Dynamic Lending under Adverse Selection and Limited Borrower Commitment: Can it Outperform Group Lending?

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Microcredit research questions

- (Microcredit = small loans for self-employment opportunities, typically in developing countres)
- Does it work? e.g. does it raise household consumption?
- *How* does it work?

  "Loans to poor people without any financial security had appeared to be an impossible idea." – Nobel Peace Prize 2006 press release

  Yet, lending has grown at unprecedented rates in these markets throughout the world

How is microlending possible?

- Given recent explosion of microlending, potential answers naturally focused on *innovative* techniques of microlenders – especially, *group lending*
  - Group lending requires groups of borrowers to bear liability for each other's loans
- But, group lending is at best a partial answer
  - Not all successful micro-lenders use group lending
  - Anecdotal evidence of a trend away from group lending (?)
  - Evidence in Gine and Karlan (2009)

How is microlending possible?

- The extensive theoretical literature justifying group lending typically compares it to **static** individual lending ...

  even though leading alternative to group lending is probably repeated, **dynamic** individual lending

- Has group lending been overemphasized theoretically by comparison to static rather than dynamic individual lending?

Dynamic Lending under Adverse Selection

- Relatively few models of dynamic lending under adverse selection exist – more focus on dynamic moral hazard
- Simple problem: how to use information about borrower type, revealed over time, to price for risk
- However, use of information often subject to constraints:
  - Borrowers can drop out (after repaying current loan) – "limited commitment"
  - Success cannot be rewarded too heavily – "monotonicity"
- In this setting, what are efficiency properties and contract structure?

This Paper

- We solve for an optimal two-period lending contract in an environment of adverse selection, subject to limited borrower commitment and monotonicity constraints
  - Show how dynamic contracting can be useful in overcoming adverse selection by improving risk pricing
  - Dynamic contracts are back-loaded – high rates for first-time borrowers, followed by lower, performance-contingent rates, as in "relationship lending"
  - A standardized (pooling) contract is optimal and robust to (hidden) savings
  - Safe borrowers prefer to be priced out of the market when they fail $\Rightarrow$ can be a tradeoff between equity and efficiency

This Paper

- We compare dynamic individual contracts with static group contracts
  - Each dominates under different circumstances – can potentially help explain co-existence of, and variation in, lending techniques across environments
  - Both reveal same amount of information to lender, but constraints on use of information make the difference
  - Serially correlated risk works against dynamic lending; spatially correlated risk works against group lending
  - Results consistent with dynamic lending playing as significant a role as group lending in reviving credit markets

Related Literature

- Extensive literature on dynamic adverse selection. Distinguishing features of this paper include:
  - Borrower types fixed (unlike large insurance literature)
  - Lender can commit to dynamic contract (unlike "ratchet effect" literature, most "relationship lending" literature)
  - Borrower can leave dynamic contract after any period

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  - Borrower can leave dynamic contract after any period
- Similar one-sided commitment also studied by
  - Harris/Holmstrom (1982) – labor contracts
  - Cooper/Hayes (1987), Phelan (1995) – insurance contracts
  - Boot/Thakor (1992) – lending contracts
  - All tend to find back-loaded contracts, as we do
  - Only Boot/Thakor study lending; there it is about inducing effort rather than pricing for inherent risk

Related Literature

- Also close is Webb (1992) – two-period lending contract under adverse selection
  - He shows borrowers can be separated by a menu of contracts where only the safe borrower's period-2 rates are contingent on period-1 performance
  - We more thoroughly explore a similar model, and add limited borrower commitment and monotonicity constraints
- We also first compare standard group lending contracts under adverse selection (Ghatak 1999, 2000) with dynamic lending contracts

