A Theory of Peer-to-Peer Equity Financing: Preference-Free and Menuless Screening Contracts

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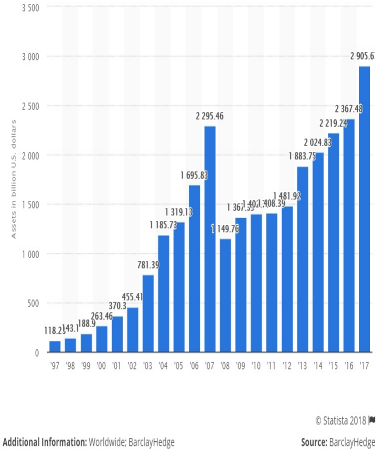
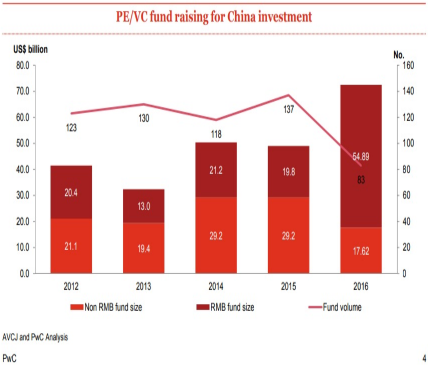
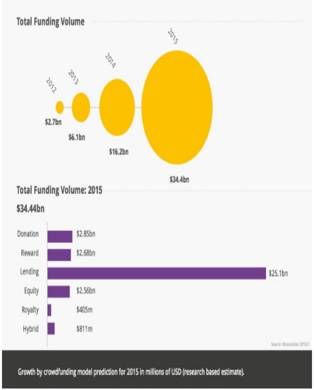


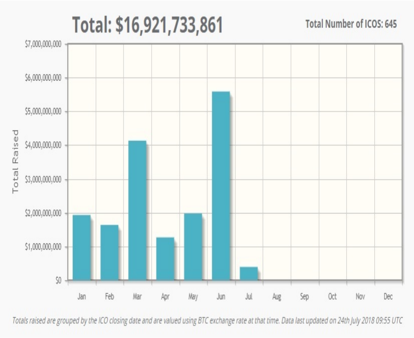


Source: https://www.statista.com/statistics/271771/assets-of-the-hedge-funds-worldwide/

;https://www.pwccn.com/en/private-equity/pe-china-review-feb2017.pdf

Crowdfunding and ICO Volume





Source: http://crowdexpert.com/crowdfunding-industry-statistics/;https://www.coinschedule.com/stats.html

Challenges

- There is a strong need for P2P financing, both privately (hedge funds, private equities) and publicly (crowdfunding, ICO).
- P2P financing is very risky: scams and unsuccessful projects/investment strategies
  - Example: $9 billion Ezubao online scam
  - According to a research, post-ICO startup survival rate is just 44 percent (https://www.ccn.com/post-ico-startup-survival-rate-just-44-percent/)

Asymmetric Information and Adverse Selection

- Asymmetric information between an entrepreneur (the manager of the hedge fund/private equity) and the funder of the entrepreneur's project (investors of a hedge fund/private equity)
  - The funders of the project does not know the project return.
  - They do not know the risk aversion degree of the entrepreneur either.
- Adverse selection

Model: Two Questions to Answer

- How to deter a bad entrepreneur? How to attract a good entrepreneur?

	Entrepreneur		Funder
	risk preferences	project return	risk preferences
Is an entrepreneur attracted/deterred by the scheme?	Involved	Involved	
Is an entrepreneur attractive/unappealing to a funder?		Involved	Involved

Main Contributions

- In this paper, we propose a new contract for P2P financing.
- This contract has two important features:
  - A first-loss capital; and
  - a liquidation boundary
- This contract can mitigate the issue of adverse selection by automatically screening out bad projects/investment strategies.
- More precisely, there exists an interval $(\alpha_{\rm att}, \alpha_{\rm det})$ such that if the incentive rate α in the contract for the entrepreneur belongs to this interval, then the contract can deter all entrepreneurs who are unappealing to the funders and attract some entrepreneurs who are attractive to the funders.
- The interval is preference-free.

