Optimal Lockout

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Big Picture

- Traditional microfinance
  - Expensive
  - Inconvenient (high transaction costs)
  - Low uptake
  - Modest effects on average borrower (Banerjee, 2015)
- Digital financial products are becoming increasingly popular. The growth has been facilitated by technological developments:
  - Access to mobile phones and other communication technologies
  - Digital payments (mobile money)
  - Better data about borrowers

How to best utilize these new technologies? What are the effects of these new products on households and firms? Implications for broader economy?

This Paper

Explore new form of secured lending that relies on .

- Traditional Collateral
  - Costly to repossess, but valuable to creditor
  - Repossession is irreversible
- Digital Collateral
  - Cheap to repossess, but little value to creditor
  - Repossession is easily reversible
  - ...but relatively expensive to install

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

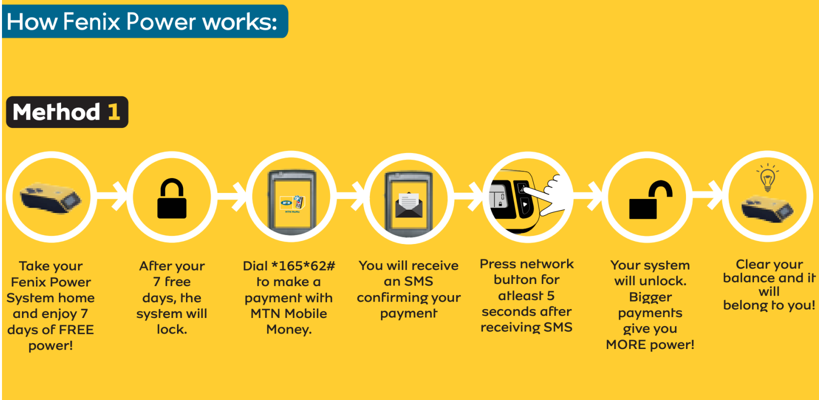
34W *ReadyPay* TV Deluxe (Zuku)	
Deposit:	149,000/-
Daily Rate:	3,000/-
Monthly Rate:	90,000/-
Duration:	26 months
Buy in Cash:	1,999,000/-
	(Includes 1 Year Zuku subscription)
Buy on Loan:	2,539,000/-
	(Includes 2 Years Zuku subscription)

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

How PayJoy Works

Apply for a phone or cash loan

At PayJoy you only need an ID, Facebook account and a valid phone number to apply.

Use your phone as a virtual guarantee

Use your phone as collateral to access more credit opportunities.

Build your credit history

Every payment you make impacts your credit history in a positive way.

"With PayJoy, I was a able to get a phone, pay over time, and now I am able to get a cash loan whenever I need money. Highly recommend!"

Customer in Mexico, since 2018.

GET STARTED

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 models of collateralized lending:

- These two roles are inherently bundled.
- Repossession (or liquidation) is irreversible.

Digital collateral facilitates a richer space of contractual arrangements.

- Decoupling of the two roles
- Temporary and reversible activation of role 2

Questions

- How valuable is securing loans with digital collateral to the lender?
  - Quantify the effect on repayment and profitability
- What is the channel?
  - Moral hazard vs adverse selection
- What are the impacts of the loans on households?

Motivating Examples

1. PAYGO for Solar Home Systems (Fenix, M-Kopa)
   - Battery, solar panel, and small appliances
   - GSM chip installed in battery
   - Battery will not discharge electricity if borrower is delinquent
2. Smart Phones (Payjoy, NuovoPay)
   - Phone locks if borrower is delinquent
3. Subprime Auto Loans (PassTime, Trax SI)
   - Interrupter installed on starter
   - Remotely activated when borrower is sufficiently delinquent
4. Telecom services (Telmex)
   - Offers credit for laptops, tablets, etc.
   - Payments automatically added to telecom bill.

What is the innovation?

