Estimating the Welfare Benefits of Lockout

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April 2022

Agenda

- Traditional microfinance
  - Expensive
  - Inconvenient (high transaction costs)
  - Low uptake
  - Modest effects on the average borrower (Banerjee, 2015)

- Digital financial products are becoming increasingly popular. The growth has been facilitated by technology:
  - Access to mobile phones, GSM chips
  - Digital payments (mobile money)
  - Better data about borrowers

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- Digital financial products are becoming increasingly popular. The growth has been facilitated by technology:
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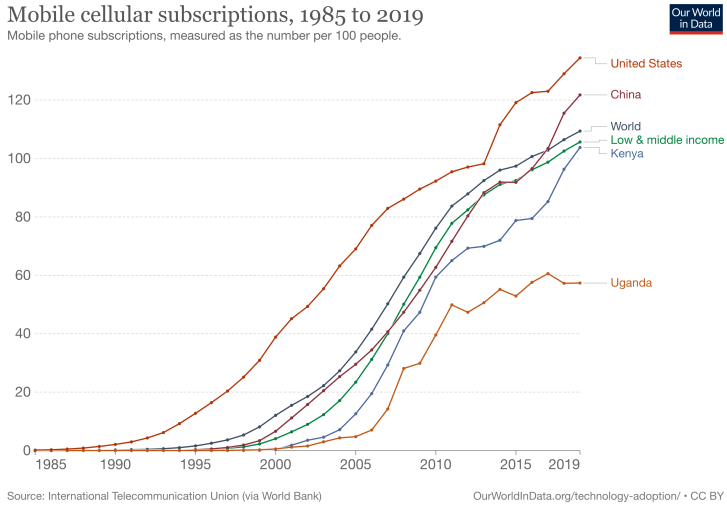
Questions:

- What are the economic effects on households and firms?
- How best should these technologies be utilized?

Adoption has been Rapid



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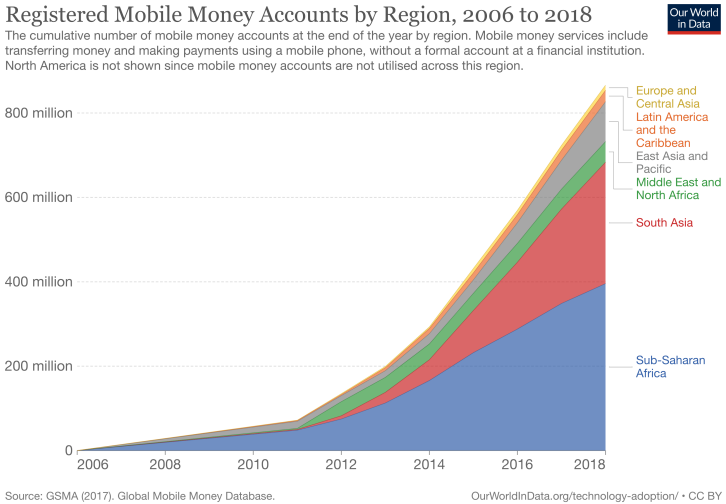

Background

Collateralized lending is the predominant source of credit for households in wealthy countries

- More than 80% of US household debt is secured

Much less widespread in poor countries. Why?

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- Demand side: Income risk

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- Supply side: Repossession costs
- Demand side: Income risk

This paper: Collateralized lending via lockout

- Lowers (marginal) repossession cost
- Facilitates better risk sharing

Role of Collateral

Repossessing collateral serves (at least) two roles:

1. Recovery (κ): Provides something of value to the creditor in case the borrower defaults.
2. Incentives and Screening (λ): Takes something of value away from the borrower.

In most collateralized lending:

- These two roles are inherently bundled
- Repossession (or liquidation) is an absorbing state

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Digital collateral facilitates a richer space of contractual arrangements.

- Decoupling of the two roles
- Dynamic control over consumption of the good
- Examples: smart phones, SHS, utilities, subprime autos

New *ReadyPay* Rates.

Enjoy **DISCOUNTS** when you complete your loan early!

10W *ReadyPay* Home Eco 2	
Deposit:	19,000/-
Daily Rate:	600/-
Monthly Rate:	18,000/-
Duration:	35 months
Buy in Cash:	519,000/-
Buy on Loan:	649,000/-

Complete in 12 months for a 100,000/- DISCOUNT

10W *ReadyPay* Home Plus	
Deposit:	39,000/-
Daily Rate:	1,000/-
Monthly Rate:	30,000/-
Duration:	25 months
Buy in Cash:	631,000/-
Buy on Loan:	789,000/-

Complete in 12 months for a 100,000/- DISCOUNT

17W *ReadyPay* Home Comfort	
Deposit:	49,000/-
Daily Rate:	1,350/-
Monthly Rate:	40,500/-
Duration:	24 months
Buy in Cash:	799,000/-
Buy on Loan:	999,000/-

Complete in 12 months for a 110,000/- DISCOUNT

Home Eco customers who pay well can upgrade to a Home Comfort in 3 months

34W *ReadyPay* Home Deluxe	
Deposit:	99,000/-
Daily Rate:	1,800/-
Monthly Rate:	54,000/-
Duration:	24 months
Buy in Cash:	1,116,000/-
Buy on Loan:	1,395,000/-

Complete in 12 months for a 160,000/- DISCOUNT

34W *ReadyPay* TV Deluxe (Zuku)	
Deposit:	149,000/-
Daily Rate:	3,000/-
Monthly Rate:	90,000/-
Duration:	26 months
Buy in Cash:	1,999,000/- (Includes 1 Year Zuku subscription)
Buy on Loan:	2,539,000/- (Includes 2 Years Zuku subscription)

Complete in 12 months for a 270,000/- DISCOUNT

Pay well to be eligible for UPGRADES in 3 months!

