Digital Payments and CBDC: Lessons from Economic Theory and Actual Markets

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The Broad Spectrum of 'Monies', the Need for Economic Theory, Three Examples

- Digital Payments
  - From fiat money (paper currency and central bank reserves)
  - To central bank digital currency (CBDC)
  - To synthetic CBDC, stable coins backed 100% by fiat
  - To private digital mobile money (M-Pesa as mobile service operator)
  - To digital assets with high velocity (e.g., Invenium and secondary market Tokeny)
  - To high velocity circulating private debt
- Economic theory juxtaposed with actual market experience
  - To think about use of and need for each of these
  - Identify problems that can arise in theory that also arise in practice
  - Solutions to those problems, especially utilizing new technologies
    - Distributed ledgers, smart contracts, encryption
  - Place the design and use of CBDC in this spectrum
- Outline of the talk: Three illustrative topics
  - Trade in digital assets
  - US repo market
  - Dealers and liquidity

Trade in Digital Assets

Distributed ledgers can facilitate trade but create problems, solved with new technology as regulatory tool

High Velocity Private Securities Traded in Segmented Markets

- Financial market crashes in the past, as with Bills of Exchange, London money markets, likely to happen again with digital assets, atomic swaps
- Townsend-Wallace (1987), contemporary interpretation
  - Segmented markets limit trades in securities in what seems to be a natural way
  - Traders when they meet can issue securities, i.e., a digital asset, a smart contract programmed to be redeemed at pre-specified date and location. Allows both short-term and long-term debts.
  - Secondary markets: Traders can buy and sell previously acquired digital assets against the good (money) or other digital assets
  - The model does not allow people to renege on their debts or to counterfeit others' debts

Example Economy, Multiple Equilibria

Table V-1. Who Meets Whom When

	Location	
Date	1	2
1	(1,2)	(3,4)
2	(1,3)	(2,4)
3	(1,2)	(3,4)
4	(1,3)	(2,4)

Source: Townsend-Wallace (1987)

- Short bilateral debt
- Long-term high velocity circulating debt used for trade in multiple markets
  - This allow us to choose nonnegative quantities of the circulating debts in any way that satisfies the equation

$$e_{13}^{1} + \left(\frac{s_{11}}{s_{13}}\right) e_{11}^{1} = \left(\frac{s_{14}}{s_{13}}\right)(d_{14}^{1} - d_{14}^{3}) - \left(\frac{s_{24}}{s_{13}}\right)(d_{14}^{2} - d_{14}^{4}) \qquad (9)$$

  - Eq. (9) is easily satisfied with all high velocity debt issued at location 1; if the LHS is positive, it can be satisfied by setting at zero all but d_{14}^{1}, and if negative d_{14}^{2}. Or all high velocity debt issued at location 2 similarly.
  - Also in various combinations: multiple equilibria

A Financial Crisis Emerges When Coordination Problems Are Not Addressed

- If the coordination problem is unresolved and agents guess wrong about what is going on in other informally separate trading venues, a slow-moving financial crisis emerges, with heterogeneous impact (Spector and Townsend, 2020)
  - The price of the unnecessary/over-issued debt collapses quickly, as the mistake is revealed, though forward-looking agents can then mitigate the disaster by reversing what would have been their short-term debt issues.
  - The time profile of end-of-period holdings fluctuates over time, especially for those buying and then selling with the high velocity assets, as for them liquidity fluctuates at intermediate dates. They suffer relatively large welfare losses.
- The coordination problem can be resolved in an additional multi-agent multi-market smart contract implemented on a distributed ledger of digital assets which is shared across trading venues.
  - The contract can specify bounds on security issues and an algorithm to achieve consensus.
  - One condition that works in the Townsend-Wallace, Spector-Townsend environment is to give specified agent types the first pass at security issues in one of the locations, and let the agent types in the other, second, location fill in gaps, if any, each up to now-conditioned upper bounds.

