The Welfare Benefits of Pay-As-You-Go Financing

Paul Gertler[1] Brett Green[2] Renping Li[2] David Sraer[1]

[1]Hass School of Business
University of California, Berkeley

[2]Olin Business School
Washington University in St. Louis

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Motivation

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- Facilitates transactions, consumption smoothing, investment, etc.

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Yet, credit supply remains limited in LMICs:

- Unsecured lending close to non-existent (e.g., no centralized credit reports)
- Limited secured lending:
  - Limited collateral; costly repossession.
- Microfinance: modest effects on the average borrower (Banerjee et al, 2015)
  - Expensive, high transaction costs, low uptake, inconvenient

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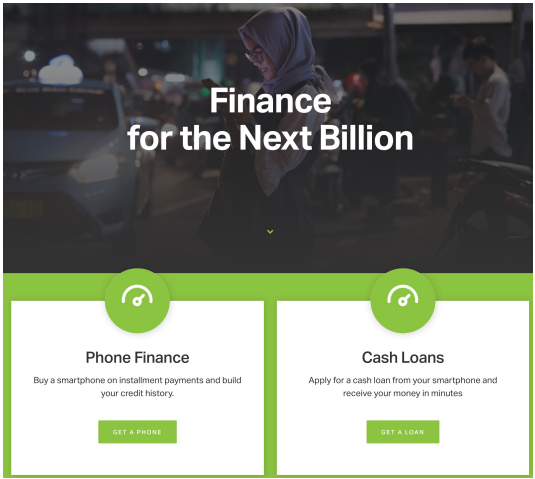
This paper: welfare analysis of PAYGo financing

- New financial contract that uses technology to "digitally" secure loans

The Promise of PAYGo?



Other Examples of Digitally Secured Lending

1. Solar Home Systems (Engie, M-Kopa)
   - Battery, solar panel, and small appliances
   - GSM chip installed in battery
   - Battery will not discharge electricity if borrower is delinquent
   - Fastest growing solar sector in Sub-Saharan Africa
2. Subprime Auto Loans (PassTime, Trax SI)
   - Interrupter installed on starter
   - Remotely activated when borrower is delinquent
3. Utilities (Telmex)
   - Finance asset purchases collateralized by access to telecom services

Related Literature: Gertler et. al. (2024)

1. Securing loans with DC significantly increases repayment and profitability
   - Default rates decrease by 19pp
2. Decomposition
   - $\approx 2/3$ due to moral hazard
   - $\approx 1/3$ due to selection
3. Consumer outcomes appear promising
   - Reasonably high take-up
   - Significant increase in investment
   - No evidence of a “debt trap"
   - Overall welfare effects?

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3. Consumer outcomes appear promising
   - Reasonably high take-up
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   - No evidence of a “debt trap"
   - Overall welfare effects?
4. Securing loans with DC is not without cost
   - Median consumer is locked 25% of days
   - Flexible repayment: feature or bug? room for improvement?

Related Literature

Reduced form Evidence of Information Asymmetries in Contracting

- Karlan and Zinman (2009), Hertzberge et al (2018), Indarte (2023), Agarwal et al (2010), Dobbie and Skiba (2013), Gupta and Hansman (2022), Stroebel (2016), Indarte, 2023).

Structural Models of Credit Markets

- Adams et al (2009), Einav et al (2012), Xing (2023), DeFusco et al (2022), Cuesta and Sepulveda (2021)

Secured Lending in LMICs

- Jack et al (2023), Gertler et al (2024),

This Paper

- Reduced-form evidence using data from a pricing experiment conducted by a fintech lender offering PAYGo financing for smartphones in Mexico
  - Heterogeneity across risk scores
  - Selection on maturity choice
  - Inconsistent repayment
- Estimate a structural model to match the 4x2 pricing experiment
  - Variation in both interest rates and down payments
  - Complication: maturity choice (+ take-up, repayment, elasticities)
- Counterfactual analysis
  - Quantify welfare effects of PAYGo financing
  - Effect of lockout on moral hazard and adverse selection
  - Welfare maximizing lockout

Main Results

- Our findings suggest a sizeable welfare gain.
  - Corresponds to 5.8% increase in income when averaged across risk scores compared to a no financing benchmark.
  - Larger for low-risk consumers and those with intermediate income
  - Welfare gains of 3-5% compared to a secured lending benchmark under reasonable assumptions about the repossession technology.
- PAYGo financing is also highly profitable for the lender
  - With competitive pricing, welfare gains for consumers are 2-3x larger
- Lender profit is concave in lock strength
  - Weaker lock $\implies$ more insurance, but higher prices
  - For low risk: welfare strictly increasing in lock strength
  - For high risk: welfare is hump-shaped in lock strength

A PAYGo Contract: $\Gamma = (D, T, \theta)$

- D: minimum down payment
- T: number of total (weekly) payments
- θ: multiple

If p: phone price; d_i: actual down payment $\Rightarrow$ loan amount: $p - d_i$

$$\Rightarrow \text{Periodic payment} : m = \frac{\theta(p - d_i)}{T}$$

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Consumers select from menu of 4 contracts based on maturity $T \in \{13, 26, 39, 52\}$

- θ specific to each maturity (longer more expensive)
- D function of internal risk score (1 = lowest, 4 = highest risk)

Pricing Experiment

- 4 multiple arms $\times$ 2 downpayment arms, $\approx$ 30,000 consumers:

