Automated Credit Limit Increases and Consumer Welfare

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Motivation

- **Big Picture:** Who gets credit, and how much, is a central question in household finance
  - Algorithms increasingly drive credit decisions, raising new challenges for regulation

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- **Notable Example:** Credit card companies proactively raise credit limits using various algorithms
  - Important source of credit: **12%** of credit cards receive a limit increase annually in the U.S.
  - As we show, **1/3** of new available credit comes from limit increases
- **Policy:** Other countries are increasingly regulating proactive limit increases
  - Restrictions on raising limits for long-term debtors of $>$12 months (UK)
  - Requirements to obtain consumer approval for limit increases (Canada, Singapore, NZ, Soon: EU)
  - Prohibitions on 'unsolicited' increases initiated by banks (Australia)

This Paper

To date, we know little about proactive (i.e., bank-initiated) credit limit increases

- Data limitations: most datasets cannot differentiate bank- vs. consumer-initiated increases
- As a result, know little about who receives bank-initiated increases & aggregate importance

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Empirical Question: Who receives bank-initiated credit limit increases?

- Distinguish between transaction (payment) and revolving (credit) functions of credit cards.
- Revolving borrowers comprise the majority of credit card profits (Adams et. al., 2022)
- Many revolvers suffer from self-control issues (Gathergood, 2012; Laibson et. al., 2024)

Welfare Question: To what extent should policymakers regulate proactive credit expansion?

Key Tensions

Potential Benefits

- Relax credit constraints for liquidity-constrained households
- Provide flexibility to smooth consumption over unemployment & adverse shocks
- Expand access to credit by reducing hidden information

Potential Concerns

- Revolving borrowers tend to be more profitable $\rightarrow$ incentive to give more credit
- If some consumers have self-control issues, giving more credit may reduce well-being

Our Contribution

- **Data:** Present new stylized facts on credit card lending strategies, using Y-14M data
  - Highlight the importance of ‘low and grow’ strategies, especially for low-credit-score borrowers

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  - Algorithmic increases help relax credit constraints, but may also exacerbate self-control issues
- **Welfare + Policy:** Assess alternative policies to regulating bank algorithms
  - Evaluate two novel policies: (i) banning increases for revolvers or (ii) requiring consumer consent

Main Results

Limit increases are a significant source of consumer credit in the U.S.

- 1/3 of new available credit comes from limit increases
- Limit increases play an important role in supporting revolving balances
- Banks that utilize ML/AI algos support a larger share of revolving balances with limit increases

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Limit increase algorithms appear to favor revolving usage

- Hump shaped correlation between revolving debt and proactive limit increases
- Revolving moderate levels of credit card debt $\approx$ a 70-point increase in credit score.

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- Revolving moderate levels of credit card debt $\approx$ a 70-point increase in credit score.

If some agents have self-control issues, may be beneficial to regulate targeted limit increases

- UK policy: Small losses for standard consumers, large gains for tempted consumers
- CA/EU policy: requiring consumer consent less robust than prohibiting increases for revolvers

Plan for Today

Stylized Facts

Empirical Analysis

Quantitative Model

Counterfactual Analysis

Motivating stylized facts about limit increases

Data

Federal Reserve's Capital Assessments and Stress Testing Reports (FR Y-14M)

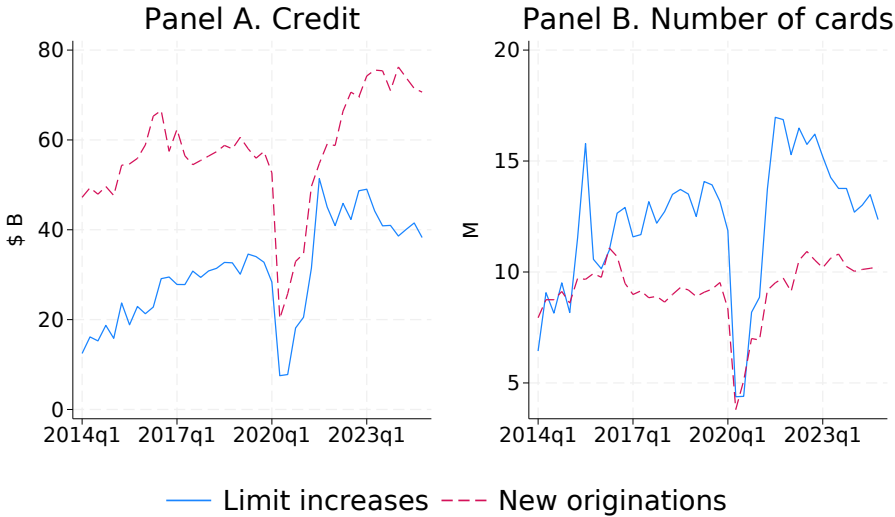
- filed by large credit card issuers, covering more than 70% of the U.S. credit card market
- covers the period between 2014 and 2024
- contains monthly, account level information on all credit cards
  (including credit limit, balances, purchase volume, finance charges, fees, credit score, and income)
- advantages over credit bureau data:
  - possible to identify whether credit limit changes are initiated by the lender or the borrower
  - observe balance and payment information $\rightarrow$ allows us to identify revolvers vs transactors
- disadvantage over credit bureau data:
  - at the account level: unable to link borrower's other loans and credit cards

Summary Stats

Stylized facts about limit increases

1. Credit card limit increases are an important source of consumer credit.

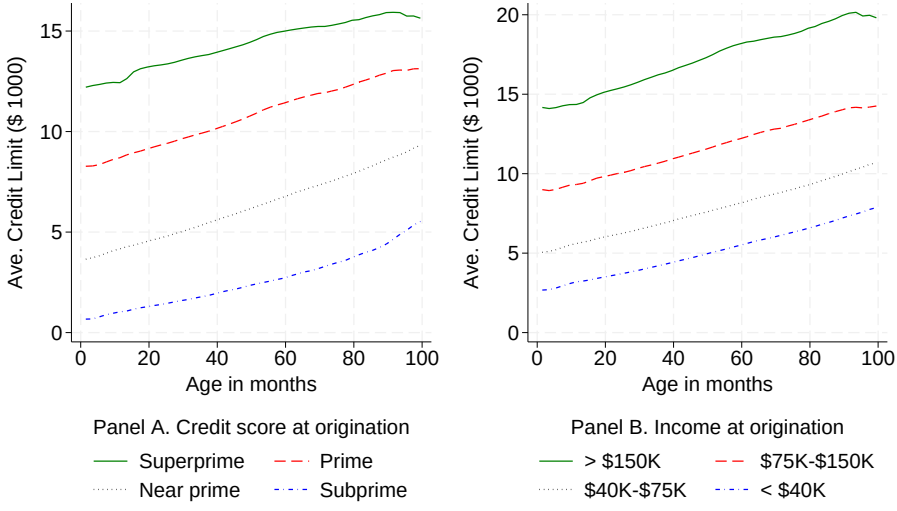
Fact 1: Credit card limit increases are an important source of consumer credit.