Several possibilities:

1. Better technology for permanent repossession
   - Provides repayment incentives without incurring repossession costs
   - Plausible, but not very interesting
2. Enables the lender to overcome a commitment problem
   - Also plausible, but not our focus here.
3. Facilitates a richer space of contracts (e.g., “temporary" repossession)
   - Our question: is this actually valuable?

Model Overview

- Principal-Agent setting
- Principal can produce good that delivers (flow) value to agent
- Two repossession technologies:
  1. Physical/Permanent: principal can physically repossess the good (at some cost c), or permanently repossess.
  2. Lockout: principal can dynamically control agent's consumption of the good.

Our Findings

1. Static Model: Equivalence
2. Discrete-Time Model
    - Risk-neutral agent
        - With observable income, no value of lockout (and no need for repossession).
        - With privately observed income, lockout strictly dominates physical/permanent repossession
    - Risk-averse agent (???)

Continuous-Time Model:

- Provide conditions under which lockout strictly dominates.

The Model

Principal-Agent Setting

- Discrete-time, infinite-horizon: $t = 1, 2, ...$
- Agent has iid income: $y_t \sim g$ on $[0, \bar{y}]$.
- Agent has no wealth and cannot save.
- Principal produces good that gives up to $\bar{q}$ units of utility to the agent per period at zero marginal cost
- Both players are risk-neutral with common discount factor δ

Two frictions

1. Agent privately observes her income ($\Rightarrow$ IC)
2. Agent can walk away from the contract at any time ($\Rightarrow$ IR)

Contracts

Given any history, $h_t = \{\hat{y}_1, ..., \hat{y}_t\}$, the contract specifies:

Lockout Contract:

- A transfer $t(h_t) \leq \hat{y}_t$ from the agent to the principal
- A quantity $q(h_t) \in [0, \bar{q}]$ of the q-good to be consumed by the agent

Repossession Contract:

- A transfer $t(h_t) \leq \hat{y}_t$ from the agent to the principal
- A date τ (can be stochastic) at which the good is repossessed

Payoffs

The per period payoffs:

- To the agent: $u(h^t) \equiv y_t - t(h^t) + q(h^t)$
- To the principal: $t(h^t)$

Denote the agent's continuation value by

$$W_t \equiv E\left(\sum_{s=t}^{\infty} \delta^{s-t} u(h^s)\right)$$

- Let W_A denote the agent's autarky value

Principal's Problem

Following SS87, formulate as a dynamic program:

- $t(\hat{y}, w)$ is the transfer given $(\hat{y}, w)$
- $q(\hat{y}, w)$ is the quantity given $(\hat{y}, w)$
- $w'(\hat{y}, w)$ is the agent's continuation value next period

$$V(w) = \max_{t(\cdot), q(\cdot)} E_y \big(t(y, w) + \delta V(w'(y, w))\big)$$

subject to

- Technological constraints: $t(y, w) \leq y$, $q(\cdot) \in [0, \bar{q}]$
- Incentive compatibility: agent wants to report income truthfully.
- Individual rationality: agent cannot do better by walking away.
- Promise keeping: principal delivers promised continuation value.

Simplifying the Problem

- IC requires that

$$y \in \arg\max y - t(\hat{y}, w) + q(\hat{y}, w) + \delta w'(\hat{y}, w)$$

- Let $v(y, w) \equiv y - t(y, w) + q(y, w) + \delta w'(y, w)$
- By the envelope theorem

$$\frac{\partial v}{\partial y}(y, w) = 1$$

  - Therefore, $v(y, w) = y(0, w) + y$
- Since $w = E(v(y, w))$ (by PK), the constraints alone allow us to solve for $w'(\cdot)$ as

