Optimal Design of Tokenized Markets*

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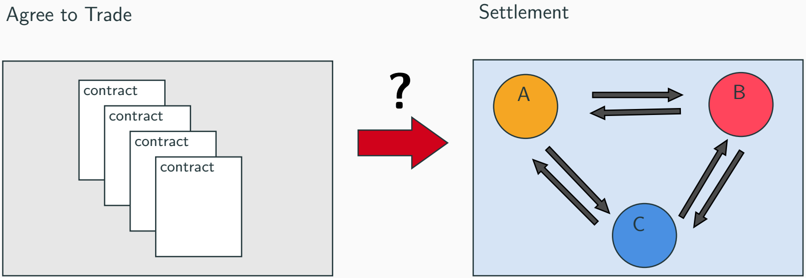
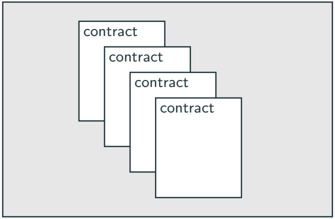
* The views expressed are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York, the Federal Reserve System, or the Swiss National Bank.

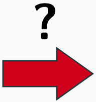
Trade and Settlement



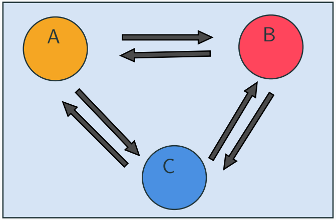
Trade and Settlement

Agree to Trade





Settlement



Age-old problem of **Limited Commitment**

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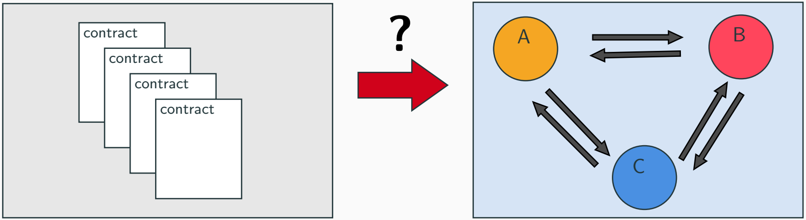

Age-old problem of **Limited Commitment**

- Third-party mediation (intermediaries and platform)
- Margin requirements and other uses of collateral
- Long-term relationships and reputation

Settlement Fails in Modern Financial Markets

Settlement fails still occur

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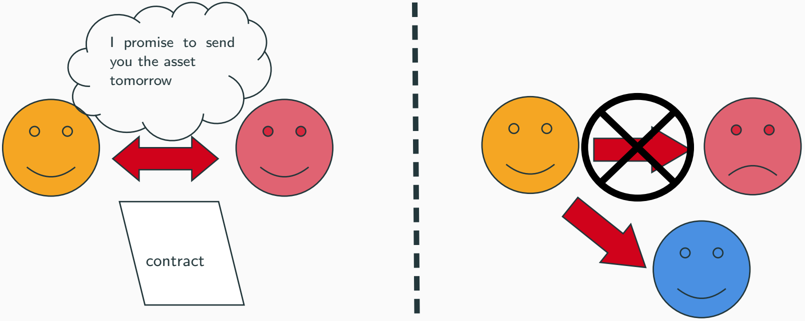
Institutional and technological feature of (current) legacy system



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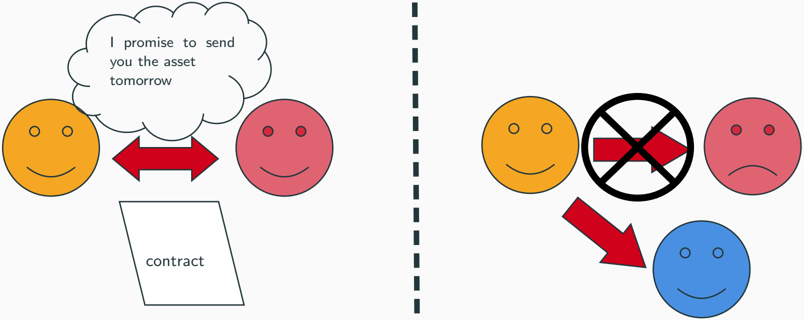

