While it is not hard to match the fraction in the SCF who hold both savings and debt, households in the model accumulate substantially too little wealth. Precautionary models, which abstract from life-cycle concerns, typically have trouble explaining the upper end of the wealth distribution (see, for example, Carroll (2001)). Since the uncertainty in the model is limited to an occasional income shortfall and rare loss of the availability to borrow, it is surprising how well the model matches the empirical distributions.

4.4 Preference heterogeneity

In figures 5 and 6, the rapid change from almost nobody holding debt and savings at the same time to a substantial fraction is mirrored by a similar rapid change as the fraction willing to hold debt and no savings drops to zero. The reason both of these change rapidly at the same level of disposable income in the bad state is that as the income in the bad state declines, the marginal utility of consuming only the bad state income increases. So as soon as it becomes valuable enough in marginal utility to pay the interest differential to save and borrow at the same time, it becomes incredibly costly to have no savings. A population with the same preferences will thus not have a significant fraction both saving and borrowing, as well as a significant fraction only borrowing except under highly restrictive conditions.

Since such tight restrictions on parameters are not credible given the stability of the credit card puzzle over time shown in figure 1, I allow some preference heterogeneity. Assuming the
population faces broadly similar probabilities and risks, it is clear from comparing figures 5 and 6 that variations in the psychological discount rate cannot explain both fractions for any but a small range of parameters while a population with different risk preferences can explain both phenomena at once. At a monthly frequency discount rates are relatively unimportant compared to the costs of consuming only disposable income in a bad period with no borrowing. Changing the psychological discount rate shifts the curves up and down, but does not affect the disposable income that marks the transition.

Allowing the population to be divided between two different preference for risk, figure 7 shows the joint savings and debt histogram of the best fit from allowing the population to hold different preferences for risk. Appendix B describes a straightforward method for finding the best mix from possible preferences using the method of simulated moments. There are enough degrees of freedom and smoothness to fit the fraction with both positive savings and positive debt, and the fraction with only debt nearly exactly. Panel (A) shows the joint histogram from the 2007 SCF, while, Panel (B) shows the simulated distribution. Considering that all of the underlying processes are binary, it does a remarkably good job of explaining the broad facets of the data. Substantial fractions of the population hold both debt and savings at the same time, and just save and hold no debt; these consumers mostly come from the more risk averse fraction of the population. A substantial portion of the population only holds debt, or has some savings, but does not accumulate much; these consumers mostly come from the less risk averse fraction of the population.

The simulated distribution also matches some of the comparative features of the data well. In the SCF, those who hold both debt and savings have, on average, slightly less debt than those who hold debt alone, but hold much lower savings. Within the model, savings are a way of self insuring against bad shocks and against not being able to borrow. But having lots of savings protects against both, and so those who are wealthy now can use accumulated savings to smooth consumption, while still having savings left over—they do not need to use debt to maintain savings as insurance. So using both savings and debt occurs among the less wealthy, although not the poorest who from preferences or necessity do not maintain any liquid wealth. This feature of the data is matched
by the simulations. Such a distribution cannot be explained by an alternative explanations based on inattention or mistakes in which some people just make a mistake and do not pay of a credit card bill used mainly for transactions, or do not consider the costs of not paying it off. Mistakes or inattention are more costly for poorer people, since marginal utility is higher, and so one would expect to see those with lower savings making mistakes less often.

4.5 Unemployment and serial correlation

The shocks to disposable income in the previous sections are independent and identically distributed. It makes more sense to allow for some serial correlation so that bad shocks are more likely after bad shocks. Losing a job is generally a low probability event, but conditional on being unemployed one month, the probability of being unemployed the next month is much higher. To model unemployment and serial correlation within the income process while still keeping the state space small, I use a Markov switching model allowing for different probabilities of switching from employment to unemployment, unemployment to unemployment, and unemployment to employment. The household now must decide how much to consume using liquid savings, and how much to consume using debt given the continuous states debt and savings, the stochastic two state debt limit, and the stochastic two state employment status.