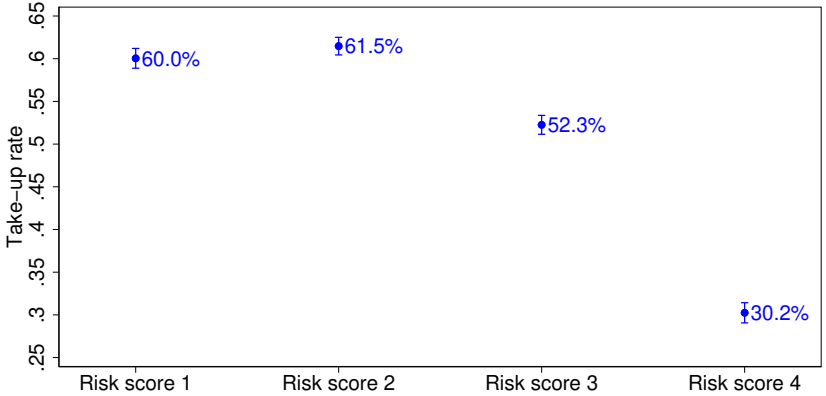
Panel A: Pricing Arms

	Ctrl	Medium	High	Steep
3 month	1.36	1.4	1.55	1.4
6 month	1.54	1.63	1.8	1.7
9 month	1.64	1.8	2	1.95
12 month	2	2.2	2.4	2.5

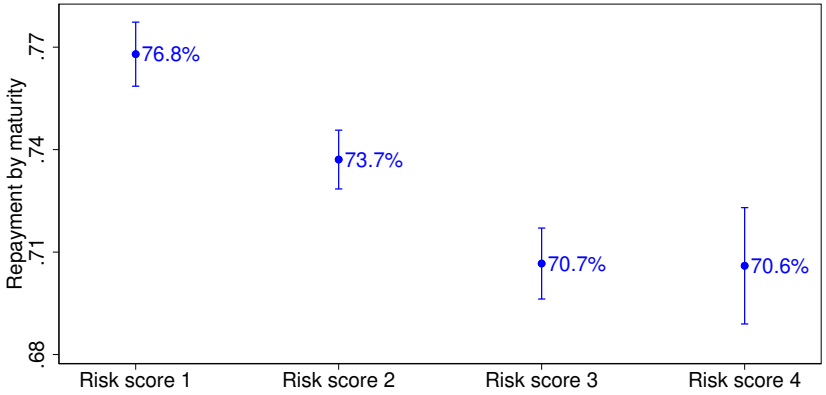
Panel B: Downpayment Arms

	Control	Lower
Risk score 1	25%	20%
Risk score 2	30%	25%
Risk score 3	35%	30%
Risk score 4	50%	40%

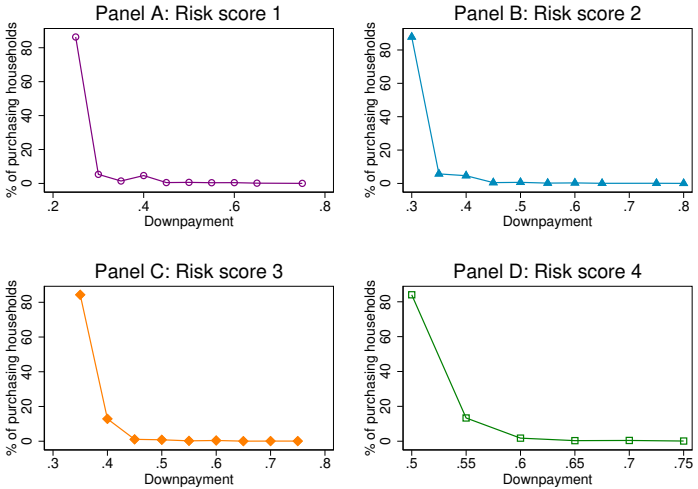
Take-up by Risk Score



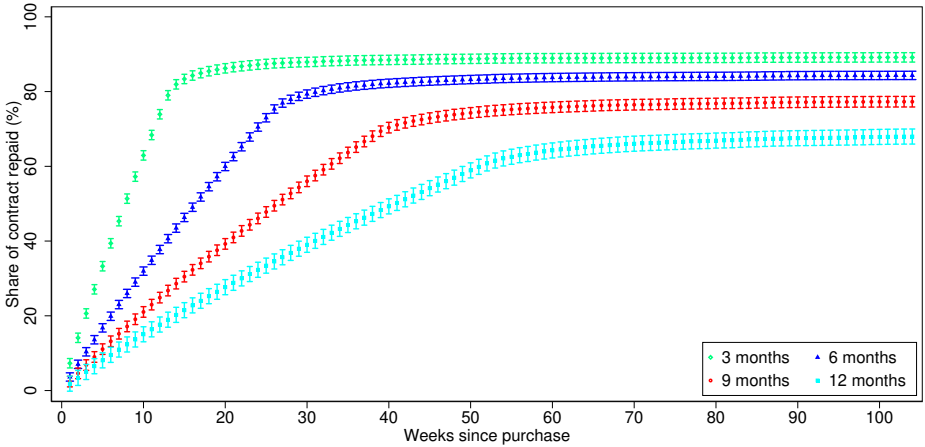
Repayment by Risk Score



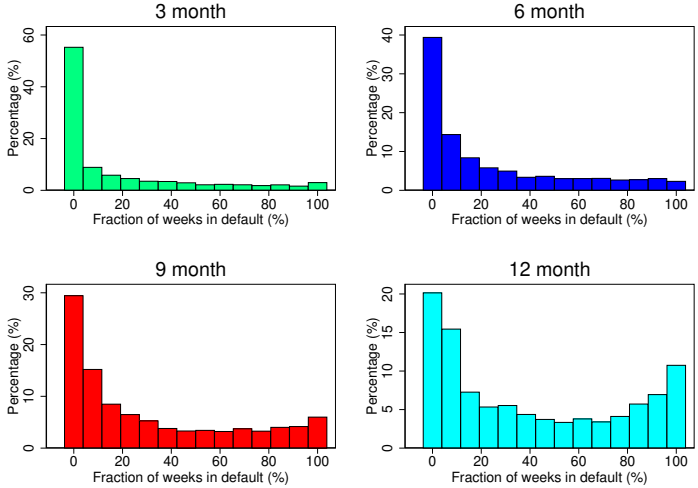
Downpayment by Risk Score



Repayment by Maturity



Default by Maturity



Structural Model

Consumers

Income:

- Heterogeneous long-run mean income, $\bar{y}_i$ (log-normally distributed)
- Consumer i income at date t, y_{it}
  - Persistent and mean reverting
  - $\log y_{it}/\bar{y}_i$ follows AR(1) process with constant drift
- Distribution of income is stationary over time in the cross-section
- Consumer i privately knows $(\bar{y}_i, y_{i0})$ when deciding whether to finance the purchase of the good

Consumers

Preferences:

- Quasi-linear utility: $u(c_{it})$ for consumption good, v_{it} for device
- CRRA utility function with risk aversion coef. γ
- Discount factor β

Wealth and savings:

- No access to external borrowing/savings technologies during repayment period
- Marginal cost for withdrawing liquidity μ_i
  - Shortcut to layering on a consumption/savings problem

Consumers

Device value:

- v_{it} is the flow utility from consuming the phone at date t
- $v_{i0} = \bar{v}_0$ on the day of purchase
- In each period, the phone depreciates with probability ϕ, upon which v_{it} becomes $\max(v_{it-1} - \bar{v}_0/N_v, 0)$

State Variables

Let $U_i(x|\Gamma)$ denote the value function of consumer i under contract Γ (arguments regularly suppressed)

- The state variables are $x = (v, y, n, m)$, where
  - v is flow utility from consuming the phone
  - y is current income
  - n is number of payments remaining
  - m is periodic payment

Consumer Bellman Equation

- For $n \geq 1$, the Bellman equation for the household is

$$U_i(v, y, n, m) = \max \Big\{ v + u(y - m) + \beta \mathbb{E}[U_i(v', y', n - 1, m)|x)], \\ (1 - \lambda)v + u(y) + \beta \mathbb{E}[U_i(v', y', n, m)|x] \Big\}$$

  where λ denotes the "strength" of the lockout technology

- The optimal policy of the individual is to make the payment if

$$\lambda v + \beta \mathbb{E}[U_i(v', y', n - 1, m) - U_i(v', y', n, m)|x] \geq u(y) - u(y - m)$$

Consumer Value Function

- The ownership boundary condition ($n = 0$) is

$$U_i(v, y, 0, m) = \Pi_i(v, y)$$

where

$$\Pi(v, y) = v + u(y) + \beta \mathbb{E}[\Pi(v', y')|x]$$

is the lifetime expected utility from being permanently “unlocked"

- We use VFI to solve for the optimal policy and value function.

Down Payment Decision

- Consumers face a menu of contracts $M = \{\Gamma_3, \Gamma_6, \Gamma_9, \Gamma_{12}\}$, corresponding to the 4 possible maturities (3, 6, 9 and 12 months)
- Conditional on choosing a contract Γ_j, the consumer chooses any downpayment $d_i \geq D_j$
- Down payment is made out of current income and wealth, $y_{i0} + L_i$
- The remainder is optimally consumed or saved

The Ex-Ante Value of a Contract

Fixing an “affordable" contract for a consumer (i.e., $y_{i0} + L_i \geq D_j$), the consumer's ex-ante value for Γ_j is

$$
\begin{aligned}
W_i(\Gamma_j) = \max_{c_{i0}, L_i} \; & v_{i0} + u(c_{i0}) - \mu_i L_i + \beta \mathbb{E}[U_i(v_{i1}, y_{i1}, T, m(d_i)) | v_{i0}, y_{i0}] \\
s.t. \quad & c_{i0} + d_i \leq y_{i0} + L_i, \\
& d_i \geq D_j, \\
& c_i, L_i \geq 0.
\end{aligned}
$$

Outside Option

- Consumers can buy with cash for price p at any future date
- This real option has value

$$O_i(y_{it}) = \max\left\{u(y_{it}) + \beta\mathbb{E}[O_i(y_{i,t+1})|y_{it}], G_i(y_{it})\right\}.$$

where $G_i(y_{it})$ is the value from purchasing with cash.

Contract Selection

- The maturity of the contract they select is partially determined by a random utility shocks ω_{ij}, which are i.i.d. across individuals and contracts.

$$\omega_{ij} \sim \mathcal{N}(0, \sigma_\omega^2)$$

- Consumers accept a contract from the menu M if and only if

$$\max_{\Gamma_j \in M} W_i(\Gamma_j) + \xi_j + \omega_{ij} \geq O_i$$

- Conditional on purchasing the good, the contract selected by an individual when facing the menu M is determined by:

$$\max_{\Gamma_j} W_i(\Gamma_j) + \xi_j + \omega_{ij}$$

Estimation

Estimation

- Parameters to estimate:
  - Distribution and evolution of income: $\{\bar{y}, \sigma_{\bar{y}}, \sigma_\epsilon, \rho\}$
  - Cost of withdrawing liquidity: $\{\mu\}$
  - Device value and depreciation: $\{\bar{v}_0, \phi\}$
  - Individual's time preference: $\{\beta\}$
  - Size of maturity-choice shocks: $\{\sigma_\omega\}$
  - Fixed effects for maturity-choice: $\{\xi_3, \xi_6, \xi_9\}$
- Calibrated parameters: $\gamma = 1$, $\lambda = 1$, $N_v = 1$, and σ_{12} is normalized to be 1
- We estimate the model separately for each risk score.