First-Loss Scheme

- Consider an entrepreneur who has a project (or fund manager who has certain investment strategy).
- The entrepreneur can raise capital for the project on a crowdfunding platform or through ICO.
- The entrepreneur and the funders of the project share the profit and loss generated by the project under the so-called first-loss scheme:
  - The entrepreneur needs to fund a fixed proportion, e.g., 10%, of the project using her own capital.
  - Profit sharing: the entrepreneur takes the profit generated by her own capital and a proportion, named incentive rate (e.g., 40%), of the profit generated by the funders' capital.
  - First-loss: the entrepreneur's capital is used to cover the project loss before the funders get a hit
  - Liquidation boundary: the project terminates and all assets are liquidated when the project loss accumulates to a certain level, e.g., 15% loss.

First-Loss Capital and Liquidation Boundary

- Without the first-loss coverage, the entrepreneur does not cover the funders' loss. Consequently, some entrepreneurs with unprofitable projects are willing to raise capital for their projects, and they are unappealing to the funders.
- In the first-loss scheme. without the liquidation, the attracting threshold (for the incentive rate), below which all entrepreneurs are deterred, and the deterring threshold, above which some entrepreneurs who are unattractive to funders are attracted, happen to be the same.
- In the first-loss scheme, with a liquidation boundary, the attracting threshold remains the same as in the case of no liquidation, but the deterring threshold becomes higher than the case of no liquidation. Thus, there exists certain incentive rate, which is above the attracting threshold and below the deterring threshold, to separate some attractive entrepreneurs from all unappealing ones.

Literature

- Crowdfunding and ICO: Rau (2017), Agrawal et al. (2014), Belleflamme et al. (2015), Strausz (2017), Chemla and Tinn (2017), Ellman and Hurkens (2015), Chang (2016), Hakenes and Schlegel (2014), Asami (2018), Adhami et al. (2018). Li and Mann (2018), Catalini and Gans (2018), and Conley (2017)
- Principal-Agent Problems: Sannikov (2007), Cvitanić et al. (2013), Cvitanic and Zhang (2013), Morrison and White (2005), Thanassoulis (2013), and Foster and Young (2010)
- First-Loss Capital: He and Kou (2018), Chassang (2013), Cuoco and Kaniel (2011), Basak et al. (2007), and Buraschi et al. (2014)
- Liquidation boundary: Goetzmann et al. (2003), Hodder and Jackwerth (2007), Quadrini (2004), Clementi and Hopenhayn (2006), and DeMarzo and Fishman (2007).

Differences from the Contract Design Literature

- In the contract design literature, both the principal and the agent's risk preferences are assumed to be known
- The preferences, however, are difficult to estimate.
- The entrepreneurs' risk preferences in our model are heterogeneous and are unknown to the funders, and so are the funders' preferences. The contract we propose does not depend on these preferences.

Differences from the Contract Design Literature (Cont'd)

- Most studies in contract design consider *screening* contracts to address the issue of adverse selection: the agent offers a menu of contracts and the principals with different levels of skill report their types honestly and choose a contract from the menu accordingly.
- In our model, we consider a *shut-down* type screening contract that screens out all entrepreneurs who are unappealing to funders and attracts some entrepreneurs who are attractive to funders.
- A few papers in contract design, such as Sannikov (2007) and Cvitanić et al. (2013), consider shut-down contracts as well, but they consider two types of principals and one agent, while we consider a group of entreprenuers with heterogeneous risk preferences and heterogeneous skill levels and a group of funders with heterogeneous risk preferences as well.

Case Study One: TopWater Capital

- TopWater Capital is an U.S. asset management company that employs the first-loss scheme.
- For example, if an account amounts to \$50 million at the beginning, then \$5 million in this account must be funded by the manager.
- The manager's stake covers the account loss first.
- The account is liquidated once the manager's stake depletes to 10% of her initial stake in the account, i.e., once the account suffers a 9% loss
- The incentive rate is 40%

Case Study One: TopWater Capital (Cont'd)

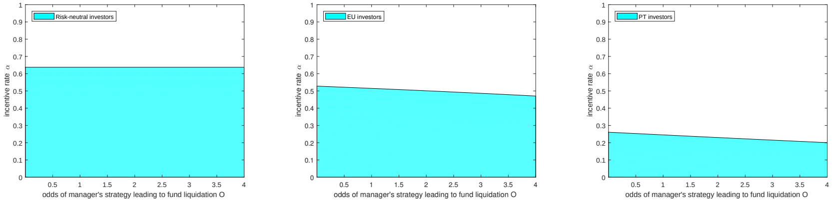


Figure: Range of separation-effective incentive rates in the first-loss scheme with respect to $\mathcal{O}$, the bound on the odds of managers' strategies leading to fund liquidation. Set $w = 10\%$, $\gamma = 0$, $b = 0.91$, and $r = 5\%$. The shaded areas in the left, middle, and right panes represent the ranges corresponding to the cases of risk-neutral investors, classical expected-utility investors whose relative risk averse degrees are bounded by $\delta = 2$, and loss-averse investors (with a piece-wise linear utility function) whose loss-averse degrees are bounded by $\lambda = 3.25$, respectively.