Basic setup

- Risk-neutral agents with (self-known) risk-types $\tau \in \{r, s\}$
  - θ **r**isky, $1-\theta$ **s**afe agents
- Type-τ agent can produce $\overline{u} \geq 0$ without capital, or undertake a project that requires 1 unit of capital and
  - "succeeds" with prob. p_τ $\Rightarrow$ returns R_τ
  - "fails" with prob. $1-p_\tau$ $\Rightarrow$ returns 0
  - $0 < p_r < p_s < 1$
- Stiglitz/Weiss Assumption: $p_\tau R_\tau = \overline{R}$, for $\tau \in \{r, s\}$
  - Agents differ in variance, not mean – no "bad" types

Basic setup

- Agents have no wealth
- Risk-neutral lender maximizes total borrower surplus subject to earning opportunity cost $\rho > 0$ per unit of capital (zero-profit constraint, "ZPC")
- Contracts subject to limited liability
- Lender does not observe output exactly, only success ($R_\tau > 0$) or failure ($R_\tau = 0$)
  - This plus limited liability $\Rightarrow$ debt contracts
- Lender does not observe borrower type

Basic setup

- Let $\mathcal{N} \equiv \frac{\overline{R}-\overline{u}}{\rho}$ *and* $\mathcal{G} \equiv \frac{\overline{R}}{\rho}$
  - $\mathcal{N}$ is the **net excess return to capital** in this market
  - $\mathcal{G}$ is the **gross** excess return to capital
- "Lending is Efficient" Assumption:

$$\overline{R} - \overline{u} > \rho \qquad \Longleftrightarrow \qquad \mathcal{N} > 1$$

  - net project payoff $(\overline{R} - u)$ exceeds cost of capital (ρ)
  - $\Rightarrow$ total surplus monotonically increasing in # projects funded
    $\Rightarrow$ full efficiency means lendings to all agents

Known Result: Potential for "Lemons" Problem

- Static, individual debt contracts are priced based on average risk in the pool, can be too expensive for safe borrowers

  $\Rightarrow$ market can partially break down and only fund risky projects – due to inability to price for risk

- Let $\overline{p}$ be average risk-type ($\overline{p} = \theta p_r + (1-\theta)p_s$)

  Efficient lending can**not** be attained by static individual lending iff

$$1 < \mathcal{N} < \overline{\mathcal{N}}_{1,1} \equiv \frac{p_s}{\overline{p}} \qquad (A3)$$

Dynamic Lending

- Two-period setting: each agent (**fixed type**) is endowed with risky or safe project, and outside option, in both periods
- First, consider two-period simple pooling contract:
  $(r_\emptyset, r_1, r_0)$, all non-negative
  - $r_\emptyset$ – period-1 interest rate (after null history)
  - r_0, r_1 – period-2 interest rate after 0,1 success, resp.

Contract Restrictions

- Deterministic
- Borrower limited liability ("**LL**")
- **Limited borrower commitment**
  - Lender can commit to 2-period contract, but borrowers cannot commit to taking a second loan

Contract Restrictions

- Assume **monotonic** contracts that involve (weakly) lower payment for failure than for success
  - Addresses concern that a borrower may pretend to have succeeded after failing – if it means paying less
  - As in Innes (1990), Che (2002), Gangopadhyay et al. (2005)
  - Monotonicity ("**MC**") constraints:

$$r_0, \mathbf{r_1} \geq 0$$

$$r_\emptyset + p_\tau r_1 \geq p_\tau r_0$$

Optimal Contract

- Lemma 1: If safe agents opt to borrow in period 1, so do risky
- Since including safe is the challenge, strategy will be to maximize safe-borrower payoff subject to constraints:
  - bank's ZPC, assuming all borrow
  - MC-2: non-negativity of period-2 rates
  - LL-failure: zero payment after failure
  - Other constraints verified later
- Let $\hat{r}_s$ be safe borrower's reservation rate on one-shot loan:

$$\overline{R} - p_s \hat{r}_s = \overline{u}$$

- Let $\hat{r}_r$ be defined similarly; can show $\hat{r}_r > \hat{r}_s$

Optimal Contract

- Consider $r_1 \in (-\infty, \hat{r}_s]$
  - (Safe borrower opts for a period-2 loan after success)
  - Lowering r_1, raising $r_\emptyset$ along ZPC raises safe borrower's payoff
    $\Rightarrow$ Set r_1 to lower bound (MC-2): $r_1 = 0$