Stylized facts about limit increases

1. Credit card limit increases comprise about 1/3 of new available credit.
2. Limit increases are particularly important for higher-credit-risk borrowers.
    - Lenders often follow ‘low and grow’ strategies for higher risk borrowers
    - Lenders have little info. about applicants – just credit score, income, and possibly credit report
    - Over time, lenders have more information that they can use in their algorithms

Fact 2. Limit increases are particularly important for higher-credit-risk borrowers.



By age

Stylized facts about limit increases

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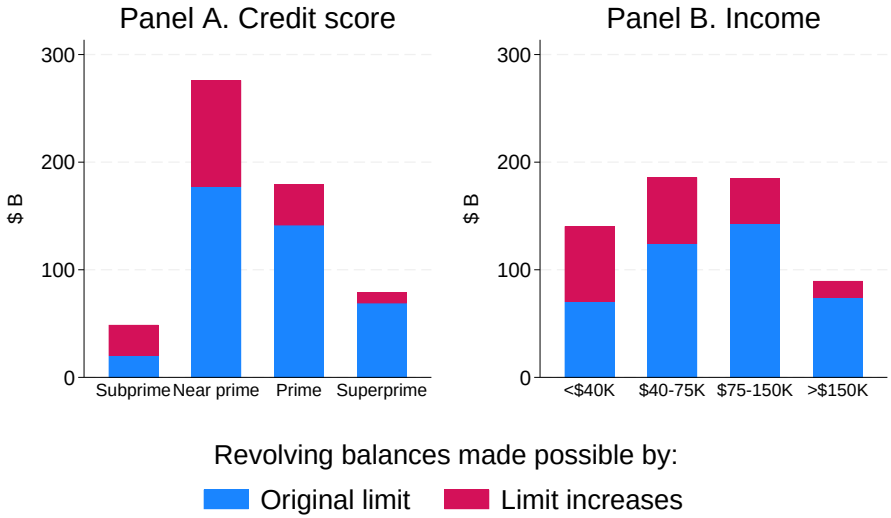
3. 80% of credit card limit increases are bank-initiated.
4. Limit increases play an important role in supporting revolving balances.
   - Revolving balances $=$ balances not paid down by consumers each month, for which they pay interest
   - Decompose revolving balances as made possible either by the original credit limit or limit increases

Fact 4. Limit increases play an important role in supporting revolving balances, especially for higher-credit-risk borrowers.



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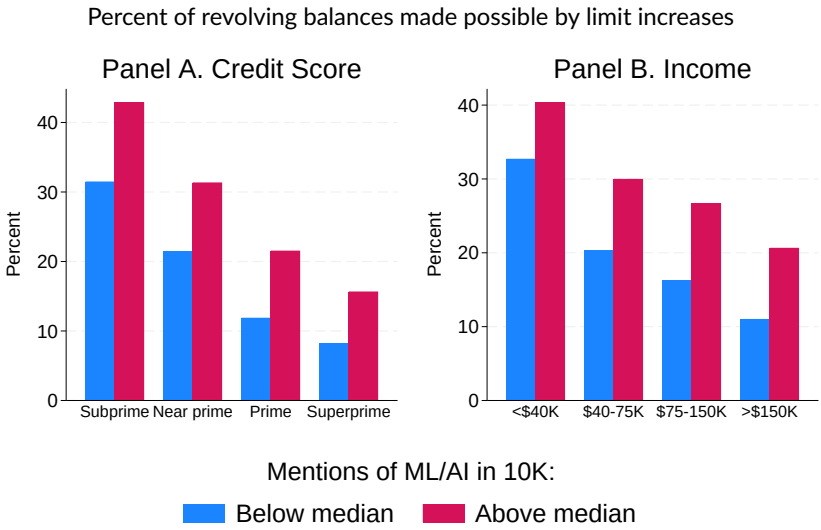
Fact 5. Lenders that mention ML/AI more have a higher share of revolving balances made possible by limit increases.



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7. Credit limit increases are more than 5 times more common than decreases.

Who receives bank-initiated limit increases?

Who receives bank-initiated limit increases?

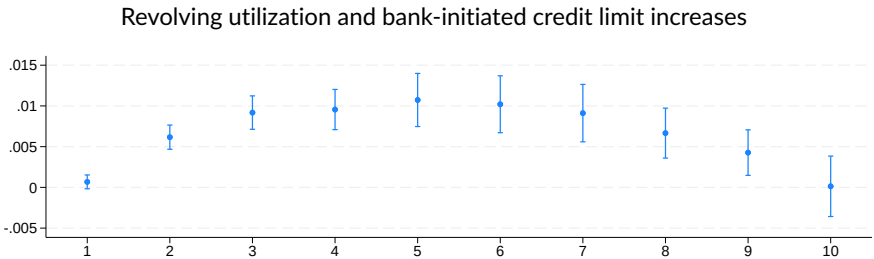
- Lenders use algorithmic approaches to target borrowers for increases.
- Exact algorithms not observable, so our analysis should be interpreted as documenting a revealed preference for giving limit increases to accounts with certain characteristics.

$$CLI_{it} = \beta Utilization_{it} + \gamma Controls_{it} + \lambda + \epsilon_{it} \quad (1)$$

- $CLI_{i,t}$: indicator for whether account i receives a bank-initiated increase at time $t+1$.
- $Utilization_{it}$: main variables of interest, split into revolving and transacting utilization
- $Controls_{i,t}$: log credit card limit, interest rate margin, indicator for other cards with same lender, indicators for increases in previous 3 months, indicator for credit score increase in previous 3 months
- λ: fixed effects (incl. month, state, lender, card type, and credit score and income decile fixed effects)

What is the correlation between revolving utilization and CLI?

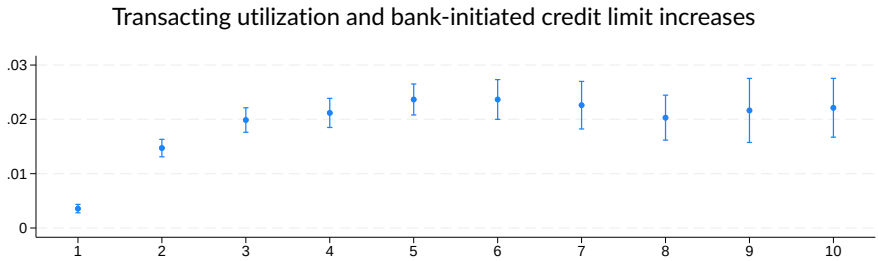
Revolving utilization: revolving debt (that the borrower pays interest on) as a share of credit limit



Correlation btwn. revolving utilization and proactive limit increases follow an inverted U-shape.