Estimation

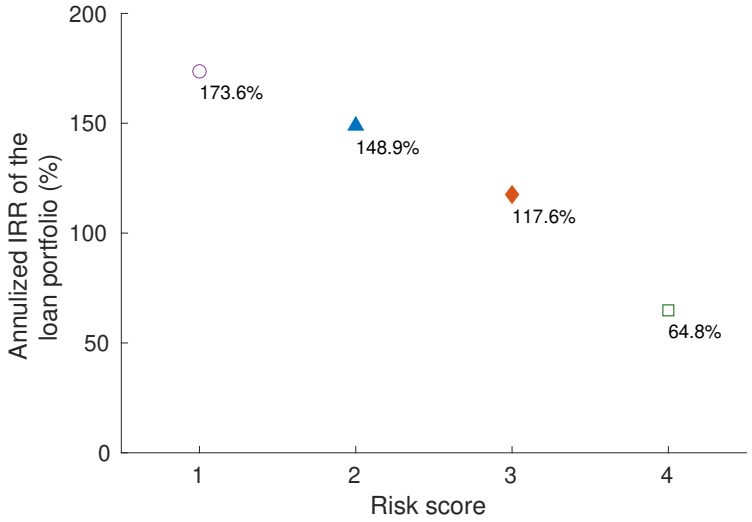
- We use Simulated Method of Moments (SMM)
- Model estimated using 4 treatment groups and validated with the remaining 4
- Each treatment group has 13 moments
  - $m_1 - m_4$: Shares purchasing 3/6/9/12 months
  - $m_5 - m_8$: Average proportion repaid by maturity for 3/6/9/12 months
  - m_9: Average repayment of first minus second half of repayment period
  - m_{10}: Share of perfect repayers
  - m_{11}: Conditional probability of resuming payment
  - m_{12}: Share of defaulters
  - m_{13}: Share of putting minimum down payment
- For each risk score, we have 13 parameters to estimate from 52 moments.

Estimates

Risk Score	1	4
Income process parameters:		
$\bar{y}$ (mean income, \$/week)	35.02	28.32
	(1.53)	(2.12)
$\sigma_{\bar{y}}$ (income dispersion)	1.18	0.90
	(0.03)	(0.11)
σ_ϵ (income shock size)	0.36	0.43
	(0.02)	(0.03)
ρ (mean-reversion coef.)	0.11	0.81
	(0.07)	(0.05)
$\bar{L}$ (avg. initial wealth, \$)	152.58	75.19
	(42.14)	(4.18)
σ_L (dispersion of initial wealth)	0.64	0.42
	(0.15)	(0.08)

Risk Score	1	4
Device value parameters:		
v_0 (initial device value)	27.17	29.75
	(3.00)	(3.77)
ϕ (prob. of depreciation, weekly)	0.0106	0.0161
	(0.0004)	(0.0008)
Other consumer preference parameters:		
β (weekly discount rate)	0.988	0.990
	(0.001)	(0.003)
μ (value of savings)	3.92	3.83
	(0.53)	(0.48)

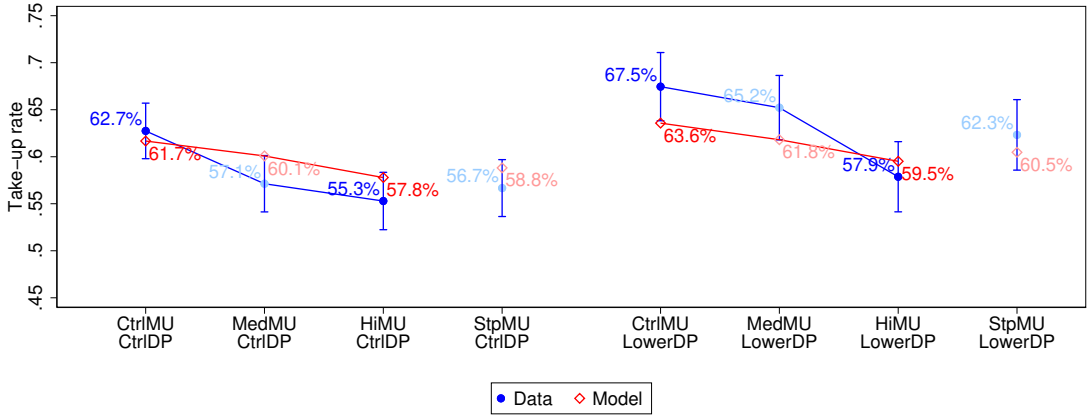
Model Implied Heterogeneity in Profitability



Model Fit and Validation

Model Fit and Validation: Take-up for Risk Score 1

Figure: Take-up in Actual (blue) vs Simulated Data (red), Risk Score 1



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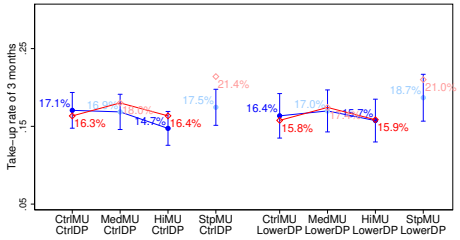
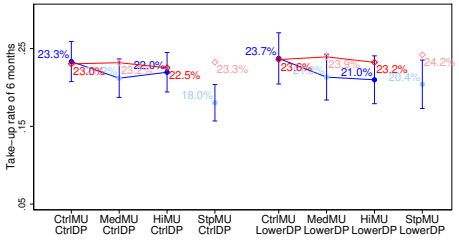
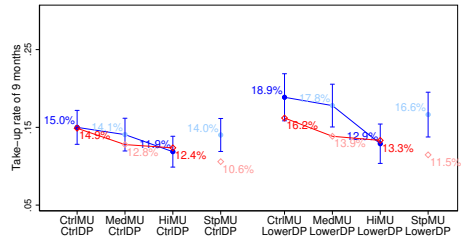
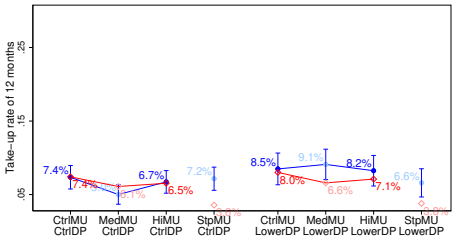
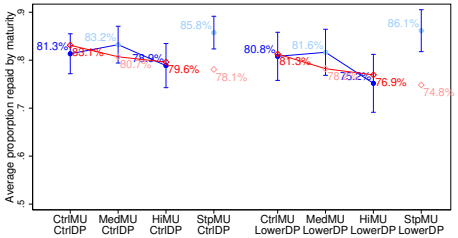


