Borrowing Premia in Unsecured Credit Markets

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Motivation

The U.S. unsecured credit market has grown $\sim 10\times$ since the 1980s.

- **existing work:** linear relationship b/w loan price, default prob
  - **risk premia** fully account for interest rate spreads
- **data:** large spreads in excess of default risk (Y-14M, Equifax)
  - large **borrowing premia** above risk premia (11.3 pp on average in 2019)
  - borrowing premia decline as risk premia increase $\implies$ flat schedules
- changes budget constraints and borrowing choices
- points to **pricing frictions** absent in existing models

This paper

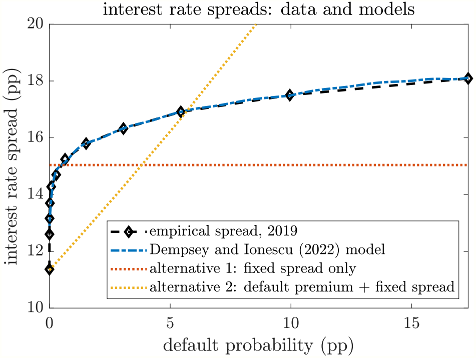
Adds empirically consistent borrowing premia to otherwise standard heterogeneous agent model with unsecured defaultable credit.

Questions

1. How do borrowing premia shape credit markets:
   in the cross-section? over the cycle?
   What do we miss by excluding them?
2. Can premia help us understand lending standards?

NOT: where do borrowing premia come from? (future!)

Approach: Confronting the theory with data



Notes: Interest rate spreads premia estimated from merged Y-14M and Equifax / CCP data set proxying the risk-free rate with the 2019 prime rate.

data require: low elasticity of loan rate w.r.t. repayment prob

- IR spreads are large
- increase *gradually* with risk

innovation: estimate **premia schedule** and feed into model (HP)

- common alternatives can't match the data
- extension: partially endogenize via loan supply constraint
  links **lending standards** to risk, borrowing premia

Related literature

Consumer bankruptcy: **supply effects** beyond default risk, **estimated** from data.

- Athreya, Tam, Young (09, ...), Livshits, MacGee, Tertilt (07, ...), CCNR (07)
- non-stationary: Nakajima and Rios-Rull (19)
- persistent distress: Athreya, Mustre-del-Rio, Sanchez (19), Chatterjee et al (20)

SLOOS / Y14 data and loan supply: bring standards data to **structural model** of **consumer** credit

- bank level data: Bassett et al. (14), Dempsey, Glancy, Ionescu (23)
- aggregate: Lown and Morgan (02, 06), Schreft and Owens (91)

Prices and premia in consumer finance: measure **aggregate** impacts of credit price dispersion

- Drozd and Kowalik (2018), Herkenhoff and Raveendranathan (2020), and Greenwald et al. (2020)
- Agarwal et al (15), Allen, Clark, and Houde (14, 19), Galenianos and Gavazza (20)

Outline

1. Measuring Borrowing Premia in the Data
2. Model: Embedding Borrowing Premia
3. Quantitative analysis: Cross-Section and Dynamics
4. Lending Standards (likely not today)

Canonical default pricing paradigm

$$p(\ell; x, s) = \mathbb{P}(\text{repay } \ell \text{ in } x', s' | x, s)$$

$$q(\ell; x, s) = \frac{p(\ell; x, s) + \xi(1 - p(\ell; x, s))}{1 + i(s)}$$

- ℓ: loan size (borrower choice)
- x: idiosyncratic states
- s: aggregate states
- $i(s)$: equilibrium interest rate
- ξ: recovery in default

Why constant?

Sovereign: Eaton-Gersovitz (81), Arellano (08), ...

Consumer: Athreya (02), Chatterjee et al (07), Livshits et al (07), ...

Punchline: loan price q linear in p with slope governed by ξ and i

Using the canonical model to measure borrowing premia

Define the **model implied rate spread** over the equilibrium interest rate

$$R(\ell; x, s) = \frac{1/q(\ell; x, s)}{1 + i(s)} = \frac{1}{\xi + (1 - \xi)p(\ell; x, s)}$$

- ℓ, x, s impact R iff they impact $p \implies$ re-define as $\tilde{R}(p)$ and focus on measuring p given observables

Given observed spreads R_{it}, ex-ante repayment probs. p_{it}, measure **borrowing premia** as proportional **excess** spread:

$$b_{it} = \frac{R_{it}}{\tilde{R}(p_{it})} - 1$$

Implementing borrowing premia measurement

Empirical issue: can't track default, contract terms, and borrower characteristics in required detail in one data set.

Solution: combine 2 data sources

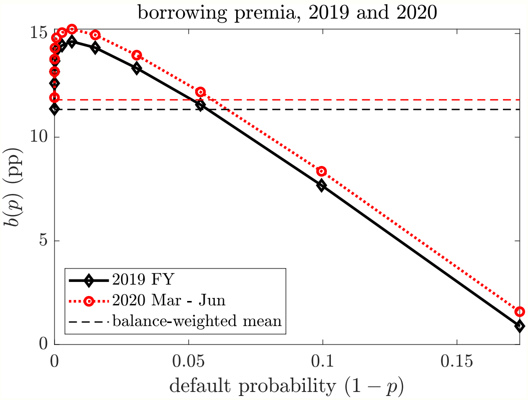
1. **Y-14M:** contract terms, borrower characteristics, **poor indiv. default**
2. **Equifax / CCP:** indiv. default, limited borrower info, **no pricing**

Implementation: match default, terms, borrower characteristics on **5% risk score bins**, using bin-specific repayment rates to proxy p

- Y-14M: average IR spreads w/in bin conditional on median debt
- Equifax: average default probability w/in bin

▸ More on data sources ▸ More on merge

3 main empirical results about borrowing premia



Notes: Borrowing premia estimated from merged Y-14M and Equifax / CCP data set. ▸ by income

Borrowing premia are:

1. large: mean 11.3 pp
2. largest for low risk borrowers (14.5 pp for 800 FICO)
3. increasing in recessions for all borrowers (avg 60 bps)

Pattern also holds if we condition on income. ▸ by income

Why is credit score / default probability sufficient?

dep var: b_{it}	[1]	[2]	[3]	[4]	[5]
FICO score	0.909	0.913	0.918	0.918	0.913
	(2e-4)	(2e-4)	(2e-4)	(2e-4)	(2e-4)
income		-0.004	-0.005	-0.005	-0.006
		(2e-5)	(3e-5)	(3e-5)	(3e-5)
account / borrower controls			X	X	X
quarter FE				X	X
bank FE					X
R^2	**0.607**	**0.608**	**0.610**	**0.610**	**0.621**

Notes: $b_{it} = \alpha + \beta_1 \text{FICO}_{it} + \beta_2 \text{income}_{it} + \gamma_1 X_{it} + \gamma_2 Y_t + \gamma_3 Z_{j(i,t)} + \varepsilon_{it}$, estimation via OLS. Number of observations is 14,426,760. ▸ Visual ▸ quadratic FICO ▸ APRs

FICO explains more variation in premia ($\uparrow R^2$) than income, other controls

Environment (static)