Case Study Two: Crudecoin

- Crudecoin is a cryptocurrency issued by Wellsite, a social network platform with an integrated marketplace built specifically for the oil and gas industry.
- Unlike the case of TopWater Capital, the asset/market value of Wellsite cannot be directly observed
- The asset value, however, is correlated to certain oil index,.
- We can contract liquidation on the oil index.
- Assume that both the oil index and the asset value of Wellsite follow geometric Brownian motions, and the correlation is ρ.

Case Study Two: Crudecoin (Cont'd)

- Suppose the entrepreneur funds 10% of an oil-related project using her own capital.
- The project terminates when a given oil index drops by 10%.
- Other parameters: risk-free rate $r = 5\%$, oil index mean return rate 5% and volatility 15%
- Consider projects with various mean return rates and volatilities whose probabilities of underperforming the risk-free asset are less than $2/3$ and risk-neutral entrepreneurs.

Case Study Two: Crudecoin (Cont'd)

- For any incentive rate in the range $(\alpha_{\mathrm{att}}, \alpha_{\mathrm{det}})$, all entrepreneurs who are unappealing to risk-neutral funders are deterred by the first-loss scheme and some entrepreneurs are attracted.
- Numerical computation of the above range:

$\rho = 0.5$	$(4.6\%, 75\%)$
$\rho = 0.9$	$(4.3\%, 68\%)$

Model: Preferences

- Entrepreneurs and funders are weakly risk averse (with various risk aversion degrees, including risk-neutrality) and have expected utility preferences; the utility function can be non-smooth so as to feature loss aversion.
- $\tilde{Z}_1$ and $\tilde{Y}_1$ are contractual payoffs to the entrepreneurs (agents) and funders (principles), respectively, which depend on the project return $\tilde{R}$.
- w is the proportion of shares owned by the entrepreneur.
- X_0 is the initial capital requirement, and r is the risk-free rate.
- An entrepreneur is attracted the contract (to raise capital for her project) if $\tilde{Z}_1$ is preferred to $wX_0 \max(e^r, \tilde{R}))$. Otherwise, the entrepreneur is deterred.
- The contract is attractive to a funder if $\tilde{Y}_1$ is preferred to $(1-w)X_0 e^r$. Otherwise, the contract is unappealing to this funder.

A General Notation

- $\tilde{Z}_1$ for the agent is increasing in α and $\tilde{Y}_1$ is for the principle decreasing in α.
- Define

$$\alpha_{\text{att}}(U_A, \tilde{R}) := \inf\{\alpha \in [0,1] \mid \mathbb{E}[U_A(\tilde{Z}_1)] > \mathbb{E}[U_A(wX_0 \max(e^r, \tilde{R}))]\},$$
$$\alpha_{\text{det}}(U_P, \tilde{R}) := \sup\{\alpha \in [0,1] \mid \mathbb{E}[U_P(\tilde{Y}_1)] > \mathbb{E}[U_P((1-w)X_0 e^r)]\}.$$

- Here U_A and U_P are the utility functions of entrepreneurs (agents) and funders (principles), respectively.
- $\alpha_{\text{att}}(U_A, \tilde{R})$ is the minimum incentive rate to attract the entrepreneur.
- $\alpha_{\text{det}}(U_P, \tilde{R})$ is the maximum incentive rate that the funder is willing to pay.

Model: Project

- We shall compute $\alpha_{\text{att}}(U_A, \tilde{R})$ and $\alpha_{\text{det}}(U_P, \tilde{R})$ for specific contracts, and find a preference-free interval (independent of U_A and U_P) for the incentive rate α.
- We present a single-period model
- An entrepreneur has a project that yields a *net* return rate $\tilde{m}_t$ from time 0 to t, $t \in (0, 1]$.
- There is a risk-free asset that generates a deterministic, continuously compounded return rate r.
- X_t denotes the total value of the project at time t.
- τ denotes the liquidation time of the project.