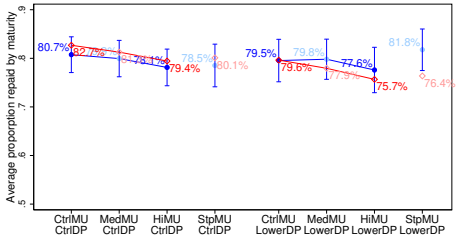


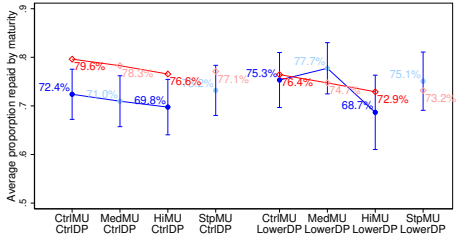


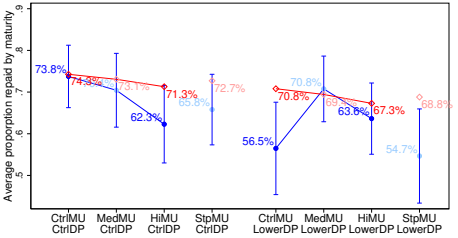


Model Fit and Validation: Repayment for Risk Score 1



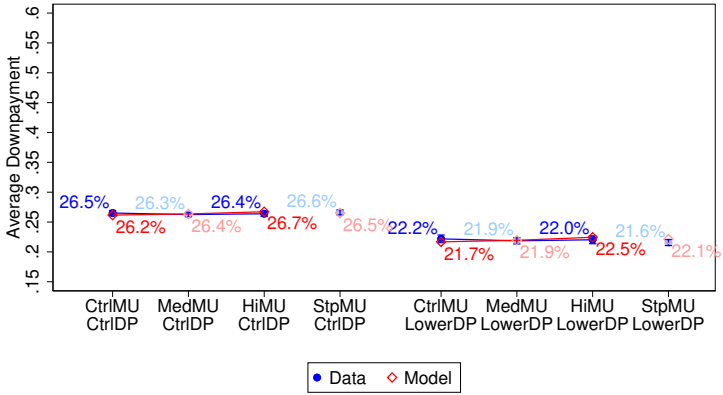






Model Validation

Figure: Average Down Payment in Actual and Simulated Data, Risk Score 1



Welfare and Profitability

Welfare Measure

- $\mathcal{W}_i$ is the percentage increase in weekly income over a two-year period that would deliver the same utility to the consumer as they enjoy from having access to the menu of PAYGo contracts.
  - Outside option: buy with cash or not at all (i.e., no access to other financing)

- Formally, $\mathcal{W}_i$ solves:

$$\max\{W_i(\Gamma_i^*), O_i(y_{i0})\} = \hat{O}_i(\hat{y}_{i0})$$

where

$$\hat{y}_{it} = \begin{cases} (1+\mathcal{W}_i)y_{it} & t \leq 104 \\ y_{it} & \text{otherwise} \end{cases}$$

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- Average welfare among takers: $\mathcal{W}_{taker} \equiv \mathbb{E}[\mathcal{W}_i | i \text{ accepts a contract}]$
- Average welfare in the sample: $\mathcal{W}_{pop} \equiv \mathbb{E}[\mathcal{W}_i]$

Consumer Welfare

- Baseline treatment group: $\mathcal{W}_{taker} = 11.3\%$.
  - Take-up rate is 63%, so $\mathcal{W}_{pop} = 6.7\%$.
- Across the different pricing arms, the welfare estimates for takers are in the range of 9-12% for risk score 1 and 3.
- Welfare effects are highest in risk score 2 (12-16%) and smallest for risk score 4 (5-7%).
- Across all risk scores: $\mathcal{W}_{taker} = 10.9\%$ and $\mathcal{W}_{pop} = 5.8\%$

Firm Profitability

Welfare gains might be hindered by market power:

- Firm profitability measured as average contract NPV
  - Assuming a firm annual discount rate of 25% and per-unit cost of \$200

  $\Rightarrow$ \$ 37.3 for baseline treatment group
- Firm profitability measured as the IRR of actual contracts' portfolio

  $\Rightarrow$ 201.0 % for baseline treatment group

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$\Rightarrow$ what would be welfare gains under competitive pricing?

Competitive Pricing

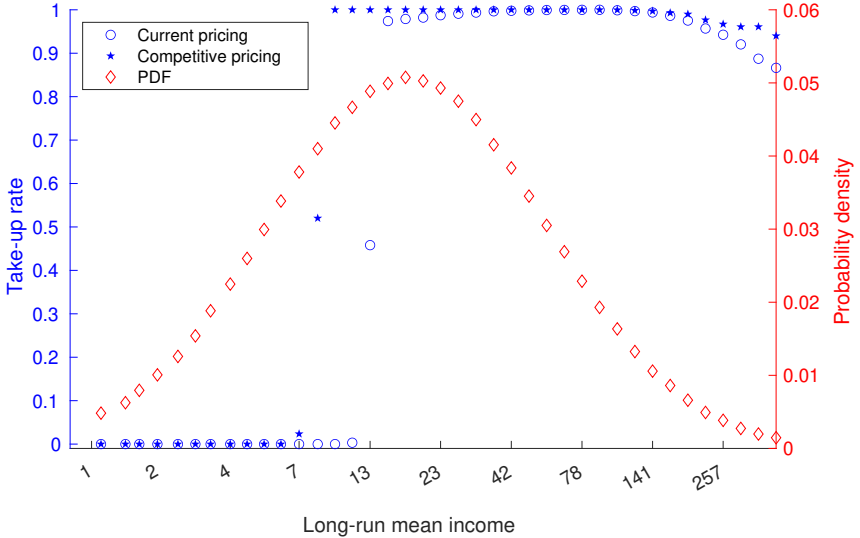
Competitive Pricing

- We solve for the 12 month contract that maximizes consumer welfare while yielding zero firm profit

