Delegation of Programmable Contracts to the Private Sector: Is There a Role for the Public Sector

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Outline of the Talk

- Background: CBDC begs issues, how much can and should private sector do
- Smart contracts, programming code: Schemata for financial and information designs w/wo DLT
- Decentralized Implementation: A primer from simplest first principles
  - Key extension: Competition in contract space
- Financial stability concerns, runs, but with a private sector remedy
- Caveat on private sector: Rules of the game are needed
- Concerns about the limits to competition
  - Economies of scale, incomplete markets, non-pecuniary externalities in platforms, pecuniary externalities in markets, role of intermediaries with aggregate shocks
- Role for active public bank: Industrial organization with few providers
- Smart contracts for regulation
- Issues in information design and data infrastructure: Public/private intermingled
- Money and monetary policy: The natural domain, and gain, from CBDC, example of revised monetary policy

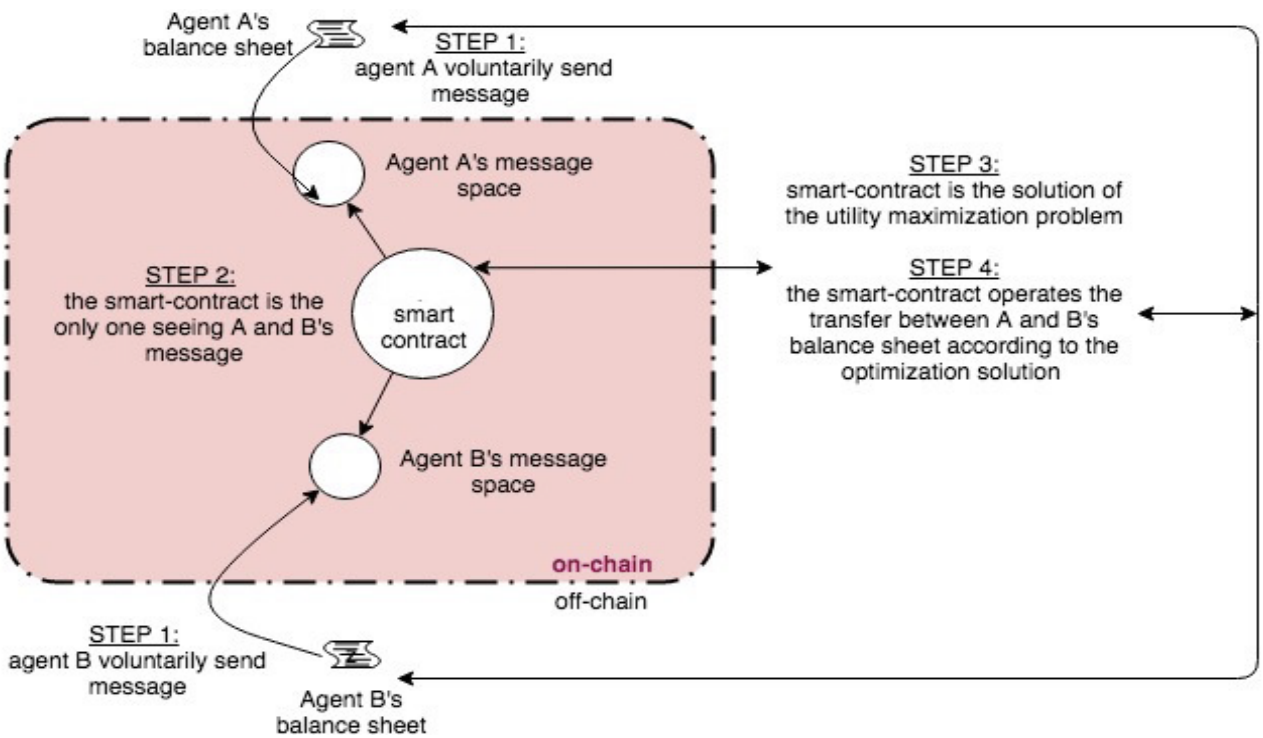
Background: CBDC Begs Issues, How Much Can and Should Private Sector Do