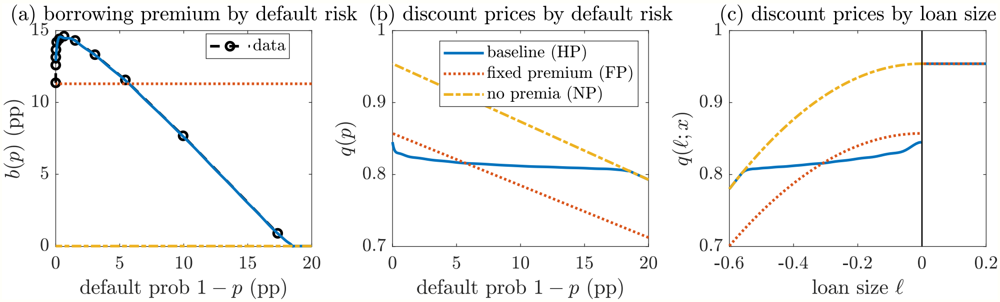
Risk averse HH with **idiosyncratic states** $x = (a, \epsilon, \beta, f, \nu)$

- a: wealth ($a < 0$ is debt, choose a' if no default)
- $\epsilon = (\epsilon_1, \epsilon_2, \epsilon_3)$: labor prod. (permanent, persistent, transitory)
- $\beta \in \{\beta_L, \beta_H\}$: persistent subjective discount factor, Markov Γ_β
- $f \in \{0, 1\}$: default flag; can't borrow with $f = 1$, lose w/ prob θ
- ν: extreme value preference shock on default / no default

HH choose savings (a'), whether to default ($d \in \{0, 1\}$)

- risk-neutral prices q defined as in canonical model *up to premia*
- standard constant returns firm for GE

Key change: loan prices and borrowing premia



$$q(p) = \frac{\xi + (1-\xi)p}{(1+i)(1+\hat{b}(p))}$$

- $\hat{b}(p)$ estimated directly, fed in as **wedges** (endogenize later)
- only **heterogeneous premia (HP)** match **data**

Quantitative strategy and calibration

1. **Assign** standard parameters externally
   - standard: CRRA = 3, depreciation rate = 7.2%, capital share = 0.36
   - labor productivity: Storesletten, Telmer, and Yaron (2004)
   - calculations: recovery rate = 16%, filing cost = 0.015, avg. exlusion = 7 yrs
2. **Estimate** $\hat{b}(p)$ schedule (direct from data / outside model) ▸ Details
3. **Internally calibrate** β process, default preference parameters

We calibrate **both** our baseline heterogenous premia economy (**HP**) **and** the fixed premium (**FP**) economy to match moments from step (3).

Parameters calibrated inside the model

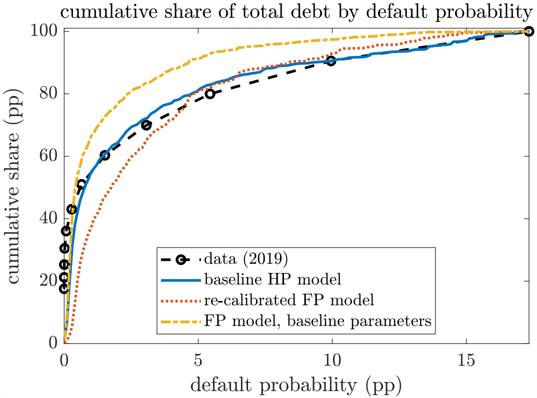
parameter		HP	FP	% diff
average β	$\overline{\beta}$	0.876	0.871	-0.55
diff, $\beta_H - \beta_L$	$\Delta\beta$	0.379	0.531	$+40.1$
high β share	μ_H	0.704	0.831	$+18.1$
$\beta_L \to \beta'_H$ prob	$\Gamma^{\beta}_{LH'}$	0.077	0.052	-32.9
EV scale	ζ	0.123	0.104	-24.7
stigma	χ	0.727	0.548	-15.6
implied:	β_H	*0.988*	*0.961*	*-2.77*
	β_L	*0.609*	*0.430*	*-29.4*

target (pp, jointly det.)	data	HP	FP
capital-output ratio	3.00	3.09	3.09
debt-to-income ratio	4.30	4.34	4.32
fraction in debt	11.7	12.3	12.2
avg. interest rate	19.6	21.1	21.1
suboptimal BK rate	44.8	45.5	45.7
bankruptcy rate	.404	.374	.390
charge-off rate	3.70	3.79	3.69
SSE		**3.07**	**3.15**

Notes: Credit market moments are computed using the 2019 Survey of Consumer Finances (SCF) and combined Y-14M / Equifax data set. SSE based on absolute squared percentage differences.

▸ External parameters | ▸ Wealth and income | ▸ Sensitivity: HP | ▸ Jacobian: HP | ▸ Sensitivity: FP | ▸ Jacobian: FP

Risk composition of debt across models



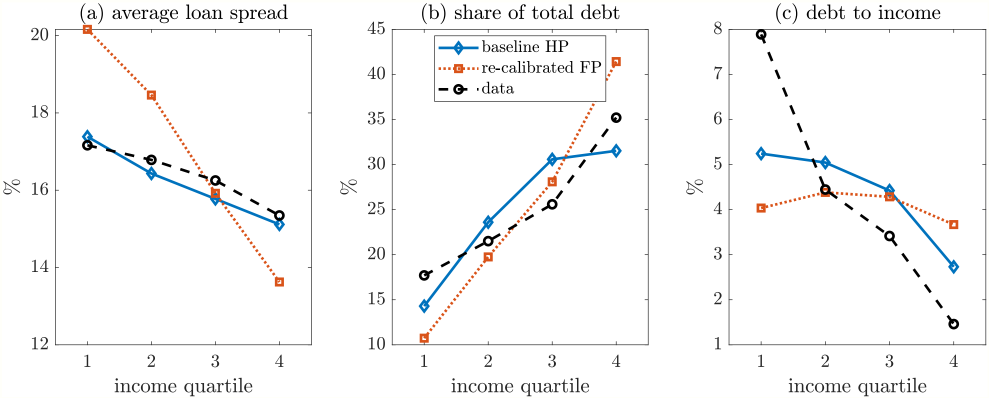
Notes: Data for 2019, excluding buckets with default probability greater than 20%.

Baseline **HP** model performs better than *naive* and re-calibrated **FP** models.

- naive: risky debt gets too expensive! Agents avoid it.
- re-calibrated: agents are “worse” $\Longrightarrow$ less very low risk debt, but still steep profile

▸ More on naive FP

Key credit market moments by income



Baseline **HP** outperforms **FP** by income across each moment.

Dynamics: IRF experiment

Keep technological, preference parameters from baseline.

Re-estimate $b(p)$ schedule for Covid impact (Mar-Jun 2020) ▸ Details

- why Covid? only recession in our Y-14M sample

Simulate impulse response to aggregate shock (perfect foresight)

- -1% TFP, increase in earnings risk (stylized), 3 year duration
- 2 questions:
  1. **incidence:** how do dynamics differ between HP and FP economies?
  2. **response:** how does **tightening of premia** affect dynamics?

Extend both (1) and (2) to business cycle analysis

How do premia shape credit outcomes?