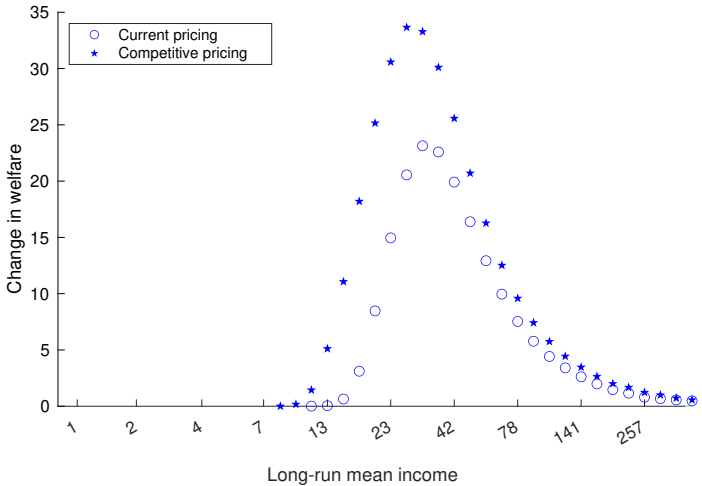
Competitive Pricing

Treatment group	(1) Markup for 12 month	(2) Minimum downpayment
Risk score 1		
CtrlMarkupCtrlDown	2.00	25.0%
Competitive Pricing	1.50	4.9%
Risk score 2		
CtrlMarkupCtrlDown	2.00	30.0%
Competitive Pricing	1.55	4.0%
Risk score 3		
CtrlMarkupCtrlDown	2.00	35.0%
Competitive Pricing	1.60	0.0%
Risk score 4		
CtrlMarkupCtrlDown	2.00	50.0%
Competitive Pricing	1.85	11.8%

Take-up under Competitive Pricing, Risk Score 1



Welfare by Income, Risk Score 1



Summary of Welfare Results

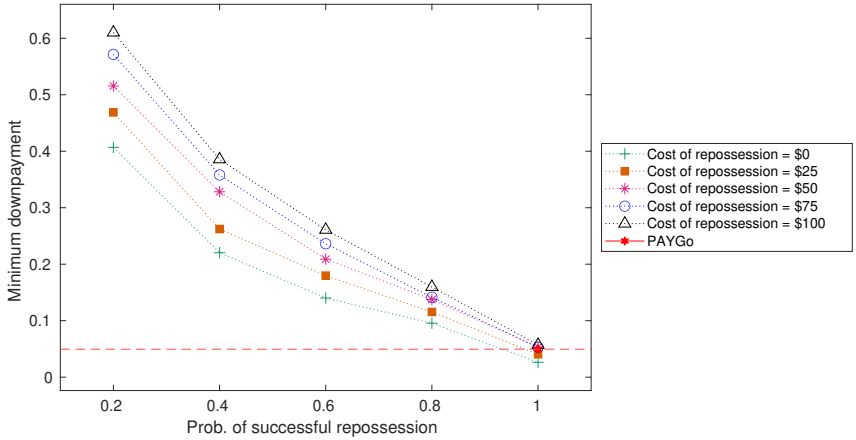
Treatment Group	(1) Take-up	(2) $\mathcal{W}_{taker}$	(3) $\mathcal{W}_{pop}$	(4) NPV	(5) IRR
Risk score 1					
LowMarkupCtrlDown	62.8%	11.3%	6.7%	37.3	201%
HighMarkupCtrlDown	55.3%	10.0%	5.5%	64.5	444%
LowMarkupLowerDown	67.5%	11.7%	7.2%	36.3	176%
Competitive Pricing	74.2%	16.3%	12.1%	0.0	25%
Risk score 2					
LowMarkupCtrlDown	61.3%	13.0%	7.8%	34.8	181%
HighMarkupCtrlDown	55.8%	12.2%	7.1%	59.7	391%
LowMarkupLowerDown	68.4%	15.5%	10.3%	35.5	164%
Competitive Pricing	94.4%	24.6%	23.2%	0.0	25%
Risk score 3					
LowMarkupCtrlDown	50.9%	9.9%	5.7%	26.8	143%
HighMarkupCtrlDown	48.9%	9.1%	4.5%	53.7	326%
LowMarkupLowerDown	59.7%	10.6%	7.0%	22.8	109%
Competitive Pricing	99.7%	22.2%	22.1%	0.0	25%
Risk score 4					
LowMarkupCtrlDown	26.2%	6.1%	1.8%	28.3	196%
HighMarkupCtrlDown	26.0%	5.1%	1.5%	37.0	239%
LowMarkupLowerDown	38.2%	7.1%	3.2%	14.4	82%
Competitive Pricing	76.8%	11.3%	8.7%	0.0	25%

Comparison to Traditional Secured Lending

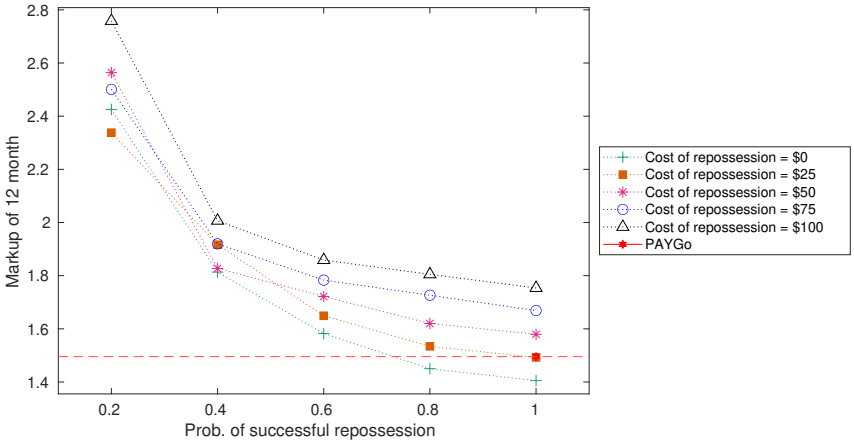
Secured Lending Counterfactual

- We simulate a counterfactual with traditional secured loans
- Firm commits to repossess after missed payment(s) at cost c_{repo}
  - If repossession successful, consumer enters autarky and firm receives phone residual value
  - If repossession unsuccessful, consumer owns the phone, and firm recovers nothing
- We use competitive prices on 12-month contracts for comparison