Simulations suggest that adding serial correlation so that bad shocks are more likely to follow each other and good shocks are more likely to follow each other which match the unemployment rate and duration from 2007 tend to reduce the number of people who both save and borrow at the same time. The reason is that since unemployment happens with low probability if one is employed, a much smaller portion of the population is hit with a bad shock at any time and so might want to borrow. So if only those who are currently unemployed or have recently been unemployed borrow, the fraction of the population that is willing to both save and borrow at the same time is small. Unemployment risk by itself does not appear to be a good way of explaining the credit card puzzle. Coupled with other shocks to disposable income, however, it may still contribute, but higher frequency shocks with lower serial correlation are necessary to induce a large fraction of
the population to borrow and save at the same time.

5 What happens when credit limit uncertainty increases?

What happens when the risk of losing access to credit changes? Consumers who are both borrowing and saving at the same time are very sensitive to the risk of losing credit, since that is why they keep liquid savings in the first place. So an increase in the probability of losing access to credit can cause large, immediate decreases in consumption and increases in the savings rate. Financial crises which increase the uncertainty of whether credit will be available can thus have immediate real consequences on consumption and savings. Figure 8 shows the comparative dynamics following a sudden and unexpected increase in the probability of losing access to borrowing from 1% to 2% or 3%. It also shows what happens when a permanent reduction in credit of 25% accompanies an increase in risk. The initial distribution is based on the best fit distribution for the 2007 SCF in the previous section.

Increases in the probability of losing access to credit causes an immediate decline in consumption. The changes occur at all levels of wealth; even those who are not borrowing increase savings substantially. Debt may increase or decrease: consumers may use the now riskier debt as a way to smooth consumption while they build a larger buffer of savings. More consumers are now cut off, however, which tends to cause debt to decrease. Unless there is a large increase in the probability of losing access to credit which pushes even those who are not risk averse into borrowing and saving at the same time, the fraction borrowing and saving at the same time changes only slightly. The changes are thus almost entirely on the intensive rather than extensive margin, and so helps explain the remarkable stability of credit card puzzle over time in figure 1.

5.1 Understanding changes between 2007 and 2009

The financial crisis of 2008 prompted large financial firms to reduce their potential liabilities by slashing credit limits. Between December 2007 and December 2009 the unused commitments on credit card lines listed by commercial banks in the United States show a decrease from $3.98
to $2.90 billion or a fall of 27%, even while the amount of credit used declined only slightly.\footnote{Source: Federal Deposit Insurance Corporation Quarterly Banking Profile.}

A follow-up survey to the 2007 Survey of Consumer Finances of the same respondents in 2009 tells a more nuanced story. Mean credit card debt barely changed (although we should be careful with levels of debt since the debt reported by households in the SCF is substantially under the debt reported by banks (Zinman, 2007b)). Reported credit limits dropped, but not by as much as reported by the banks.

The averages hide substantial and important heterogeneity which is only evident when using the panel. While 42% of households had credit limits that were lower by $1,000 or more in 2009 than in 2007, 40% reported credit limits that were higher by more than $1000. Yet responses of these two groups is startlingly different when their credit limits change. Table 3 shows summary statistics for each group in 2007 and 2009. In 2007, other than their credit limits and debt, these groups are quite similar; they had a similar likelihood to have been turned down for credit, similar incomes, and similar amounts of savings. Those who lost credit were slightly older. For those who lost credit the decrease was from an average credit limit of $43,000 credit to less than $20,000, while those who gained went from $22,000 to $41,000. These differences are not caused by changes in incomes: incomes barely changed, and the credit card limit to income ratio shows nearly the same story. Indeed it looks much like the two groups have switched places in terms of savings, debt and credit limit ratios.

Losing or gaining credit is closely related to increases and decreases in credit card debt. Those whose credit limits increased also increased their borrowing substantially, while those whose credit limits decreased also decreased their borrowing. What is not obvious from the table is that nearly 14% of households in 2007 had credit limits in 2009 below their credit card debt in 2007. About 60% of these households had credit limits cut to below $1000 and so were largely if not entirely cut off from credit. The households whose credit limit was cut below their debt are responsible for the vast majority of deleveraging: their average debt drops from more than $14,000 to about $2,700, while it barely changes for other households who also lost credit. These households are
also responsible for the large drop in those who are borrowing and saving at the same time among
those who lose credit; many of them have completely paid back any debts and can no longer borrow
substantial amounts.