What is the correlation between transacting utilization and CLI?

Transacting utilization: credit card balances (ex. revolving balances) as a share of credit limit



Correlation btwn. transacting utilization and proactive limit increases follow a logistic growth curve.

Other empirical results

Credit limit increases:

- Accounts are more likely to receive a limit increase:
  - If the consumer has a high credit-score or their credit score has recently increased

Controls

- Magnitudes are economically meaningful:
  - Being in the 4th decile of revolving utilization $\approx$ a 70-point increase in credit score

Magnitude

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How do consumers respond to credit limit increases?

- Limit increases are following by additional borrowing
- Borrowers use about a third of the bank-initiated increase for revolving balances

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How do consumers respond to credit limit increases?

- Limit increases are following by additional borrowing
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Taking stock:

- Proactive credit limit increases are an important source of consumer credit
- Lenders target revolvers for limit increases $\rightarrow$ and consumers respond by borrowing more

Model

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Goals: Develop a model that allows us to

- Evaluate who currently gets credit limit increases
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Life-cycle consumption-saving model similar to Nakajima (2017) and Fulford and Schuh (2024) with

- Exogenous income and employment risk
- Credit card borrowing, with possibility of default
- Preference heterogeneity (two types: with and w/out self-control problems)
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Novel features

- Credit limits vary by household and time – may grow based on borrower behavior
- Credit limit increases allocated based on empirical evidence from Y-14M

Environment

1. Fully liquid financial asset, a_t
   - When saving ($a_t \geq 0$), get fixed return r^a
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3. Default resembles a Chapter 7 bankruptcy
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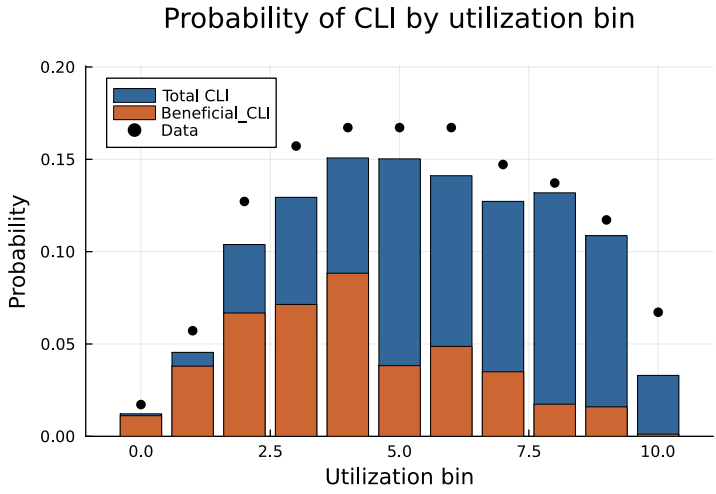
4. Model calibrated to fit US data
   - Externally set many institutional parameters (e.g. income risk, limit increase function, etc.)
   - Set remaining parameters to target: share of revolvers, utilization rate, default rate, debt-to-income
   - Result: roughly 40 percent of consumers have self-control issues, remaining are standard

Baseline model: probability of limit increase



Counterfactual Analysis

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Counterfactual #1: Prohibit Limit Increases for Revolvers

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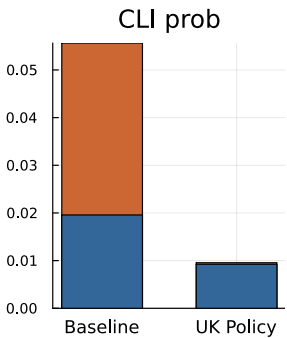
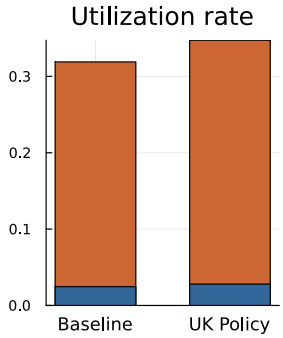
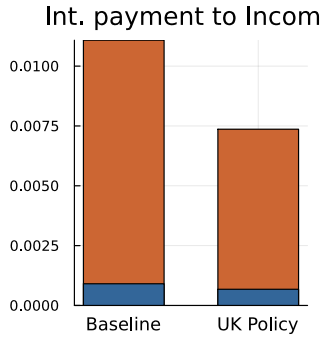
Counterfactual #2: Require Consumer Consent

- Inspired by Canadian policy: bank can only raise credit limit with consumer consent
- Will not show results today due to time

Counterfactual #1: Prohibit Limit Increases for Revolvers







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Welfare Effects of Prohibiting Limit Increases for Revolvers

Scenario	Overall Effect	Standard	Tempted
With Psychological Costs	**1.15%**	-0.13%	3.08%
Without Psychological Costs	0.97%	-0.06%	2.51%

The effect of prohibiting limit increases for revolving borrowers (measured by CEV, %)

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The effect of prohibiting limit increases for revolving borrowers (measured by CEV, %)

- Robustness: similar results even if firm re-optimizes the limit increase function Re-Optimization
- Canadian policy: similar if consumers sophisticated, but no benefit if consumers are naive

Conclusion

- We provide novel evidence on the role and prevalence of bank-initiated credit limit increases
  - Banks have revealed preference for giving CLI to revolving borrowers
- We analyze the costs and benefits of proactive CLIs through the lens of a structural model
  - If some HHs struggle with self-control $\rightarrow$ beneficial to limit targeting of revolving borrowers
- We view this as a first step in evaluating the regulation of credit limit increases
  - Would love to see empirical analysis of the novel policies implemented by other countries

Thank you

Questions? Feel free to reach out.