Incidence	Heterogeneous		Fixed
Response	None	Tighten	None
% diff, impact v SS	[1]	[2]	[3]
total debt	-0.06	-0.30	-0.80
debt to income	0.77	0.54	0.15
fraction in debt	0.43	0.30	-0.05
bankruptcy rate	11.8	14.4	16.6
avg loan rate spread	0.13	4.36	0.89
avg borrowing premium	-0.55	3.75	0.00
aggregate consumption	-0.21	-0.22	-0.23

▸ Figure

Baseline IRF [1]:

- no spike in total debt, spreads, BP
- bankruptcies rise

Incidence (HP, FP) [3] v [1]:

- much larger drop in debt, rise in BKs
- modest rise in spreads
- 9% larger drop in consumption

BP response [2] v [1]:

- larger drop in debt, rise in BKs
- rise in BP (esp. for high risk), drives spike in spreads

Business cycles

Main idea: Aiyagari (94) $\rightarrow$ Krusell-Smith (98), CCNR (07) $\rightarrow$ NR (21)

- now account for **aggregate state** $s = (z, \mu(x))$

Implementation: BP schedule: $b(p) \rightarrow b(p; z)$, matches data from 2019 for expansions (z_H), March - June 2020 for recessions (z_L). ▸ Details

Results: mostly extension of IRF insights ▸ Results

- **incidence:** HP matches credit cyclicality, volatility better
- **response:** $\uparrow$ BP in recessions explains cyclical vol. of spreads

Taking stock: What do BP imply in credit models?

1. **Cross-section**
   - HP model matches the **composition** of credit balances wrt default risk
   - neither simple nor re-calibrated "fixed premium" (FP) can
   - premia are costly, but **incidence** benefits poor / high risk
2. **Aggregate dynamics (recession shock)**
   - **omit incidence:** 0.7 pp larger drop in debt, 4.8 pp larger rise in BKs
   - **omit response:** 0.2 pp smaller drop in debt, 2.6 pp smaller rise in BKs
   - **BC:** HP model more closely matches observed cyclical properties
3. **Lending standards:** requires model extension
   - control for demand (endog), shifts in premia (exog) to infer standards
   - reallocation from high to low risk, consistent with survey evidence

Summary: 4 key takeaways

1. The U.S. unsecured credit market features **large borrowing premia** which (i) decline in borrower risk and (ii) increase in recessions.

2. Incorporating empirical **incidence** of BP brings standard models closer to granular data moments, such as the joint distribution of balances and risk.

3. The **response** of BP to negative shocks limits consumption smoothing and drives interest rate volatility.

4. **Inference** from extended model suggests tightening of lending standards is a reallocation from high to low risk lending.

Next steps and future directions

Where do these premia come from?

- Dempsey, Ionescu, and Raveendranathan (2023): use Y-14 to explore price discrimination by lenders between "transactors" and "revolvers"
- theory: extend Raveendranathan and Stefanidis (2021)

How and why do banks actually implement changes in standards?

- Dempsey, Glancy, and Ionescu (2023): link Y-14, Call Reports, and SLOOS to create full picture around tightening / easing
- theory: adapt Fishman, Parker, and Straub (2021) with learning and financial frictions

Y14-M and Equifax data ▸ Back

Y-14M

- collected monthly as part of banks' annual stress tests
- includes detailed loan-level data on:
  - loan terms
  - borrower characteristics (incl. credit score, income)
- does not contain good measures of default at the borrower level

Equifax

- rich set of variables on consumers' credit behavior (e.g. delinquency, default)
- some borrower characters (incl. risk score, no income)
- does not contain pricing or contract term information

Merging Y14-M and Equifax data

- group borrowers in each data set by vigintiles of credit scores
- **Equifax:** compute average likelihood of default for each bin
  - "default" defined as bankruptcy or severe derogatory
  - other definitions possible
- **Y-14M:** compute average interest rates for each bin (unconditional on debt and conditional on the median level of debt)
  - also average credit limits and credit outcomes
- using equivalence between credit score bins in Y-14M and Equifax, map all credit outcomes, terms from Y-14M to borrowers' likelihood of default

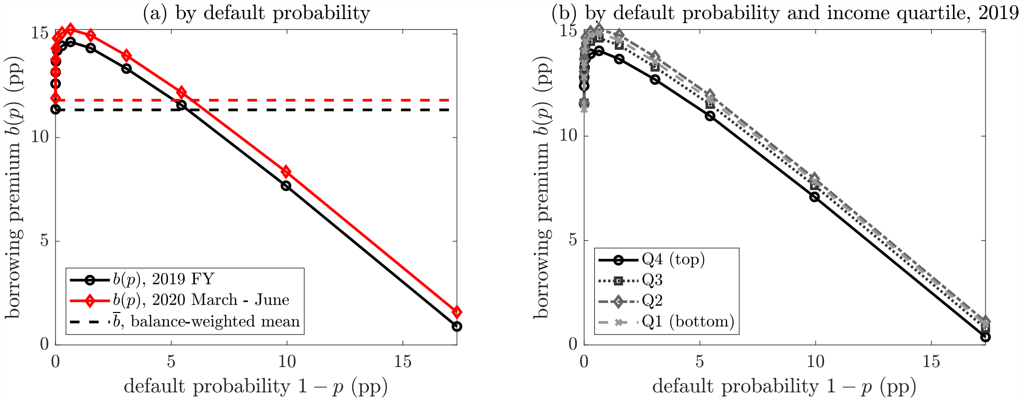
Back

Canonical model

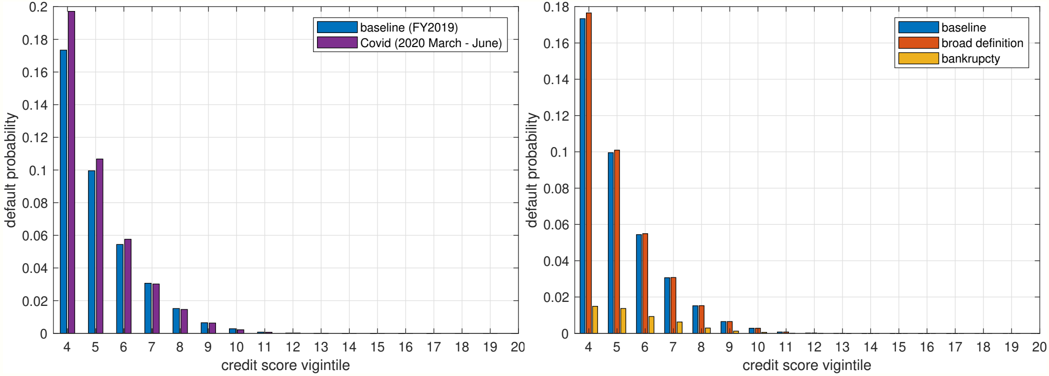
Eaton-Gersovitz (81), Athreya (02), Chatterjee et al (07), Livshits et al (07)

- Profit maximizing competitive lenders offer various contracts to households.
- Lenders may borrow at the equilibrium interest rate $i(s)$.
- A loan contract specifies a size $l < 0$ and a discount price q.
- The household pays the lender ql today to consume l tomorrow.
- Lenders choose how many contracts of size l to issue to households with state (x, s).
- Households may choose to default; the lender recovers fraction $\xi \in [0, 1]$ of l.