- The limitations of CBDC on distributed ledger technology
  - Validation on decentralized distributed ledgers does not scale up easily- there are improved algorithms
  - Confusion: Smart contracts and Ethereum on DLT are not synonymous
- Is CBDC needed? Improved payments systems as alternative: Debit and credit balance sheets, not on distributed ledger, but public infrastructure, PIX in Brazil and Unified Payment Interface, India
  - One current option for Brazil: Build on top of PIX, as with Open Banking for the private sector
    - Buyer/seller with shipping, invoice financing and hence change of recipient of funds, DvP for real assets such as cars, real estate, interface with other digital authentication platforms
    - Multi-party is more difficult, plus this path is one application at a time, and may have limits, not clear
- Alternative: Open platform as infrastructure for contracts, providing tools to write any contract
  - Example, entirely private: EvryNet
    - No connection to central bank, the BOT in Thailand
  - A public provision of such an open platform for contracting
    - Not involved with the contracts per se, let the private sector do that part
  - Multiple private sector platforms which are in principle interoperable
    - As evidenced by hashed timelock, but not yet clear how robust this is
- Hybrid, contracts as separate from CBDC, but could do both, with fiat as legal tender for the object transferred on the ledgers, executing the contract, has credibility
- Bottom lines for the talk
  - Is this vision of delegation to private sector sensible? Role for public in this context
  - A rationale for CBDC: Is as above, but see slides below for other rationales

Smart Contracts: Programming Code

- Mechanism design problem
  - Max weighted sum of utilities of agents, participants
  - Subject to resource constraints, information incentive constraints, limited commitment constraints, participation constraints
- Consequence
  - Internalizes incentives to "tell the truth"
  - And to take specified actions, follow the recommended plan, consistently
  - Validation per se is not necessary
- Smart contracts as code
  - Coded instructions to execute applications and solutions to mechanism design problems
  - Not related to distributed ledgers per se
  - Could be separate or could use CBDC for programmed value transfer, it is optional
- Cryptography
  - Privacy for incoming messages, outgoing messages with signatures
    - Generates commitment
  - Prime example: "Trustless" escrow service (hashed timelock contract)
  - Can design data systems, as part of endogenous design
- Consequence
  - Dealing with strangers, no need for 'trusted' third party intermediaries, enhanced vison for DeFi
  - More efficiency, flexibility, and potential to reduce rent extraction

Schemata for Financial- Information Designs with Examples



- Auctions with privacy settings concerning bids and no trusted third party
- Flexible financial risk-sharing contracts
  - Halfway between full insurance and rigid borrowing-lending
  - In mechanism design terms, as in Townsend (1982, *JPE*), and Townsend (1988, *JME*)
- Financial and information infrastructure for SMEs, a proposal
  - As in Townsend, Sztutman and Zhang (2020)

Decentralized Implementation: A Primer from Simplest First Principles

- Broker-dealers, platforms, financial service providers
  - Do not have to be commercial banks
  - Open, free entry
- Intermediary agent specifying prices for trade, rates of exchange to buy or sell commodities, or assets, to attract customers - as in Townsend (1988, JME)
- Two ways that work
  - First, customers can chose one or several platforms
    - Arbitrage works to pin down the Walrasian price with 2 (or more) willing to-be-active intermediaries
    - Each is calling out same price vector, as intermediary must accept the trades and cannot run short– if price not the same, then arbitrage arbitrarily large quantities.
    - Intermediary prefers to be customer rather than dealer, as can then choose its own quantities
    - Insight: Competitive outcome can be achieved with competing platforms quickly
  - Second way, customers choose one and only one platform
    - Intuition
      - If trial equilibrium is not in the core, it can be blocked by a coalition, meaning that its resource allocation is feasible and all are made better off
      - Further, can be blocked by trade supported by intermediary naming a price vector -- its equivalent
    - This can work perfectly in the limit
      - Core shrinks to competitive equilibrium as the economy is 'cloned' with more and more agents