- Transfer instructions are independently taken
- Settlement (**tomorrow**) must be incentive compatible

Resolving Settlement Uncertainty through Tokenization

- Tokenize financial assets for full programmability, **token system**
  - Assets can be programmed to self-execute transfers
  - “Collapse” between trade and settlement

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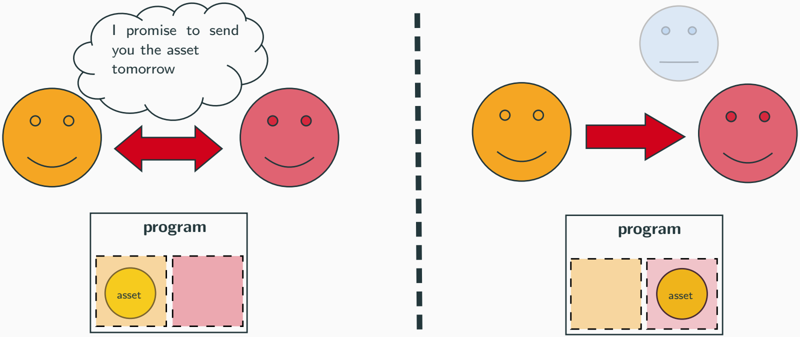

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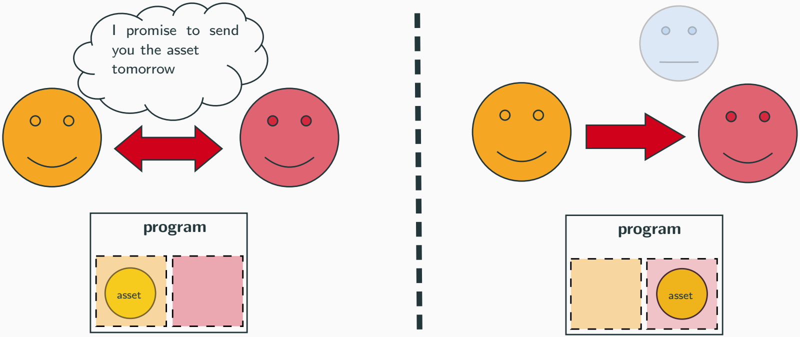

Programmatic commitment → **zero** potential for fails

Question

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- In a setting with endogenous trading, **not** true
- Eliminates settlement risk, but information problem emerges.
- Token system implicitly requires traders to reveal more info about position

Optimal Design

Optimal design hinges on joint design of settlement & trading systems

Modify

Token system

Trading system

Broaden programmability
to avoid information leakage

But

Requires identity registry
to reinforce commitment

Modify matching to minimize dependence on intermediation

But

Implicitly requires coordination

Model

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- Three traders A, B, C

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- Single long-lived asset, initially owned by A

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- Single long-lived asset, initially owned by A
- Traders have period-dependent payoffs for holding asset

Model Timeline

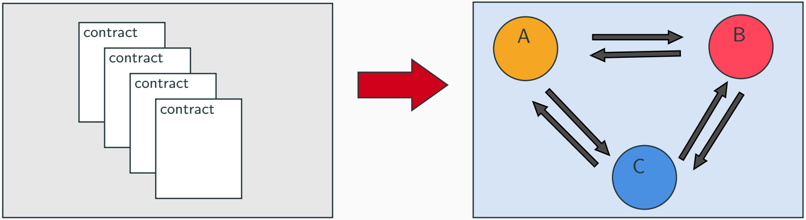
Two stages

- **Trading stage.** $t = m1, m2$
  Two sequential bilateral meetings between traders

- **Settlement stage.** $t = 1, 2, 3$
  Actual transfer of asset between traders

Trading Stage
$t = m1, m2$

Settlement Stage
$t = 1, 2, 3$



Trading Stage $t = m1, m2$

- Two meetings sequentially occur at $t = m1$ and $t = m2$

[A meets with B]   [B meets with C]

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- In a meeting, traders negotiate asset lending contract over $t = 1, 2, 3$