Patrick Moran: patrick.e.donnellymoran@frb.gov

Summary Statistics

Variable	All		Bank-Initiated Increase		Borrower-Initiated Increase	
	Mean	SD	Mean	SD	Mean	SD
Log CC Limit	8.717	1.124	8.366	1.207	8.410	1.203
Interest rate margin	14.586	5.157	15.299	5.664	15.545	4.873
Mult CC with Lender	0.383	0.486	0.290	0.454	0.359	0.480
Credit score	751.216	80.056	732.718	65.776	739.140	66.640
Superprime	0.442	0.497	0.248	0.432	0.293	0.455
Prime	0.231	0.422	0.326	0.469	0.334	0.472
Near prime	0.253	0.435	0.366	0.482	0.317	0.465
Subprime	0.073	0.261	0.060	0.238	0.056	0.229
Income: $>$ \$150,000	0.091	0.287	0.080	0.271	0.125	0.331
Income: \$75,000 - \$150,000	0.227	0.419	0.224	0.417	0.262	0.440
Income: \$40,000 - \$75,000	0.279	0.449	0.316	0.465	0.296	0.456
Income $<$ \$40,000	0.240	0.427	0.320	0.467	0.249	0.432
Utilization	0.295	0.350	0.411	0.302	0.353	0.312
Revolving Utilization	0.224	0.334	0.278	0.308	0.210	0.296
Transactional utilization	0.073	0.113	0.136	0.143	0.145	0.163
Revolver	0.435	0.496	0.598	0.490	0.449	0.497
Heavy Revolver past 12 Mo	0.253	0.435	0.303	0.460	0.213	0.409
Light Revolver past 12 Mo	0.381	0.486	0.469	0.499	0.473	0.499
Transactor	0.356	0.479	0.219	0.413	0.308	0.462
Observations	160059951		2008939		466631	

Summary Statistics

Back

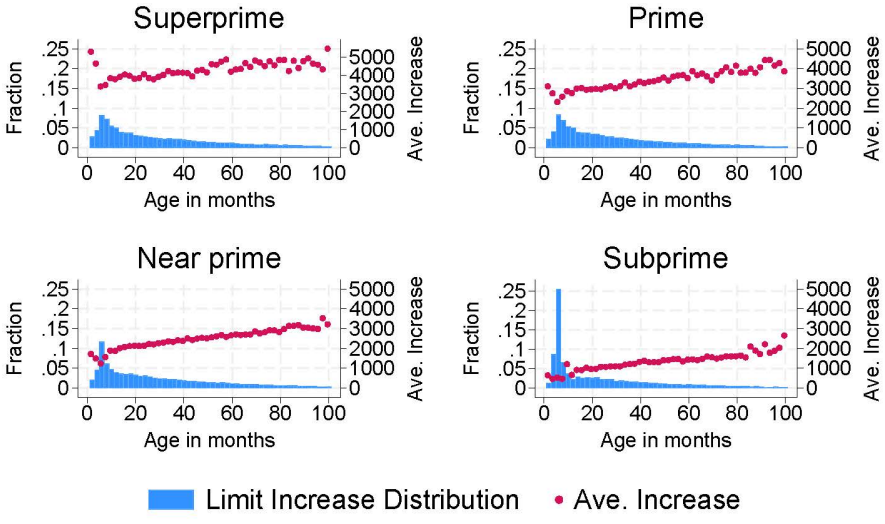
Variable	All		Bank-Initiated Increase		Borrower-Initiated Increase	
	Mean	SD	Mean	SD	Mean	SD
Log CC Limit	8.717	1.124	8.366	1.207	8.410	1.203
Recent bank-initiated increase	0.037	0.189	0.016	0.126	0.015	0.122
Recent borrower-initiated increase	0.009	0.092	0.005	0.068	0.036	0.185
Recent credit score increase	0.752	0.432	0.790	0.407	0.811	0.391
Age $<$6m	0.046	0.209	0.108	0.310	0.054	0.227
Age 6m-1y	0.062	0.241	0.125	0.331	0.098	0.297
Age 1-2y	0.356	0.479	0.405	0.491	0.489	0.500
Age 3-5y	0.244	0.429	0.268	0.443	0.313	0.464
Age 5-10y	0.230	0.421	0.200	0.400	0.210	0.407
Age 10+	0.306	0.461	0.162	0.368	0.150	0.357
Chg Limit			2,524.417	2,412.428	2,980.702	3,449.598
Pct Chg Limit			0.413	0.337	0.423	0.330
Observations	160059951		2008939		466631	

Summary Statistics

Variable	Bank-Initiated Increase		Borrower-Initiated Increase	
	Mean	SD	Mean	SD
All	0.01244	0.11083	0.00289	0.05373
Subprime	0.01007	0.09985	0.00215	0.04627
Age 10+	0.00657	0.08077	0.00140	0.03732
Util Decile 0	0.00224	0.04730	0.00129	0.03593
Util. Decile 0 x Subprime	0.00675	0.08189	0.00138	0.03709
Util. Decile 0 x Near prime	0.00459	0.06761	0.00210	0.04575
Util. Decile 0 x Prime	0.00459	0.06761	0.00210	0.04575
Util. Decile 0 x Superprime	0.00110	0.03321	0.00079	0.02814
Rev. Util. Decile 0	0.00765	0.08710	0.00260	0.05093
Rev. Util. Decile 0 x Subprime	0.02085	0.14288	0.00351	0.05912
Rev. Util. Decile 0 x Near prime	0.01546	0.12339	0.00457	0.06742
Rev. Util. Decile 0 x Prime	0.01546	0.12339	0.00457	0.06742
Rev. Util. Decile 0 x Superprime	0.00466	0.06811	0.00173	0.04155
Tr. Util. Decile 0	0.00343	0.05842	0.00148	0.03847
Tr. Util. Decile 0 x Subprime	0.00765	0.08712	0.00146	0.03816
Tr. Util. Decile 0 x Near prime	0.00664	0.08122	0.00239	0.04888
Tr. Util. Decile 0 x Prime	0.00664	0.08122	0.00239	0.04888
Tr. Util. Decile 0 x Superprime	0.00167	0.04078	0.00086	0.02938

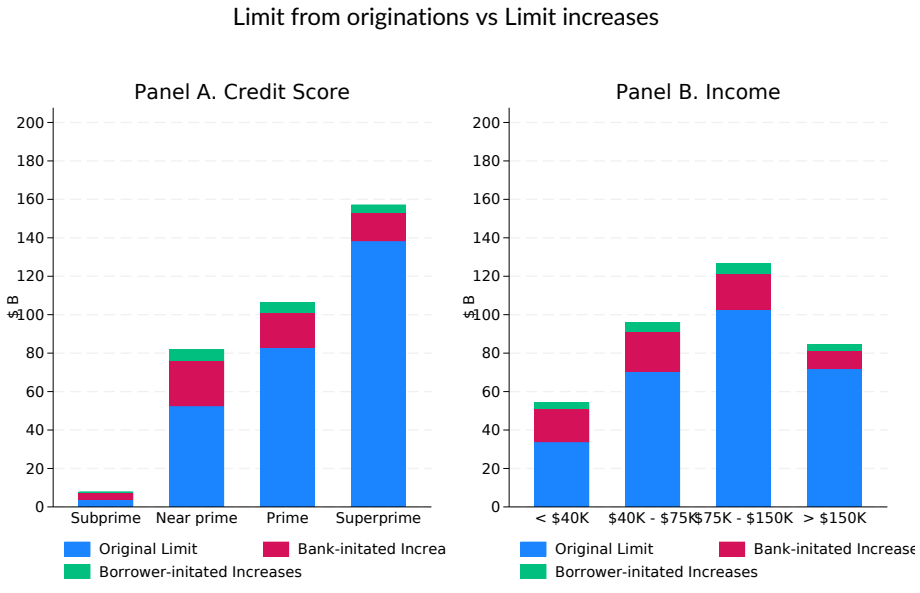
Back

Fact 2. Limit increases are particularly important for higher-credit-risk borrowers.