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- Consider $r_1 \in (\hat{r}_s, \infty)$
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    $\Rightarrow$ Set r_1 to risky reservation rate: $r_1 = \hat{r}_r$
- Can show safe borrower prefers $\mathbf{r_1 = 0}$ to $r_1 = \hat{r}_r$
  - Free loan after success is best for safe borrowers

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  - (Safe borrower opts for a period-2 loan after failure)
  - Raising r_0, lowering $r_\emptyset$ along ZPC raises safe borrower's payoff
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  - Safe borrower does not pay r_0, prefers it to be set to maximally extract surplus from risky borrower, e.g. to allow for lower $r_\emptyset$
    $\Rightarrow$ Set r_0 to risky reservation rate: $r_0 = \hat{r}_r$
- Either way, safe borrowers get reservation payoff after failure; but $r_0 = \hat{r}_r$ raises most revenue (under Assumption A3)
  - Safe borrowers prefer to be priced out of the market after failure

Optimal Contract

- $\Rightarrow$ Best-for-safe contract:

  $r_1 = 0,\ r_0 = \hat{r}_r,\ r_\emptyset$ from ZPC

- This contract attracts safe borrowers in period 1 iff $\mathcal{N} \geq \overline{\mathcal{N}}^*_{1,2}$
  - $\overline{\mathcal{N}}^*_{1,2}$ a function of only (p_r, p_s, θ)
    (Recall $\mathcal{N}$ is net excess return, equals $(\overline{R} - \overline{u})/\rho$)
  - $1 < \overline{\mathcal{N}}^*_{1,2} < \overline{\mathcal{N}}_{1,1}$, i.e. a dynamic contract can sometimes attract safe borrowers when a static contract cannot
  - But investment is only "nearly"-efficient: unlucky safe borrowers take only one loan, all others take two
  - Can another contract achieve higher borrower surplus?

Optimal Contract

- Any higher-surplus contract must attract failed safe borrowers
  $\Rightarrow$ must involve $r_0 \leq \hat{r}_s$
- Maximizing safe payoffs with extra constraint $r_0 \leq \hat{r}_s$ gives:
  $r_1 = 0$, $r_0 = \hat{r}_s$, $r_\emptyset$ from ZPC
- This contract attracts safe borrowers in period 1 iff $\mathcal{N} \geq \overline{\mathcal{N}}_{1,2}$
  - $\overline{\mathcal{N}}_{1,2}$ a function of (p_r, p_s, θ)
  - $\overline{\mathcal{N}}^*_{1,2} < \overline{\mathcal{N}}_{1,2} < \overline{\mathcal{N}}_{1,1}$, implying that
    - Dynamic contract can sometimes achieve full efficiency when a static contract cannot
    - Dynamic contract can sometimes achieve "near"-efficiency when it cannot achieve full efficiency

Efficiency Results

- Proposition 1: With $\mathcal{G}$ high enough, either
  - $\mathcal{N} \geq \overline{\mathcal{N}}_{1,2} \Rightarrow$ Fully efficient lending is achievable
  - $\overline{\mathcal{N}}^*_{1,2} \leq \mathcal{N} < \overline{\mathcal{N}}_{1,2} \Rightarrow$ Nearly efficient lending is achievable – only failed safe borrowers drop out
  - $1 < \mathcal{N} < \overline{\mathcal{N}}^*_{1,2} \Rightarrow$ Only risky agents borrow
- ($\mathcal{G}$ needs to be high enough for $r_\emptyset$ to be affordable)
- Dynamic lending works under adverse selection by improving risk-pricing as information is revealed
  - Targets higher expected rates toward risky borrowers, reduces cross-subsidy from safe to risky

Contract Structure

- Borrower limited commitment leads to back-loaded incentives.

