Towards Anonymous Undercollateralized Loans

Tim Dong[1]

[1]Department of Finance
University of Tennessee

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- All of DeFi loans are overcollateralized, with collateral-to-loan ratio ranging from 200% to 500%
- DeFi does not provide liquidity

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Research question

- Is it possible to have anonymous and permissionless undercollateralized lending? (whether it's on blockchain or not is irrelevant)

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Motivation

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- Centralized credit info = More extreme consequences when data breaches occur
- Current financial system is not efficient and inclusive enough (Harvey, 2021)
- DeFi can help, but it only offers overcollateralized lending

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Literature

- Early research regarding a semi-anonymous credit market was done by cryptographers

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- Semi-anonymous because one party still know the identity of borrowers and may hold them accountable

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Contributions

- Propose a model for anonymous (permissionless) and undercollateralized lending

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- Propose a model for anonymous (permissionless) and undercollateralized lending
- Show conditions for incentive compatible loans

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Why borrowers may want to stay honest

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- Collateral loans are exposed to liquidation risk

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- Two types of players: borrower and a lending platform

Players

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- A borrower has 3 possible strategies:
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  2. Always pay back credit loans (honest)
  3. Pay back only if collateral's value > principal + interests (mixed/strategic)

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- A lending platform that:
  1. Offers only overcollateralized lending to new users, i.e. users who have been borrowing for τ years
  2. After τ years, users can take undercollateralized loans with no early liquidation

Assumptions

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- Overcollateralized loans are risk-free
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- Borrowers can always pay back loans if want to
- Asset prices are log-normal (*)
  - Only for convenience.

Parameters

Table 1. Parameter definitions

Parameter	Meaning
P	loan amount
r	anonymous credit borrowing rate
τ	number of periods (years) before credit loans are allowed
i	discount or risk-free rate
c	overcollateral borrowing rate
u	unobservable borrower's return from using the loan
y	return the borrower gains from holding his collateral assets
k	collateral-to-loan ratio for overcollateralized loans ($k > 1$)
l	collateral-to-loan ratio for undercollateralized loans ($l \leq 1$)
ρ_t	stochastic collateral assets' return
F	the probability $Pr(\rho_t < r)$

Possible payoffs

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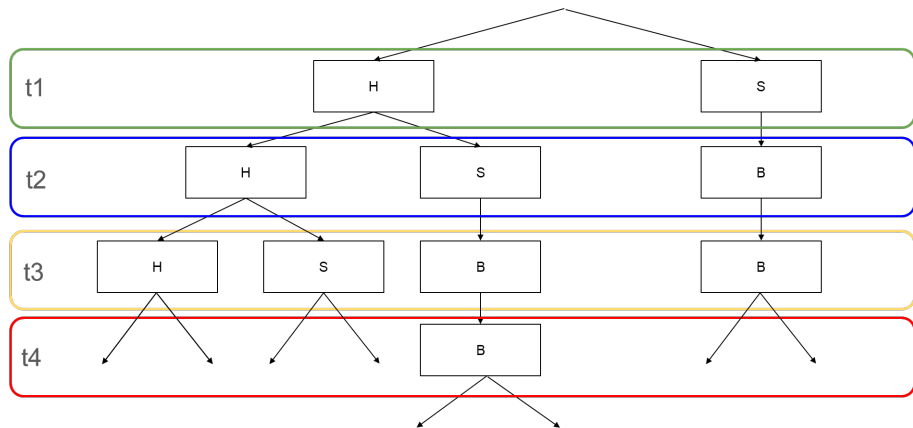$$H := P(u - r + l\rho_H) + G$$

- If default on undercollateralized loans:

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- If pay back on undercollateralized loans:

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- If default on undercollateralized loans:

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- For overcollateralized loans:

$$B := P(u - c)$$

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- For overcollateralized loans, all strategies give the same payoffs
- The only time when strategies matter is for credit/undercollateralized loans
- Only need to compute the expected payoff differences up to the point of options, i.e., where the borrowers can choose.

Visualization of payoffs for $\tau = 2$
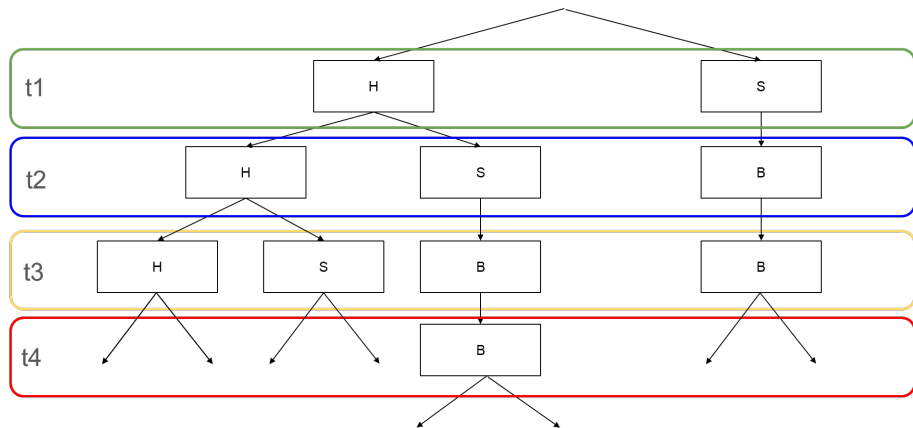
Main result