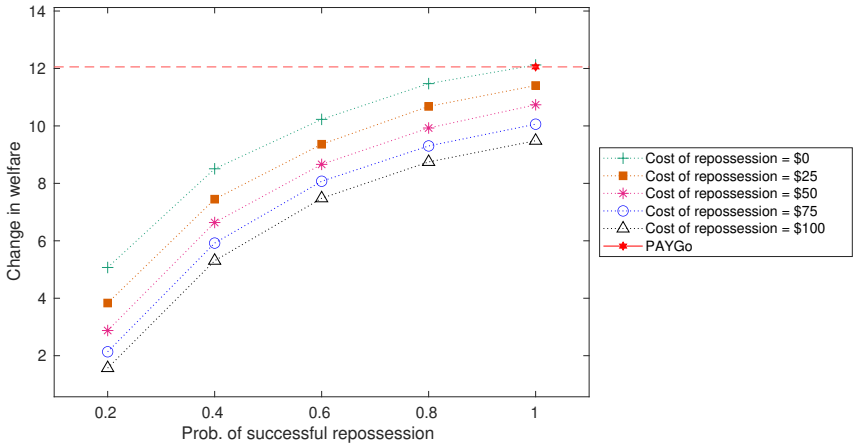
Downpayment Comparison, Risk Score 1



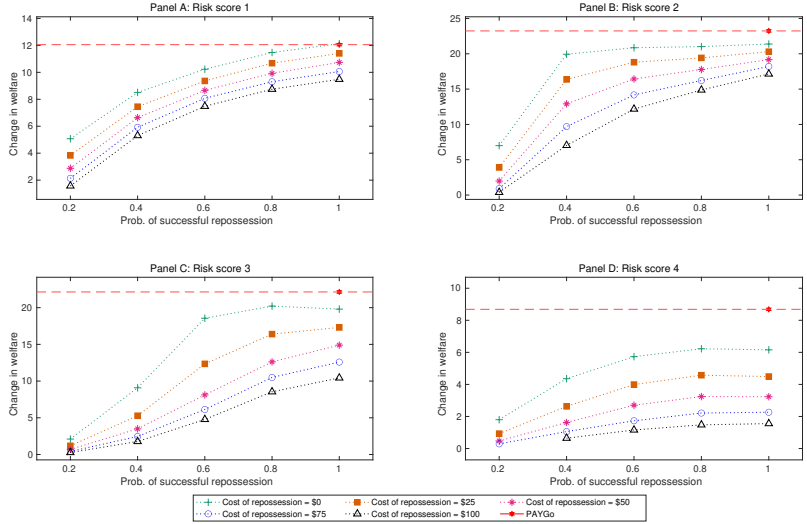
Multiple Comparison, Risk Score 1



Welfare Comparison, Risk Score 1



Welfare Gains

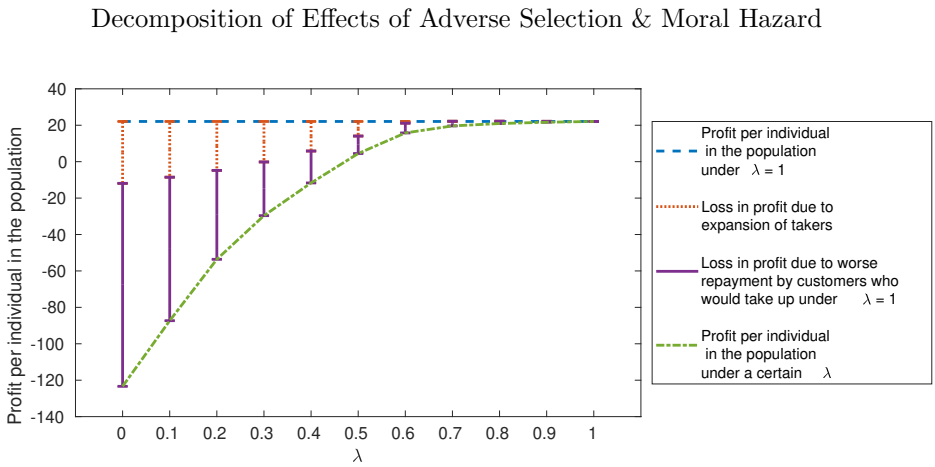


Welfare Gains: Secured Lending → PAYGo

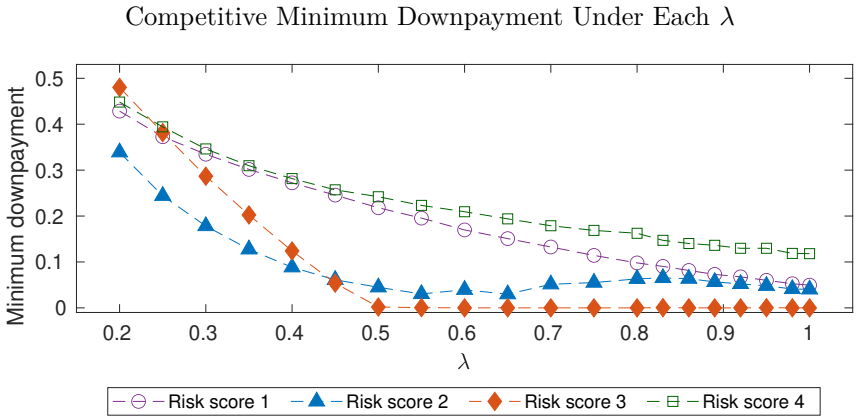
	(1) Baseline Technology $c_{\text{repo}} = \$25$, $p_{\text{repo}} = 0.8$	(2) Worse Technology $c_{\text{repo}} = \$50$, $p_{\text{repo}} = 0.6$	(3) Better Technology $c_{\text{repo}} = \$0$, $p_{\text{repo}} = 1$
Risk score 1	2.0%	4.1%	1.0%
Risk score 2	4.0%	6.3%	2.8%
Risk score 3	4.8%	12.6%	2.8%
Risk score 4	5.4%	8.8%	3.1%