Back

Fact 3. Most credit card limit increases are bank-initiated.



Credit limit increase regressions

Bank-Initiated Limit Increases

	(1)	(2)	(3)	(4)	(5)	(6)
Utilization	0.012***	0.012***	0.014***	0.014***		
	(0.001)	(0.001)	(0.002)	(0.002)		
Chg. in utilization				-0.001		
				(0.003)		
Revolving utilization					0.008***	0.009***
					(0.002)	(0.002)
Chg in rev. utilization						-0.015***
						(0.002)
Transactional utilization					0.057***	0.067***
					(0.003)	(0.003)
Chg in tr. utilization						-0.006**
						(0.003)
State, Date, Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Card group FE		Yes	Yes	Yes	Yes	Yes
CS and Income Decile FE			Yes	Yes	Yes	Yes
Observations	160059951	160059951	160059951	157461074	160059951	155375050
R-Squared	0.010	0.012	0.012	0.013	0.014	0.016

Credit limit increase regressions

Bank-Initiated Limit Increases

	(1)	(2)	(3)	(4)	(5)	(6)
Superprime	0.015***	0.017***				
	(0.002)	(0.002)				
Prime	0.021***	0.023***				
	(0.002)	(0.002)				
Near prime	0.015***	0.017***				
	(0.002)	(0.002)				
Income: $>$ \$150,000	-0.000	-0.000				
	(0.001)	(0.001)				
Income: \$75,000 - \$150,000	-0.001	-0.000				
	(0.000)	(0.000)				
Income: \$40,000 - \$75,000	-0.000	0.000				
	(0.000)	(0.000)				
State, Date, Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Card group FE		Yes	Yes	Yes	Yes	Yes
CS and Income Decile FE			Yes	Yes	Yes	Yes
Observations	160059951	160059951	160059951	157461074	160059951	155375050
R-Squared	0.010	0.012	0.012	0.013	0.014	0.016

Credit limit increase regressions

Bank-Initiated Limit Increases

	(1)	(2)	(3)	(4)	(5)	(6)
Age <6m	0.022***	0.021***	0.020***	0.023***	0.016**	0.028***
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.009)
Age 6m-1y	0.018***	0.017***	0.017***	0.017***	0.016***	0.016***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Age 2-5y	0.006***	0.006***	0.005***	0.005***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age 5-10y	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
State, Date, Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Card group FE		Yes	Yes	Yes	Yes	Yes
CS and Income Decile FE			Yes	Yes	Yes	Yes
Observations	160059951	160059951	160059951	157461074	160059951	155375050
R-Squared	0.010	0.012	0.012	0.013	0.014	0.016

Credit limit increase regressions

Bank-Initiated Limit Increases

	(1)	(2)	(3)	(4)	(5)	(6)
Mult CC with Lender	-0.003***	-0.003***	-0.003***	-0.003***	-0.003***	-0.002***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log CC Limit	-0.002***	-0.002***	-0.002***	-0.002***	-0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Interest rate margin	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Recent bank-initiated increase	-0.014***	-0.016***	-0.017***	-0.017***	-0.019***	-0.020***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Recent borrower-initiated increase	-0.009***	-0.010***	-0.010***	-0.010***	-0.014***	-0.015***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Recent credit score increase	0.002***	0.002***	0.003***	0.002***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
State, Date, Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Card group FE		Yes	Yes	Yes	Yes	Yes
CS and Income Decile FE			Yes	Yes	Yes	Yes
Observations	160059951	160059951	160059951	157461074	160059951	155375050
R-Squared	0.010	0.012	0.012	0.013	0.014	0.016

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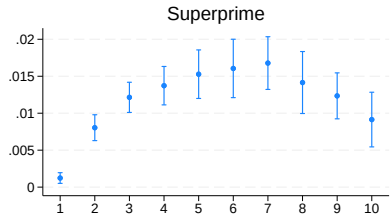
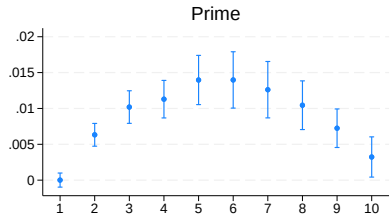
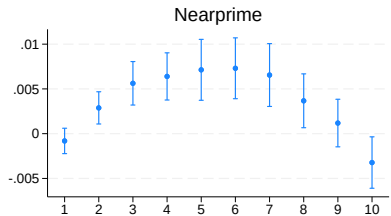
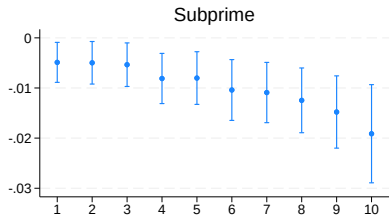
Revolving Utilization Decile by Credit Score









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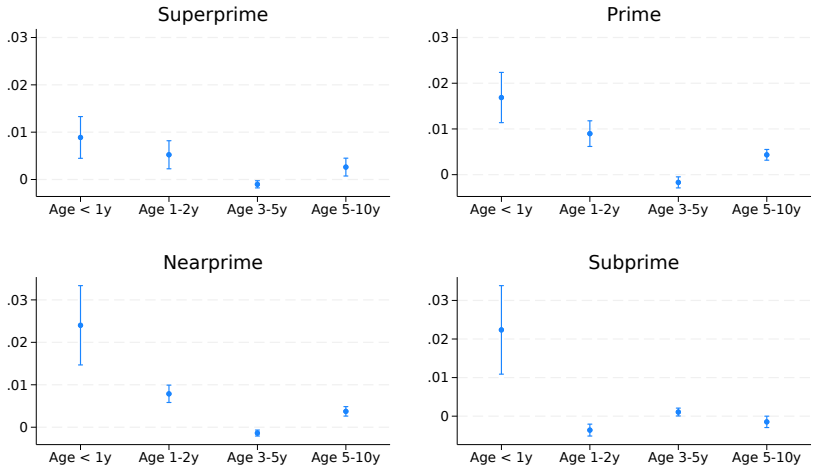
Revolving Utilization Decile by Age