$\mathbb{E}[H(r) - M(r)] > 0$

$$\Leftrightarrow \frac{F(\mathrm{D}_{HB}\mathrm{e}^{(-2\tau-1)i}\,(1-F)^{\tau+1})}{(\mathrm{e}^i - 1 + F)\,(\mathrm{e}^i - 1)} + \frac{F\left((-\mathrm{D}_{HB} + \mathrm{D}_{HS})\,\mathrm{e}^{-i(\tau+1)} - \mathrm{D}_{HS}\mathrm{e}^{-i\tau}\right)(1-F)^{\tau+1}}{(\mathrm{e}^i - 1 + F)\,(\mathrm{e}^i - 1)}$$

$$+ \frac{F(\mathrm{D}_{HS}\mathrm{e}^i + \mathrm{D}_{HB} - \mathrm{D}_{HS}\mathrm{e}^{-i\tau}\mathrm{D}_{HB})}{(\mathrm{e}^i - 1 + F)\,(\mathrm{e}^i - 1)} > 0 \qquad (1)$$

where

$$\begin{aligned}
\mathrm{D}_{HS} &= \mathbb{E}\left[H_B - S_B \mid l(1 + \rho_t) < 1 + r\right]\\
&= \mathbb{E}\left[P(l(1 + \rho_t) - (1 + r)) \mid l(1 + \rho_t) < 1 + r\right] < 0\\
\mathrm{D}_{HB} &= \mathbb{E}\left[H_B - B_B\right]\\
&= P\left(c - r + l\bar{\rho}\right) + (k - l)\,Py\,(1 + \bar{\rho})
\end{aligned}$$

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Key observations

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- It might be possible to have incentive compatible anonymous credit lending market
- Honest incentive compatible credit rate does not depend on borrower's return
- Higher τ leads to higher honest advantage, but at a diminishing rate
- Higher collateral asset's expected return linearly and positively correlate with higher credit rate

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Agent-based simulation

- Utilize cadCAD framework
  - cadCAD has been applied in production, e.g. THORChain

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- Validate theoretical results and extend to more complex scenarios

Moral hazard

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- Moral hazard causes the unobserved borrower return, u, to appear in the profit difference
- If the expected utility maximization assumption holds, then the results are unchanged. See Figure 3

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Validating theoretical results
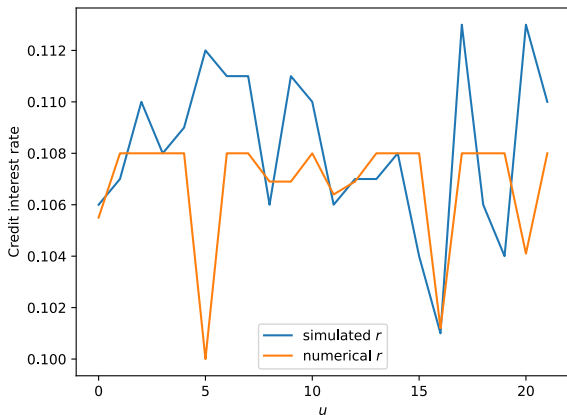
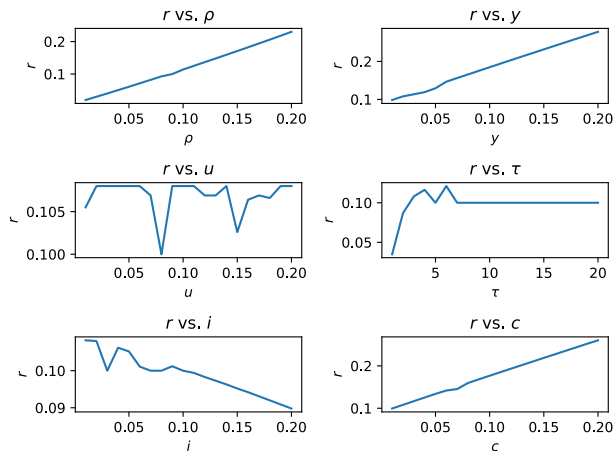Figure: Formula validation (SPY as the underlying asset)

Comparative statics

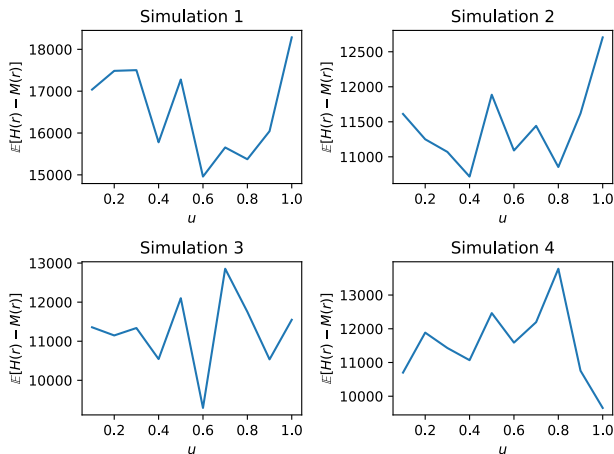Figure: Comparative statics

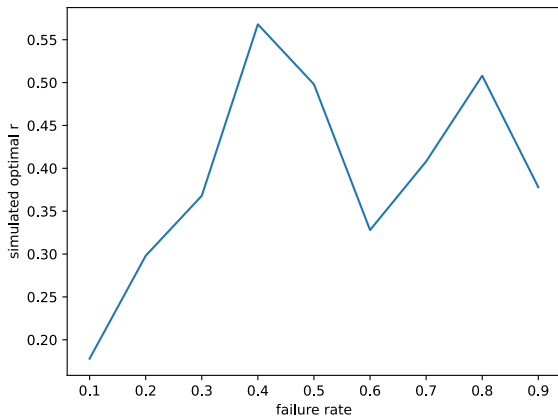# Moral hazard

Figure: Moral hazard

Accidental default

Figure: Accidental default

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Conclusion

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- The results provide the theoretical foundation for P2P undercollateralized loan market and can help scale up this type of market