Warranty:

- All systems come with a **3-year** limited warranty on the battery and panel.
- Accessories come with a **2-year** limited warranty.
- Any faults caused during manufacturing will be replaced for FREE at a *ReadyPay* service centre.

How Fenix Power works:

Method 1

1. Take your Fenix Power System home and enjoy 7 days of FREE power!
2. After your 7 free days, the system will lock.
3. Dial *165*62# to make a payment with MTN Mobile Money.
4. You will receive an SMS confirming your payment
5. Press network button for atleast 5 seconds after receiving SMS
6. Your system will unlock. Bigger payments give you MORE power!
7. Clear your balance and it will belong to you!


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Partner With Us
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for the Next Billion
Phone Finance
Buy a smartphone on installment payments and build your credit history.
GET A PHONE
Cash Loans
Apply for a cash loan from your smartphone and receive your money in minutes
GET A LOAN

Research Objectives

Goal: quantify/understand the economics effects of lockout technology

- For consumers:
  - Access to credit and other financial services
  - Access to new technology
  - $\Rightarrow$ Quantifying these welfare gains

- For Firms:
  - Increase sales
  - Expands the set of profitable lending opportunities
  - $\Rightarrow$ Estimate profits

Related Literature: Gertler et. al. (2022)

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. Household outcomes appear promising
   - Reasonably high take-up
   - Significant increase in investment
   - No evidence of a “debt trap"
   - Overall welfare effects?

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   - 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 household is locked 25% of days
   - Flexible repayment: feature or bug? room for improvement?

Approach

- Develop a structural model of households (and firms)
- Estimate the model using a pricing experiment from a PAYGO lender
  - Variation in both interest rates and downpayments
  - Complication: maturity choice (+take-up, repayment, elasticities)
- Counterfactuals:
  - No lockout ($\lambda = 0$)
  - Perfectly competitive pricing
  - Welfare maximizing λ

Structural Model

Households

Income:

- Heterogeneous long-run mean income, $\bar{y}_i$ (log-normally distributed)
- Household 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
- Household i privately knows $(\bar{y}_i, y_{i0})$ when deciding whether to finance the purchase of the good

Households

Preferences:

- Quasi-linear utility: $u(c_{it})$ for consumption good, v_{it} for device
- CARA utility function
- Device depreciates each period with probability ϕ
- Heterogenous discount factor β_i

Wealth and savings:

- Initial wealth (or liquidity) L_i, lognormally distributed
- No access to external borrowing/savings technologies
- Marginal value for wealth μ_i
  - Shortcut to layering on a consumption/savings problem

The PAYGO Contract

Summarized by $\Gamma = (D, T, \theta)$

- D: minimum down payent
- T: number of total (weekly) payments
- θ: markup

Let p be the price of the phone.

$\Rightarrow$ The loan amount is $p - D$

$\Rightarrow$ The payment is $m = \frac{\theta(p-D)}{T}$

State variable

Fix a contract Γ:

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

Household Value Function

Let $U_i(x, \Gamma)$ denote the value function of household i under some arbitrary contract Γ.

- For brevity, Γ is regularly suppressed.

The ownership boundary conditions is

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

where

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

is the expected utility from being permanently “unlocked"

Household Bellman Equation

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

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

The optimal policy of the individual $a_i(x) \in \{0, 1\}$ is to make the payment (i.e., $a_i(x) = 1$) if

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

We solve for $a(\cdot)$ and $U_i(\cdot)$ by backward induction on a grid. We then interpolate the solution, which we denote by $a^*(\cdot)$ and $U_i^*(\cdot)$

Maturity Choice Decision

- Households 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 household must make a downpayment D_j
- Downpayment made out of current income and wealth, $L_i + y_{i0}$
- Remainder is optimally consumed/saved

Value of a Contract

Fixing an “affordable" contract for household i (i.e., $y_{i0} + L_i \geq D_j$):

- The household's value of Γ_j is

$$W(\Gamma_j, x_{i0}) = \max_{c_{i0}, w_i \geq 0} v_{i0} + u(c_{i0}) + \mu w_i + \beta \mathbb{E}[U(v_{i1}, y_{i1}, T, m(D_j))|v_{i0}, y_{i0}]$$

s.t.

$$c_{i0} + w_i + D_j = y_{i0} + L_i$$

Outside Option

- Households can buy with cash for price p iff $y_{i0} + L_i \geq p$.

$$O^{i,\text{cash}} = \max_{c_{i0}, w_i \geq 0} v_{i0} + u(c_{i0}) + \mu_i w_i + \beta_i \mathbb{E}[\Pi(v_{i1}, y_{i1}) | v_{i0}, y_{i0}]$$
$$\text{s.t.} \quad c_{i0} + w_i + p = y_{i0} + L_i$$

- Households also have the outside option of not buying

$$O^{i,\text{autarky}} = u(y_{i0}) + \mu L_i + \beta_i \mathbb{E}[\Pi(0, y_{i1}) | y_{i0}]$$

- Household's (optimal) outside option is

$$O_i^* = \max\{O^{i,\text{cash}}, O^{i,\text{autarky}}\}$$

Contract Selection

A necessary condition for purchasing is

$$\max_{\Gamma_j \in M} W_i(\Gamma_j) \geq O_i^*$$

Household i experiences random utility shocks ω_{ij} from Γ_j, which are i.i.d. across individuals and contracts.

$$\omega_{ij} \sim \max\{0, \mathcal{N}(0, \sigma^2_{\omega_j})\}$$

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

$$\arg\max_{\Gamma_j \in M} W_i(\Gamma_j) + \omega_{ij}$$

Firm Profit

Let $F_i(x, \Gamma)$ denote the value function of the firm under the contract Γ with household i. It is defined recursively by

$$F_i(x) = a_i^*(m + \delta\mathbb{E}[F_i(v', y', n-1))|v, y]) + (1 - a_i^*)\delta\mathbb{E}[F_i(v', y', n)|v, y]$$

where δ is the firm's discount rate

The ownership boundary conditions is

$$F_i(v, y, 0) = K$$

where K is the life-time value of a customer that has fully repaid individual.

