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 countries)

- 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 ⇒ 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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- Similar one-sided commitment also studied by
  - Harris/Holmström (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 $\tau \in \{r, s\}$
  - $\theta$ risky, $1 - \theta$ safe agents

- Type-$\tau$ agent can produce $\bar{u} \geq 0$ without capital, or undertake a project that requires 1 unit of capital and
  - “succeeds” with prob. $p_{\tau} \Rightarrow$ returns $R_{\tau}$
  - “fails” with prob. $1 - p_{\tau} \Rightarrow$ returns 0
  - $0 < p_r < p_s < 1$

- Stiglitz/Weiss Assumption: $p_{\tau} R_{\tau} = \bar{R}$, 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 $\mathcal{N} \equiv \frac{\bar{R} - \bar{u}}{\rho}$ and $G \equiv \frac{\bar{R}}{\rho}$

  - $\mathcal{N}$ is the net excess return to capital in this market
  - $G$ is the gross excess return to capital

- “Lending is Efficient” Assumption:
  
  $\bar{R} - \bar{u} > \rho \iff \mathcal{N} > 1$

  - net project payoff ($\bar{R} - u$) exceeds cost of capital ($\rho$)
  - $\Rightarrow$ 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

  \[ p = \theta \bar{p}_r + (1 - \theta) \bar{p}_s \]

  \[ \Rightarrow \text{market can partially break down and only fund risky projects – due to inability to price for risk} \]

- Let \( \bar{p} \) be average risk-type \( (\bar{p} = \theta \bar{p}_r + (1 - \theta) \bar{p}_s) \)

  Efficient lending cannot be attained by static individual lending iff

  \[ 1 < \mathcal{N} < \overline{\mathcal{N}}_{1,1} \equiv \frac{\bar{p}_s}{\bar{p}} \quad (A3) \]
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: $(r_0, r_1, r_0)$, all non-negative

  - $r_0$ – 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:
    \[
    r_0, \ r_1 \geq 0
    \]
    \[
    r_\emptyset + p_\tau r_1 \geq p_\tau r_0
    \]
Optimal Contract

- Lemma 1: If safe agents opt to borrow in period 1, so do risky agents.

- 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:
  \[
  \bar{R} - p_s \hat{r}_s = \bar{u}
  \]

- 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): $r_1 = 0$
Optimal Contract

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- Consider \( r_1 \in (\hat{r}_s, \infty) \)
  
  - (Safe borrower opts out of period-2 loan after success)
  
  - Safe borrower does not pay \( r_1 \), prefers it to be set to maximally extract surplus from risky borrower, e.g. to allow for lower \( r_{\emptyset} \)
    \( \Rightarrow \) Set \( r_1 \) to risky reservation rate: \( r_1 = \hat{r}_r \)
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- Can show safe borrower prefers \( r_1 = 0 \) to \( r_1 = \hat{r}_r \)
  - Free loan after success is best for safe borrowers
Optimal Contract

- Consider $r_0 \in (-\infty, \hat{r}_s]$
  - (Safe borrower opts for a period-2 loan after failure)
  - Raising $r_0$, lowering $r_\emptyset$ along ZPC raises safe borrower’s payoff
    \[ \Rightarrow \text{Set } r_0 \text{ to upper bound: } r_0 = \hat{r}_s \]
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- 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

▷ ⇒ Best-for-safe contract:

\[ r_1 = 0, \quad r_0 = \hat{r}, \quad r_\emptyset \text{ from ZPC} \]

▷ This contract attracts safe borrowers in period 1 iff \( N \geq \overline{N}_{1,2} \)

▷ \( \overline{N}_{1,2} \) a function of only \((p_r, p_s, \theta)\)
  (Recall \( N \) is net excess return, equals \((\overline{R} - \overline{u})/\rho\))

▷ 1 < \( \overline{N}_{1,2} < \overline{N}_{1,1} \), 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:
  \[ r_1 = 0, \quad r_0 = \hat{r}_s, \quad r_∅ \text{ from ZPC} \]

- This contract attracts safe borrowers in period 1 iff \( \bar{N} \geq \bar{N}_{1,2} \)
  \[ \bar{N}_{1,2} \text{ a function of } (p_r, p_s, \theta) \]
  \[ \bar{N}_{1,2}^* < \bar{N}_{1,2} < \bar{N}_{1,1}, \text{ implying that} \]
  \[ \text{Dynamic contract can sometimes achieve full efficiency when a static contract cannot} \]
  \[ \text{Dynamic contract can sometimes achieve “near”-efficiency when it cannot achieve full efficiency} \]
Efficiency Results

- Proposition 1: With $G$ high enough, either
  
  - $N \geq \overline{N}_{1,2} \Rightarrow$ Fully efficient lending is achievable
  
  - $\overline{N}_{1,2} \leq N < \overline{N}_{1,2} \Rightarrow$ Nearly efficient lending is achievable – only failed safe borrowers drop out
  
  - $1 < N < \overline{N}^* \Rightarrow$ Only risky agents borrow
  
  - ($G$ 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
  - 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 $G$ high enough, safe borrowers are included iff $\mathcal{N} \geq \overline{\mathcal{N}}_{2,1}$
  
  - $\overline{\mathcal{N}}_{2,1}$ a function of only $(p_r, p_s, \theta)$
Dynamic vs Group

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

\[ 1 < \bar{N}_{2,1} < \bar{N}_{1,2} \]

- Why does group lending dominate?
Dynamic vs Group

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

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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:

\[
p_r \left[ r + (1 - p_r) \right] c \]
\[
p_r \left[ \frac{r_0 + r_1}{2} + (1 - p_r) \frac{(r_0 - r_1)}{2} \right]
\]

- Both are quadratic in borrower risk-type, \( p_r \)
- The efficient-lending ZPCs are also isomorphic

⇒ Ignoring constraints, they can achieve identical outcomes

⇒ Constraints on using information make the difference
Efficiency requires large discount in interest rate for safe borrowers
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Under group lending, the safe-borrower discount in “effective” interest rate is $(p_s - p_r)c$

- Equals expected savings in joint liability payment from having a safe partner instead of risky
- Size of this discount is limited by monotonicity: $c \leq r$
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Under group lending, the safe-borrower discount in “effective” interest rate is \((p_s - p_r)c\)

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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.

\[ \overline{N}_{1,2}^* < \overline{N}_{2,1} < \overline{N}_{1,2} \]

(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.
    \[ N_{2,2} < N_{1,2}, N_{2,1} \]

- 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, $\rho/p_r$
  - Instead charge $r_0 = \rho/p_r$
  - This limits lender’s ability to reduce cross-subsidy
    $\Rightarrow \overline{N}^{*}_{1,2}$ increases but remains below $\overline{N}_{1,2}$
  - 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 $G$ are large enough
  - But, is the condition on $G$ realistic?

- (Group lending with group size $n$: efficient lending achievable if $n$ high enough (Ahlin 2012)
  - Condition on $G$ 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