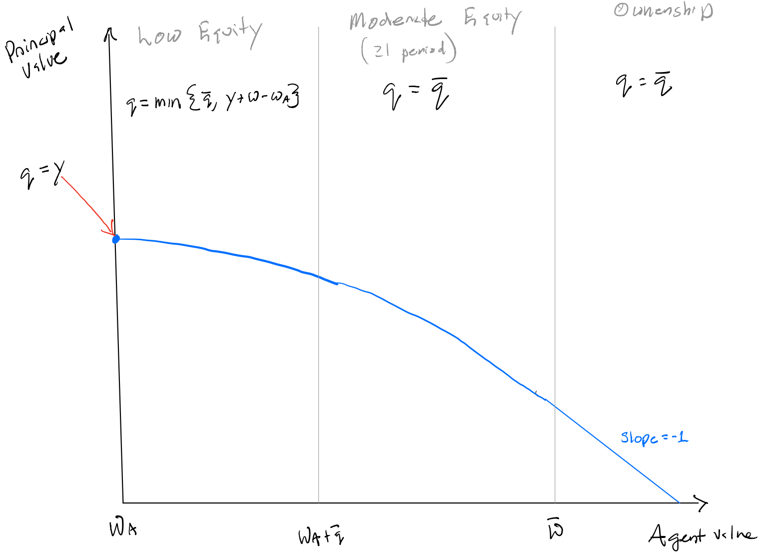
$$\delta w'(y, w) = w + t(y, w) - q(y, w) - E(y)$$

- So, we have reduced the problem to choosing over $\{t(\cdot), q(\cdot)\}$

Characterizing the Solution

- Solution only feasible for $w \geq W_A$
- First-best (i.e., "ownership") for $w \geq \bar{W} = W_A + \frac{\bar{q}}{1-\delta}$
- V is strictly decreasing in w, $V'(w) \geq -1$
  - Implies a pecking order for rewarding agent
  - Cheapest to compensate with q-good
  - Then CV, and then finally consumption good
- Thus, solution is characterized by three different regions of the continuation value domain
  - Low equity
  - Moderate equity
  - Ownership

Illustrating the Solution



Comparison to Traditional Repossession

Traditional Repossession: the principal can (only) permanently repossess the good.

- Agent will consume $\bar{q}$ of q-good prior to repossession
- Since the agent can always walk away, $w'(y,w) \geq W_A$
- When equity is low, the principal *must* repossess with positive probability.
- Otherwise, by reporting low income, the agent can guarantee a payoff of $W_A + \bar{q} > w$.

Comparison to Traditional Repossession

- Assume zero repossession value (for now).
- Let $1 - p(\hat{y}, w)$ denote the probability of repossession
- Principal's problem can be expressed in terms of choosing $\{t, \tilde{q}\}$, where $\tilde{q}(\hat{y}, w) = p(\hat{y}, w)\bar{q} \in [0, \bar{q}]$
- The constraints are identical to the original problem
- But the objective is now

$$\max_{t(\cdot),\tilde{q}(\cdot)} E_y \left(t(y,w) + \delta \underbrace{\frac{\tilde{q}(y,w)}{\bar{q}} V(w'(y,w))}_{\leq V(w'(y,w))} \right)$$

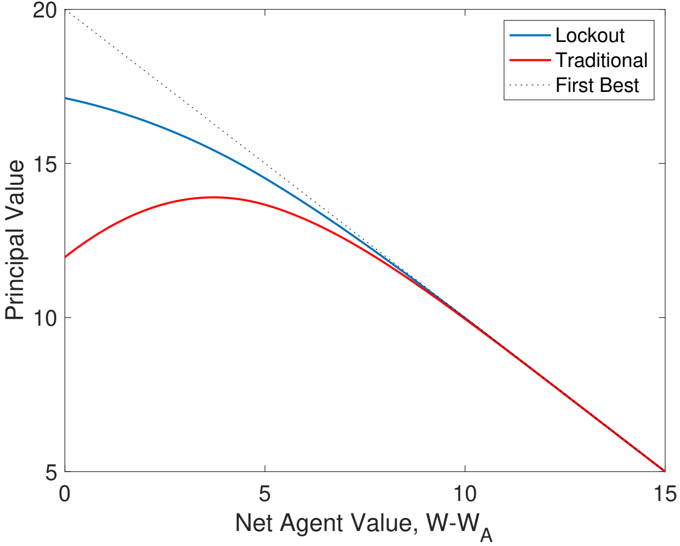
Theorem (Discrete time)

Lockout facilitates a Pareto improvement over traditional repossession.