- Currently we set $K = 0$

Estimation

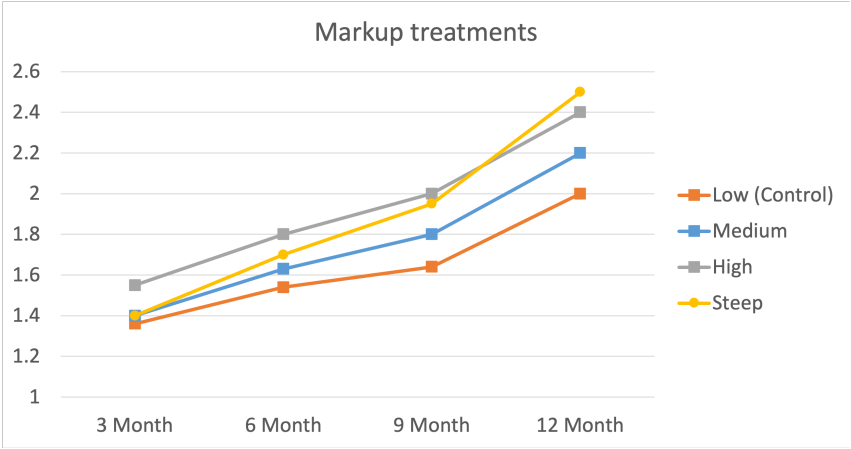
Estimation

- Assume CRRA $u(y) = \frac{y^{1-\gamma}-1}{1-\gamma}$
- Calibrated parameters: $\gamma = 0.95$, $\lambda = 1$
- Parameters to estimate (21):
  - Distribution and evolution of income: $\{\bar{y}, \sigma_y, \sigma_\epsilon, \rho\}$
  - Liquidity: $\{\bar{L}, \sigma_L, r_{y,L}\}$
  - Device value and depreciation: $\{\bar{v}, \phi\}$
  - Individual's time preference: $\{\beta_L, \beta_M, \beta_H, b_L, b_M\}$
  - Value of liquidity: $\{\mu_L, \mu_M, \mu_H\}$
  - Size of random utility shocks: $\{\sigma_{\omega_\Gamma}\}$
- We use $16 \times 3 + 2 = 50$ moments in the data to estimate them

Estimation

- We use administrative data from a smartphone PAYGO lender. The firm conducted a randomized pricing experiment from 11/2018-6/2019 using a 2×4 interaction of
  - Four markup treatment groups: Low, Medium, High, Steep
  - Two minimum down payment treatment groups: Control, Lower

Estimation


Markup treatments
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
3 Month
6 Month
9 Month
12 Month
Low (Control)
Medium
High
Steep

Estimation

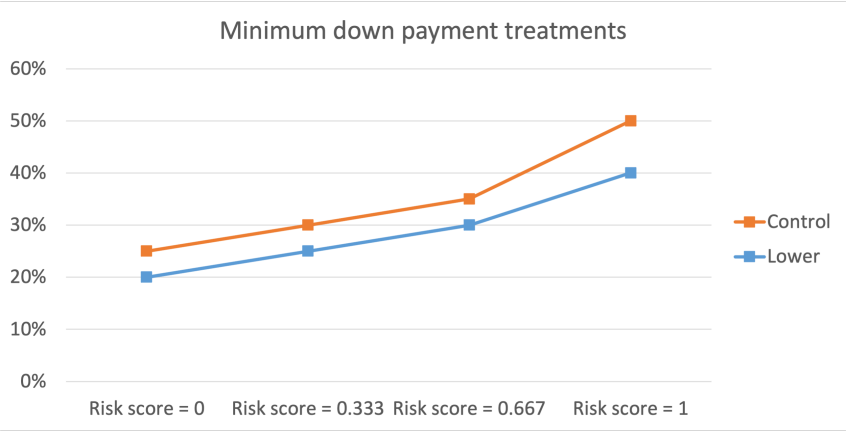

Minimum down payment treatments
60%
50%
40%
30%
20%
10%
0%
Risk score = 0
Risk score = 0.333
Risk score = 0.667
Risk score = 1
Control
Lower

Table 1: Assignment of individuals into treatment groups

Down Payment Treatment	Markup Treatment	# of Customers in This Arm	Percentage
Ctrl	0 Ctrl	4,357	15.1%
Ctrl	1 Medium	4,402	15.3%
Ctrl	2 High	4,336	15.1%
Ctrl	3 Steep	4,322	15.0%
Lower	0 Ctrl	2,851	9.9%
Lower	1 Medium	2,956	10.3%
Lower	2 High	2,818	9.8%
Lower	3 Steep	2,744	9.5%
N		28,786	

Table 2: Summary statistics of the whole sample

	# of Obs.	Mean	SD
Customer Characteristics			
Age	N	32.4	9.6
Gender available	N	0.85	
Is male	N	0.43	
Has bank account	N	0.57	
Has credit card	N	0.21	
Occupation			
- Private sector worker	N	0.53	
- Public sector worker	N	0.24	
- Independent entreprenuer	N	0.16	
- Other (informal economy)	N	0.07	
- Retired	N	0.00	
Risk category			
- 0/0.333/0.666/1	N	0.24/0.30/0.27/0.20	