Borrowing premia by income ▸ back

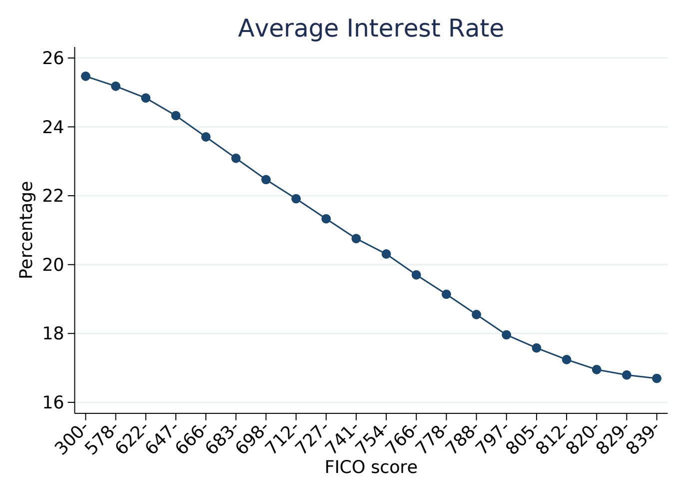


Credit scores and default probability ▸ back



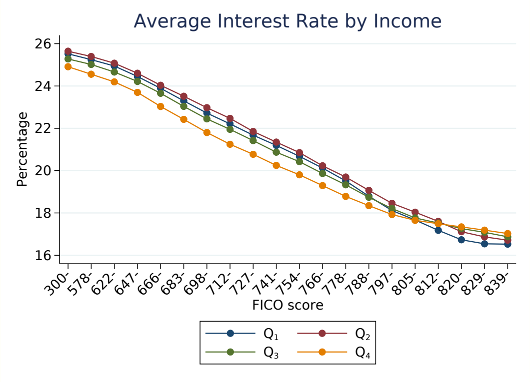
Notes: The left panel plots the probability of default by 5% credit score bin using our baseline (severe derogatory plus bankruptcy) measure for 2019 and 2020. The right panel plots the three measures (baseline, broad, and narrow) for the year 2019.

Interest rates by FICO score, 2019

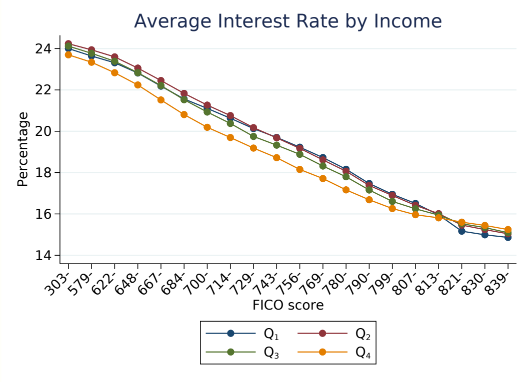


Notes: This figure shows the interest rate schedule across bins. Note that figures here are reported in raw percentage points, not spreads as in the main text. ▸ Back

Interest rates by income and FICO score ▸ Back



(a) **Full year 2019**



(b) **Covid crisis: March - June 2020**

Alternative regression specification 1: quadratic FICO

dep var: b_{it}	[1]	[2]	[3]	[4]	[5]	[6]
FICO score	0.642	0.645	0.629	0.632	0.632	0.634
	(2e-4)	(2e-4)	(2e-4)	(2e-4)	(2e-4)	(2e-4)
FICO^2	-5.2e-6	-5.2e-6	-5.3e-6	-05.2e-6	-5.2e-6	-5.2e-6
	(2e-9)	(2e-9)	(2e-9)	(2e-9)	(2e-9)	(2e-9)
income		-0.002		-0.003	-0.003	-0.004
		(2e-5)		(3e-5)	(3e-5)	(3e-5)
borrower / account controls			X	X	X	X
quarter FE					X	X
bank FE						X
R^2	0.696	0.697	0.699	0.699	0.699	0.710

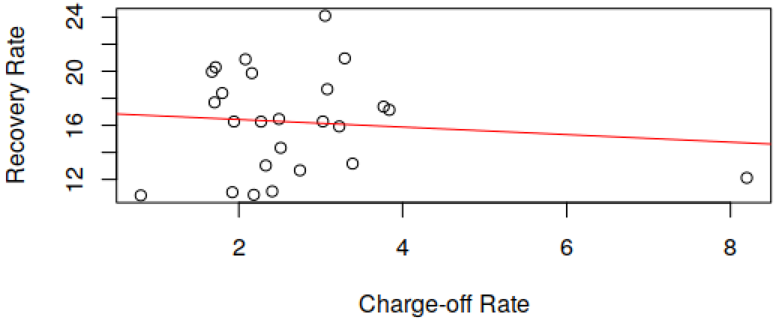
Notes: Number of observations is 14,426,760. Back

Alternative regression specification 2: APR

dep var: R_{it}	[1]	[2]	[3]	[4]	[5]	[6]
FICO score	-0.141	-0.139	-0.145	-0.143	-0.143	-0.137
	(1e-4)	(1e-4)	(1e-4)	(1e-4)	(1e-4)	(1e-4)
income		-0.001		-0.002	-0.002	-0.003
		(2e-5)		(2e-5)	(2e-5)	(2e-5)
borrower / account controls			X	X	X	X
quarter FE					X	X
bank FE						X
R^2	0.146	0.147	0.168	0.170	0.170	0.283

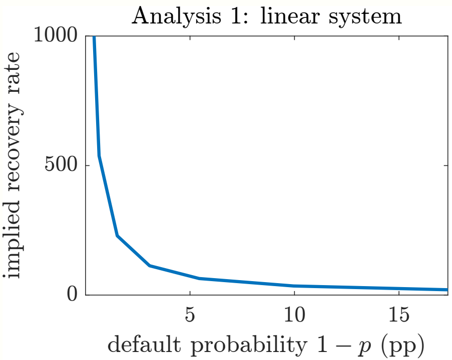
Notes: Number of observations is 14,426,760. ▸ Back

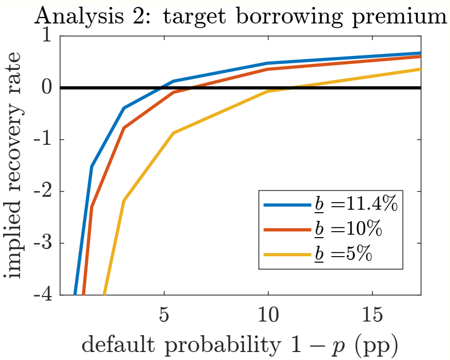
Recovery rate defense: data



Notes: This figure plots recovery rates against charge-off rates for the 25 banks comprising our sample from the Call Reports which we use to estimate recovery rates. Back Theory

Recovery rate defense: theory





Notes: Analysis 1 asks: is there a set of bin-specific recovery rates ξ_i for which our measurements would imply a fixed borrowing premium? Analysis 2 asks: does there exist a schedule of recovery rates that explains the low borrowing premia for high risk borrowers? Back Data