These results suggest that credit variability is key to understanding the debt and savings de-
cisions of households. The changes from 2007 to 2009 are more consistent with a permanent or
long-term drop in credit limits for some of the population than a widespread increase in the proba-
ability of a reduction in the credit limit. The group that lost credit was not poorer on average as table
3 shows, but they had large declines in credit limits while others had substantial gains. Moreover,
a substantial portion of the population was cut off entirely, and so benefited directly from having
liquid savings. That suggests that just as cyclical drops in income are not distributed evenly across
the population with large welfare consequences, decreases in credit limits are concentrated as well.

6 Conclusion

Variability in credit limits matters for household decisions. The credit card puzzle is only a puzzle
because of the modeling simplicity that assumes that consumers face a simple world where every-
thing except their incomes is certain. I show that allowing even a small amount of uncertainty in
whether a consumer will be able to borrow can explain why such a large fraction of people hold
both expensive credit card debt and liquid savings at the same time. With some heterogeneity in
risk preferences, the model can explain the joint distribution of savings and debt of U.S. house-
holds very well. The model also points to a new way that financial uncertainty can affect the real
economy. A financial crisis may increase that uncertainty—some firms may go under and so not
offer any credit, others may try to reduce credit limits in order to reduce potential liabilities. A
small increase in the probability of losing access to borrowing can have a large immediate negative
impact on consumption, even without any decrease in average income. Since three quarters of of
households hold credit cards, the ability to borrow is part of a portfolio of options for managing
consumption of a large majority of US households. Moreover, it is by far the largest component
of resources available immediately to households. In the short term, household budget constraints
are determined mostly by credit constraints, not by savings. Examining changes in debt and savings between 2007 and 2009 makes it clear that it is impossible to understand debt and savings decisions without understanding variable credit limits.

Yet there is far more work to be done. While credit limits do vary, it is difficult to determine how frequently, by how much, and why. If credit is cut \textit{because} income is cut, then the household loses credit exactly when it wants it most, which makes liquid savings especially valuable. Poor households may be particularly vulnerable to such cuts exactly because they have few other resources. With the ability to borrow so important in the constraints faced by households, we still know very little about how credit limits change and their effects on households.
References


A Simulations

The two continuous decision variable, two continuous state, multiple discrete state infinite horizon stochastic problem described has a number of complexities that make it difficult to simulate. The first is that the “curse of dimensionality” means that a discrete approximation of the continuous state variables that is fine enough to capture the changes in, for example, figure 4, quickly grows in the memory required. I use cubic spines to approximate the value function, reducing the number of states necessary to achieve a good approximation.

A second difficulty is that the natural monthly frequency makes the discount factor close to one for reasonable annual discount factors (the conversion is \( \beta_{\text{monthly}} = (1 + \beta_{\text{annual}})^{-1/12} \)). Function iteration techniques therefore tend to converge slowly, since initial conditions matter for many iterations.

The form of the problem creates its own difficulties. The function iteration step which takes a function \( V_{t+1} \) to a function \( V_t \):

\[
V_t(w_t, b_t, B_t) = \max_{X \in \Omega(w_t, b_t, B_t)} u(X) + \beta E_t V_{t+1}(w_{t+1}(X), b_{t+1}(X), B_{t+1}),
\]

where \( X = (c^w_t, c^b_t) \) and \( \Omega(w_t, b_t, B_t) \) is the constraint set. The consumer cares relatively little about debt versus cash consumption, but cares a great deal about their sum, total consumption. The maximization problem in the function iteration step for a given set of state variables tends to look like a ridge rather than a mountain: along a locus that keeps total consumption constant the function increases slowly to an optimum allocation of consumption to debt and cash. Stepping off from that ridge—increasing or decreasing total consumption—makes a big difference in utility, while moving along it the change in utility is relatively small. This scaling problem leads to a tendency to overshoot in one direction or another, and makes single derivative “method of steepest ascent” approaches tend to oscillate instead of converge. One solution would be to rewrite the problem so that the decision variables are total consumption \( C_t \) and a portfolio allocation \( c^w_t \) or \( c^b_t / C_t \). The problem with this approach is that it is no longer possible to write the constraints for each variable in terms of the state alone: they depend on the other decision variable (for example, the portfolio allocation is bounded by total consumption so that it is impossible to consume more than total consumption as cash consumption). Such constraints require a different optimization approach than the standard linear complementary problem.

