"Smart" Contracts and External Financing

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Financing frictions and lack of trust

- Individuals and (start-up) firms who lack own funds find it difficult to raise external financing (see e.g., Tirole 2006). Financing frictions are about "lack of trust":
  - Limited pledgeability and commitment.
  - Moral hazard.

"the [Blockchain] Technology itself is all about creating one priceless asset: trust" (MIT Technology Review, May/June 2018).
Hash-linked times-stamping - key feature of blockchain(s)

IBM's introductory material, 2018

Satoshi Nakamoto, whitepaper 2008

Ahto Buldas and Märt Saarepera
(Guardtime IP Holdings LtD, Priority Date 22/12/2003)
Smart contract - programmer’s perspective

**PARTIES**
Parties agree on terms: the contract is recorded on blockchain (parties may remain anonymous/pseudonymous), but the code is verifiable.

**SMART CONTRACT**
Pre-agreed contracting terms may be based on incoming data (e.g., debt payments and maturity, trigger event of a convertible asset).

**EXECUTION**
Automatic and verifiable by contracting parties, lawyers, and regulators. The burden of proof regarding enforcement is reversed.
Smart contract - finance perspective

▶ Just a cheaper/better way to execute traditional contracts? Closer to Modigliani-Miller?

▶ Complete contracts? - not really, as human effort remains neither verifiable nor contractible, there is still a dynamic moral hazard.

▶ Does it benefit to have contracts that have terms that adjust depending on time-stamps/cronological order of cash flow arrivals?
Setting

Firm’s project

Time

Investment

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Selling opportunities

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Selling requires entrepreneur’s effort
Learning from data

▶ Incoming cashflows (e.g., sales) provide information about future prospects.

▶ Trend towards better data analytic capabilities => more frequent learning (possibly enhanced by blockchain technology):

▶ Crucial features of my model:

▶ Borrowers have a limited control over potential sales prospect (these are determined by target market and target consumer preferences).

▶ Borrowers can adjust effort frequently - I explore the role of more frequent learning.
Debt, frequency of decisions and outcomes

![Bar chart showing probability of total sales over different levels of total sales.

Legend:
- Effort choice in "Jan" only]
Debt, frequency of decisions and outcomes
Debt, frequency of decisions and outcomes

![Probability vs Total Sales Chart]

- **Total sales**
- **Probability**
- **Effort choice in "Jan" only**
- **Effort choice in "Jan" and "Jul"**
- **Effort choice in "Jan", "Feb", "Mar",...**
The setting

- Risk-neutral borrower with lexicographic preferences (1: maximize profits, 2: minimize own investment).

- At each period $t = 0, \ldots, T - 1$, the borrower decides whether to make an effort

$$1_t = \begin{cases} 
1 \text{ at cost } e_t \geq 0 \\
0 \text{ otherwise}
\end{cases}$$

Conditional on effort the next period sales is a random variable $s_{t+1} = \{0, 1\}$. Realized sales is $\hat{s}_{t+1} = 1_t s_t$.

- Effort is not contractible; risk-neutral lenders must break even.
The setting

- The joint distribution of potential sales

\[ p (s_1, \ldots, s_T) \]

is known, and has no restrictions apart from the restriction that all outcomes occur with positive probability.

- Potential sales are typically statistically dependent.
The setting

- Borrower offers a contract $w(\hat{s}_1, ..., \hat{s}_T)$. Borrower’s profit

$$U = w(\hat{s}_1, ..., \hat{s}_T) - A_0 - \sum_{t=0}^{T-1} 1_t e_t,$$

where $\hat{s}_t = 1_{t-1}s_t$ and $A_0 \in [0, A]$, subject to

- Lender’s break even constraint

$$I - A_0 = \mathbb{E}[\hat{s}_1 + ... + \hat{s}_T] - \mathbb{E}[w(\hat{s}_1, ..., \hat{s}_T)].$$