Model timeline

1. HHs choose whether to default ($d \in \{0,1\}$), savings ($a^{'}$)
   - face risk-neutral prices q defined as in canonical model *up to premia*
2. CRS firm chooses aggregate capital and labor
3. Banks choose contract quantities $m'(\ell; x)$
   - loan $q(\ell; x) \cdot \ell$ to m' HH with state x, repay ℓ tomorrow
4. Distribution updates, next shocks drawn
   - HH labor productivity, preference evolves, default flag updates

▸ HH problem ▸ Distribution ▸ Firm problem ▸ Lender problem ▸ Recursive formulation ▸ Equilibrium definition

Lender Problem

Choose future capital and contract quantities $m'(\ell;x)$ to max discounted flow of profits:

$$\pi(K',\mathcal{M}';K,\mathcal{M}) = \underbrace{(1+r-\delta)K - K'}_{\text{net return on capital}} + \underbrace{\int_{\mathcal{X}\times\mathcal{L}} q(\ell;x)\ell dm'(\ell;x)}_{\text{issuances, new contracts}}$$
$$- \underbrace{\int_{\mathcal{X}_{-1},\mathcal{X},\mathcal{L}} \left(1 - g_{BK}(\ell;x) + \xi g_{BK}(\ell;x)\right)\ell dm(\ell;x_{-1}) d\mathbb{P}(x|x_{-1})}_{\text{repayments, last period contracts}} \quad (1)$$

The lender problem is

$$W(K,\mathcal{M}) = \max_{K',\mathcal{M}'} \pi(K',\mathcal{M}';K,\mathcal{M}) + \frac{1}{1+i}\mathbb{E}\left[W(K',\mathcal{M}')\right] \quad (2)$$

$$\text{s. t.} \quad -\int_{\mathcal{X}\times\mathcal{L}_-} \lambda(p(\ell;x))q(\ell;x)\ell dm'(\ell;x) \leq \int_{\mathcal{X}\times\mathcal{L}_+} q(\ell;x)\ell dm'(\ell;x) \quad (3)$$

▸ Back to environment ▸ Back to timeline ▸ HH problem ▸ Distribution ▸ Equilibrium definition

HH problem (no default flag)

An agent with no default flag first decides whether to default:

$$V_0(a,\beta,\epsilon,\nu) = \max\left\{ V_0^{BK}(a,\beta,\epsilon) + \nu^{BK},\, V_0^{R}(a,\beta,\epsilon) + \nu^{R} \right\} \tag{4}$$

- $a \geq 0 \implies d^* = 0$ by feasibility

This decision compares default and no default values:

$$V_0^{BK}(a,\beta,\epsilon) = u\left(w\epsilon_1\epsilon_2\epsilon_3 - \kappa\right) + \beta\mathbb{E}\left[V_1(0,\beta',\epsilon')\right] \tag{5}$$

$$V_0^{R}(a,\beta,\epsilon) = \max_{a'} u\left(a + w\epsilon_1\epsilon_2\epsilon_3 - q(a';\beta,\epsilon)a'\right) + \beta\mathbb{E}\left[V_0(a',\beta',\epsilon',\nu')\right] \tag{6}$$

- optimal policies $g_a(x)$ and $g_d(x) \in \{0,1\}$
- for later analysis, define the expected repayment probability to be

$$p(a';\beta,\epsilon) = \mathbb{E}\left[(1 - g_d(a',\beta',\epsilon')|\beta,\epsilon\right]$$

HH problem (default flag)

An agent with a default flag can only save

$$\begin{aligned} V_1(a, \beta, \epsilon) &= \max_{a' \geq 0} u\left(a + w\epsilon_1\epsilon_2\epsilon_3 - \overline{q}\, a'\right) \\ &\quad + \beta \mathbb{E}\left[\theta\, V_0(a', \beta', \epsilon', \nu') + (1-\theta)\, V_1(a', \beta', \epsilon')\right] \end{aligned} \tag{7}$$

- may lose the flag next period (Pr θ)

▸ Back to environment ▸ Back to timeline ▸ w/o default flag

Distribution of households

The distribution of HH reflects default and asset choices, earnings shocks, and evolution of flag status:

$$
\begin{aligned}
T^*\mu_0(a',\beta'\epsilon') &= \underbrace{\int \Gamma^{\beta}(\beta,\beta')\Gamma^{\epsilon}(\epsilon,\epsilon')(1-g_d(x))\mathbf{1}\left[a'=g_a(a,\beta,\epsilon)\right] d\mu_0(a,\beta,\epsilon)}_{f=0,d=0} \\
&\quad \underbrace{+\,\theta\int \Gamma^{\beta}(\beta,\beta')\Gamma^{\epsilon}(\epsilon,\epsilon')\mathbf{1}\left[a'=g_a(a,\beta,\epsilon)\right] d\mu_1(a,\beta,\epsilon)}_{f=1,\text{ lose flag}} \\
T^*\mu_1(a',\beta',\epsilon') &= \underbrace{\int \Gamma^{\beta}(\beta,\beta')\Gamma^{\epsilon}(\epsilon,\epsilon')g_d(a,\beta,\epsilon)\mathbf{1}\left[a'=g_a(a,\beta,\epsilon)\right] d\mu_0(a,\beta,\epsilon)}_{f=0,d=1} \\
&\quad \underbrace{+\,(1-\theta)\int \Gamma^{\beta}(\beta,\beta')\Gamma^{\epsilon}(\epsilon,\epsilon')\mathbf{1}\left[a'=g_a(a,\beta,\epsilon)\right] d\mu_1(a,\beta,\epsilon)}_{f=1,\text{ keep flag}}
\end{aligned}
$$

Back to environment

Firm problem

The firm operates a constant returns technology $zF(K,N)$

$$\max_{K,N} zF(K,N) - rK - wN$$

In equilibrium, then, prices must satisfy

$$r = zF_K(K,N) \quad (8)$$
$$w = zF_N(K,N) \quad (9)$$

with an equilibrium interest rate of

$$i = r - \delta \quad (10)$$

▸ Back to environment

Recursive equilibrium definition

law of motion Δ, value function V and policies g_a and g_d, distribution of HH $\mu(x)$, and pricing functions (w, r, q, i, η) s.t.

- value functions V and policies g_a and g_d solve the HH problem taking Δ as given
- factor prices r and w solve firm problem
- q and i consistent with solution to bank problem
- markets clear for goods, labor, loan supply, and capital
  - goods [resource balance follows CCNR (2007)]

$$\int c(x;s)d\mu(x) + K' = F(K,N) + (1-\delta)K - \kappa \int g_d(x;s)d\mu(x)$$

  - labor: $N = \int(\epsilon + \xi)d\mu(x)$
  - loans (of each type): $m'(x,\ell;s) = \mu(x)\mathbf{1}[\ell = g_a(x;s)]$
  - capital: $K = \int a(1 - g_d(x;s))d\mu(x)$, bank absorbs losses through B
- the distribution $\mu(x)$ evolves according to $\Delta(\cdot)$