Estimation

	# of Obs.	Mean	SD
Transaction Characteristics			
List price	0.52N	206.09	77.85
Minimum down payment ratio	0.52N	0.30	0.07
Actual down payment ratio	0.52N	0.31	0.08
Financed amount	0.52N	142.79	57.93
Markup	0.52N	1.70	0.28
Term Length			
- 3 Months/6 Months/9 Months/12 Months	0.52N	0.29/0.38/0.22/0.11	
Weekly payment obligation	0.52N	9.84	4.91
Loan Outcomes (Samsung only)			
Repayment at maturity	0.52*0.94N	0.73	0.32
Repayment at half maturity	0.52*0.94N	0.39	0.15

Table 3: Summary statistics of the subsample with Risk Score = 0

	# of Obs.	Mean	SD
Customer Characteristics			
Age	0.24*N	36.0	9.8
Gender available	0.24*N	0.89	
Is male	0.24*N	0.46	
Has bank account	0.24*N	0.56	
Has credit card	0.24*N	0.25	
Occupation			
- Private sector worker	0.24*N	0.52	
- Public sector worker	0.24*N	0.25	
- Independent entreprenuer	0.24*N	0.16	
- Other (informal economy)	0.24*N	0.06	
- Retired	0.24*N	0.01	
Risk category			
- 0/0.333/0.666/1	0.24*N	1.00/0.00/0.00/0.00	

Estimation

	# of Obs.	Mean	SD
Transaction Characteristics			
List price	0.24*0.60N	210.10	82.59
Minimum down payment ratio	0.24*0.60N	0.23	0.04
Actual down payment ratio	0.24*0.60N	0.25	0.06
Financed amount	0.24*0.60N	158.52	63.60
Markup	0.24*0.60N	1.71	0.28
Term Length			
- 3 Months/6 Months/9 Months/12 Months	0.24*0.60N	0.28/0.36/0.25/0.12	
Weekly payment obligation	0.24*0.60N	10.71	5.49
Loan Outcomes (Samsung only)			
Repayment at maturity	0.24*0.52*0.96N	0.77	0.30
Repayment at half maturity	0.24*0.52*0.96N	0.41	0.14

Estimation

- We use administrative data from a smartphone PAYGO lender. The firm conducted a randomized pricing experiment from 11/2018-6/2019 using a 2×4 interaction of
  - Four markup treatment groups: Low, Medium, High, Steep
  - Two minimum down payment treatment groups: Control, Lower
- We observe the take-up decision, contract choice and repayment time series of customers
- We estimate the model using LowMarkupCtrlDown, SteepMarkupCtrlDown, and LowMarkupLowerDown treatment groups and validate the model using the rest five treatment groups
- We run the estimation separately within each risk score and we start from the lowest risk group (risk score = 0)

Estimation

We simulate the model and compute the following moments for each of the three treatment groups used in estimation:

- Take-up rate and maturity choice:
  - shares purchasing 3/6/9/12 months and overall take-up rate
- Repayment:
  - average proportion repaid at maturity and half of the maturity for 3/6/9/12 months and on average
  - proportion of contracts with perfect repayment
  - conditional probability of resuming payment

And also elasticities of take-up rate to markup (Low to Steep) and to down payment (Ctrl to Lower)

Estimation

- We minimize the distance between simulated moments $\hat{\mathcal{M}}(\Theta)$ and data moments $\mathcal{M}$
- We define the distance as the sum of squared percent deviation of simulated moments from data moments

$$\hat{\Theta} = \underset{\Theta}{\operatorname{argmin}} \left(\frac{\hat{\mathcal{M}}(\Theta) - \mathcal{M}}{\mathcal{M}} \right)' \left(\frac{\hat{\mathcal{M}}(\Theta) - \mathcal{M}}{\mathcal{M}} \right)$$

- We use the Tik-Tak algorithm proposed in Arnoud, Guvenen, and Kleineberg (2019) for global optimization

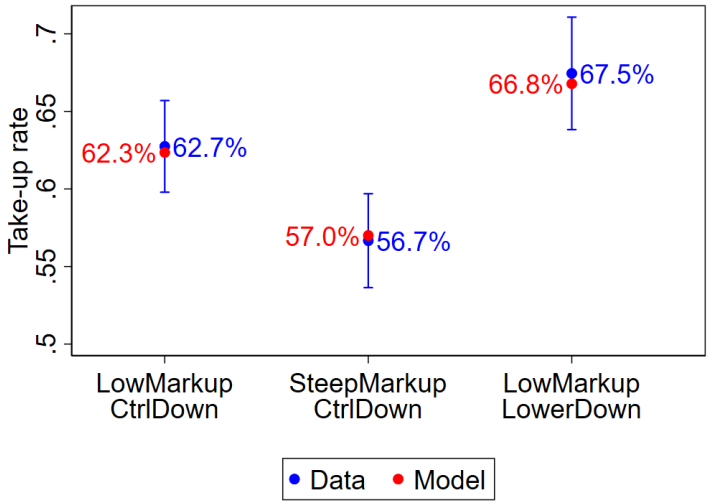
Parameter Estimates

Income process and wealth	
$\bar{y}$	45.55
σ_y	0.77
σ_ϵ	0.33
ρ	0.76
$\bar{L}$	120.41
σ_L	0.88
$r_{\mathbf{y},L}$	-0.01

