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

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Motivation

- Consumer lending markets are frought with economic frictions
  - Adverse selection, moral hazard, limited commitment, etc.
- To overcome them, lenders use sticks to discourage default
  - "A pound of flesh"
  - Collateral repossession
- Technology is making this cheaper for the lender
  - Lenders can remotely 'lock' collateral at zero marginal cost
  - Enlarges the space of feasible contracts

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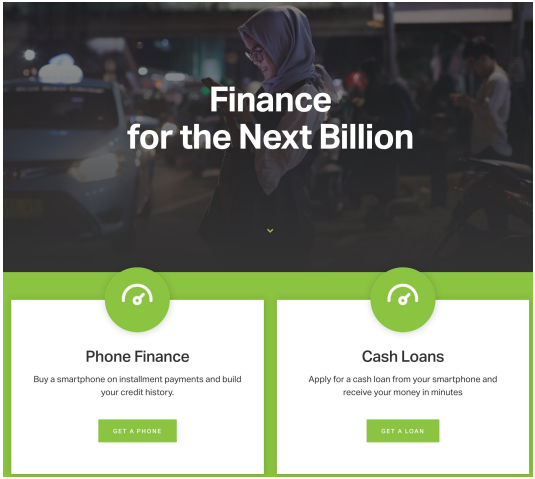
This Paper: Welfare analysis of PAYGo financing for smartphones

The Promise of PAYGo?



How Does PAYGo Financing Work?

You want to buy $200 smart phone, but you don't have $200.

- You apply for financing in the store. You are presented with a menu of different maturities and multiples. All require a 25% minimum downpayment.
- You select the 6-month maturity, which has a multiple of 1.54.
- You make the minimum downpayment and finance the remaining $150.

$$\text{Weekly payment} = \frac{\text{Loan Amount} \times \text{Multiple}}{\text{Number of payments}} = \frac{150 \times 1.54}{26} = \$8.88$$

- If you miss a payment, your phone locks (i.e., is unusable) until you make a payment.
- The phone permanently unlocks after you make your 26^{th} payment.
  - Regardless of when that payment is made.

How PAYGo differs from a Traditional Loan Contract

1. No pecuniary consequences for missing payment (i.e., fees or accrued interest).
   - Subject of debate among practitioners. Other models being used/explored.
2. Interest rate depends on repayment behavior
   - Faster repayment=higher interest rate + less frequently locked
3. Collateral is not repossessed in default
   - Lockout substitutes for repossession in screening/incentive provision
   - Locking is ex-post inefficient

Other Applications 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
   - Several states have restricted or banned this tactic

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3. Telecommunications (Verizon, AT&T)
   - Loan is collateralized by access to telecom services
   - Financed phones are "locked" to the provider

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
  - Consistently inconsistent repayment
- Estimate a dynamic structural model to match the 4x2 pricing experiment
  - Exploit variation in both multiples and required downpayments
  - Identify “deeper" primitives from maturity choice and repayment (+usage) behavior
- Use the estimated model for counterfactual analysis
  - Quantify welfare effects of PAYGo financing
  - Decompose the effect of lockout on moral hazard and adverse selection
  - Quantitatively explore trade-offs in contract design: incentives vs insurance

Main Results

- Our findings suggest a sizeable welfare gain, primarily driven by low-risk borrowers.
  - Corresponds to 3.4% increase in income when averaged across risk scores
  - Larger welfare gains those with intermediate income
  - PAYGo outperforms secured lending for low risk borrowers
- PAYGo financing is also highly profitable for the lender
  - With competitive pricing, welfare gains for consumers are 30-50% larger
- Contract design
  - Leniency can increase welfare gains
  - Harsher punishments for missed payments cannot

Related Literature

Reduced-Form Evidence of Information Asymmetries in Contracting

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

Structural Models of Credit Markets

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

Selection Markets

- Einav et al. (2010a), Einav et al (2010b), Einav et al (2010c), Cardon and Hendel (2001), Einav et al. (2013), Handel (2013), ...

Secured Lending in LMICs

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

Pricing Experiment

- 4 multiple arms $\times$ 2 downpayment arms, $\approx$ 30,000 customers in Mexico

Panel A: Pricing Arms

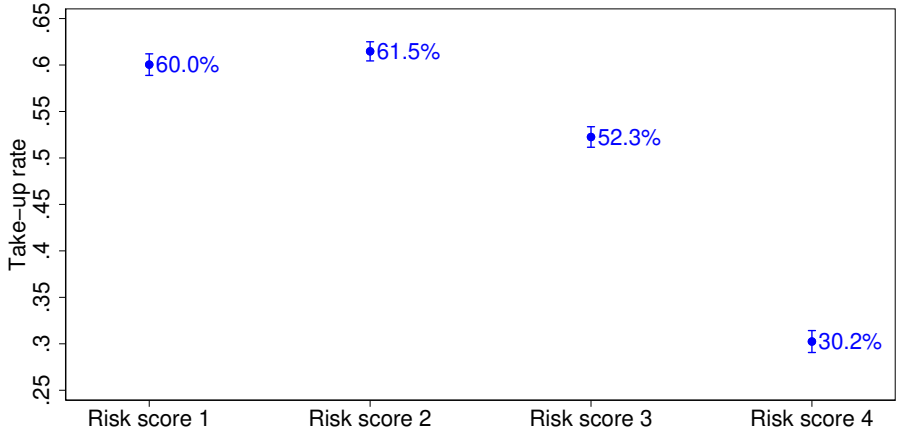
	Ctrl	Medium	High	Steep
3 month	1.36	1.4	1.55	1.4
6 month	1.54	1.63	1.8	1.7
9 month	1.64	1.8	2	1.95
12 month	2	2.2	2.4	2.5