Model: Traditional Scheme

- The entrepreneur contributes w and the funders contribute $1 - w$ proportion of the total capital
- The entrepreneur takes α (*incentive rate*) proportion of the gain on the funders' capital as performance fee, and the gain is calculated relative to the risk-free return of the funders' initial capital.
- Entrepreneur's payoff at time $\tau \wedge 1$

$$\underbrace{wX_0(\tilde{m}_{\tau\wedge 1} + 1)}_{\text{entrepreneur's stake}} + \underbrace{\alpha(1-w)X_0\left[\tilde{m}_{\tau\wedge 1} + 1 - e^{r(\tau\wedge 1)}\right]^+}_{\text{entrepreneur's performance fee}}.$$

- Funder's payoff at time $\tau \wedge 1$

$$(1-w)X_0(\tilde{m}_{\tau\wedge 1} + 1) - \underbrace{\alpha(1-w)X_0\left[\tilde{m}_{\tau\wedge 1} + 1 - e^{r(\tau\wedge 1)}\right]^+}_{\text{entrepreneur's performance fee}}.$$

Model: First-Loss Scheme

- The entrepreneur contributes the same and takes the same performance fee as in the traditional scheme.
- The entrepreneur's contribution is first-loss, and γ proportion is held in the risk-free asset and the remaining invested in the project
- The entrepreneur's capital covers the project loss, including that on the funders' stake, first.
- For the first-loss coverage, the loss amount is calculated as the difference of the current value and initial value of the investor's stake.

Model: First-Loss Scheme (Cont'd)

- Entrepreneur's payoff at time $\tau \wedge 1$

$$\underbrace{X_0\left[\gamma w e^{r(\tau\wedge 1)} + (1-\gamma)w(\tilde{m}_{\tau\wedge 1}+1) - \left((1-w)\tilde{m}_{\tau\wedge 1}\right)^{-}\right]^{+}}_{\text{entrepreneur's stake after covering the project loss}}$$

$$+\underbrace{\alpha(1-w)X_0\left[\tilde{m}_{\tau\wedge 1}+1-e^{r(\tau\wedge 1)}\right]^{+}}_{\text{entrepreneur's performance fee}}.$$

- Funder's payoff at time $\tau \wedge 1$

$$\underbrace{X_0\left(\gamma w e^{r(\tau\wedge 1)} + (1-\gamma w)(\tilde{m}_{\tau\wedge 1}+1)\right)}_{\text{project asset value}} - \underbrace{\alpha(1-w)X_0\left[\tilde{m}_{\tau\wedge 1}+1-e^{r(\tau\wedge 1)}\right]^{+}}_{\text{entrepreneur's performance fee}}$$

$$-\underbrace{X_0\left[\gamma w e^{r(\tau\wedge 1)} + (1-\gamma)w(\tilde{m}_{\tau\wedge 1}+1) - \left((1-w)\tilde{m}_{\tau\wedge 1}\right)^{-}\right]^{+}}_{\text{entrepreneur's stake after covering the project loss}}.$$

Model: Project Gross Return

- Suppose both the entrepreneur and the funders accumulate their payoffs to time 1 in case of a liquidation
- Denote by $\tilde{R} := (\tilde{m}_{\tau\wedge 1} + 1)e^{r(1-\tau\wedge 1)}$ the project's gross return in the period $[0, 1]$.

Model: Option to Default and First-Loss Coverage

- In the first-loss scheme, entrepreneur's payoff

$$\tilde{Z}_1 = wX_0 \Bigg\{ \Bigg[(1-\gamma+\alpha(1-w)/w) \underbrace{\tilde{R}}_{\text{Project's gross return}} + \big(\gamma - \alpha(1-w)/w\big) \underbrace{e^r}_{\text{risk-free return}} \Bigg] + \underbrace{\big(\alpha(1-w)/w\big)(e^r - \tilde{R})^+}_{=:\tilde{D}\text{, option to default}} - \underbrace{\min\left\{\gamma e^r + (1-\gamma)\tilde{R}, \big((1-w)/w\big)\left(e^{r(1-\tau\wedge 1)} - \tilde{R}\right)^+\right\}}_{=:\tilde{F}\text{, first-loss coverage}} \Bigg\},$$

- In the first-loss scheme, funder's payoff

$$\tilde{Y}_1 = (1-w)X_0 \left\{ \left[\alpha e^r + (1-\alpha)\tilde{R}\right] + \big(w/(1-w)\big)\left(-\tilde{D} + \tilde{F}\right) \right\}.$$