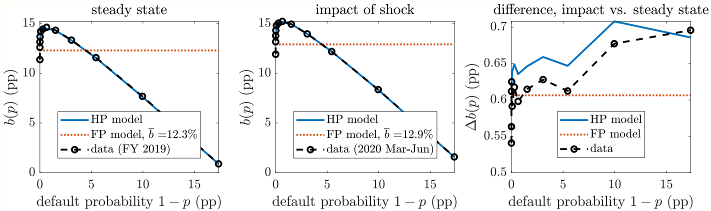
▸ Back to timeline

Calibration: parameters calibrated externally

	Parameter		Value	Target / Notes
technology,	average TFP	$\overline{z}$	1.0	normalization
preferences, and	capital share	α	0.36	standard capital-output ratio
legal	depreciation rate	δ	0.072	standard, annual model
	risk aversion	γ	3.0	CRRA preferences
	recovery rate	ξ	0.16	authors' estimates
	bankruptcy filing cost	κ	0.0152	authors' estimates
	prob of regaining credit status	θ	1/7	7-yr avg. exclusion
labor productivity	std. dev., ϵ_1	σ_{ϵ_1}	0.448	permanent component ("type")
Storesletten et al. (2004)	persistence, ϵ_2	ρ_{ϵ_2}	0.957	persistent component
	std. dev., ϵ_2, steady state	$\overline{\sigma}_{\epsilon_2}$	0.129	
	std. dev., ϵ_3 component	σ_{ϵ_3}	0.351	transitory component

Back to quantitative strategy
Back to main calibration

Fit of estimated premia to data

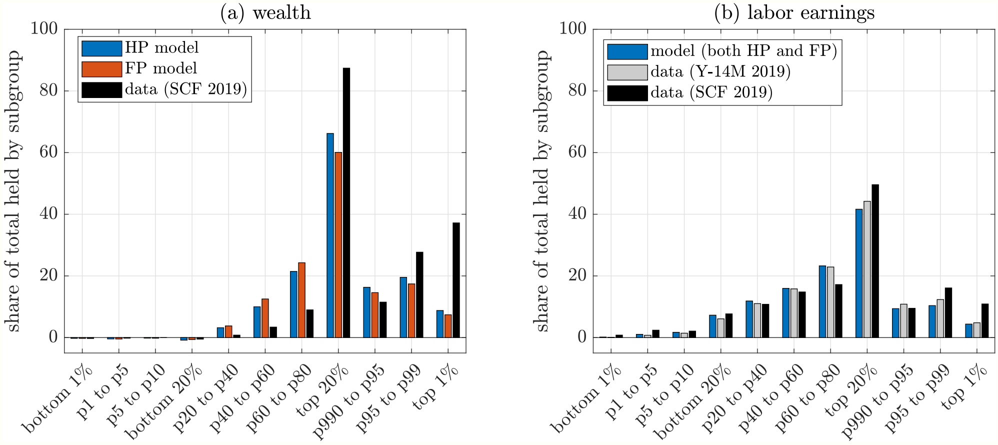


▸ Back to quantitative strategy ▸ Back to IRF overview

Seek a smooth function over all p(interpolated between the measured bins).

$$\text{Estimate for } N = 20\text{:}\;\; b(p) = \begin{cases} \sum_{n=0}^{N} x_n \left(\frac{p-m_0}{m_1}\right)^n & \text{if } p \geq \underline{p} \\ 0 & \text{if } p < \underline{p} \end{cases}$$

Distributions of wealth and income



Notes: This figure reports the steady distributions of wealth and labor income in the baseline (HP) and fixed premium (FP) models and in the data (2019 SCF). We also report the empirical distribution from Y-14M in 2019 for labor earnings. Since labor productivity is exogenous in the model and the HP and FP model have the same equilibrium wage by construction, the distribution of labor earnings in these economies is identical. The SSE of the HP (FP) model relative to the data for the wealth moments shown in panel (a) is 0.155 (0.208). The wealth Gini coefficient for the HP (FP) model is 0.655 (0.616). The SSE of the model relative to the Y-14M (SCF) data for the labor earnings moments shown in panel (b) is 0.002 (0.012).

▸ Parameters and moments

Jacobian analysis: HP model ‣ Back

Moment	BK rate	fraction in debt	debt to income ratio	avg IR spread on loans	K-Y ratio	chargeoff rate	share of subopt default
average beta	-7.42	-0.02	4.13	-7.16	9.43	-7.42	37.8
difference, H to L beta	-0.72	0.11	0.64	0.36	-0.88	-0.80	5.40
beta H share	-2.29	-0.35	-0.20	0.61	-1.26	-2.50	3.97
L to H transition	-0.34	-0.70	-1.06	0.08	0.00	0.27	0.53
stigma	-0.99	-0.09	0.24	-0.12	-0.06	-2.61	-2.17
EV scale	1.04	-0.21	-0.23	0.18	-0.05	1.41	1.36

Sensitivity analysis: HP model ▸ Back

Moment	BK rate	fraction in debt	debt to income ratio	avg IR spread on loans	K-Y ratio	chargeoff rate	share of subopt default
average beta	0.00	-0.03	0.02	0.09	-0.02	-0.02	-0.01
difference, H to L beta	-0.01	1.91	-1.33	-0.40	0.44	0.83	0.09
beta H share	0.02	-1.88	1.20	-0.20	-0.31	-0.52	-0.17
L to H transition	0.01	1.54	-0.05	0.19	0.36	0.78	0.08
stigma	-0.03	2.77	-1.79	-0.09	0.05	0.05	0.17
EV scale	-0.05	2.47	-1.76	-0.51	-0.48	-1.31	-0.02

Jacobian analysis: FP model ▸ Back

Moment	BK rate	fraction in debt	debt to income ratio	avg IR spread on loans	K-Y ratio	chargeoff rate	share of subopt default
average beta	-14.8	-0.53	5.29	-6.02	8.46	-4.43	18.3
difference, H to L beta	20.0	0.32	4.34	-0.39	1.03	0.75	17.1
beta H share	-4.08	-3.70	-5.03	2.35	-3.61	0.16	-0.25
L to H transition	19.3	0.06	3.06	-0.42	0.98	0.63	18.5
stigma	-1.86	0.47	0.87	-0.51	-0.03	-2.55	-4.03
EV scale	21.1	-0.70	2.27	0.54	0.26	3.24	22.7

Sensitivity analysis: FP model ▸ Back

Moment	BK rate	fraction in debt	debt to income ratio	avg IR spread on loans	K-Y ratio	chargeoff rate	share of subopt default
average beta	-0.03	0.14	-0.06	0.29	0.10	-0.05	-0.01
difference, H to L beta	-0.27	0.97	-0.33	-1.61	-1.31	0.02	0.37
beta H share	-0.09	0.30	0.09	-0.50	-0.38	0.13	0.08
L to H transition	-0.46	-1.01	1.53	-2.25	-2.05	0.82	0.21
stigma	0.60	-0.26	-1.05	2.69	2.82	-0.18	-0.53
EV scale	0.66	-0.07	-1.14	3.22	3.00	-0.67	-0.57

Parameter differences in HP and FP economies

parameter		%Δ, FP v HP
average β	$\overline{\beta}$	-0.55
diff., $\beta_H - \beta_L$	$\Delta\beta$	40.1
share, high β	μ_{β_H}	18.1
$\beta_L \to \beta'_H$ prob	$\Gamma^{\beta}_{LH'}$	-32.9
stigma	χ	-24.7
EV scale	ζ	-15.6
high β	β_H	-67.6
low β	β_L	-29.4
$\beta_H \to \beta'_L$ prob	$\Gamma^{\beta}_{HL'}$	-2.77
avg. BP	$\overline{b}$	**0.00%**