What's going on?

- Incentives for the agent are the same...she gets her autarky payoff if
  - $q(y, w) < \bar{q}$ (lockout), or
  - the asset is repossessed with positive probability (traditional)
- But temporary repossession facilitates the option to deliver the q-good in the future (and collect associated payments), which is efficient.
- The long-run implications are also different
  - Lockout $\implies$ convergence to ownership
  - Traditional $\implies$ positive probability of repossession

Comparison to Traditional Repossession



What about the liquidation value?

- Suppose the repossession value to the principal is $L > 0$
  - Only realized if asset is permanently repossessed
  - Principal's production cost $K \geq L$ (presumably)

- Can permanent repossession be optimal in this case?
  - No!

- Two cases:
  1. $V(W_A) > K \implies$ Principal does strictly better using only lockout.
  2. $V(W_A) \leq K \implies$ Principal does better by not lending!

- However, larger L reduces the gap between the two value functions.

Continuous-Time Version

Adaptation of DeMarzo and Sannikov (2006):

Agent

- Private income process: $dY_t = \mu dt + \sigma dB_t$
  - Can “divert" income for consumption at rate $\lambda \leq 1$
- Derives utility from two goods: $dU_t = dC_t + q_t dt$
  - The consumption good, dC_t
  - The lockout good, $q_t dt$
- Risk-neutral, discount rate γ.

Principal

- Technology to produce q-good
  - Fixed up-front cost of production
  - Zero marginal cost up to capacity $\bar{q}$
- Can also deliver consumption good to agent at mc=1
- Risk neutral, discount rate $r < \gamma$

Contracts and Payoffs

A contract is a triple (I, q, τ), measurable w.r.t. reported income $\hat{Y}_t$:

- $dI_t \geq 0$ amount of consumption good to agent at t
- $q_t \geq 0$ amount of q-good to agent at t
- τ repossession date

The payoff to the agent

$$U_A = \int_0^\tau e^{-\gamma s}(dI_s + q_s ds) + e^{-r\tau} W_A$$

The payoff to the principal

$$U_P(c, q) = \int_0^\tau e^{-rs}(d\hat{Y}_s - dI_s) + e^{-r\tau} L$$

where L denotes the liquidation value of the good.

Truthful Reporting

- Let W_t denote the continuation value of the agent at time t
- By the MRT

$$dW_t = (\gamma W_t - q_t)dt - dI_t + \beta_t(\hat{Y})(d\hat{Y} - \mu dt)$$

- At any t, the agent chooses a report to solve

$$\max_{d\hat{Y}} \underbrace{dI_t + \lambda(dY_t - d\hat{Y}_t)}_{dC_t} + q_t dt + \beta(d\hat{Y}_t - \mu dt)$$

- Reporting truthfully ($d\hat{Y}_t = dY_t$) is incentive compatible provided that

$$\beta_t \geq \lambda \tag{IC}$$

- Concavity of Principal's VF implies $\beta = \lambda$ is optimal.
- Plugging back into dW_t, we get

$$dW_t = (\gamma W_t - q_t)dt - dI_t + \lambda(dY_t - \mu dt) \tag{PK}$$

Principal's Problem

- Principal's HJB

$$rb(W) = \max_{dI,q} \left\{ \mu - dI + (\gamma W - q - dI) b'(W) + \frac{1}{2} (\lambda\sigma)^2 b''(W) \right\}$$