Model: Three Types of Entrepreneurs without Liquidation

- Suppose there is no liquidation, i.e., the liquidation time $\tau > 1$.
- Assume that there are only three types of entrepreneurs, in terms of their project returns, in the market:
  - Perfectly skilled entrepreneurs: $\tilde{R}$ is deterministic and strictly higher than e^r.
  - Skilled entrepreneurs: (i) $\tilde{R} = 0$ or $\tilde{R} = m_1 + 1$ for some constant m_1, (ii) $\mathbb{P}(\tilde{R} = 0) > 0$, and (iii) $\mathbb{E}[\tilde{R}] > e^r$.
  - Unskilled entrepreneurs: (i) $\tilde{R} = 0$ or $\tilde{R} = m_1 + 1$ for some constant m_1, (ii) $\mathbb{P}(\tilde{R} = 0) > 0$, and (iii) $\mathbb{E}[\tilde{R}] \leq e^r$.

Main Results: Case of No Liquidation

Theorem

For any given entrepreneur's smooth utility function, neither the traditional scheme nor the first-loss scheme is separation-effective. More precisely,

(i) *For any smooth U_A, there exists a project return $\tilde{R}$, such that entrepreneurs with these projects and the given utility function are attracted by the traditional scheme but are unappealing to all funders, i.e. $\alpha_{\text{att}}(U_A, \tilde{R}) > \sup_{U_P} \alpha_{\text{att}}(U_P, \tilde{R})$.*

(ii) (a) *Either the first-loss scheme deters all entrepreneurs, i.e. $\alpha_{\text{att}}(U_A, \tilde{R}) = 1$.*

(b) *Or for any U_A, there exists a project return $\tilde{R}$ such that entrepreneurs with these projects and the given utility function are attracted by the first-loss scheme but are unappealing to all funders, i.e. $\alpha_{\text{att}}(U_A, \tilde{R}) > \sup_{U_P} \alpha_{\text{att}}(U_P, \tilde{R})$.*

The part (i) of the theorem generalizes the result in Foster and Young (2010), which is for the traditional scheme with two types of entrepreneurs (perfectly skilled and unskilled).

Model: Three Types of Entrepreneurs with Liquidation

- Assume a liquidation boundary $b \in (0, 1)$, i.e., the project is liquidated when it loses b of its initial investment
- Assume that there are only three types of entrepreneurs, in terms of their project returns, in the market:
  - Perfectly skilled entrepreneurs: $\tau > 1$ and $\tilde{R}$ is deterministic and strictly higher than e^r.
  - Skilled entrepreneurs: (i) $\tau \leq 1$ with a positive probability, (ii) $e^{-r(1-\tau)}\tilde{R} = \tilde{m}_\tau + 1 = b$ on $\{\tau \leq 1\}$, (iii) $\tilde{R} = m_1 + 1$ for some constant m_1 on $\{\tau > 1\}$, and (iv) $\mathbb{E}[\tilde{R}] > e^r$.
  - Unskilled entrepreneurs: (i) $\tau \leq 1$ with a positive probability, (ii) $e^{-r(1-\tau)}\tilde{R} = \tilde{m}_\tau + 1 = b$ on $\{\tau \leq 1\}$, (iii) $\tilde{R} = m_1 + 1$ for some constant m_1 on $\{\tau > 1\}$, and (iv) $\mathbb{E}[\tilde{R}] \leq e^r$.

Main Results: Traditional Scheme with Liquidation

Theorem

Assume a liquidation boundary. The traditional scheme is not separation-effective. More precisely, for any smooth U_A, there exists a project return $\tilde{R}$, such that entrepreneurs with these projects and the given utility function are attracted by the traditional scheme but are unappealing to all funders, i.e. $\alpha_{\rm att}(U_A, \tilde{R}) > \sup_{U_P} \alpha_{\rm det}(U_P, \tilde{R})$.

Main Results: Risk-Neutral Funders

Theorem (Risk-Neutral Funders)

Assume a liquidation boundary b and denote

$$L := \frac{\gamma w}{1-w}, \quad U := \min\left\{\frac{\gamma w}{1-w} + \frac{wb}{(1-w)(e^r - b)}, \frac{1-b}{e^r - b}\right\}.$$

For any given $\alpha \in (L, U)$, the first-loss scheme is separation effective. More precisely:

(i) *Any entrepreneur (i.e., with any utility function and any project return) who is attracted by the first-loss scheme must be attractive to all risk-neutral funders, i.e.* $\sup_{U_A} \alpha_{\text{att}}(U_A, \tilde{R}) < \inf_{U_P} \alpha_{\text{det}}(U_P, \tilde{R})$, *if* $\sup_{U_A} \alpha_{\text{att}}(U_A, \tilde{R}) < 1$.