Back

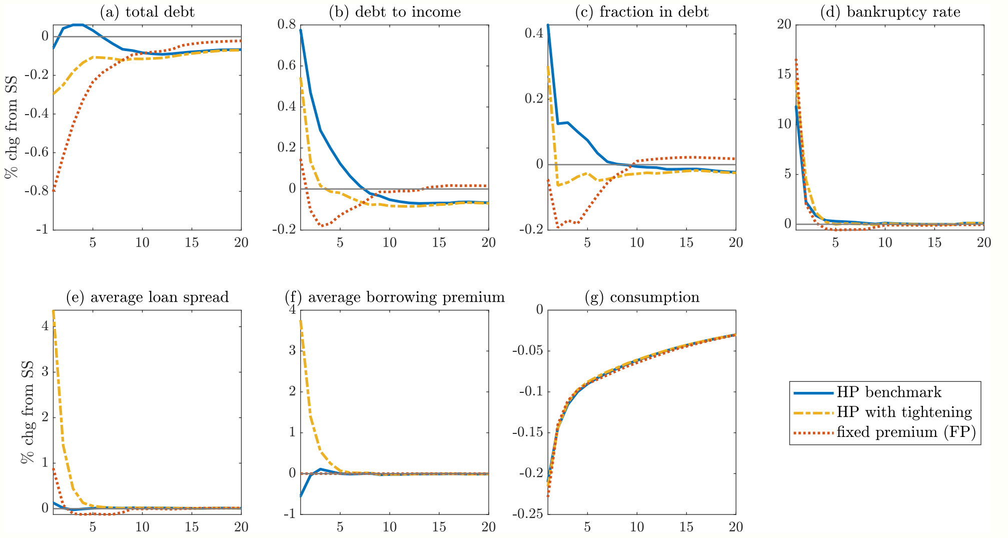
Relative to HP, FP economy has:

1. very different β process
   - β_L and β_H both lower
   - 40% larger $\Delta\beta$
   - 18% more agents w/ high β
   - more persistence in β
2. slightly different default parameters
   - 25% smaller stigma (χ)
   - 16% lower scale (ζ)

Aggregate credit market outcomes in steady state ▸ Back

Incidence of premia	Heterog.	Fixed			
Parameterization	HP	FP	HP	FP	HP
Moment		level		% diff, $[j]-[1]$	
Column	[1]	[2]	[3]	[2] − [1]	[3] − [1]
bankruptcy rate	0.374	0.390	0.213	+4.53	-43.0
fraction in debt	12.3	12.2	12.1	-1.36	-1.73
debt to income	4.34	4.32	1.87	-0.52	-57.0
average loan rate spread	21.1	21.1	19.1	+0.01	-9.25
capital-output ratio	3.09	3.09	3.09	-0.10	+0.01
charge-off rate	3.79	3.69	1.90	-2.69	-50.0
suboptimal bankrupt share	45.5	45.7	53.1	+0.37	+16.8
average borrowing premium	12.2	12.2	12.2	0.00	0.00
cumulative share of total debt, def. prob $\leq$					
1%	54.8	37.1	66.4	-32.4	+21.2
5%	81.2	80.8	91.4	-0.45	+12.6
10%	90.5	92.9	97.4	+2.59	+7.61

Figure: impulse response ▸ Back



Business cycles: details

1. aggregate TFP shock, $z \in \{z_R, z_E\}$, AR(1) process chosen to match
   - $\overline{z} = 1$, 1% downturn in recessions (consistency with IRF)
   - 21.1% of years with a recession
   - avg. duration of recession 1.5 years
   - output volatility of 1.20% (log, HP-filter, cyclical component)
2. countercyclical earnings risk: STY (2004 JPE)
   - $\sigma^E_{\epsilon_2} = 0.094$, $\sigma^R_{\epsilon_2} = 0.163$
3. borrowing premia schedules:
   - 2019 for expansions, Covid for recessions

Solve via state space approximation and forecasting a-la KS (98).

▸ Back to main ▸ Results

How do premia affect business cycles?

Premia Incidence		[Data]		Heterogeneous				Fixed	
Tighten in Rec.?				N		Y		-	
Moment		σ_X/σ_Y	ρ_{XY}	σ_X/σ_Y	ρ_{XY}	σ_X/σ_Y	ρ_{XY}	σ_X/σ_Y	ρ_{XY}
Column		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Macro	output	*1.20%*	*1.00*	*1.20%*	*1.00*	*1.20%*	*1.00*	*1.20%*	*1.00*
	consumption	0.81	0.92	0.14	0.78	0.15	0.79	0.16	0.81
Credit	total debt	3.20	-0.29	0.83	-0.78	0.82	-0.80	0.34	-0.92
	bankruptcy filings	17.9	-0.11	1.51	-0.94	1.52	-0.95	1.14	-0.99
	debt to income	5.23	-0.27	8.51	-0.99	8.85	-1.00	10.7	-1.00
	fraction in debt	6.62	0.48	0.94	-0.94	0.96	-0.94	0.15	-0.82
Rates	avg IR, all loans	0.90	-0.88	0.10	-0.98	1.18	-1.00	0.55	-1.00
	avg BP, all loans	0.19	-0.56	0.29	0.98	0.90	-1.00	0.00	0.00

Notes: All results HP filtered in logs with smoothing 6.25. Back to main Back to details

Can borrowing premia help us understand lending standards?

BP may be related to widely discussed but opaque **lending standards**

- **data:** Senior Loan Officer Opinion Survey (SLOOS)
  - "how have your bank's standards for approving X loans changed?"
  - responses on 1-5 scale (ease $\rightarrow$ tighten), convert to diffusion indices ▸ Details
  - many components: terms, limits, approvals (companion!)
- **approach:** use model to control for demand, observe shifts in premia
  1. augment model to endogenize borrowing premia
  2. simulate response to a shock that looks like Covid
  3. infer change in exogenous component of $b(p)$

Modified model environment

Basic structure of our baseline with one **key change**:

Lenders maximize discounted flow profits s.t. **loan supply constraint**

$$\underbrace{-\sum_{x,\ell<0} \overbrace{\lambda_t(\ell;x)}^{\text{standards}} \cdot \overbrace{q_t(\ell;x)}^{\text{loan price}} \cdot \ell \cdot m_{t+1}(\ell;x)}_{\text{total standards-weighted funds \textbf{lent}}} \leq \underbrace{\sum_{x,\ell>0} \overbrace{\overline{q}_t}^{\text{save price}} \cdot \overbrace{\ell \cdot m_{t+1}(\ell;x)}^{\text{size, mass of contracts}}}_{\text{total funds \textbf{saved}}}$$

- risk-weighted limit on share of savings to allocate to borrowers
- **"lending standards" function** $\lambda(\cdot)$ specifies the weights
- why? tractable and allows aggregate credit demand to affect premia
- **binds:** multiplier $\eta > 0 \implies$ **borrowing premia**