Panel B: Downpayment Arms

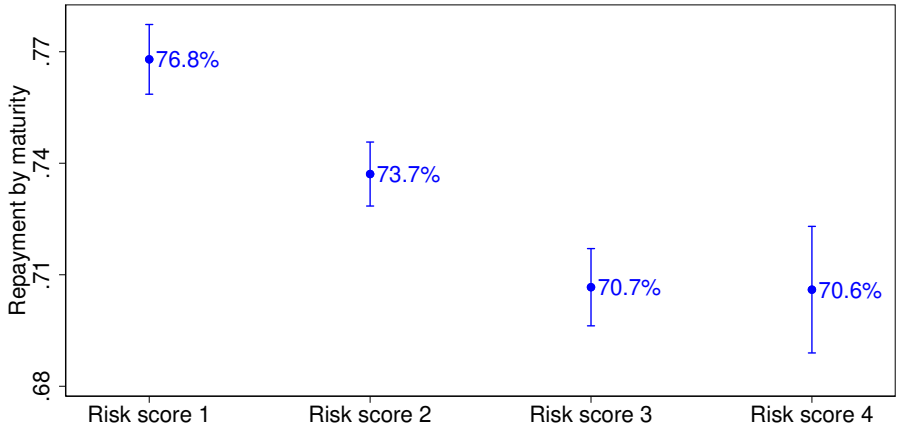
	Control	Lower
Risk score 1 (lowest risk)	25%	20%
Risk score 2	30%	25%
Risk score 3	35%	30%
Risk score 4 (highest risk)	50%	40%

- Multiples imply weekly APR of 3-5% for on-time repayers

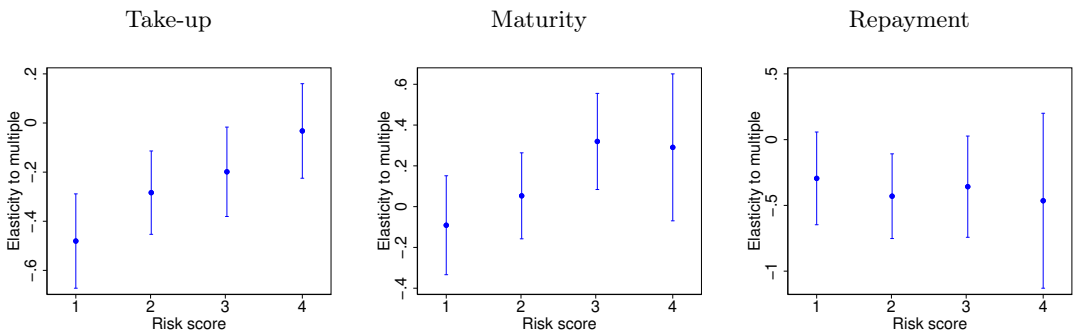
Take-up by Risk Score



Repayment by Risk Score

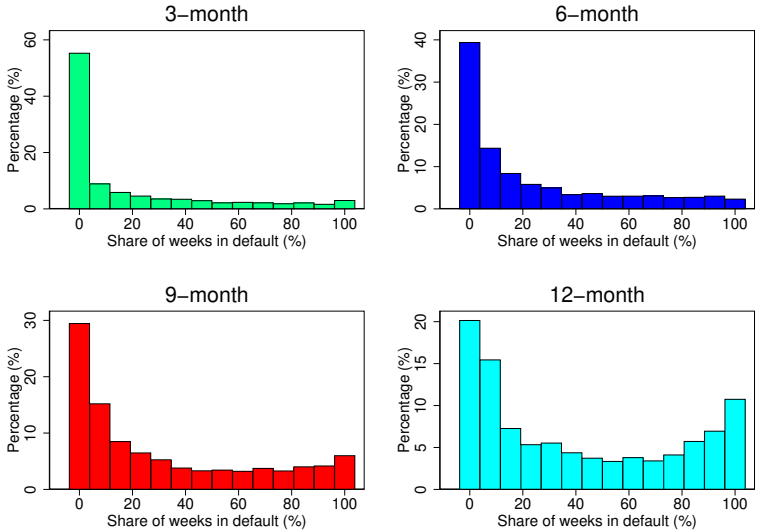


Reduced-Form Evidence: Heterogeneity Across Risk Scores



- Low risk more elastic to multiple. High risk lengthen maturity.
- Repayment decreases with multiple (consistent with MH or AS)
  - Repayment elasticity is 1/3 of what De Fusco et. al. (2022) find for unsecured loans

Reduced-Form Evidence: Selection on Maturity, Inconsistent Repayment



Model

Model Overview

Firm

- A firm produces a good that delivers flow utility to consumers.
- The firm offers a menu of PAYGo contracts to each consumer based on their risk score.

Consumers

- Rational agents with time-separable, quasilinear utility $u(c_{it}) + q_{it}$.
- Heterogeneous private income subject to iid shocks: $y_{it} = \bar{y}_i + \epsilon_{it}$.
- Usage value for the good, v_{it}, which depreciates stochastically.
- Face three types of decisions in the model.
  1. Take-up and maturity choice
  2. Downpayment choice
  3. Repayment

The Economics of the Repayment Decision

- While in repayment, the Bellman equation for the consumer 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 lock.