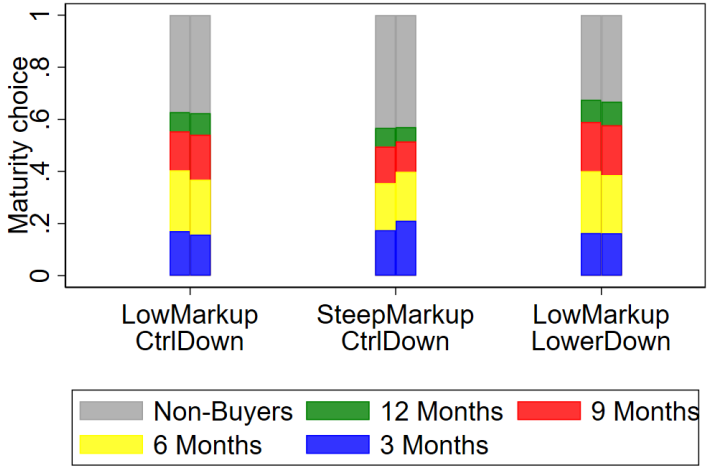
Preferences and device value	
β	{0.940, 0.972, 0.998}
b	{0.32, 0.16, 0.51}
$\bar{v}$	13.12
ϕ	0.09
μ	{0.61, 3.73, 3.10}
σ_ω	{38.05, 70.00**, 37.59, 12.72}

$\bar{v}$, μ, B and ω_Γ are scaled by the marginal utility evaluated at $\bar{y}$

Model Fits


Take-up rate
.5
.55
.6
.65
.7
62.3%
62.7%
57.0%
56.7%
66.8%
67.5%
LowMarkup CtrlDown
SteepMarkup CtrlDown
LowMarkup LowerDown
Data
Model

Model Fits



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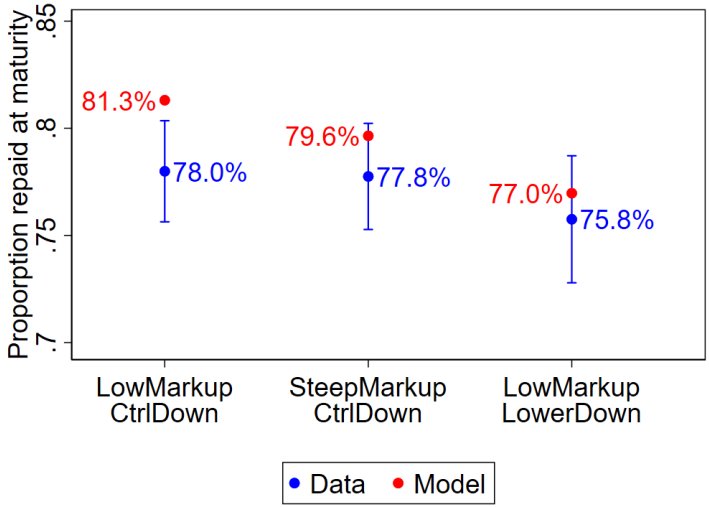
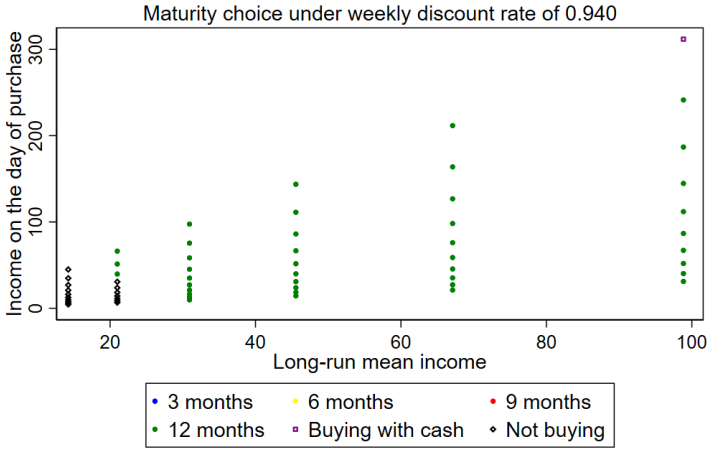


The Economics of Maturity Choice

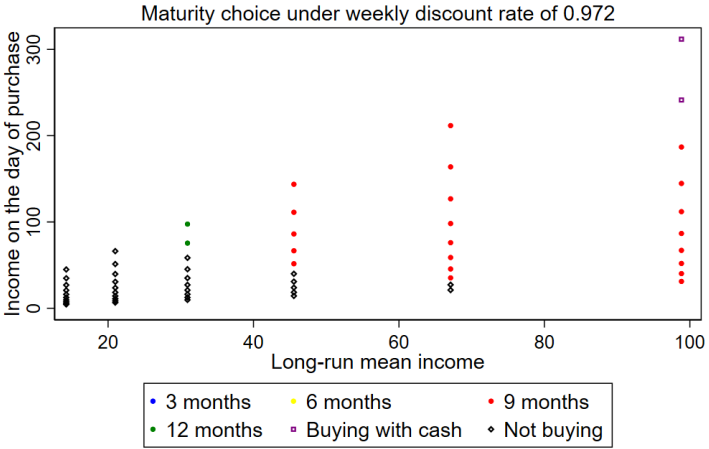
- Patient households (high β)
  - Prioritize selecting lowest (affordable) mark-up
  - Rich $\Longrightarrow$ 3 month
  - Poorer households select 6 or 9 month
- Impatient households (low β)
  - Prioritize lowest weekly payment $\Longrightarrow$ 12 month
- Intermediate households
  - Mostly 9 month contracts

Maturity Choice



Customers have the median level of extra liquidity, zero random maturity shocks, and are treated with LowMarkupCtrlDown.