(ii) (a) *The first-loss scheme attracts all perfectly skilled entrepreneurs.*
(b) *For any U_A, there exists $\tilde{R}$ such that skilled entrepreneurs with these projects and the given utility function are attracted.*
(c) *The first-loss scheme deters all unskilled entrepreneurs.*

Weakly Risk-Averse Funders under the First Loss Scheme

- For a risk averse funder, an entrepreneur is unappealing to the funder if
  - either the entrepreneur's project entails a large amount of risk
  - or the funder is extremely risk averse.
- Thus, we cannot find a compensation scheme that is separation-effective for *any* risk-averse funder.

Weakly Risk-Averse Funders under the First Loss Scheme

- Consider $\tilde{R} \in \mathcal{R}$, where $\mathcal{R} = \{\mathbb{P}(\tau \leq 1)/\mathbb{P}(\tau > 1) \leq \mathcal{O}\}$. In other words, the odds of being liquidated is less than a given constant $\mathcal{O} > 0$.
- We assume the funder's utility function u is smooth everywhere except at $(1-w)X_0 e^r$, and the *relative risk averse degree (RRAD)* is defined to be $-xu''(x)/u'(x), x \neq (1-w)X_0 e^r$, and the *loss aversion degree (LAD) in the small* is defined to be $u'((1-w)X_0 e^r -)/u'((1-w)X_0 e^r +)$.
- Consider $\mathcal{U}_P$ to be the class of the preference such that the RRAD $\leq \delta$ and the LAD in the small $\leq \lambda$, for given constants $\delta \geq 0$ and $\lambda > 0$. Note that this includes the risk-neutral preference.
- Consider $\mathcal{U}_A$ arbitrary.

Main Results: Weakly Risk-Averse Funders

Theorem (Weakly Risk-Averse Funders)

Suppose that there is a liquidation boundary $b \in (0,1)$*. Define*

$$L := \frac{\gamma w}{1-w}, \quad U := \min\left\{\frac{\gamma w}{1-w} + \frac{wb}{(1-w)(e^r - b)}, \frac{1-b}{e^r - b}\right\}.$$

$$\mathbb{U}(\delta, \lambda, \mathcal{O}) := \min\left\{L + H(\mathcal{O}, \delta, \lambda), U\right\}.$$

For a given triplet $(\delta, \lambda, \mathcal{O})$*, the first-loss scheme with an incentive rate* $\alpha \in (L, \mathbb{U}(\delta, \lambda, \mathcal{O}))$ *is separation effective. More precisely:*

(i) *Any entrepreneur (i.e., with any utility function and any project return) who is attracted by the first-loss scheme must be attractive to all funders in* $\mathcal{U}_P$*, i.e.* $\sup_{U_A} \alpha_{\mathrm{att}}(U_A, \tilde{R}) < \inf_{U_P} \alpha_{\mathrm{det}}(U_P, \tilde{R})$*, if* $\sup_{U_A} \alpha_{\mathrm{att}}(U_A, \tilde{R}) < 1$.

(ii)
- (a) *The first-loss scheme attracts all perfectly skilled entrepreneurs.*
- (b) *For any* U_A*, there exists* $\tilde{R}$ *such that skilled entrepreneurs with these projects and the given utility function are attracted.*
- (c) *The first-loss scheme deters all unskilled entrepreneurs.*

Extensions

- Management fees and cost
  - The entrepreneur may charge a management fee, and the project management may incur some cost as well.
- Different hurdle and reference rates
  - The entrepreneur may collect a performance fee only when the funder's capital return exceeds a general hurdle rate, not necessarily the same as the risk-free return.
  - The entrepreneur may cover the funder's loss calculated as the difference between the current value of the funder's stake and a general reference return rate of the funder's initial capital, and the reference rate may not be equal to 0.

Extensions (Cont'd)

- A limited-liability hurdled contract
  - The entrepreneur needs to pay a fixed amount to the funder at the beginning so as to raise the funder's capital and start the project.
- Overshoot and random losses
  - The project return in case of a loss may be lower than the liquidation boundary b because the project asset may not be continuously monitored or because the project asset value may have unexpected jumps.
- Random gains
  - The project's return in case of a gain may also be random
- Multi-period model
  - The project may be managed in multiple periods, the entrepreneur takes a performance fee at the end of each period, and new funders can invest at the beginning of each period.

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