  Under the fully-efficient contract:

$$r_{\emptyset} > r_0 > r_1$$

  - A borrower with no credit history faces a higher rate than one with any credit history
  - Lender starts agents at high rate and offers performance-dependent "refunds" over time
  - Starting at a neutral rate and raising it after failure would risk excluding unlucky safe borrowers in period 2
  - New rationale for "relationship lending" – here it is the optimal way to dynamically price for risk when borrowers can drop out

Contract Structure

- Safe agents prefer "nearly"-efficient lending even when fully efficient lending is possible
  - I.e. they prefer to be priced out of the market when they fail (Even when priced into the market after they fail, it is at their reservation rate)
  - The loss in total surplus is more than compensated for by the shift in repayment burden toward the risky
  - $\Rightarrow$ Tradeoff between efficiency and equity (since safe borrowers earn less than risky)

More Complicated Contracts

- Proposition 2: Cannot do better with forced savings or collateral, menu of contracts, subsidies after success
  - Forced savings/collateral can be collected upfront through initial interest rate, $r_{\emptyset}$
    - Hidden savings also no problem – borrower will take free loan
  - Subsidies after success have to be mirrored by equally strong subsidies of failure – by monotonicity
  - Screening safe and risky with two contracts cannot improve:
    - Risky IC will bind at optimum
    - Risky payoff and lender profits are zero-sum
    - $\Rightarrow$ Give risky borrower the safe contract, he and lender are just as happy

Group lending – Ghatak et al.

- Consider static lending to agents in groups of size 2; agents know each others' types and can match frictionlessly
- Contract contains 2 parameters:
  - interest rate r, due from a borrower who succeeds
  - joint liability payment c, due from a borrower who succeeds and whose partner fails
- Key result: joint liability ($c > 0$) $\Rightarrow$ homogeneous matching: safe with safe, risky with risky
- The relevant MC constraint is "no more than full liability":

$$c \leq r$$

Group lending – Ghatak et al.

- Optimal contract: raising liability c, lowering interest rate r along ZPC raises the safe-borrower payoff
- Since including safe borrowers is the binding constraint, impose full liability: $c = r$
  - Maximally targets payments to states with more failures, i.e. to risky borrowers (subject to MC)
- For $\mathcal{G}$ high enough, safe borrowers are included iff $\mathcal{N} \geq \overline{\mathcal{N}}_{2,1}$
  - $\overline{\mathcal{N}}_{2,1}$ a function of only (p_r, p_s, θ)

Dynamic vs Group

- Corollary 1: Static group lending achieves full efficiency under weaker conditions than dynamic individual lending, i.e.

$$1 < \overline{\mathcal{N}}_{2,1} < \overline{\mathcal{N}}_{1,2}$$

- Why does group lending dominate?

Dynamic vs Group

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- Why does group lending dominate?

- Both contracts ultimately reveal the **same information**: observations of 2 draws from a borrower's distribution
  - Group lending: two cross-sectional observations (equally informative due to homogeneous matching)
  - Dynamic lending: two time-series observations
  - $\Rightarrow$ lender's posterior assessment of borrower type is identical in each case

- Compare expected per-period repayment under group lending and dynamic lending:

$$p_\tau\left[\quad r \quad + (1-p_\tau) \quad c \quad\right]$$
$$p_\tau\left[\frac{r_\emptyset + r_1}{2} + (1-p_\tau)\,\frac{(r_0 - r_1)}{2}\right]$$

  - Both are quadratic in borrower risk-type, p_τ
  - The efficient-lending ZPCs are also isomorphic

- $\Rightarrow$ Ignoring constraints, they can achieve identical outcomes
- $\Rightarrow$ Constraints on using information make the difference