Comparative Statics on Strength of Lock λ

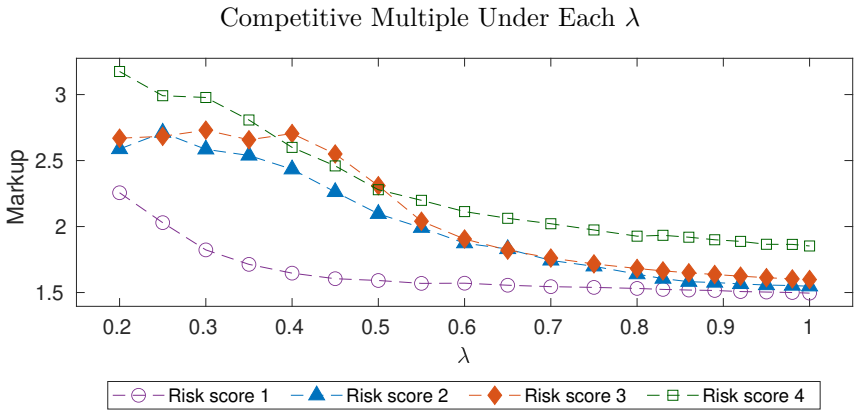
Decomposition of Effects of λ



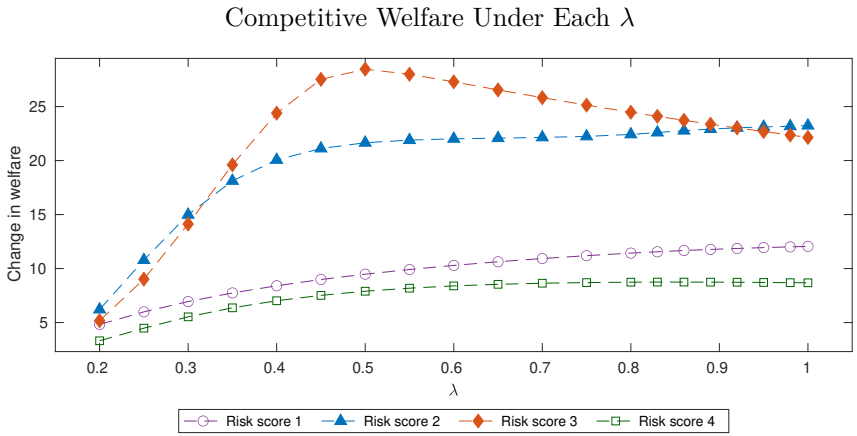
Optimal Lockout



Optimal Lockout



Optimal Lockout

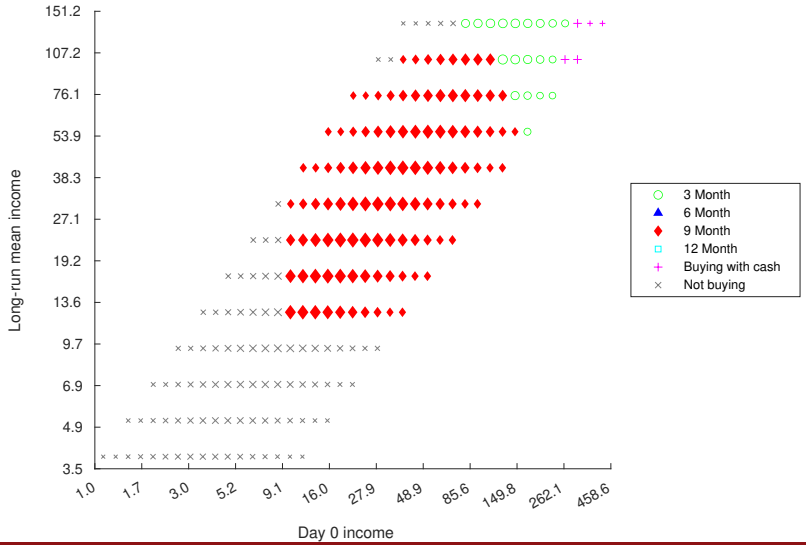


Conclusion

- The welfare gains to consumers from access to PAYGo financing are significant, corresponding to a 5.8% increase in income.
  - Gains are largest for less risky and intermediate income individuals.
- PAYGo lending remains highly profitable for the lender
  - Under competitive pricing, the welfare gains are 2-3x larger
- An intermediate strength of lock can be welfare maximizing for high risk consumers

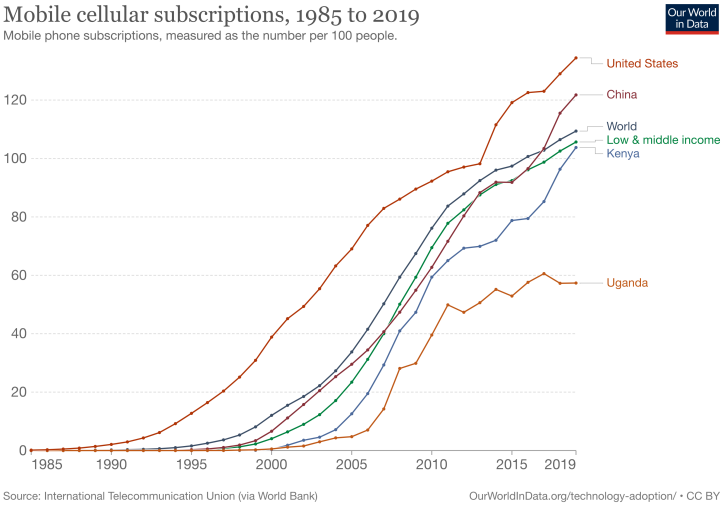
Supplemental slides

The Economics of Maturity Choice



Maturity Choice by $\bar{y}_i$ and $y_{i0}/\bar{y}_i$

Rapid Adoption



Rapid Adoption