- Optimal to make the payment if

$$\underbrace{\lambda v}_{\text{usage value}} + \underbrace{\beta \mathbb{E}[U_i(v', y', n - 1, m) - U_i(v', y', n, m)|x]}_{\text{principal reduction}} \geq \underbrace{u(y) - u(y - m)}_{\downarrow \text{ consumption}}$$

- Reasons for non-repayment:
  1. Negative income shocks
  2. Depreciation shocks

Boundary Condition

- The ownership boundary condition is

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

where

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

is the lifetime expected utility from being permanently "unlocked"

The Ex-Ante Value of a Contract

- Fixing a contract, the consumer must choose how much to put down
- The ex-ante value for Γ^j is

$$
\begin{aligned}
W_i(x|\Gamma^j) = \max_{L,d,c} \; & v + u(c) - \mu_i L + \beta \mathbb{E}[U_i(v', y', j, m(d))|x] \\
s.t. \quad & c + d \leq y + L \\
& d \geq D^j \\
& c, L \geq 0 \\
& m(d) = \frac{\theta^j (p - d)}{j}
\end{aligned}
$$

Outside Option

- Consumers can buy with cash for price p at any future date (or never)
- This real option has value

$$O_i(y) = \max\left\{u(y) + \beta\mathbb{E}[O_i(y')|y], G_i(y)\right\}$$

where $G_i(y)$ is the value from buying with cash.

$$\begin{aligned} G_i(y) = &\max_{L,c} v_0 + u(c) - \mu_i L + \beta\mathbb{E}[\Pi_i(v', y')] \\ \text{s.t. } &c + p \leq y + L \\ &c, L \geq 0 \end{aligned}$$

Contract Selection

- Each consumer faces a menu of contracts $\mathcal{M}_i = \{\Gamma_j\}_{j \in J}$
  - Longer maturity $\Rightarrow$ more payments but lower weekly payment
- Consumers choose the contract that solves

$$\Gamma_j^* = \arg \max_{\Gamma^j \in \mathcal{M}_i} W_i(\Gamma^j) + \xi_j + \omega_{ij} \geq O_i$$

- Fixed and random utility shock mirror classic logit demand system (Berry 94) and capture unmodeled heterogeneity
  - ξ_j fixed effect, ξ_6 normalized to zero
  - ω_{ij} mean-zero, random utility shock

Estimation

Estimation

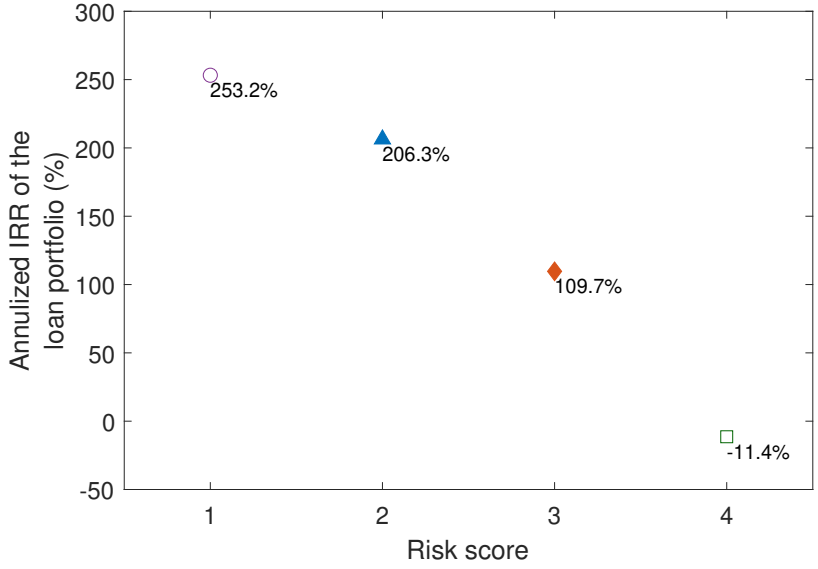
- We estimate the model using Simulated Method of Moments (SMM)
  - Employ the Tik-tak algorithm (Guvenen, 2011; Arnoud et al., 2019)
  - 50,000 starting points, take 100 best, then do local optimization
- Each risk score is estimated using 4 treatment groups and validated with the remaining 4 treatments
- Each treatment group has 13 moments
  - Four take-up moments
  - Eight repayment moments
  - One downpayment moment
- Assume log utility, log-normal income, $\lambda = 1$
- For each risk score, we have 11 remaining parameters to estimate from 52 moments.

Key Parameter Estimates

	RS1	RS2	RS3	RS4
$\bar{y}$ (average mean income, weekly in \$)	33.7	34.8	37.3	35.5
$\sigma_{\bar{y}}$ (dispersion of mean income)	0.98	0.87	0.86	0.97
σ_ϵ (size of income shock)	0.35	0.38	0.37	0.41
v_0 (initial usage value)	24.1	23.6	15.7	10.3
ϕ (prob. of depreciation, weekly)	0.030	0.030	0.034	0.041
β (discount factor, weekly)	0.997	0.989	0.995	0.996
μ (liquidity cost)	4.1	3.1	3.3	4.5