A final difficulty with the optimization is that intermediate value functions are not necessarily everywhere second order differentiable. Using information on the second derivative of the objective function is standard in many optimization methods such as Newton and quasi-Newton methods (Judd, 1998; Miranda and Fackler, 2002), and is important in this problem because of the tendency to oscillate. Along regime changes for \( V_{t+1} \), where the decision variables go from being constrained to unconstrained, the first derivative tends exhibit a kink, and so the second derivative becomes discontinuous. Close to the states \( (w_t, b_t) \) for which \( (w_{t+1}, b_{t+1}) \) is at a regime change, the second derivative is very irregular since the smooth approximation of \( V_{t+1} \) cannot approximate discontinuities well. Increasing the number of nodal points for the splines does not solve the problem,

\[\text{When I attempted a discretized version of the problem, it exceeded the addressable memory of a 32-bit system (approximately 4GB are possible, although Windows and some Unix systems throttle that to 2GB, see } \text{http://www.mathworks.com/support/tech-notes/1100/1106.html} \text{ well before the approximations of the continuous choices were anywhere close to smooth.} \]
but only more precisely finds the states \((w_t, b_t)\) with the problem. The ridge nature of the problem makes method of steepest ascent (Judd, 1998, p. 111) frequently not converge, and so after allowing convergence as far as possible, I switch to a derivative free method. The options available for derivative free optimization of a continuous problem with multiple dimensions and constraints tend to be slow since they cannot rely on any information about curvature to determine step size. I use the “Complex” method implemented by Wiens (2009) which is the linear complementarity version of the simplex method for multiple dimensions.

### B Calculating a best fit

Given a moment vector from the data \(h_D\) and a moment vector \(h_S(\theta, \gamma)\) from simulations based on a given vector of parameters \(\theta\) and preference \(\gamma\), calculate the difference vector \(g(\theta, \gamma) = h_D - h_S(\theta, \gamma)\). Then for a positive symmetric weight matrix \(W\), for any \(\theta\) and \(\gamma\), \(H(\theta, \gamma) = g(\theta, \gamma)'Wg(\theta, \gamma)\) summarizes how far the simulation moments are from the data moments. The method of simulated moments (MSM, see (Davidson and MacKinnon, 2004, pp. 383–93) for an introduction) then seeks to find the \(\theta^*\) and \(\gamma^*\) which minimize \(H\). For a mixed population made up of some fraction \(\lambda\) with preference parameter \(\gamma_1\) and \((1 - \lambda)\) with parameter \(\gamma_2\), it is necessary to combine two difference vectors \(g_1 = g(\theta, \gamma_1) = h_D - h_S(\theta, \gamma_1)\) and \(g_2 = g(\theta, \gamma_2)\), so that \(H(\theta, \gamma_1, \gamma_2, \lambda) = (\lambda g_1 + (1 - \lambda)g_2)'W(\lambda g_1 + (1 - \lambda)g_2)\). The MSM then seeks to minimize \(H(\theta, \gamma_1, \gamma_2, \lambda)\).