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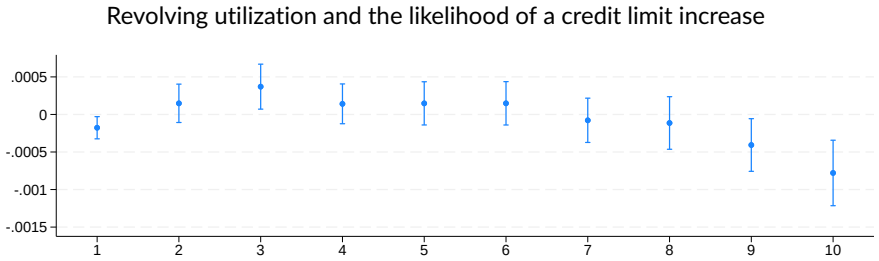
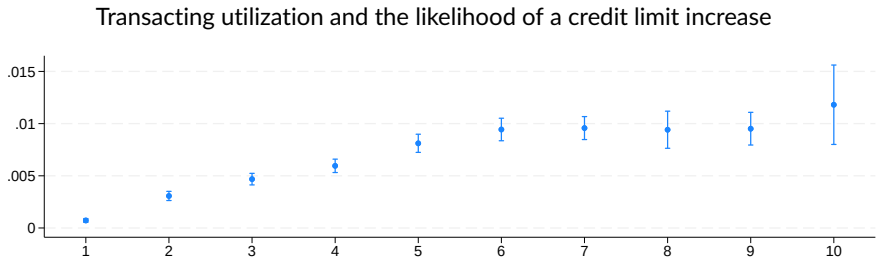
Borrower-initiated Increases by Revolving Utilization Decile



Correlation between revolving utilization and borrower-initiated limit increases also follows an inverse U-shape, but with a faster and steeper decline.

Borrower-initiated Increases by Transacting Utilization Decile



Correlation between transacting utilization and borrower-initiated limit increases follow a logistic growth curve, but with a slower increase across the deciles.

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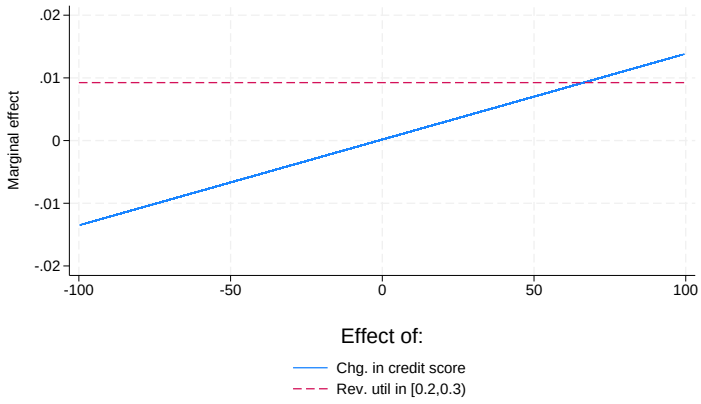
Magnitude of credit limit increase likelihood



Magnitudes: comparison with the effect of an increase in credit score or income

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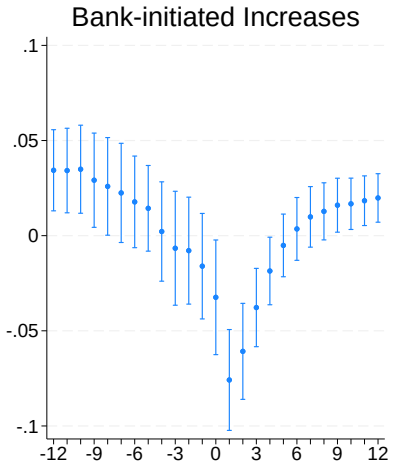
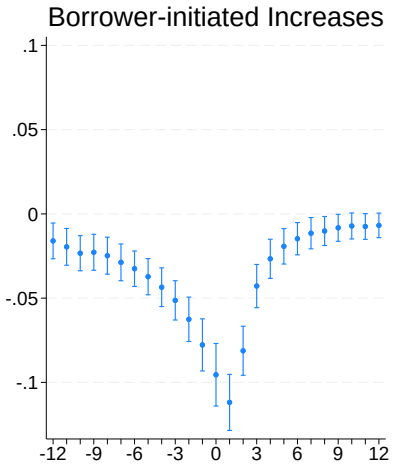
Constrained Accounts





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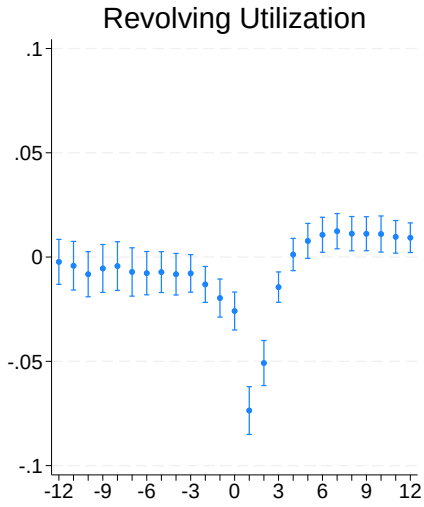
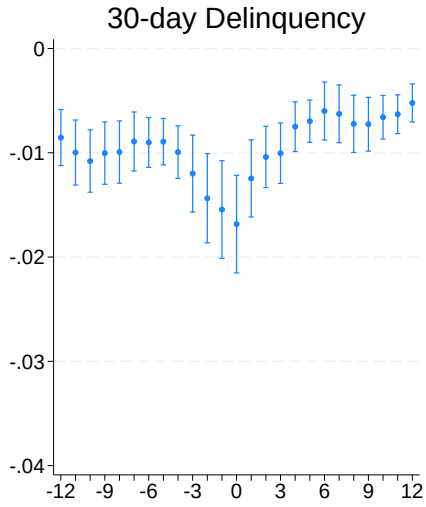
What happens after consumer-initiated limit increases?





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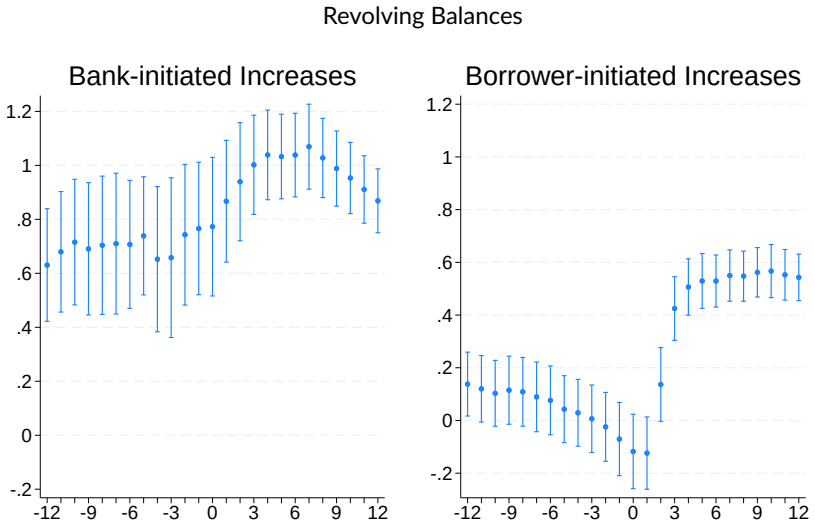
What happens to revolving balances after limit increases?