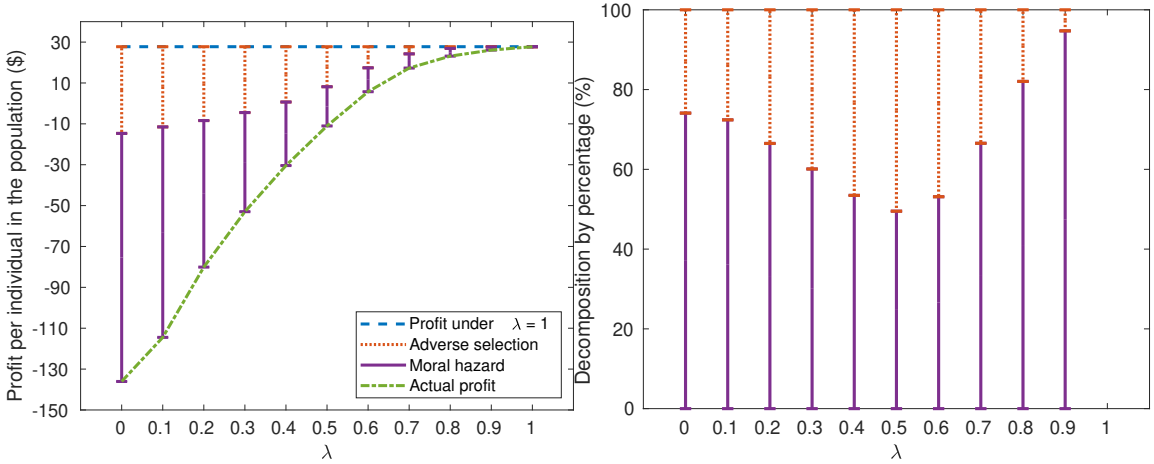
- Similar average income across risk scores, roughly minimum wage in Mexico
- Riskier consumers: more volatile income and lower usage value
- Identification of $\bar{y}$ vs v_0 by maturity choice

Model Implied Profitability by Risk Score



The Effect of Lock Strength on Lender Profits

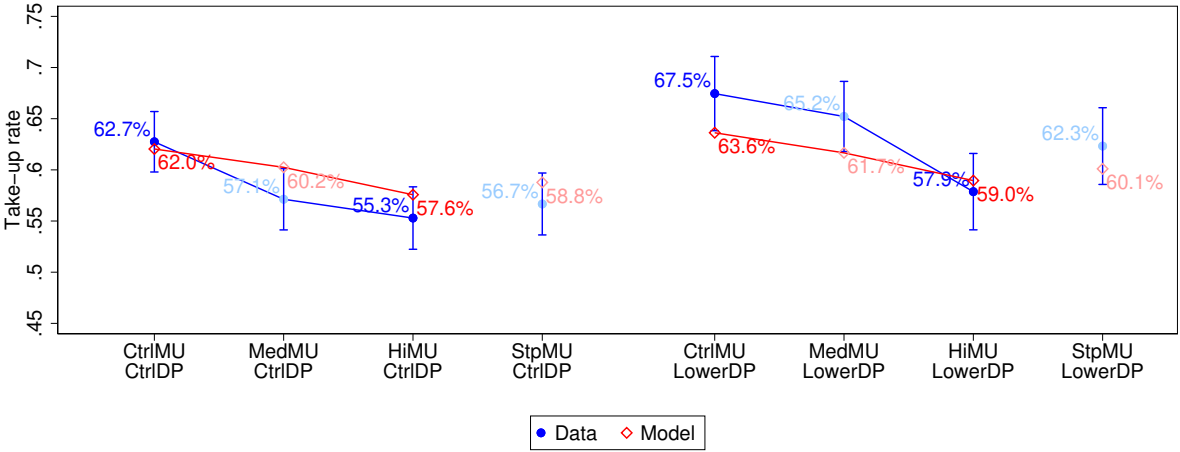
Decomposition of Effects of Adverse Selection & Moral Hazard



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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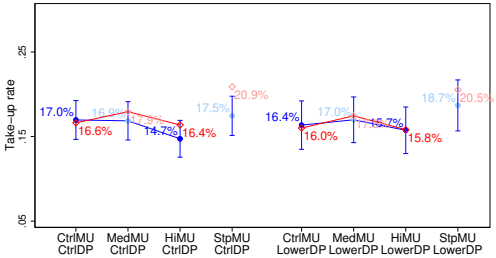
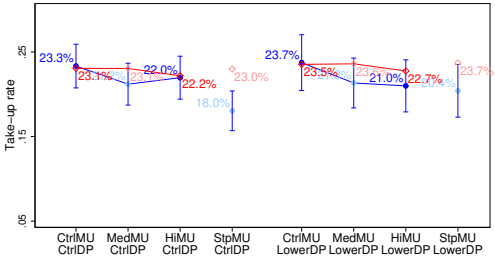
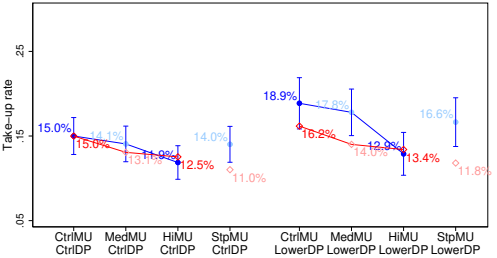
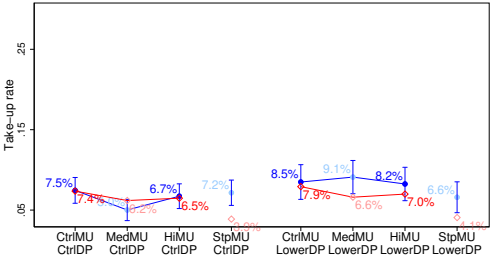
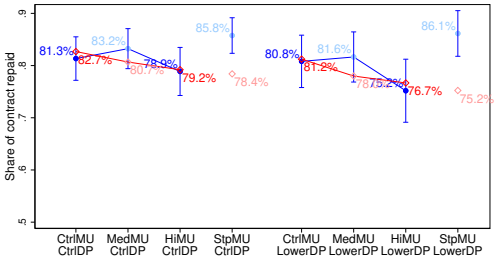