The problem can be rewritten to reduce the optimization problem since \(\lambda\) depends only on the best mix of moments, it can be solved for any given \(\gamma_1, \gamma_2\) and their corresponding preferences. Since the simulations are computationally intensive, this approach uses the structure of the problem to find \(\lambda\) without any additional simulation. Define \(H_1 = g_1'Wg_1\), \(H_2 = g_1'Wg_1\) and the cross moment \(H_{12} = g_1'Wg_2\). Then some matrix algebra can show that the optimal \(\lambda = \frac{H_1 - H_{12}}{H_1 - 2H_{12} + H_2}\) since \(W\) is symmetric \(H_{12} = H_{21}\). The denominator can be written \((g_1 - g_2)'W(g_1 - g_2)\), which is positive as long as \((g_1 - g_2)\) since it is a quadratic form with \(W\) positive definite. The denominator may be positive or negative, and the entire expression need not necessarily be less than one, in which case the data is suggesting that it would like to have even less than none of one the two populations. So \(\lambda\) is 0 if the expression is negative, and one if greater than or equal to one.
Figure 1: Trends in use of electronic payment methods and household credit use

Notes and sources: The left axis shows the fraction of households who hold a charge or credit card, and the fraction that maintain both positive debt and savings balances (using method 2 to define liquid savings: Savings + (Checking - Income) if (Checking-Income)>0). 95% confidence intervals (accounting for multiple imputation by the SCF) are shown by dashed lines. These values are calculated from the SCF from various years. The right axis shows the number of non-cash payments per person each year made using electronic payment methods (credit cards, debit cards) and checks. Source: Gerdes (2008). Cash payments are more difficult to track, but the evidence suggests that cash payments are being replaced by card payment methods (Gerdes, 2008).
Figure 2: Possible timing of consumption, income, and credit card payments

(A) Model timing

(B) An alternative timing

Notes: In both panels (a) is the amount left over after the credit card bill has been paid (possibly not completely leaving debt for the next period) but before income or any consumption. The model timing has income coming at the beginning of the period, then consumption and the savings/debt decision at the end. In reality, income may come at any time in during the month, and consumption need not take place at the same time that the credit card bill is paid. We may observe (b) or (c) instead, of (a).
Figure 3: Consumption and savings policies with certain borrowing

Notes: The left column shows the debt and cash consumption policies $c^w_t(w, b_t)$ and $c^b_t(w, b_t)$ over a range of cash wealth $w_t$ and for debt this period $b_t$ equal to 0 in the first row and 0.5 in the second row. The right column shows the corresponding debt and savings held to the next period: $S_t = w_t - c^w_t(w_t, b_t)$ and $D_t = b_t + c^b_t(w_t, b_t)$. Consumers may borrow up to $B_t = 1$ in every period; there is no borrowing uncertainty. See appendix for approximation algorithms. The parameters used are: subutility is CRRA with $\gamma = 2$; annual rates $r_b = 0.12$, $r_s = 0.02$, $\beta = 1/(1−0.10)$ are all converted into monthly by $(1+r)^{(1/12)}−1$; $y_{t+1}$ is a three point Gaussian quadrature approximation of a lognormal with mean of 1 and variance parameter 0.1 combined with an iid 10% chance of unemployment in which the earnings are 0.3.
Figure 4: Savings policies with uncertain borrowing

Notes: Each subplot shows the debt and savings held to the next period: $S_t = w_t - c^w(w_t, b_t)$ and $D_t = b_t + c^b(w_t, b_t)$ over a range of cash wealth $w_t$ and for debt this period $b_t$ equal to 0 in the first row and 0.5 in the second row. The left column shows the debt and savings decisions when borrowing is possible this period and $B_t = 1$. The right column shows the debt and savings decisions when borrowing is not possible this period $B_t = 0$. $B_{t+1}$ is an i.i.d. random variable which is 0 with probability 0.1 and 1 otherwise so consumers face a 10% chance of not being able to borrow in the next period. See appendix for approximation algorithms. The parameters used are: subutility is CRRA with $\gamma = 2$; annual rates $r_b = 0.12$, $r_s = 0.02$, $\beta = 1/(1 - 0.10)$ are all converted into monthly by $(1 + r)^{1/12} - 1$; $y_{t+1}$ is a three point Gaussian quadrature approximation of a lognormal with mean of 1 and variance parameter 0.1 combined with an iid 10% chance of unemployment in which the earnings are 0.3.
Figure 5: Savings and debt moments with varying bad state and risk aversion