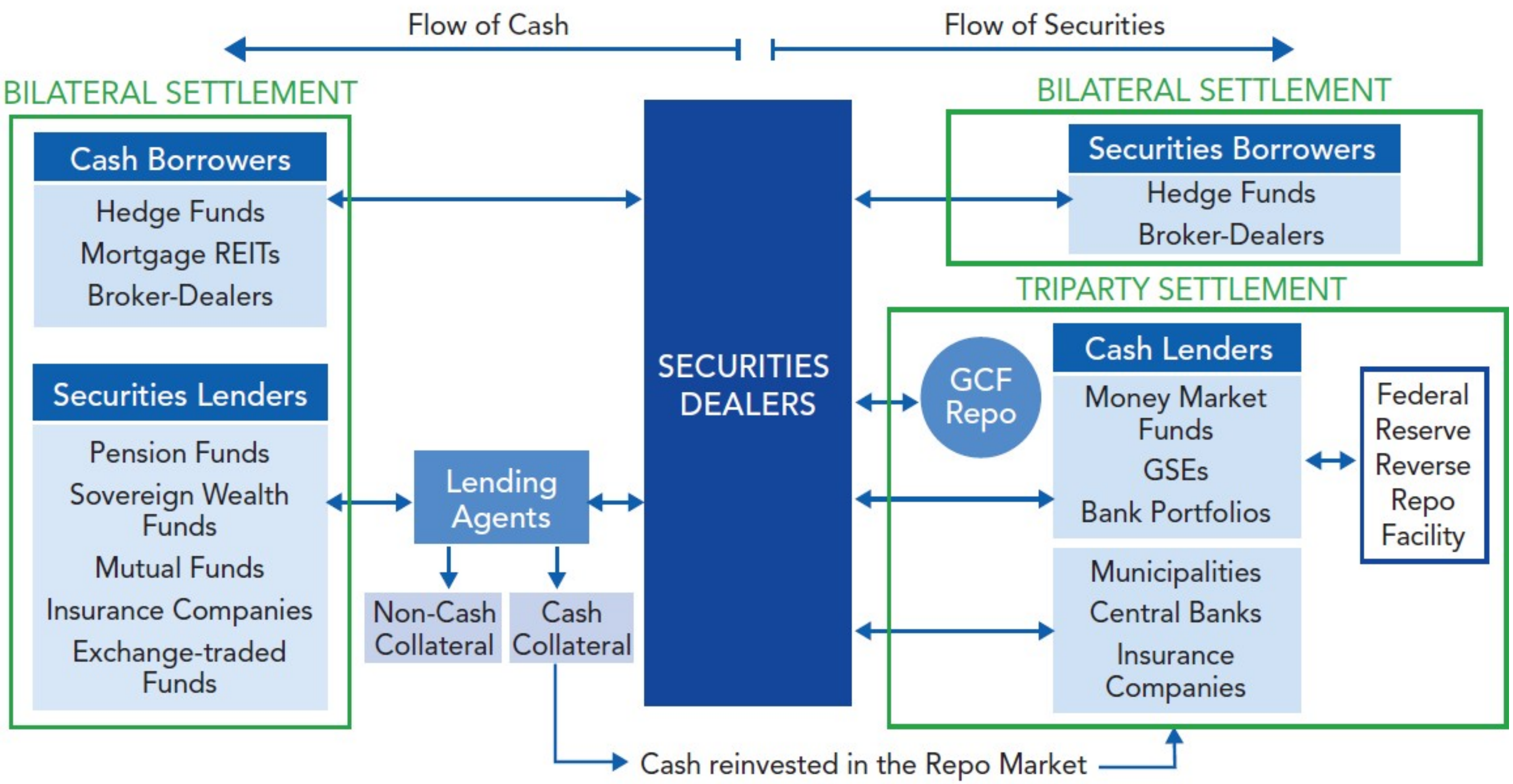
US Repo Market

Problem: Coordination failures and restrictions limiting liquidity

Solution: Wholesale CBDC

Repo Market Structure: Background, Key Market for US Federal Reserve

Figure 1: Key Secured Financing Market Participants



Notes: REITs = real estate investment trusts. GCF = general collateral financing trades. GSEs = government-sponsored enterprises.
Source: OFR analysis

Baklanova, Caglio, Cipriani and Copeland (2016) "The U.S. Bilateral Repo Market: Lessons from a New Survey"

Repo Market: Aronoff, Townsend and Zhang (2020), in Collaboration with DCI at MIT

- Broker-dealers have to decide whether or not to accept trades from customers, either liquidity suppliers, who offer money in exchange for treasuries, and/or risk managers, who offer treasuries in exchange for money.
  - Each customer is subject to its own shock.
  - If a broker-dealer agrees to act on behalf of its customers, after seeing the shocks of those customers, and if its own order book does not balance, then it carries inventory into the inter-dealer market.
  - Retrade among broker-dealers provides liquidity and an ability to meet underlying needs of trade of the various agent types.
- But there is a cost to potential mismatch of quantities, if a dealer is unable to pass along its inventory, hence a need to coordinate among dealers.
  - Coordination problem with multiple equilibria includes some with little or no trade
  - Likely some volatility due to wrong guess about matches
  - Trades are on balance sheets of dealers, with liquidity regulation limiting intermediation