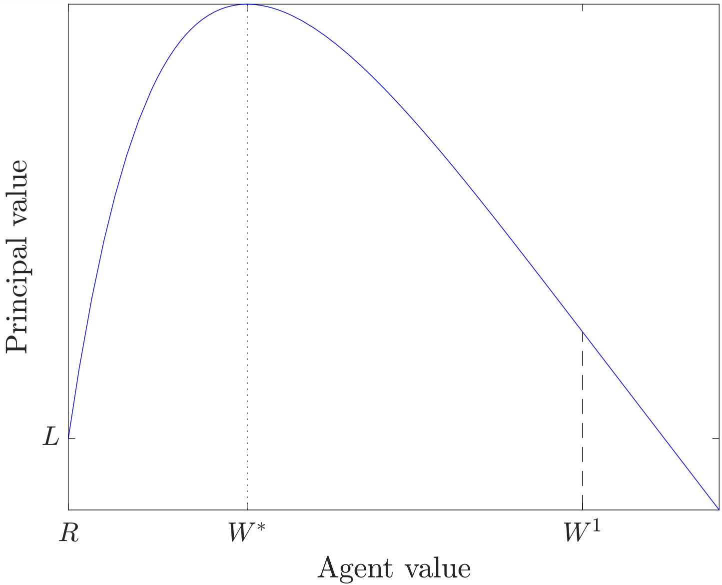
- The marginal benefit of q and dI is the same: $-b'(W)$
- Only the marginal costs differ
  - Optimal payout boundary for consumption good

$$dI^* = \begin{cases} 0 & \text{if } b'(W) \geq -1 \\ W^1 - W & \text{otherwise} \end{cases} \tag{1}$$

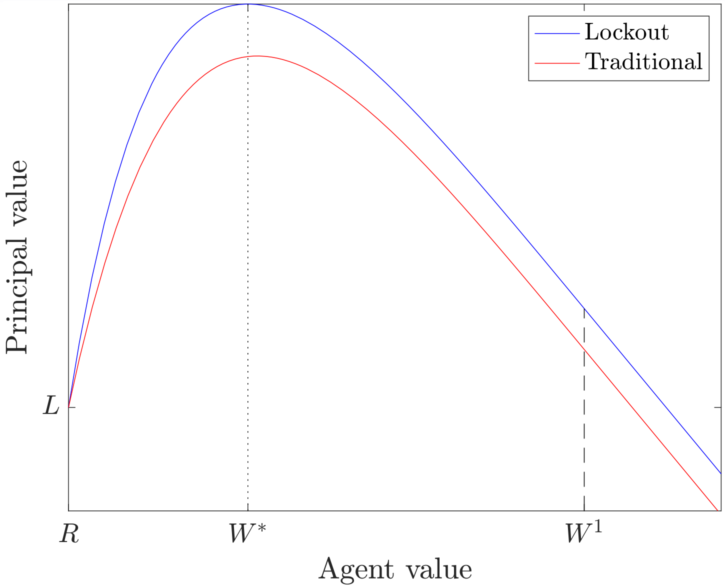
  - Optimal payout for q-good

$$q^* = \begin{cases} 0 & \text{if } b'(W) \geq 0 \\ \bar{q} & \text{otherwise} \end{cases} \tag{2}$$

Graphical Illustration



Graphical Illustration



When is lockout valuable?

- Recall $b(W)$ denotes the principal's value function with lockout.
- Let $f(W)$ denote the principal's value function with traditional repossession.

Theorem (Continuous Time)

Lockout facilitates a Pareto improvement if and only if $f'(W_A) > 0$.

- If f is everywhere decreasing, then marginal benefit of increasing W is always negative
- Optimal contract with lockout is $q^*(W) = \bar{q}$ for all $W \geq W_A$
- No way to improve over traditional repossession

Note: that $f'(W_A) > 0$ does not imply that the principal can make a profit with traditional repossession

- f does not account for the up-front production cost

Differences

- In the DT model, lockout strictly dominates physical repossession
- In the CT model, the optimal contract features both and lockout only dominates under some conditions.
- What's going on here?
  - Brownian income shocks are order $\sqrt{dt}$
  - Flow benefit of q-good is order dt
  - Controlling consumption of q-good is not sufficient to induce truthful reporting at the autarky boundary (i.e., where principal cannot reduce continuation value any further).

Summary

- Recent technological innovations have facilitated a new form of collateralized lending featuring temporary repossession.
- We embed this technology into two canonical (dynamic moral hazard) settings and provide conditions under which it leads to a Pareto improvement.