Settlement Stage $t = 1, 2, 3$

- Trades specify "transfer" of asset between A, B, and C over $t = 1, 2, 3$

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B borrows asset from A in period $t = 1$ for price P

- A transfers asset to B at the beginning of $t = 1$
- B transfers asset to A at the end of $t = 1$

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B borrows asset from A in period $t = 1$ for price P

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- Consider settlement under Legacy v. Token system

Settlement in Legacy System

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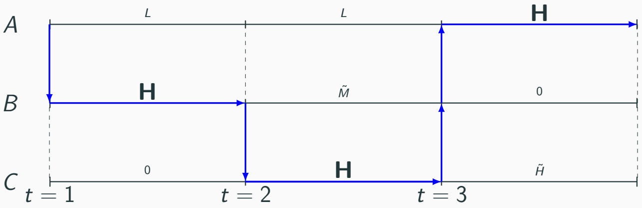
Implication: Both parties know that conditions of the trade are satisfied, e.g. A must own the asset to lend the asset, **and** B **knows**

Trader Payoffs and Optimal Ownership of Asset

- Maximum payoff from holding asset:

$$A \text{ in } t = 3$$
$$B \text{ in } t = 1$$
$$C \text{ in } t = 2$$



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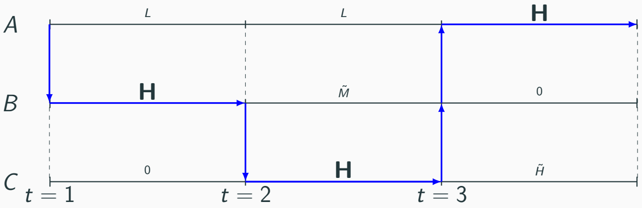


Optimal Trades:

1. A must agree to lend asset to B for $t = 1$ *and* $t = 2$
2. B must agree to lend asset to C for $t = 2$

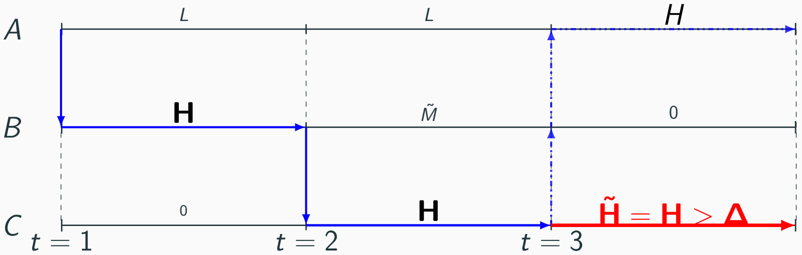
Legacy System

Two Tensions

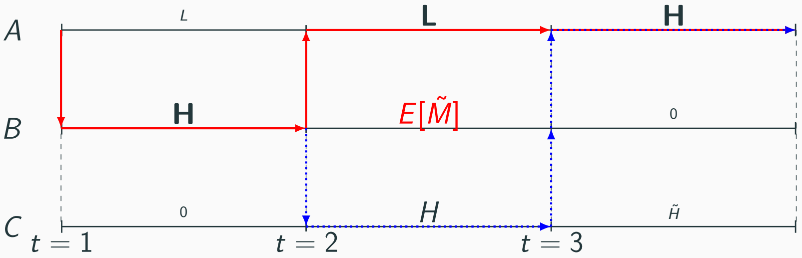
1. Commitment Problem

2. Latent Hold-up Problem

- C decides on settlement action *after* trade and learning $\tilde{H}$
- $\tilde{H} = H \Rightarrow C$ wants to keep asset
- If C fails on $B \Rightarrow B$ fails on A



- B may need to pay A in excess of his own valuation to obtain asset for C.
- Potential for C to make "low-ball" offer to B, knowing B might have already acquired the asset from A.



Trader C's Temptation

If B already traded with A, C simply needs to offer B's reservation price

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BUT

1. C does not know if B met with A prior
2. C does not know if B has obtained the asset from A

Legacy has no information leakage, because trade and settlement is decoupled.