Extension: Competition in Contract Space

- As in Diamond-Dybvig model, customers are patient or urgent to consume
- These shocks to preferences are private, incentivized truth-telling constraints
- Competitive equilibrium with broker-dealers, could be banks, or other intermediarires, pooling risks in the population
- As in securitization pooling, over contracts with options, automated with incentivized messages
- The options are pooled: Fractions of the pool experiencing high vs. low shocks, i.e., urgent vs. patient
- Welfare theorem: Competitive equilibrium still optimal, as earlier with basic commodities and securities
  - Prescott and Townsend (1984, IER)
  - Achieved in the limit by converting contract notation to standard commodity space, x, y notation
- Logic: Core shrinks to CE, essentially the same intuition
  - Histograms converge to fractions in the population with continuum
- Implication: Broker-dealers can compete in contract space and everything is fine

Financial Stability Concerns, Runs, But with a Private Sector Remedy

- Diamond-Dybvig is about runs on banks and markets
  - Multiple equilibria or with explicit sequential service constraints
- Solution: Green-Lin (2002) implementing efficient allocation with intermediation
  - Can mitigate or even eliminate the runs
- Expanded to cryptography, implementable with privacy if commit to code (no trusted third party)
- Role of public sector: Understanding this and going for direct private sector solution, as part of regulatory design

Caveat on Private Sector: Rules of the Game Are Needed, Welfare Enhancing

- Example: Ex ante competition is good, ex post competition for customers is not
  - Jacklin (1987)
  - Those who do not join the Diamond-Dybvig bank are prohibited from dealing with bank customers, no "on-the-side" intermediation
  - Enforceable rules with transactions on ledgers, monitored but encrypted
- Example: Delegation, preferable to let intermediary manage the entire investment portfolio of clients rather than client-managed
  - Doepke-Townsend (2006)
  - So entirely private and unobserved is not good, need data from monitoring
  - Paper fiat money, currency in particular has low rate of return but can still undercut incentives as unobserved (an argument for DLT)
- Implication for Crypto: utility coins are good, but a market for them is not
  - Internal control with coins as history is good
  - But market for coins undercuts internal incentives
  - Extends to multiple colored tokens, money as memory, Kocherlokota, and Townsend (AER) partitioned ledgers
- Otherwise, in each above, a second-best notion of optimality, with unobserved exchange, which is ok, rest goes though, but comes with welfare loss

Concerns About the Limits to Competition: Economies of Scale, Not Always a Problem

- As in Townsend (1978), intermediation with costly bilateral exchange
- Random iid endowments and gain to diversification from larger group
  - Marginal gain is positive but decreasing
- Transaction cost for each bilateral link, economies of scale, as group gets bigger
  - Positive per capita marginal costs but decreasing
- Though both are declining, marginal cost can exceed marginal gain and thus limit group size
- Finite group allocation in core, Finite-sized coalitions
- As above, supported as a decentralized equilibrium with broker-dealers calling terms of trade to attract customers, who choose a group to join

Concerns About the Limits of Competition: Incomplete Markets, Allow Coordination

- Intermediaries buy primitive securities and sell resulting portfolios to household customers
- Pesendorfer (1995); Makowski (1980) – Financial Innovation in GE
- Fixed marketing costs per household, continuum of intermediaries for each of a finite number of types, small and competitive
- Can get stuck at inefficient outcome, despite further gains to innovation, not Pareto optimal
- Solution: Need to allow joint innovation across providers to take advantage of complementarities, more securities imply more gains, a coordination problem
- Example: Hash timelock for coordination, solve multiple equilbria problem
- Not the usual regulatory scheme
  - Silos, i.e., by product or service
  - Example: Credit separate from insurance
  - Not clear thinking on crypto: SEC vs. bank regulation vs. commodities
- Role for public sector is to provide unified regulation coming from an appropriate conceptual framework

Concerns Continued: Non-Pecuniary Externalities in Platforms, Solution with Design

- Utility from platform depends on others using it
- A non-pecuniary externality: Termed two-sided markets
- Examples: Buyers want sellers and vice versa; credit card users want card accepted by merchants and vice versa
- Mis-regulation on this rationale: US Fed intervened in setting prices, redemption fees that issuing bank charges presenting bank on behalf of customers
- Better design, user-type-based fees for joining a platform, covers costs, Jain and Townsend (2021)
- Payments via card companies too narrow, there are others now
- Example: Cryptocurrency as means of payment, but depends on others' willingness to accept it
- Yet, even with a fixed cost per platform, room for many platforms of a given type in large economy, fixed costs can be scaled up or down
- Key to limiting size of platform and ensuring competition is marginal cost
  - Increasing users well known problem of scaling up validation algorithms on distributed ledgers