- Optimal effort decisions for $t = 0, ..., T - 1$, i.e., $1_t = 1$ if, and only if

$$\mathbb{E}[U|\hat{s}_1, .., \hat{s}_t, 1_0, .., 1_{t-1}, 1_t = 1] \geq \mathbb{E}[U|\hat{s}_1, .., \hat{s}_t, 1_0, .., 1_{t-1}, 1_t = 0].$$
Main results: optimal contract

- Can be expressed as a **dynamically adjusting sharing rule**:

  \[ w(s_1, \ldots, s_T) = \alpha_1 s_1 + \ldots + \alpha_t (s_1, \ldots, s_{t-1}) s_t + \ldots + \alpha_T (s_1, \ldots, s_{T-1}) s_T \]

- The optimal "**sharing rule**" \( a_t (s_1, \ldots, s_t) \)

  - depends on core properties of potential sales distributions, and dynamics of effort costs.
  - determined by intuitive quantities that can be calculated and implemented based on econometric algorithm embedded in the smart contract code.
Learning from sales data

It is informative to distinguish two types of learning environments.

- **"Success raises prospects"**/ Stochastically affiliated (log-supermodular) potential sales.

- **"Success lowers prospects"**/ Opposite to stochastic affiliation (log-submodular) potential sales.

**Start-up projects**: often a new niche product targeting a finite target market; there is some uncertainty regarding target consumer preferences as well as how easy it is to interested consumers. Also possible network effects, consumer preferences for rarity etc.
Main results: timestamps and own investment

- The **optimal contract generally benefits from timestamps**: unless success raises prospects, sales are exchangeable random variables and effort is constant.

- **Asymmetry** between environments where "success raises prospects" and "success lowers prospects" - own funds are needed in former, but not latter.

- Closer to Modigliani-Miller as own funds are no more expensive than external funds, but contracts are not equivalent.
Example: "success lowers prospects"
Example: "success lowers prospects"
Example: "success lowers prospects"
Example: "success lowers prospects"
Optimal contract example: "success raises prospects"
Optimal contract example: "success raises prospects"
Optimal contract example: "success raises prospects"
Optimal contract example: "success raises prospects"
Not necessarily "smart", but always non-standard
Related literature streams: Blockchain and its’ applications


Related literature streams: Raising external financing

- Debt is often (the second best) optimal contract because of costly state verification (e.g., Townsend 1979, Diamond 1984, Gale and Hellwig 1985); ex-ante effort incentives (Innes 1990); re-negotiation, (e.g., Hermalin and Katz 1991, Dewatripont et. al. 2003).

- Sub-optimality of debt when reacting to the arrival of new information - e.g., Chiesa 1992.

- Equity and convertible assets used by venture capital and angel investors (e.g., Lerner et.al 2012); different profit sharing rule also in Bergemann and Hege (1998).
Related literature streams: Dynamic moral hazard problem in principal-agent settings:


- Dynamic moral hazard with i.i.d. cash flows conditional on the agent’s actions (e.g., Biais et. al. 2007, 2011, Demarzo and Fishman 2007); "Information rents" in DeMarzo and Sannikov (2016); He, Wei, Yu, Gao (2017), Prat and Jovanovic (2014).
Platforms for smart contracts and FinTech initiatives

- Blockchain based platforms that incorporate smart contract functionality - Ethereum, Hyperledger project and others.

- Initial coin offerings - relevant subset offers some forms of profit sharing.

- FinTech initiatives that incorporate blockchain, including those that offer equity/profit sharing contracts, e.g.:
  - Funderbeam - VC-type equity investment with secondary market trading.
  - Corl.io - "de-equity", where a firm pays a proportion of monthly income until a given fixed amount has been repaid.
Conclusion and discussion

- Secure time-stamped records (blockchain) can make borrowing widely accessible, even to agents that do not have or want to use their own funds.

- Optimal contract is a dynamically adjusting profit sharing rule.

- Traditional debt or equity contracts may not be desirable in an environment where there is faster learning and reliable time-stamped data (blockchain) is available.
Thank you!