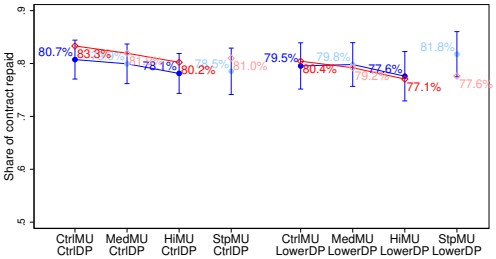


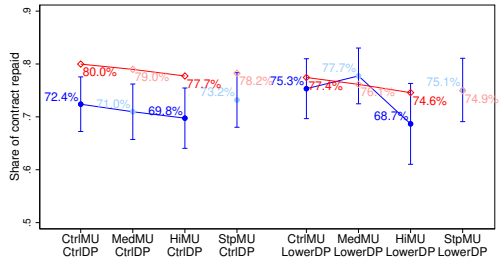


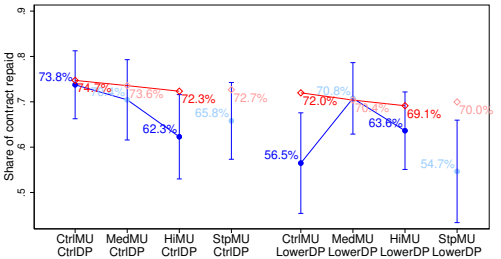


Model Fit and Validation: Repayment for Risk Score 1



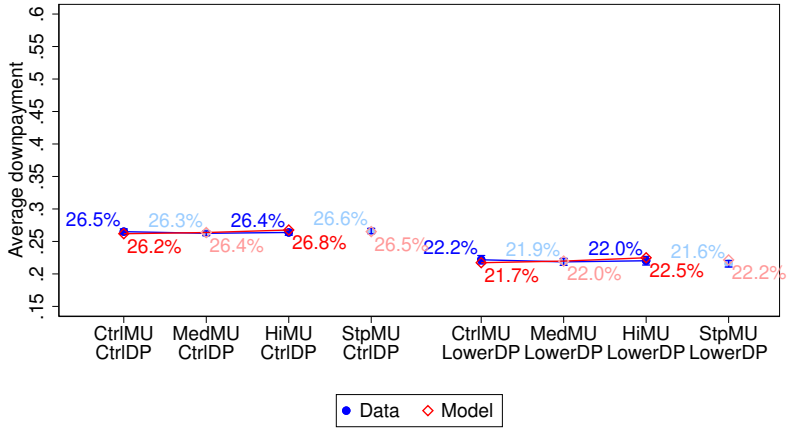






Model Fit and Validation: Average Downpayment

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



Welfare and Profitability

Welfare Measure

- $\mathcal{W}_i$: percentage increase in weekly income that would deliver the same utility as they get from having access to PAYGo financing
  - Benchmark: buy with cash at any future date or not at all
  - We partial out the “love of variety" effect by giving consumers access to the same menu of utility shocks from buying with cash

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

Consumer Welfare

- Risk score 1 (control pricing): $\mathcal{W}_{taker} = 7.7\%$.
  - Take-up rate is 63%, so $\mathcal{W}_{sample} = 4.8\%$.
- Welfare effects are decreasing in risk score
  - Risk score 4 (control pricing): $\mathcal{W}_{taker} = 4.3\%$, $\mathcal{W}_{sample} = 1.2\%$
- Averaging across all risk scores: $\mathcal{W}_{taker} = 6.2\%$ and $\mathcal{W}_{sample} = 3.4\%$

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

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

  $\Rightarrow$ IRR of 201.0% for baseline treatment group

Question: What are the welfare gains under competitive pricing?

Competitive Pricing

	By maturity				
	(1) 3 month	(2) 6 month	(3) 9 month	(4) 12 month	(5) Overall
Risk score 1					
Control multiple	1.36	1.54	1.64	2.00	
Control minimum down payment					25.0
Competitive multiple	1.10	1.24	1.32	1.62	
Competitive minimum down payment					10.6
Risk score 2					
Control multiple	1.36	1.54	1.64	2.00	
Control minimum down payment					30.0
Competitive multiple	1.11	1.26	1.34	1.63	
Competitive minimum down payment					14.9
Risk score 3					
Control multiple	1.36	1.54	1.64	2.00	
Control minimum down payment					35.0
Competitive multiple	1.18	1.33	1.42	1.73	
Competitive minimum down payment					20.5
Risk score 4					
Control multiple	1.36	1.54	1.64	2.00	
Control minimum down payment					50.0
Competitive multiple	1.37	1.55	1.65	2.01	
Competitive minimum down payment					28.1

Summary of Consumer Welfare and Firm Profitability

Treatment Group	(1) Take-up	(2) $\mathcal{W}_{taker}$	(3) $\mathcal{W}_{sample}$	(4) NPV	(5) IRR
Risk score 1					
CtrlMultipleCtrlDown	62.8%	7.7%	4.8%	37.3	201%
HighMultipleCtrlDown	55.3%	5.9%	3.4%	64.5	444%
CtrlMultipleLowerDown	67.5%	8.1%	5.2%	36.3	176%
Competitive Pricing	74.1%	11.3%	8.4%	0.0	25%
Risk score 2					
CtrlMultipleCtrlDown	61.3%	7.0%	4.5%	34.8	181%
HighMultipleCtrlDown	55.8%	5.1%	3.0%	59.7	391%
CtrlMultipleLowerDown	68.4%	7.4%	4.9%	35.5	164%
Competitive Pricing	76.4%	10.8%	8.3%	0.0	25%
Risk score 3					
CtrlMultipleCtrlDown	50.9%	4.6%	2.5%	26.8	143%
HighMultipleCtrlDown	48.9%	3.6%	1.8%	53.7	326%
CtrlMultipleLowerDown	59.7%	4.9%	2.7%	22.8	109%
Competitive Pricing	65.9%	6.3%	4.2%	0.0	25%
Risk score 4					
CtrlMultipleCtrlDown	26.2%	4.3%	1.2%	28.3	196%
HighMultipleCtrlDown	26.0%	3.9%	1.1%	37.0	239%
CtrlMultipleLowerDown	38.2%	5.1%	1.7%	14.4	82%
Competitive Pricing	40.5%	6.0%	2.4%	0.0	25%