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  - Size of this discount is limited by monotonicity: $c \leq r$
- Under dynamic lending, safe-borrower discount in per-period "effective" interest rate is $(p_s - p_r)(r_0 - r_1)/2$
  - Equals expected per-period savings in interest rate from succeeding more often in period 1
  - Limited commitment and monotonicity cap this discount: $r_0 \leq \hat{r}_s$ and $r_1 \geq 0$
  - Ultimately, dynamic lending constrained in risk-pricing by limited commitment: cannot vary interest rate much while retaining all borrowers

- Corollary 2: Dynamic individual lending can in some cases achieve "nearly"-efficient lending when static group lending only attracts risky borrowers, i.e.

$$\overline{\mathcal{N}}^*_{1,2} < \overline{\mathcal{N}}_{2,1} \; (< \overline{\mathcal{N}}_{1,2})$$

  - (under some parameter values: p_r low enough)

- Thus, dynamic individual lending can outperform group lending – but only by giving up on failed safe borrowers

- Other factors affecting group vs dynamic comparison
  - Strong local information, frictionless matching required for group lending
    Dynamic project endowment and lender commitment required for dynamic lending
  - Spatial correlation hampers group lending, serial correlation hampers dynamic lending – limits information revelation
  - Constraints on relationship duration or group size, since more periods/larger groups allow for greater information revelation
- No universally dominant contract structure

Dynamic Group Lending

- If both sets of assumptions are met, lender need not choose **between** group lending or dynamic lending
- Consider a two-period group lending contract
  - Efficiency. Can achieve fully efficient lending over more of parameter space than group or dynamic, i.e.

$$\overline{\mathcal{N}}_{2,2} < \overline{\mathcal{N}}_{1,2}, \overline{\mathcal{N}}_{2,1}$$

  - Structure. Hybrid of group and dynamic contracts:
    - Full liability on all loans
    - Free loan after first loan repaid, otherwise safe borrower's reservation rate (backloading)
    - Dynamic aspect works against but does not overturn homogeneous matching

Competition

- Consider competitive market instead of single non-profit lender
- Charging $r_0 = \hat{r}_r$ as in "nearly"-efficient lending not feasible
  - Because risky borrowers can always get the full-information competitive rate, ρ/p_r
  - Instead charge $r_0 = \rho/p_r$
  - This limits lender's ability to reduce cross-subsidy $\Rightarrow \overline{\mathcal{N}}^*_{1,2}$ increases but remains below $\overline{\mathcal{N}}_{1,2}$
  - Dynamic contract can still outperform group contract
- Fully efficient contract does not survive competition
  - Even if feasible for non-profit lender
  - Because safe borrowers prefer the "nearly"-efficient contract, and they pay more than their share

T Periods

- Information revelation increases with T
- Preliminary work suggests full efficiency can always be achieved if T and $\mathcal{G}$ are large enough
  - But, is the condition on $\mathcal{G}$ realistic?
- (Group lending with group size n: efficient lending achievable if n high enough (Ahlin 2012)
  - Condition on $\mathcal{G}$ relatively weak)

Conclusion

- Dynamic lending useful in overcoming adverse selection
  - Provides a way to lower cross-subsidy from safe borrowers, target greater repayment obligation to risky borrowers by "penalizing" failure
- But, usefulness limited by borrowers' ability to drop out
  - Goal of retaining borrowers limits the ability to use revealed information to price for risk
- As a result, contracts feature high rates for new borrowers, better for returning customers
  - "Relationship lending" as optimal dynamic risk-pricing when borrowers can drop out

Conclusion

- Given borrowers know each others' types, group lending and dynamic lending extract similar information
  - Group lending: cross-section observations, informative about the individual borrower due to homogeneous matching
    Dynamic lending: time-series observations
- Relative ability to achieve efficient lending depends on constraints on using the information
  - Dynamic lending can outperform when it gives up on unlucky safe borrowers in order to shift the repayment burden more toward risky borrowers – at the expense of some efficiency
  - Model consistent with dynamic lending playing a role similar to group lending's in the success of microcredit