Notes: Notes: Simulations for different values of the disposable income in the bad state and variations in the discount rate. See sections 4.2 and 4.3. The SCF 2007 line represents the equivalent mean or fraction from the 2007 Survey of Consumer Finances.
Figure 6: Savings and debt moments with varying bad state and impatience

Notes: Simulations for different values of the disposable income in the bad state and variations in the discount rate. See sections 4.2 and 4.3. The SCF 2007 line represents the equivalent mean or fraction from the 2007 Survey of Consumer Finances.
Figure 7: Joint histograms of savings and debt
(A) From the 2007 SCF

(B) Best simulated fit

Notes: Panel (A) is from 2007 SCF with savings defined as Savings account + (Checking - Income) if (Checking - Income) > 0. Panel (B) is from the best fit simulated distribution in which a fraction 0.24 of the population a coefficient of risk aversion $\gamma = 1.25$ and the rest have $\gamma = 2.5$ and $y_{low} = 0.19$. The rest of the parameters are $\pi_{low} = 1/12$, $\pi_B = 0.01$, and at an annual rate $\beta = 0.90$, $B = 2$, $r_b = 0.1422$, and $r_s = 0.004$. 
Figure 8: Comparative dynamics of increasing the probability of losing access to borrowing

Notes: Shows the evolution of debt, savings, and consumption following a change in the probability of losing access to credit in month 12. Preferences and risks are those that best fit the 2007 SCF distribution with preference heterogeneity.
Table 1: Credit Card Puzzle in the 2007 SCF

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frac. both debt &gt;0 &amp; savings &gt;0</td>
<td>0.366</td>
<td>0.414</td>
<td>0.242</td>
<td>0.585</td>
<td>0.333</td>
</tr>
<tr>
<td>Frac. debt &gt;0, no savings</td>
<td>0.237</td>
<td>0.188</td>
<td>0.360</td>
<td>0.017</td>
<td>0.160</td>
</tr>
<tr>
<td>Frac. savings &gt;0, no debt</td>
<td>0.252</td>
<td>0.323</td>
<td>0.280</td>
<td>0.393</td>
<td>0.402</td>
</tr>
<tr>
<td>Frac. no debt, no savings</td>
<td>0.146</td>
<td>0.075</td>
<td>0.118</td>
<td>0.005</td>
<td>0.105</td>
</tr>
<tr>
<td>Debt/inc if debt &gt;0 &amp; savings &gt;0</td>
<td>1.463</td>
<td>1.558</td>
<td>1.559</td>
<td>1.539</td>
<td>1.859</td>
</tr>
<tr>
<td>Debt/inc if debt &gt;0 &amp; no savings</td>
<td>1.617</td>
<td>1.448</td>
<td>1.500</td>
<td>0.996</td>
<td>1.792</td>
</tr>
<tr>
<td>Savings/inc if debt &gt;0 &amp; savings &gt;0</td>
<td>2.232</td>
<td>2.585</td>
<td>3.970</td>
<td>2.305</td>
<td>4.217</td>
</tr>
<tr>
<td>Savings/inc if savings &gt;0 &amp; no debt</td>
<td>6.175</td>
<td>6.958</td>
<td>7.724</td>
<td>6.360</td>
<td>8.741</td>
</tr>
<tr>
<td>Log debt if debt &gt;0 &amp; savings &gt;0</td>
<td>-0.682</td>
<td>-0.639</td>
<td>-0.741</td>
<td>-0.592</td>
<td>-0.546</td>
</tr>
<tr>
<td>Log debt if debt &gt;0 &amp; no savings</td>
<td>-0.471</td>
<td>-0.512</td>
<td>-0.504</td>
<td>-0.837</td>
<td>-0.365</td>
</tr>
<tr>
<td>Log savings if debt &gt;0 &amp; savings &gt;0</td>
<td>-0.851</td>
<td>-0.670</td>
<td>0.133</td>
<td>-0.293</td>
<td>-0.174</td>
</tr>
<tr>
<td>Log savings if savings &gt;0 &amp; no debt</td>
<td>0.594</td>
<td>0.834</td>
<td>1.056</td>
<td>0.835</td>
<td>1.132</td>
</tr>
<tr>
<td>Carrying cost of extra debt (% of income)</td>
<td>0.533</td>
<td>0.596</td>
<td>0.797</td>
<td>0.650</td>
<td>0.759</td>
</tr>
<tr>
<td>Frac. available resources credit</td>
<td>0.751</td>
<td>0.689</td>
<td>0.760</td>
<td>0.569</td>
<td>0.687</td>
</tr>
</tbody>
</table>