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CtrlMultipleCtrlDown	62.8%	7.7%	4.8%	37.3	201%
HighMultipleCtrlDown	55.3%	5.9%	3.4%	64.5	444%
CtrlMultipleLowerDown	67.5%	8.1%	5.2%	36.3	176%
Competitive Pricing	74.1%	11.3%	8.4%	0.0	25%
Risk score 2					
CtrlMultipleCtrlDown	61.3%	7.0%	4.5%	34.8	181%
HighMultipleCtrlDown	55.8%	5.1%	3.0%	59.7	391%
CtrlMultipleLowerDown	68.4%	7.4%	4.9%	35.5	164%
Competitive Pricing	76.4%	10.8%	8.3%	0.0	25%
Risk score 3					
CtrlMultipleCtrlDown	50.9%	4.6%	2.5%	26.8	143%
HighMultipleCtrlDown	48.9%	3.6%	1.8%	53.7	326%
CtrlMultipleLowerDown	59.7%	4.9%	2.7%	22.8	109%
Competitive Pricing	65.9%	6.3%	4.2%	0.0	25%
Risk score 4					
CtrlMultipleCtrlDown	26.2%	4.3%	1.2%	28.3	196%
HighMultipleCtrlDown	26.0%	3.9%	1.1%	37.0	239%
CtrlMultipleLowerDown	38.2%	5.1%	1.7%	14.4	82%
Competitive Pricing	40.5%	6.0%	2.4%	0.0	25%

Summary of Consumer Welfare and Firm Profitability

Treatment Group	(1) Take-up	(2) $\mathcal{W}_{taker}$	(3) $\mathcal{W}_{sample}$	(4) NPV	(5) IRR
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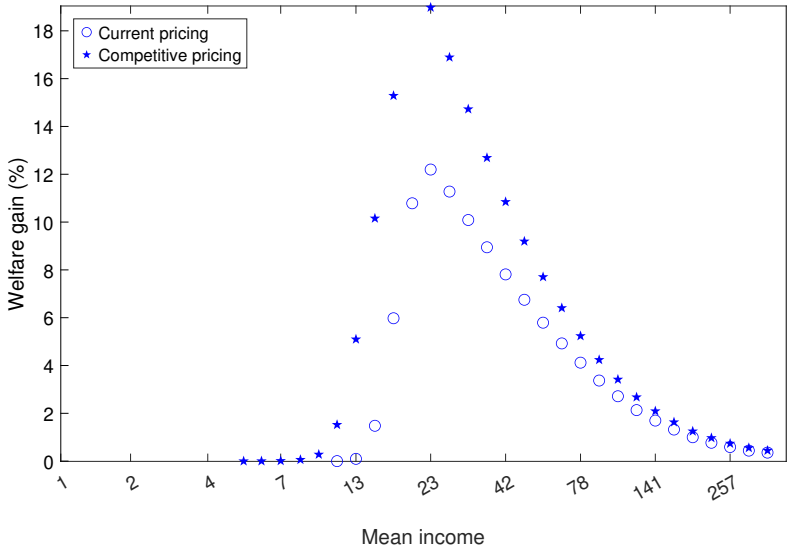
Welfare by Income, Risk Score 1

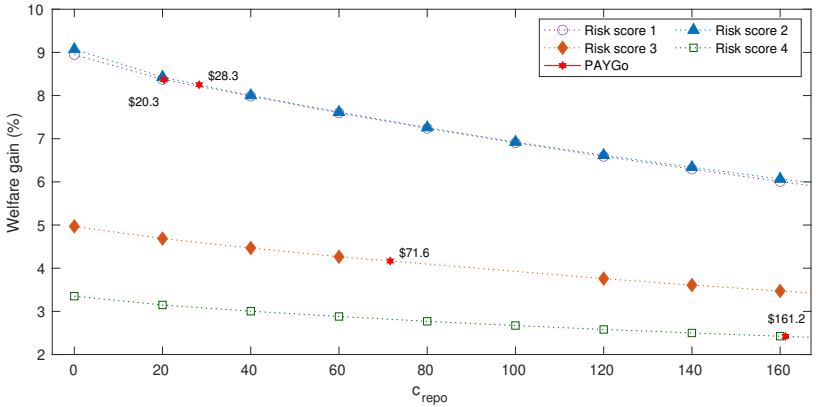


Counterfactuals

Secured Lending Counterfactual

- We analyze a counterfactual with traditional secured loans
- Firm commits to repossess after missed payment(s) at cost c_{repo}
  - Upon repossession, the firm recovers the residual value and consumer enters autarky
  - In the paper, we also vary probability repossession is successful.
  - Assume it is successful w.p.1 here.
- We use competitive prices for a clean comparison
  - Under competitive pricing, both the multiple and downpayment increase with c_{repo}
- Key trade-off: stronger incentives (secured) vs more insurance (PAYGo)

Welfare Comparison: PAYGo vs Secured Lending



- Low risk scores have higher usage values
  - Strong incentive to repay without the threat of repossession
  - Larger economic loss associated with reallocation to firm (i.e., insurance is more valuable)

Contract Design

We consider several modifications of the PAYGo contract and ask whether they can improve welfare.