Concerns Continued: Pecuniary Externalities in Markets, Solution with Market Design, skip

- Fire sales, as pecuniary externalities: Sales of assets in a given time or state impose losses on others
- More formally: If markets are incomplete, standard competitive equilibria are not Pareto optimal
  - Prices matter, as in Geanakoplos and Polemarchakis (1986)
- Agents aware, plan accordingly, limiting market positions, less trade
- Remedies proposed: Government and public sector, regulations on credit, savings, bank portfolios, and/or taxes
- Though this requires complete knowledge of the environment
- Alternative remedy, as in Stein's auction (2013) for future FRB reserves, create market and a price, Kilenthong and Townsend (2021)
- Here fees for ex ante security exchanges for trade in assets and a commitment with rights to unwind in corresponding spot exchange at pre-designated price
- Intuition, type-specific fees to trade on a given exchange are pricing that type's contribution to excess demand (or supply), which influences the price, internalizing the externality
- Lesson: The best solution is market design, with the new technologies

Rules for Intermediation, when aggregates matter

- Example: Controlling the form of intermediation
- Townsend and Xandri (2021), Acemoglu and Zilibotti (l997)
- Aggregate shocks determine sector-specific yields with diverse minimum scales to operate, not enough resources to do all of them
- Intermediaries are essential as go-betweens for funding investments of firms and for providing portfolios to customers
  - Do not let households deal with firms (e.g., equity markets can be bad)
- Intuition: Once project is funded, households want completely a balanced portfolio
- But in the constrained optimum, as economy 'stretches' to diversify more into high cost large scale funded projects on the extensive margin, the portfolio is not balanced
- Again, with smart contracts, ledgers there is the needed monitoring and control

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Role for Active Public Bank: Industrial Organization with Few Providers, with Twists

- Imperfect competition in the provision of financial contracts is an issue
- Small-numbers-of-intermediares problem, profits vs. welfare, surprising tradeoffs
  - Lowering obstacles may give counter-intuitive results
  - Can hurt the public and help the banks extract rents
- Quantifying obstacles, feeding into public policy choices
  - Joaquim, Townsend and Zhorin (2019)
  - Artificial product distinction creates rents for financial providers
  - Large gains to getting rid of these, and lowering spatial costs, larger than increasing number of banks
- Public sector bank
  - Conventional
    - Commercial banks provide insurance, credit, saving and/or payments
    - Private sector acts to preempt entry, to capture rents, prevent innovation
    - Public sector as providing competition for private sector, recent literature
  - More nuanced
    - Assuncao, Mityakov and Townsend (2021)
    - Role for public bank that cares not only about own profit but also public welfare
    - Anti-preemption, steps out of the way if private is providing access
    - In an application, can almost recover pattern of access as in unconstrained optimum
- A role for CBDC, as in recent literature, Andolfato (2020), Williamson (2021)but overall financial system design though largely commercial banks do the intermediation. With appropriately regulated DeFi, that need not be the case. CBDC can help private contracting, as discussed earlier in mechanism design.

Smart Contracts for Regulation

- The impossibility of decentralized monetary exchange
  - Ostroy-Starr (1974)
  - Players need information on what happened at key node pairings to achieve objective (Walrasian Pareto optimum)
- High velocity circulating private debt, coexisting with other assets
  - Townsend and Wallace (1987) and Spector and Townsend (2020)
  - Multiple equilibria, if uncoordinated issue, can lead to financial crisis
  - Likely problem as we get more and more digital assets traded in secondary markets
  - But with a smart contract remedy, coordination across markets
- US repo markets
  - Aronoff, Townsend, and Zhang (2021)
  - Multilateral smart contract allows coordination across dealers while preserving relationships, solves the coordination problem
  - Smart contracts also solve the liquidity problem induced by regulation, assets not really held by the brokers
  - Otherwise there are liquidity shortages, erratic pricing, and multiple equilibrium problems (arguably, as observed)