$\rightarrow$ Settlement doesn't impose any restrictions on what trades are permissible.

Equilibrium Trade in Legacy System

Result.

- If C's limited commitment problem is not too severe, optimal trades are achieved with certainty.
- If severe, C obtains the asset with probability < 1, decreases in λ_C.

Token System

Settlement in Token System

Token system resolves commitment problem ✓

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- C wants to hold onto asset at $t = 3$
- If B and C agree for C to borrow asset for $t = 2$, asset programmed to transfer back to B automatically
- Settlement occurs irrespective of realization of $\tilde{H}$

Two Issues

- Trade Asynchronicity
- Aggravation of Hold-Up Problem

Order of Trades Matter in Token System

Issue 1. Trade Asynchronicity

- Trade asynchronicity was desirable in legacy system

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Issue 1. Trade Asynchronicity

- Trade asynchronicity was desirable in legacy system
- In the token system, B can only trade with C with the asset.
- B needs to meet with A *before* C
- With probability $\frac{1}{2}$, when B matches with C first, **no trade**

Hold-Up Problem Worsens

Issue 2. Hold-Up

- When B meets C, B de-facto reveals to C about $t = 2$ ownership of asset

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- When B meets C, B de-facto reveals to C about $t = 2$ ownership of asset
- Whenever B obtains the asset from A on behalf of C, C knows!
- C **optimally** offers the hold-up price, B's reservation price.

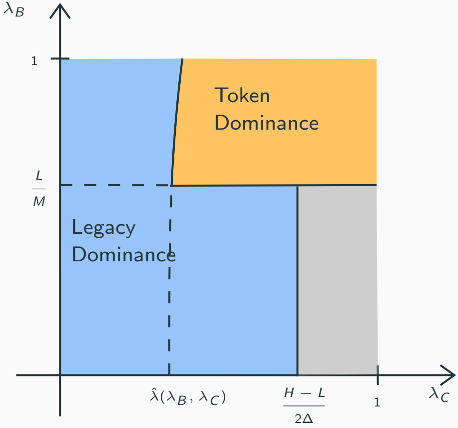
Trade Breaks Down in Token System

Result.

- Suppose the hold-up problem binds ($E[\tilde{M}] < L$). Then, C fails to trade.
- Otherwise, C obtains $t = 2$ ownership of asset with probability $\frac{1}{2}$.

Relative Efficiency

Result. Token system improves efficiency over legacy system only if hold-up problem does not bind ($E[\tilde{M}] \geq L$), and limited commitment problem is sufficiently high.



Optimal Tokenized Markets

Joint Design toward Optimality

- Results demonstrates need for joint consideration of trade and settlement

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- Results demonstrates need for joint consideration of trade and settlement
- To this end, we characterize two designs of tokenized markets that attain optimal allocations through different means:
    - One that modifies the token system,
    - One which modifies the trading system.

Modified Token System

Hold trading environment fixed.

Modification: **Conditional Execution** with **Identity Registry**

- Enable *conditional execution contracts*:
  Lending agreement executes iff pre-specified event $\mathcal{E}$ is reached.

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Solution: *Identity registry*. Maps traders to their accounts, binding traders' positions to their programmable commitments.

Modified Trading System

Hold baseline token system fixed

Modification: **Direct trading system**

- End-sellers are end-buyers are matched
- Direct trading lower sensitivity to information regarding ownership
- Alleviate problems arising from intermediated transactions.

  $\Rightarrow$ Optimal allocation is achieved

(Note: Direct trading **worsens** commitment problems for the legacy system.)

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  - Tokenization affects equilibrium trade in an decentralized market
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- Collapsing trade and settlement, however, comes at a tradeoff
- Some features are not amenable to certain market structures
    - Tokenization affects equilibrium trade in an decentralized market
    - Depends highly on intermediaries to facilitate complex intermediation chains
- Efficiency intricately tied to compatibility between settlement and trading mechanism
    - Enriching programmability resolves tensions from info revelation, but requires identity management
    - Direct trading lowers sensitivity to info revelation, but requires coordination
    - Tradeoffs based on applications to financial markets