Notes: [1] Savings account only; [2] Savings + (Checking - Income) if (Checking-Income) < 0; [3] Savings + Checking - Income; [4] Savings + Checking; [5] Same as [2] but for household heads under age 50. Savings and debt are greater than zero if they are greater that 0.01% of income. Includes only households with credit cards. All calculations are survey weighted and take into account multiple imputation. Use data from the 2007 Survey of Consumer Finances.
Table 2: Logit marginal effects of both simultaneous borrowing and saving

<table>
<thead>
<tr>
<th>Variable</th>
<th>Marginal probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age/10</td>
<td>0.0745*</td>
</tr>
<tr>
<td>(Age/10)^2</td>
<td>-0.0232**</td>
</tr>
<tr>
<td>Size of household</td>
<td>0.00867</td>
</tr>
<tr>
<td>Spouse/partner in household</td>
<td>0.0373</td>
</tr>
<tr>
<td>Log income</td>
<td>-0.0279**</td>
</tr>
<tr>
<td>Good idea to buy with credit?</td>
<td>-0.0137**</td>
</tr>
<tr>
<td>(1 good, 3, 5 bad)</td>
<td>(0.00657)</td>
</tr>
<tr>
<td>Is it all right to borrow money to</td>
<td></td>
</tr>
<tr>
<td>—pay for a vacation?</td>
<td>0.108***</td>
</tr>
<tr>
<td>—cover living expenses</td>
<td>0.0199</td>
</tr>
<tr>
<td>when income is cut?</td>
<td>(0.0208)</td>
</tr>
<tr>
<td>—purchase a fur coat or jewelry?</td>
<td>0.0216</td>
</tr>
<tr>
<td>—purchase a car?</td>
<td>0.0556*</td>
</tr>
<tr>
<td>—finance education expenses?</td>
<td>0.0345</td>
</tr>
<tr>
<td>Own current home?</td>
<td>0.0273</td>
</tr>
<tr>
<td>Attitude to financial risk/returns</td>
<td>0.000463</td>
</tr>
<tr>
<td>(1 no risks/low returns to 4 )</td>
<td>(0.0134)</td>
</tr>
<tr>
<td>Can get emergency aid from friends or family?</td>
<td>0.0126</td>
</tr>
<tr>
<td></td>
<td>(0.0241)</td>
</tr>
<tr>
<td>Observations</td>
<td>3,518</td>
</tr>
</tbody>
</table>

Notes: The table shows the marginal effects from a multinomial (non-ordered) logit regression of those with credit cards using the 2007 SCF. The reported coefficients are calculated at the mean and show the marginal effect of moving into having both savings and debt simultaneously using savings defined as Savings + (Checking - Income). The four categories are (1) positive debt, positive savings, (2) positive debt, no savings, (3) positive savings, no debt, (4) no savings, no debt. The regression uses only a single imputation since the sample and categories vary over imputations. Not accounting for imputation variability leaves the coefficients unbiased, but understates the standard errors.
Table 3: Changes between 2007 and 2009