Maturity Choice



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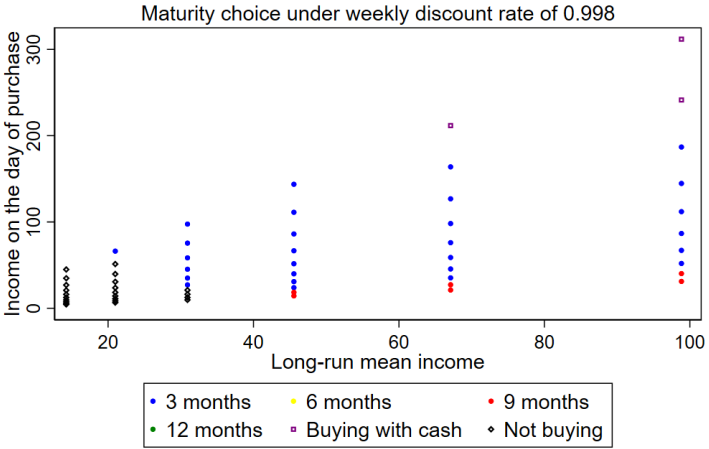

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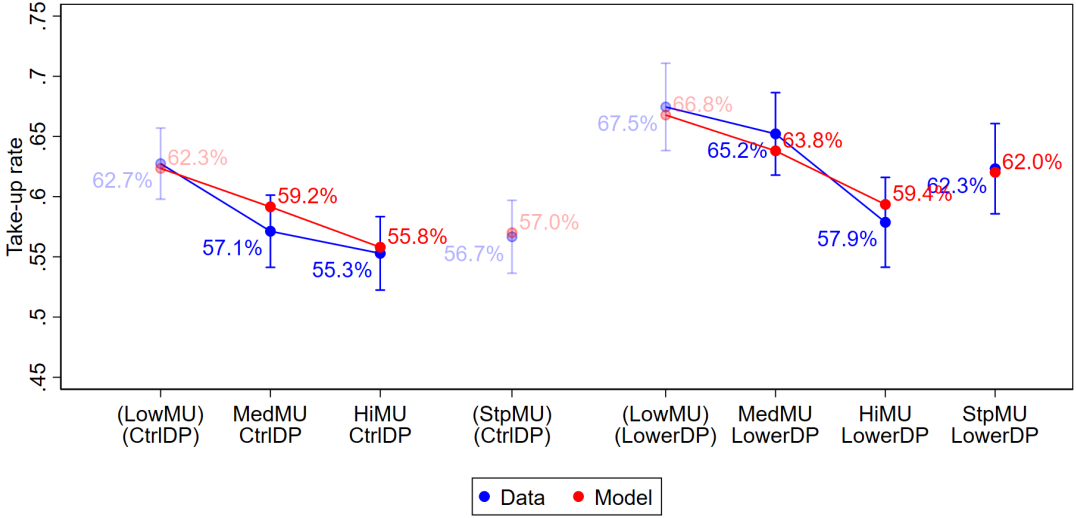
Model Validation



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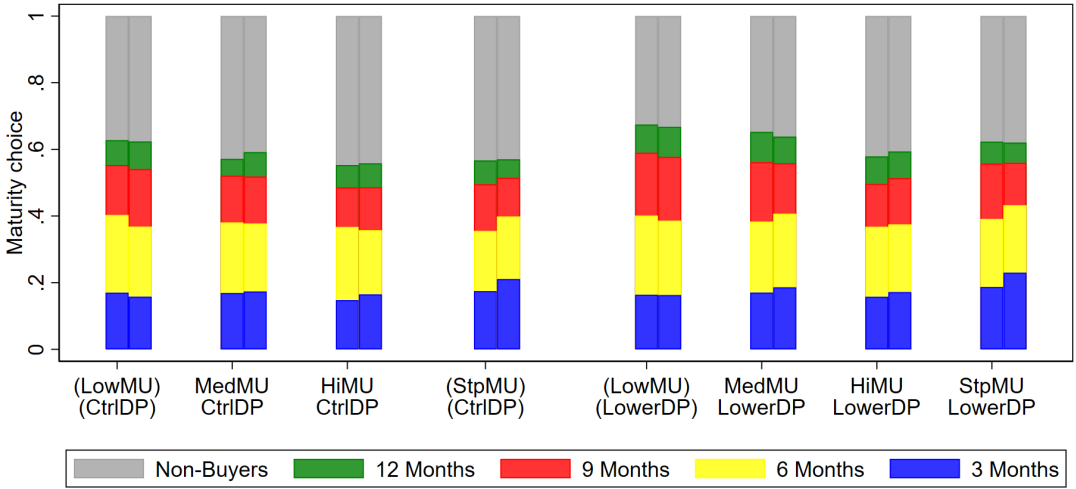

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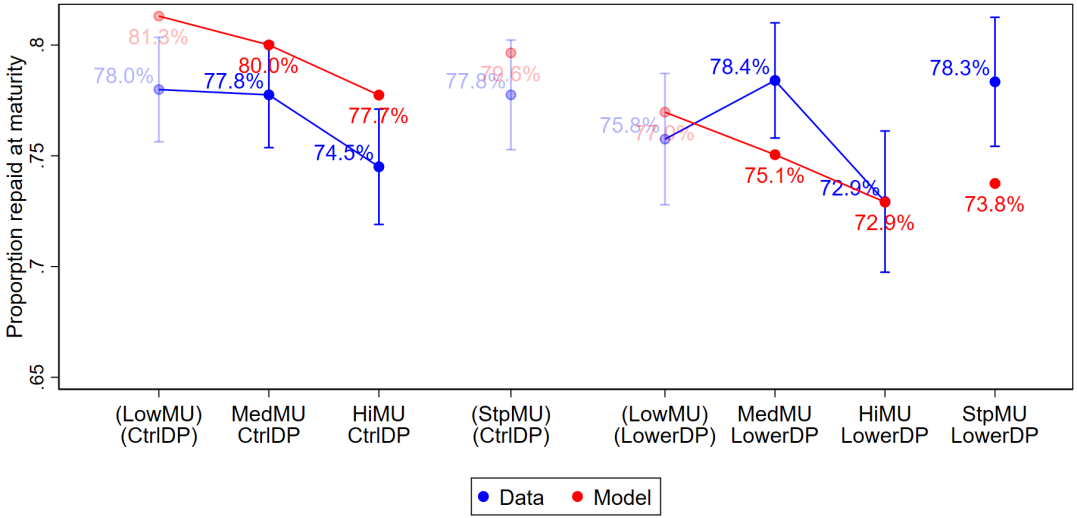