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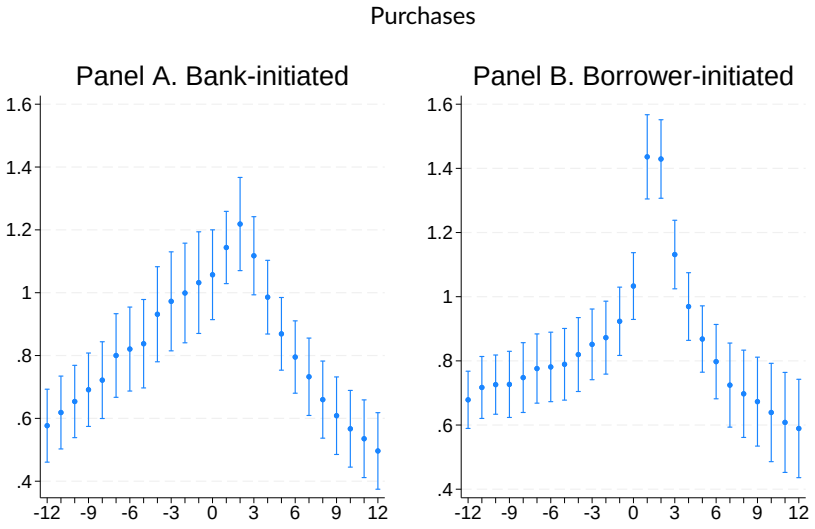
What happens to purchases after limit increases?



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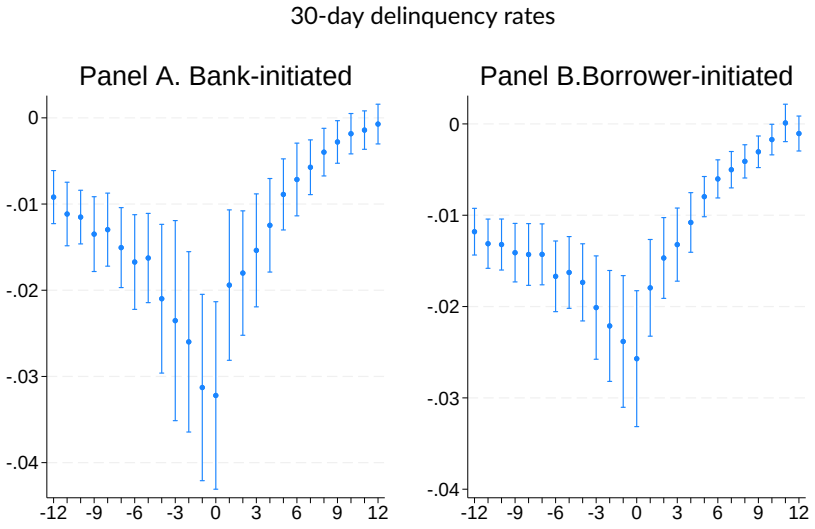
What happens to delinquencies after limit increases?



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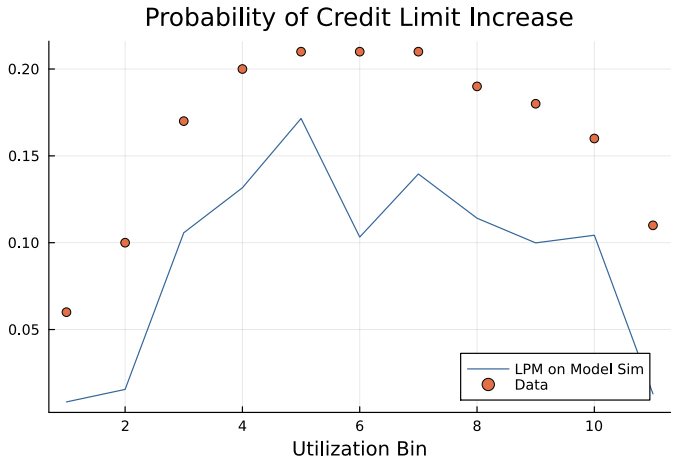
Firm Re Optimization



Credit limit increase by utilization with re-optimizing firm

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Income Process

Employment evolves through a first-order Markov process ($\pi_{e,t}(\pi_{e,t-1})$)

1. When employed:

$$\ln y_t = g_t + z_t$$

   - g: Deterministic age profile for income (third order polynomial)
   - z: Idiosyncratic income process

$$z_t = \rho z_{t-1} + \varepsilon_t$$
$$\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$$
$$z_0 \sim N(0, \sigma_0^2)$$

2. When Unemployed

$$\ln y_t = \ln b$$

Income Taxation

Progressive Income Taxation following Keane and Wasi (2016)

- After tax income given by $\widetilde{y_t} = y_t - \tau(y_t)$
- Nonlinear tax function

$$\tau(y_t) = e^{\tau_1 + \tau_2 \log(y_t - \tau_d)}$$

  where τ_1 and τ_2 are estimated on CPS data and τ_d is the deduction

- $\tau_d = \max\left[\text{Mortgage Interest Tax Deduction}, \quad \text{Standard Deduction}\right]$

Social Security

Following retirement at age $\overline{T}$, households receive income

$$\widetilde{y}_t = \max\left\{\text{SS Income Floor},\ \ \text{Annual PIA}(y_{\overline{T}})\right\} \quad \forall t > \overline{T}$$

- where Annual PIA$(y_{\overline{T}})$ is the annual social security benefit (the primary insurance amount) received upon retirement, based on average indexed monthly earnings (AIME), which we approximate based on last period income $y_{\overline{T}}$
- The PIA is computed as 90% of AIME up to breakpoint 1, 32% of AIME up to breakpoint 2, and 15% of AIME up to the SS wage base
- The SS Income Floor, PIA breakpoints, and SS wage base are taken from 2015

Households' problem

1. For a household with bad credit history, the budget set is:

$$\mathcal{B}_t^{h=1} = \left\{ a_{t+1} \in R^+ : c_t + a_{t+1} = \tilde{y}_t + (1 + r^a) a_t, c_t \geq 0 \right\} \tag{2}$$

2. For a household with good credit history, the budget set is:

$$\mathcal{B}_t^{h=0} = \{ a_{t+1} \in R : c_t + a_{t+1} = \tilde{y}_t + (1 + r^a) a_t, c_t \geq 0 \} \tag{3}$$

The problem's state variables are (a_t, z_t, u_t, h_t), where a_t represents asset position, z_t is the persistent labor income shock, u_t is unemployment status and h_t is credit history.