More insurance

- Leniency: lock activated only after missing X payments
- Weaker lock: consumes a fraction of usage value after missing a payment

Stonger incentives

- Fees for missed payments
- Locked for multiple periods

Contract Design

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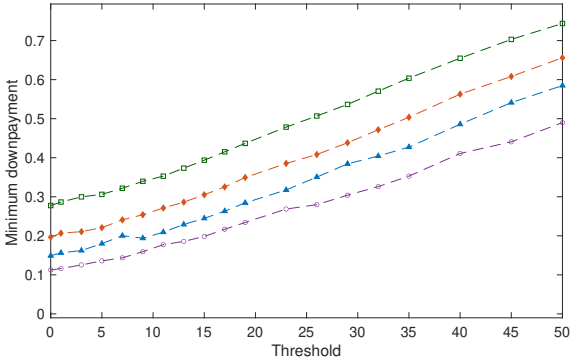
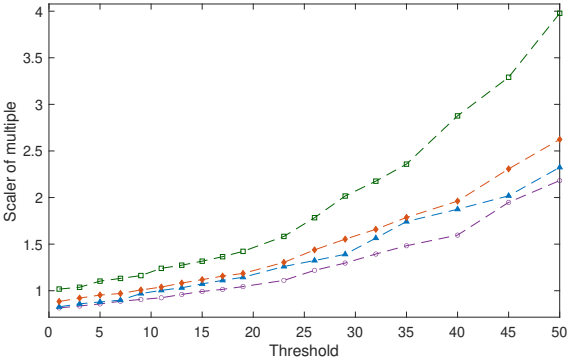
Main Finding: Only the leniency policy can improve on PAYGo

Competitive Prices with Leniency

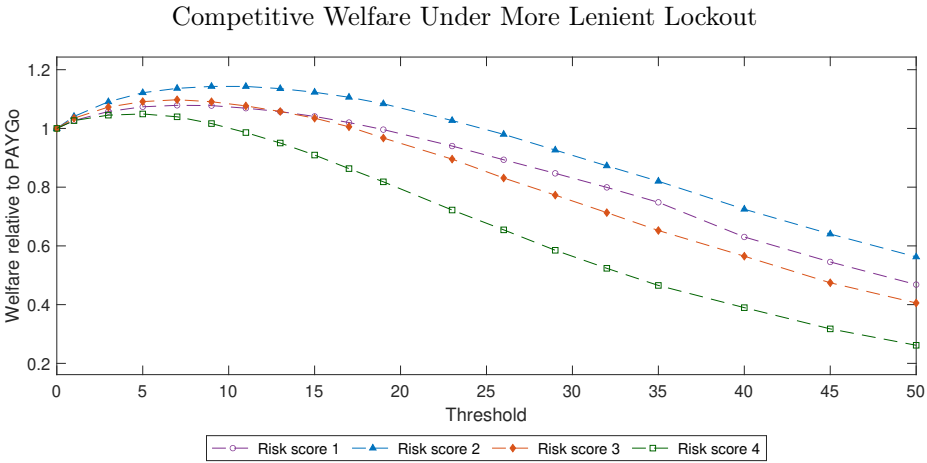
Competitive Minimum Downpayment



Competitive Multiple

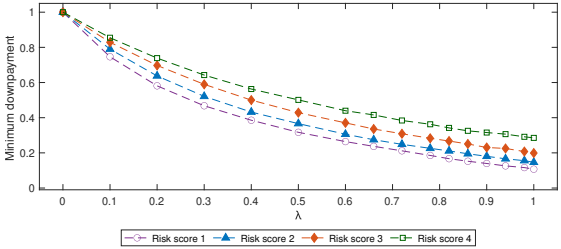


Welfare with Leniency

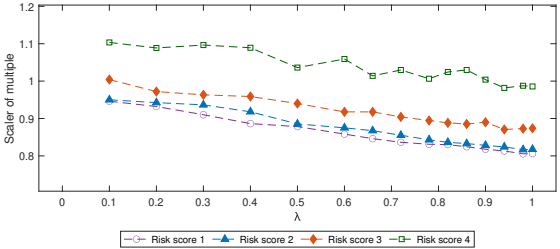


Competitive Pricing with a Weaker Lock

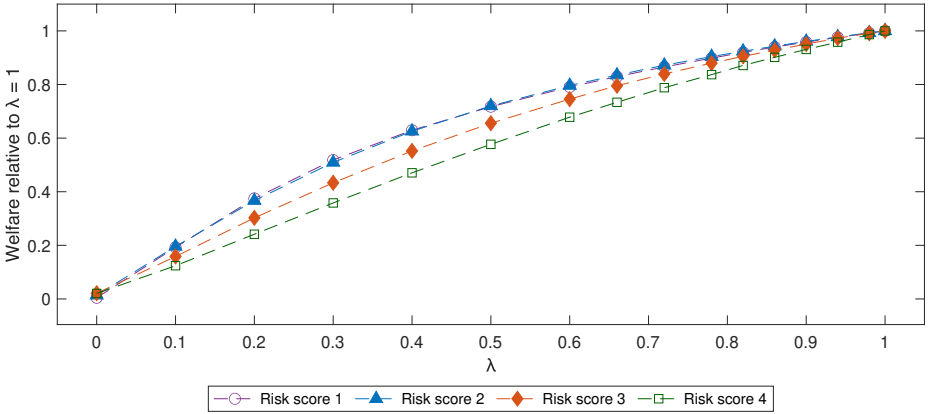
Competitive Minimum Downpayment



Competitive Multiple



Welfare with a Weaker Lock



Summary

We study new form of lending that relies on lockout technology to screen borrowers and incentivize repayment

- Recent rapid growth so important to understand the welfare implications.
- The welfare gains to consumers from access to PAYGo financing are significant, corresponding to a 3.4% 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 30-50% larger
- A more lenient contract can be welfare maximizing. More stringent contracts reduce welfare.