Welfare & Profitability

Welfare

- Our first measure of consumer welfare is

$$\frac{\text{Buyer's utility over 2 years} - \text{Buyer's outside option over 2 years}}{\text{Buyer's outside option over 2 years}}$$

  - The outside option is either paying the cash price or not having a phone
- Our second measure of consumer welfare is the equivalent weekly extra cash distributed over 2 years that makes the buyer as well-off as having the contract
- For the LowMarkupCtrlDown group, they are

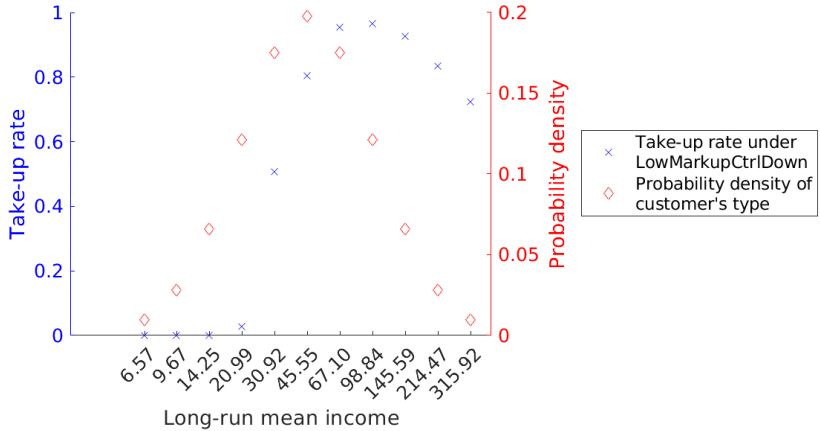
$$1.21\%$$

and

$$\$3.85$$

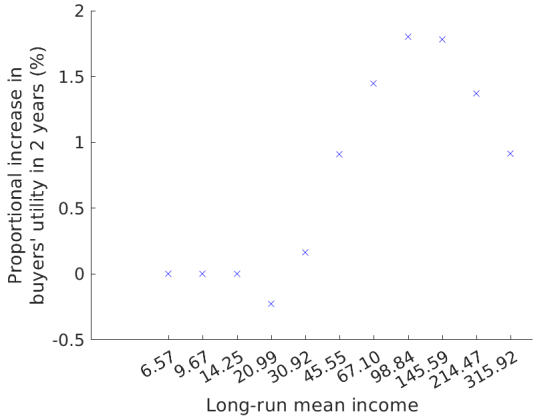
Welfare

- The take-up rates by $\bar{y}_i$ are



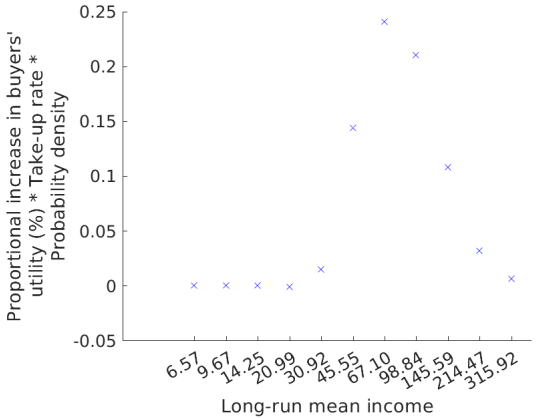
Welfare

- The proportional increases in houshould's utility by $\bar{y}_i$ are



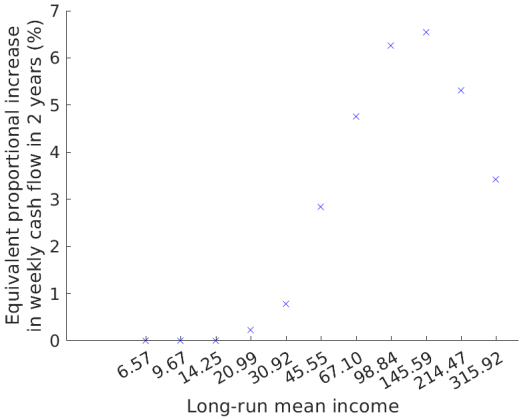
Welfare

- The welfare effects scaled with probability density and take-up rates by $\bar{y}_i$ are



Welfare

- The equivalent weekly cash flows as a proportion of long-run mean income by $\bar{y}_i$ are



Profitability

- Our first measure of firm profitability is the average NPV of PayJoy contracts
  - We assume a firm annual discount rate of 25% and per-unit cost of $200
- Our second measure of firm profitability is the annualized IRR of the portfolio of PayJoy contracts
- We show measures calculated using actual data and over a 2-year period
- For the LowMarkupCtrlDown group, they are

$$\$37.04$$

and

$$201.04\%$$

Welfare & Profitability

Treatment Group	Take-up rate (%)	% Increase in buyers' utility (2y)	Equivalent cash flow in $ (2y)	NPV in $	% IRR
LowMarkupCtrlDown	0.63	1.21	3.85	37.04	201.04
MediumMarkupCtrlDown	0.59	1.17	3.81	49.43	298.02
HighMarkupCtrlDown	0.56	1.07	3.66	64.48	443.75
SteepMarkupCtrlDown	0.57	1.13	3.76	58.01	384.98
LowMarkupLowerDown	0.67	1.20	3.77	36.34	175.50
MediumMarkupLowerDown	0.64	1.15	3.69	57.41	302.27
HighMarkupLowerDown	0.59	1.06	3.57	64.89	397.87
SteepMarkupLowerDown	0.62	1.10	3.59	64.09	404.44