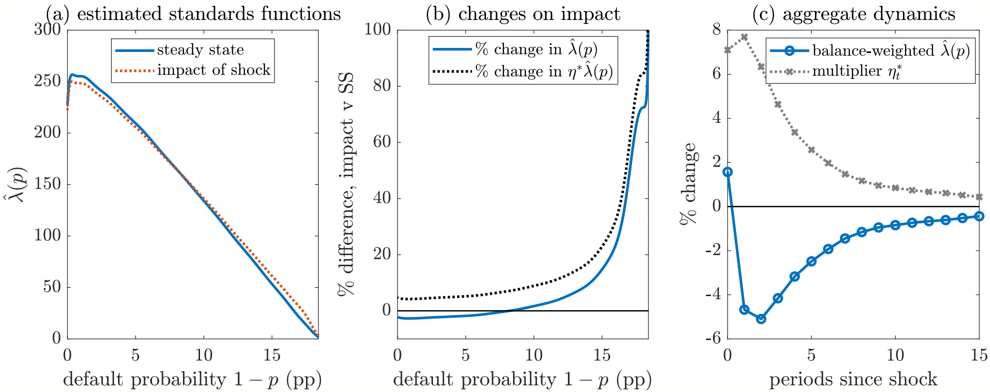
Equilibrium prices and premia

$$q(\ell; x) \to q(p) = \frac{\xi + (1-\xi)p}{(1+\eta\lambda(p))(1+i))} \implies b(p) = \eta\lambda(p)$$

- η: endogenous, governs level based on tightness of constraint
- $\lambda(p)$: exogenous, governs incidence (note: $\ell, x, s \to p$)
- $b(p)$: borrowing premia combine endogenous and exogenous
  - tighter standards $\neq$ higher premia, necessarily

$$\underbrace{\lambda_1(p)/\lambda_0(p)}_{\text{estimated shift in standards}} = \underbrace{b_1(p)/b_0(p)}_{\text{observed shift in premia}} \Big/ \underbrace{\eta_1/\eta_0}_{\text{endogenous change in multiplier}}$$

What does the model say happened to “standards?”



Data: BP shift up across the board. **Model delivers** via 2 channels:

1. endogenous: credit market tightens $\Longrightarrow$ η increases
2. exogenous: standards rotate against high risk (FICO $<\approx$ 680)

▸ Sanity check 1: dynamics ▸ Sanity check 2: heterogeneity

Extended model bank problem in recursive form

The lifetime value of the bank is

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \left(\prod_{j=0}^{t-1} (1+i_j)^{-1} \right) \pi_t \right],$$

so we can write the bank problem recursively as

$$\begin{aligned} W(\mathcal{M}, K, B; s) \quad = \quad & \max_{B', K' \geq 0, \mathcal{M}' = \{m'\}} [r + 1 - \delta] K - K' + B' - (1+i) B \\ & - \sum_{x,\ell} [p(\ell; x, s) m(\ell, x) \ell - q(x, \ell; s) m'(x, \ell) \ell] \\ & + \frac{1}{1+i} \mathbb{E} \left[W(\mathcal{M}', K' B'; s') \right] \\ \text{subject to:} \quad & - \sum_{x, \ell < 0} \lambda(p(\ell; x, s)) q(\ell; x, s) m'(\ell, x) \ell \leq \sum_{x, \ell > 0} q(\ell; x, s) m'(x, \ell) \ell \end{aligned} \tag{11}$$

with multiplier η on the loan supply constraint.

▸ Back

SLOOS data: background and approach

Quarterly survey on bank lending policies conducted by the FRB

- ~80 U.S. commercial banks participate in each survey
- includes questions on features of multiple credit types
  - 1 - 5 scale, easing to tightening
  - "standards," limits, spreads, and demand

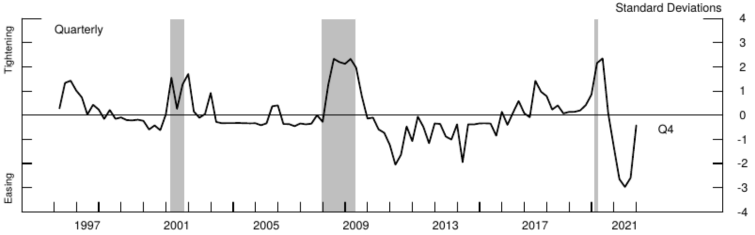
We construct aggregate indices using a 3-step approach

1. use SLOOS questions to create **bank-specific indices**
   - positive (negative) values $\implies$ tightening (easing)
2. **aggregate** bank-specific indices using loan shares from Call Reports
   - units: net % of loans with tightened (eased) standards
3. **normalize** aggregate index to historical mean
   - units: SD in net % of loans

▸ SLOOS questions ▸ Empirical approach

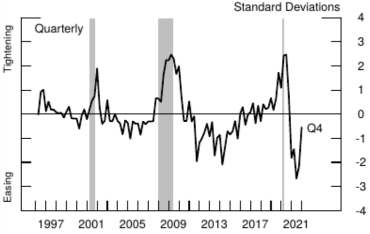
Sanity check 1: standards and terms over the cycle

Bank Index of Changes in Credit Card Lending Standards



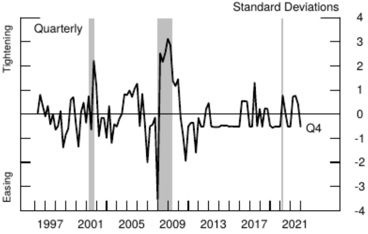
Note: Results are reported as standard deviations from the historical mean. Before normalizing, the mean (standard deviation) was 12.3 (37.2).
Source: Senior Loan Officer Opinion Survey

Bank Index of Changes in Credit Card Limits



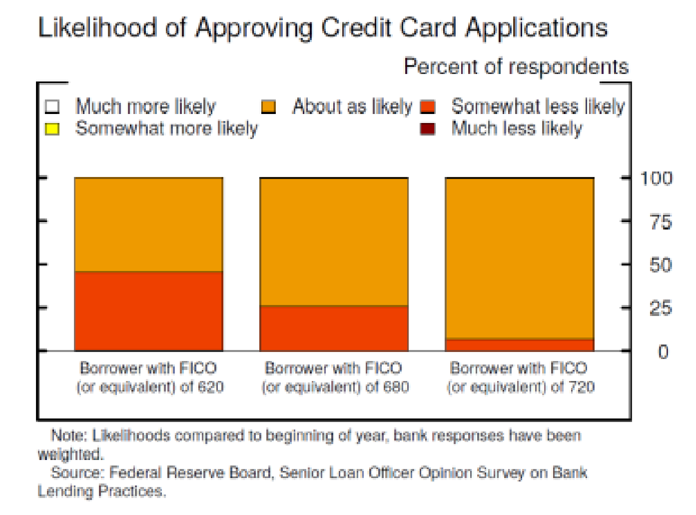
Note: Results are reported as standard deviations from the historical mean. Before normalizing, the mean (standard deviation) was 10.2 (36).
Source: Senior Loan Officer Opinion Survey

Bank Index of Changes in Credit Card Spreads



Note: Results are reported as standard deviations from the historical mean. Before normalizing, the mean (standard deviation) was 12.1 (23.4).
Source: Senior Loan Officer Opinion Survey

Sanity check 2: standards by borrower risk



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