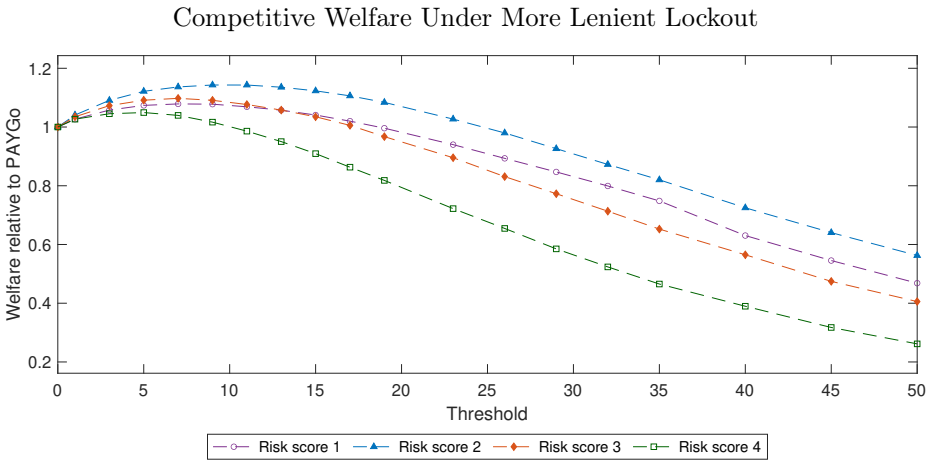
Supplemental Slides

Optimal Lockout: More Lenient

- Can a more lenient lockout benefit consumers?
  - Pro: Facilitate risk sharing and consumption smoothing
  - Con: Lower repayment incentive $\implies$ higher prices

- $\Gamma \equiv (D, T, \theta, \bar{a})$
  - Allow a "buffer" of $\bar{a}$ missed payments
  - $\bar{a}$ is number of cumulative payments missed at which the lender initiates the lockout technology

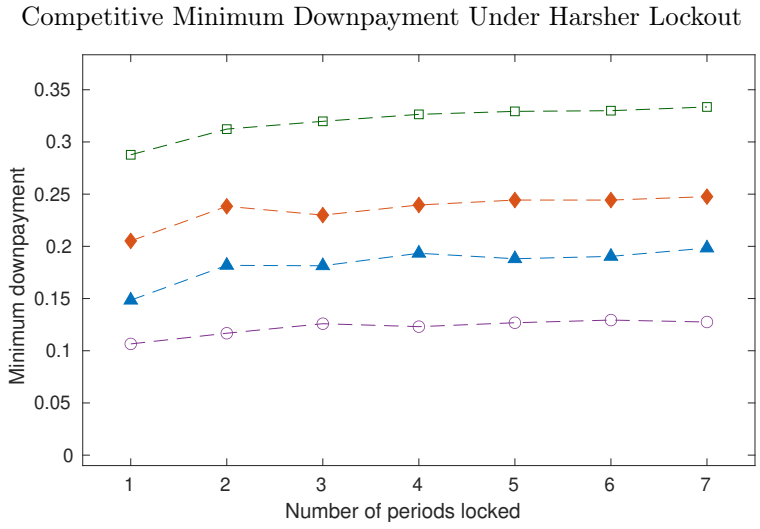
Optimal Lockout: More Lenient



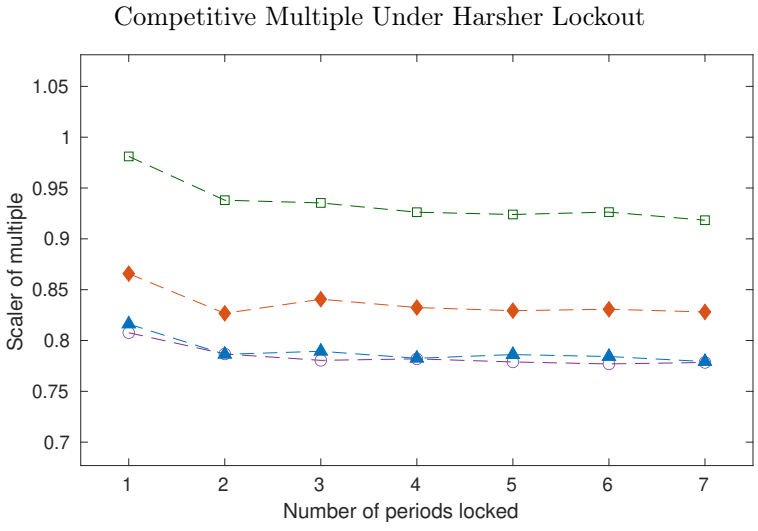
Optimal Lockout: Harsher

- Can a harsher lockout benefit consumers?
  - Pro: Create more repayment incentive, reduce prices
  - Con: Destroy more welfare upon lockout
- Two ways we have considered this:
  - Lock for multiple periods after missing a payment
  - Charge a higher price following missed payments
- Conclusion: harsher punishments decrease the welfare gains from PAYGo

Optimal Lockout: Harsher



Optimal Lockout: Harsher



Optimal Lockout: Harsher