Counterfactuals

Competitive Pricing

- We solve for the contract menu that maximizes consumer welfare while yields zero profit
- The solution is a menu with markups for each maturity equal

$$\{1.37, 1.27, 1.31, 1.49\}$$

and down payment equal

$$10.48\%$$

- The take-up rates of each maturity and overall are

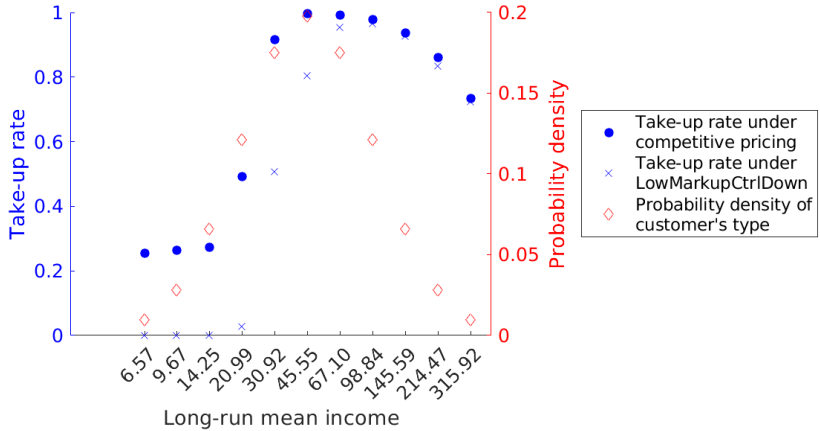
$$\{6.11\%, 28.39\%, 27.79\%, 20.75\%\}/83.04\%$$

- The proportional increase in buyer's utility/equivalent weekly cash flow in 2 years is

$$1.46\%/\$3.93$$

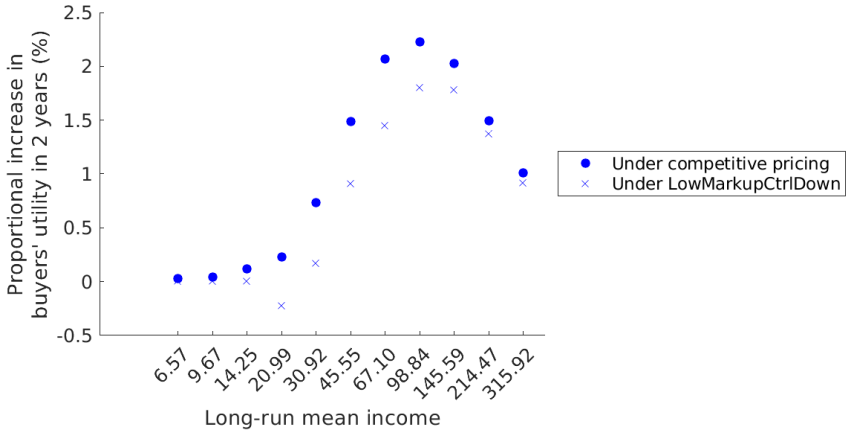
Competitive Pricing

- The take-up rates by $\bar{y}_i$ are



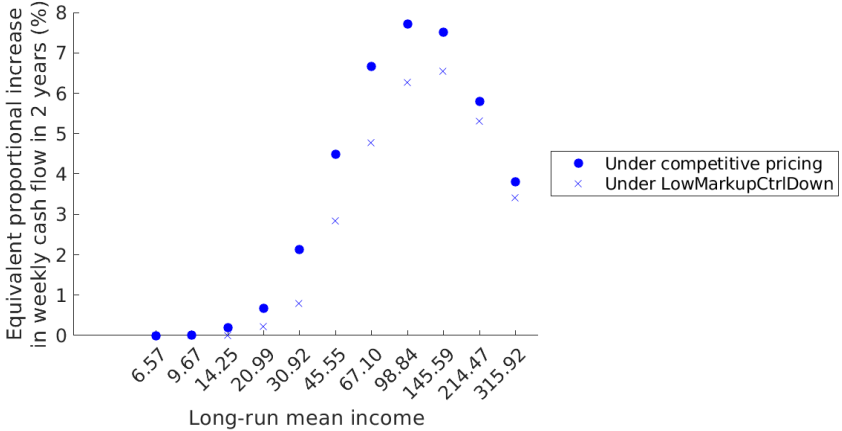
Competitive Pricing

- The proportional increases in buyer's utility by $\bar{y}_i$ are



Competitive Pricing

- The equivalent weekly cash flows as a proportion of long-run mean income by $\bar{y}_i$ are



Welfare & Profitability

Treatment Group	Take-up rate in %	% Increase in buyers' utility (2y)	Equivalent cash flow in $ (2y)	NPV in $	Annual IRR in %
LowMarkupCtrlDown	0.63	1.21	3.85	37.04	201.04
MediumMarkupCtrlDown	0.59	1.17	3.81	49.43	298.02
HighMarkupCtrlDown	0.56	1.07	3.66	64.48	443.75
SteepMarkupCtrlDown	0.57	1.13	3.76	58.01	384.98
LowMarkupLowerDown	0.67	1.20	3.77	36.34	175.50
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HighMarkupLowerDown	0.59	1.06	3.57	64.89	397.87
SteepMarkupLowerDown	0.62	1.10	3.59	64.09	404.44
Competitive pricing	83.04	1.46	3.93	0.00	25.00

Optimal Lockout

- We simulate counterfactuals where we vary the strength of lock λ under the assumption of competitive pricing