Issues in Information Design and Data Infrastructure: Public/Private Intermingled

- Credit registries: Sztutman, Townsend and Immorlica (2021)
  - Optimal designs of credit registries with AI and commitment
  - It may be optimal to be constrained in information the platforms provide to investors to prevent market from unraveling, need to prevent other platforms from undercutting
- Trade reporting: Garrett, Lee, Martin, and Townsend (2020)
  - Broker-dealer with bid-ask spreads in OTC markets for clients
  - Coupled with subsequent inter-dealer market for re-trade in order to balance
  - Restrictions on third party clearing platforms, not sell information on trades, as this exacerbates the adverse selection problem and dries up liquidity from dealers
  - Better to provide no information or all of it, not price and sell
- Atomic swaps: Lee, Martin and Townsend (2021)
  - Limit reneging and the limited commitment problem
  - But to prevent leakage, all trades are not contingent
  - Problems with partial innovation rather then design of entire system, but need the cryptography in that design

Money and Monetary Policy: The Natural Domain, and Gain, from CBDC

- Competitive equilibrium can be Pareto optimal, but not with incomplete markets, under which we get valued fiat money
- Plus scope for optimal activist monetary policy
- Given this fiat base, a hierarchy of other monies layered on top
  - Bank deposit, debit and credit cards
  - Multiple means of payment per se not a problem
  - Structure still not complete (though if mts are complete, fiat goes away)
- With CBDC, another option: Paper replaced by digital currency
- May potentially enhance monetary policy, e.g., interest earned on the coin, more generally, it is programmable
- By analogy to the above, layered on top, fully fiat-backed stable coins backed by CBDC
  - Much like ideal commercial bank accounts
  - With monitoring of the backing, narrow banks
  - Smart contracts for pooling resources, maturity and risk transformation without requiring a trusted third party. Just a different kind of financial intermediation, in some aspects easier to monitor.
- Conclusion domestic: Public and private money can co-exist, fiat fills some gaps, leaves gaps which private sector layered on top can help fill, both can be complementary and valuable
- Conclusion international: for cross border problem or more: CBDC, M-CBDC, depository receipts as in Ithanon-LionRock

Example of Revised Monetary Policy, skip as time permits

- In the US, we got COVID crisis relief transfers (micro) and ad hoc special facilities (macro financial)
  - Neither very successful
  - Micro: How to get to supply chains
    - Relationship banking though SBA was a problem
  - Macro financial: Balance sheet of Fed grows yet again, intermediary of last resort
- Consider as an alternative: Liquidity injections in thin markets
  - As in joint work, Chandrasekhar, Townsend and Xandri (2021)
  - A model of risk-sharing, with money and risky assets
  - Inject liquidity to named key players, taking into account their interconnectedness, a new notion of financial centrality
  - Those that provide liquidity to others precisely when the market is thin, when there is more covariate risk
  - Using data to identify these players
    - Executed in Thai villages successfully, shows up in implicit consumption premium
    - In the US, existing regulatory data is not enough

* Optimal Activist Monetary Policy as in Townsend JPE and multi-country Townsend AER

Summary

- Background: CBDC begs issues, how much can and should private sector do. Private sector can do quite a lot but role is left for CBDC
- Key point: Smart contracts = programming code
  - DLT per se is not needed, except perhaps for execution of transfers
- Decentralized private sector implementation: A primer from simplest first principles
  - Key extension: Competition in contract space
- Financial stability concerns, runs, but with a private sector remedy, required by reg
- Caveat on private sector: Rules of the game are needed, clear from mechanism design
- Concerns about the limits to competition, often there is an answer
  - Economies of scale not always a problem, basic decentralization works
  - Incomplete markets, allow coordination, new type of regulation
  - Non-pecuniary externalities in platforms, solution with design, Pecuniary externalities in markets, solution with market design
  - Rules for Intermediation when aggregates matter
- Role for active public bank: Industrial organization with few providers, but with some twists and a larger vision
- Smart contracts for regulation (digital assets, repo)
- Issues in information design: Public/private intermingled
  - Credit registries, trade reporting, atomic swaps
- Money and monetary policy: The natural domain, and gain, from CBDC, domestic example of revised monetary policy, international cross border payments