<table>
<thead>
<tr>
<th></th>
<th>Lose Credit</th>
<th></th>
<th>No Change</th>
<th></th>
<th>Gain Credit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frac. of all households</td>
<td>0.42</td>
<td>0.18</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frac. both debt &gt;0 &amp; savings &gt;0</td>
<td>0.44</td>
<td>0.30</td>
<td>0.36</td>
<td>0.31</td>
<td>0.44</td>
<td>0.41</td>
</tr>
<tr>
<td>Frac. debt &gt;0, no savings</td>
<td>0.18</td>
<td>0.12</td>
<td>0.27</td>
<td>0.16</td>
<td>0.17</td>
<td>0.16</td>
</tr>
<tr>
<td>Frac. savings &gt;0, no debt</td>
<td>0.30</td>
<td>0.45</td>
<td>0.30</td>
<td>0.41</td>
<td>0.33</td>
<td>0.38</td>
</tr>
<tr>
<td>Frac. no debt, no savings</td>
<td>0.07</td>
<td>0.14</td>
<td>0.07</td>
<td>0.13</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Debt/inc if debt &gt;0 &amp; savings &gt;0</td>
<td>2.85</td>
<td>1.57</td>
<td>0.90</td>
<td>0.92</td>
<td>1.35</td>
<td>2.04</td>
</tr>
<tr>
<td>Debt/inc if debt &gt;0 &amp; no savings</td>
<td>2.19</td>
<td>1.90</td>
<td>1.01</td>
<td>1.42</td>
<td>1.23</td>
<td>2.84</td>
</tr>
<tr>
<td>Savings/inc if debt &gt;0 &amp; savings &gt;0</td>
<td>3.12</td>
<td>2.64</td>
<td>2.06</td>
<td>2.29</td>
<td>2.04</td>
<td>2.09</td>
</tr>
<tr>
<td>Savings/inc if savings &gt;0 &amp; no debt</td>
<td>7.00</td>
<td>4.87</td>
<td>5.32</td>
<td>4.92</td>
<td>5.56</td>
<td>7.47</td>
</tr>
<tr>
<td>Credit card debt</td>
<td>6,378</td>
<td>3,508</td>
<td>2,453</td>
<td>2,234</td>
<td>3,925</td>
<td>6,335</td>
</tr>
<tr>
<td>Credit card limit</td>
<td>43,194</td>
<td>19,748</td>
<td>16,425</td>
<td>16,293</td>
<td>21,550</td>
<td>40,495</td>
</tr>
<tr>
<td>Credit card limit/inc</td>
<td>9.48</td>
<td>3.99</td>
<td>3.52</td>
<td>3.70</td>
<td>4.19</td>
<td>8.62</td>
</tr>
<tr>
<td>Checking account</td>
<td>10,819</td>
<td>7,508</td>
<td>7,258</td>
<td>5,564</td>
<td>10,561</td>
<td>7,831</td>
</tr>
<tr>
<td>Savings account</td>
<td>28,044</td>
<td>29,729</td>
<td>17,221</td>
<td>26,594</td>
<td>27,714</td>
<td>29,792</td>
</tr>
<tr>
<td>Age of head</td>
<td>52.59</td>
<td>54.57</td>
<td>48.82</td>
<td>51.12</td>
<td>48.97</td>
<td>51.08</td>
</tr>
<tr>
<td>Log income</td>
<td>8.51</td>
<td>8.51</td>
<td>8.26</td>
<td>8.32</td>
<td>8.56</td>
<td>8.65</td>
</tr>
<tr>
<td>Been turned down for credit?</td>
<td>0.18</td>
<td>0.12</td>
<td>0.22</td>
<td>0.19</td>
<td>0.16</td>
<td>0.12</td>
</tr>
<tr>
<td>Fraction resources credit</td>
<td>0.75</td>
<td>0.58</td>
<td>0.65</td>
<td>0.57</td>
<td>0.65</td>
<td>0.76</td>
</tr>
</tbody>
</table>

Notes: Losing or gaining credit is reporting a credit limit that was more than $1000 larger or small in 2009 than in 2007. The savings definition for the savings and debt to income ratios is $\text{Savings} + (\text{Checking} - \text{Income})$ if $(\text{Checking} - \text{Income}) > 0$. Checking and savings accounts are as reported in the survey. Income is converted to monthly, so ratios are the number of months of income. Whether a household has been turned down for credit is in the last 5 years in 2007, while in the last 2 years in 2009, and is included to compare across populations, not time. The fraction of resources credit calculates how much of the resources immediately available to the household is credit: $(\text{credit limit} - \text{credit debt})/(\text{savings (using definition [2])} + \text{credit limit} - \text{credit debt})$. 

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