For households with good credit history ($h = 0$), the value function is:

$$V_t^*(a_t, z_t, u_t, h_t = 0) = \max \left\{ V_{\text{non},t}^*(a_t, z_t, u_t, h_t = 0), V_{\text{def},t}^*(a_t, z_t, u_t, h_t = 0) \right\} \tag{4}$$

Households' problem

The Bellman equation for a household with good credit history ($h_t = 0$), conditional on not defaulting, is:

$$V^*_{\text{non},t}(a_t, z_t, u_t, h_t = 0) = \begin{cases} -\infty & \text{if } \mathcal{B}_t^{h=0} = 0 \\ \max_{a_{t+1} \in \mathcal{B}_t^{h=0}} \left\{ U_t + \beta E_t V_{t+1}(a_{t+1}, z_{t+1}, u_{t+1}, h_{t+1} = 0) \right\} & \text{if } \mathcal{B}_t^{h=0} \neq 0 \end{cases} \tag{5}$$

With the budget constraint:

$$c_t = (1 + r^a) a_t + \tilde{y}_t(z_t) - a_{t+1} \tag{6}$$

The first case in equation (5) handles credit constrained scenarios, where an empty budget set leads to involuntarily default.

Households' problem

For households with good credit history choosing to default, the Bellman equation is:

$$V^*_{\text{def},t}(a_t, z_t, u_t, h_t = 0) = U_t + \beta E_t V_{t+1}(0, z_{t+1}, u_{t+1}, h_{t+1} = 1) \tag{7}$$

Subject to:

$$c_t = \max\{\tilde{y}_t(z_t)(1-\eta) - \tilde{\zeta}, \bar{c}\} \tag{8}$$

Households' problem

For households with bad credit history ($h_t = 1$), the value function is:

$$V_t^*(a_t, z_t, u_t, h_t = 1) = \begin{cases} V_{\text{def},t}^*(a_t, z_t, u_t, h_t = 1) & \text{if } \mathcal{B}_t^{h=1} = 0 \\ \max_{a_{t+1} \in \mathcal{B}_t^{h=1}} \left\{ U_t + \beta E_t V_{t+1}(a_{t+1}, z_{t+1}, u_{t+1}, h_{t+1} = \tilde{h}) \right\} & \text{if } \mathcal{B}_t^{h=1} \neq 0 \end{cases} \tag{9}$$

subject to the constraint:

$$c_t = (1 + r^a)a_t + \tilde{y}_t(z_t) - a_{t+1}$$

The Bellman equation for a household with bad credit history, conditional on defaulting is defined:

$$V_{\text{def},t}^*(a_t, z_t, u_t, h_t = 1) = U_t + \beta E_t V_{t+1}(0, z_{t+1}, u_{t+1}, h_{t+1} = 1) \tag{10}$$

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Firm's problem

Representative credit card company's profit:

$$\pi = \sum_{i,t} \Big((r^c - r^a)(a^d_{i,t})(1 - \mathcal{I}^{\text{def}}) - ((1 + r^a)(a^d_{i,t}) - \eta \widetilde{y}_{i,t}) \mathcal{I}^{\text{def}} \Big) \tag{11}$$

- $\mathcal{I}^{\text{def}}$: indicator function denoting default status
- $a^d_{i,t} = \max\{-a_t, 0.0\}$: household's revolving balance

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Parameters set outside the model

Parameter	Symbol	Value	Source
Income Persistence	ρ	0.97	PSID 1999-2015
Std Dev Income Shocks	σ_ε	0.180	PSID 1999-2015
Initial Income	σ_0	0.410	PSID 1999-2015
Income Constant	d_0	8.2007	PSID 1999-2015
Income *Age* Effect	d_1	0.1378	PSID 1999-2015
Income Age^2 Effect	d_2	-0.0019	PSID 1999-2015
Income Age^3 Effect	d_3	0.000007	PSID 1999-2015
Unemployment probability	π_u	0.053	PSID 1999-2015
Re-employment probability	π_{re}	0.397	PSID 1999-2015
Unemployment benefit	b	\$11,270	Hsu et al. (2018)
Liquid asset return	r	0.02	Annual risk free interest rate
Credit card rate	r^C	0.14135	Fulford (2024)
Credit recovery probability	π_h^0	0.10	Nakajima (2017)
Cost of a bankruptcy filing	ξ	\$1,117	Nakajima (2017)
Income garnishment ratio	η	0.335	Nakajima (2017)
Share with zero initial assets	a_0^{zero}	0.433	PSID 1999-2015
Cond. mean initial assets	μ_{a_0}	7.117	PSID 1999-2015
Cond. std dev initial assets	σ_{a_0}	1.972	PSID 1999-2015

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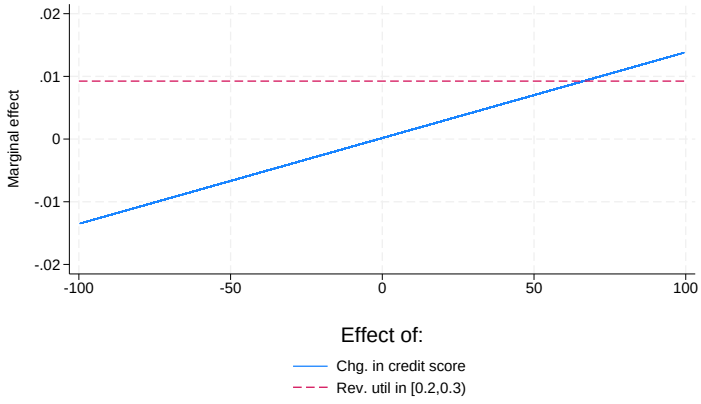
Credit limit increases to credit score and income



Magnitudes: comparison with the effect of an increase in credit score or income

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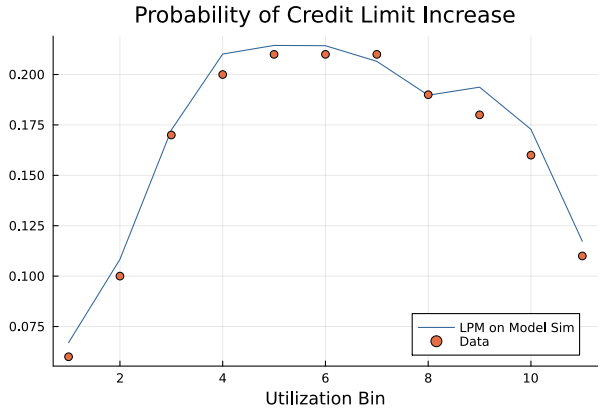
Credit limit increases by utilization: Model vs Data



Credit limit increase by utilization

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