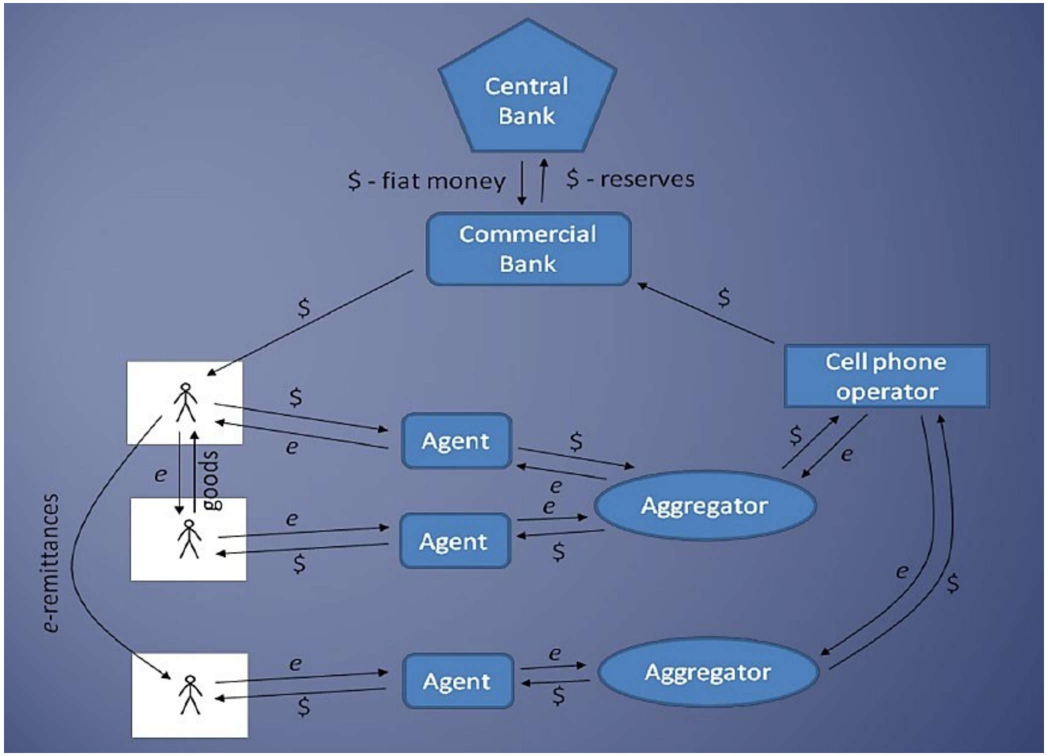
Market Organization: Smart Contracts on Wholesale CBDC Ledgers, details skipped

- Private sector would like to keep existing long-term relationships but replace large bank dealer-brokers who currently deal with overflow when trades do not balance
- Our design includes broker-dealers, in a centralized market
  - Can be seen as limit orders, as in Dubey (1982)
  - Clients have treasuries or liquidity, but do not know with whom to transact
  - They lock it up in an escrow account and share these escrow account addresses with their broker-dealers -- a timelock
  - The broker-dealers submit this list of account addresses with the smart contract node, which homomorphically does the matching and settlement of repo, without gaining any information in the process
  - Not even know who are the counterparties and how much they transacted, but alternatively can put in matching restrictions
  - Multi-agent smart contracts solve the coordination problem and effectively match origin and destination, keeping risk objects off of broker-dealers while programming in relationships and risk pricing

Dealers and Liquidity

A hybrid borrowing/lending insurance scheme in private sector executed with escrow and transfers on ledgers

M-Pesa as E-Money, and Shortages



Source: Jack, Suri and Townsend (2010)

e-Money	Fraction	Cash	Fraction
More than once a day	3.2%	More than once a day	3.2%
Once a day	6.4%	Once a day	8.4%
Once a week	14.0%	Once a week	10.0%
Once a month	5.6%	Once a month	4.8%
Once every 3 months	1.2%	Once every 3 months	1.2%
Once every 6 months	0.4%	Once every 6 months	0.4%
Less often than that	12.0%	Less often than that	22.4%
Never	57.2%	Never	49.6%

Source: Joint research initiative of FSD Kenya, Consultative Group to Assist the Poor(CGAP) and the Central cBank of Kenya (CBK), 2009

Mechanism Design Problem, a Contract

- Viewing agents' specific liquidity shortages as an idiosyncratic shock
  - Ex ante insurance is good
  - But revealing those shocks over time too quickly can damage beneficial trades
    - Ex ante insurance possibilities are lost once the ex post adverse event has occurred
- A mechanism design problem featuring concealment
- Example: Townsend (*JME* 1988)
  - Two agents (agent *a* and agent *b*) have utility functions subject to privately observed preference shocks, two periods, and a planner
  - Agent *a* in the first period can be either patient or urgent to consume, long or short, sending private knowledge (message) to the planner
  - Likewise for agent *b* in the second period
  - The planner sees the messages, but makes sure the other agent does not
  - Set incentives to tell the truth in second period
  - The information-constrained optimal allocation is that lying in the second period generates a very bad outcome for the sender with positive probability
  - Agents *A* and *B*, and "pseudo agent" *C*, which help to conceal new elements

Summary and Conclusions

- Trade in digital assets
  - Distributed ledgers can facilitate trade but also create problems, financial market crashes past and future, solved with new technology, programmed assets as regulatory tool
- US repo market
  - Key market for US Federal Reserve, central banks inherently involved
    - Coordination failures and restrictions limiting liquidity
    - Solution: Wholesale CBDC linked to Treasuries on a ledger
- Dealers and liquidity problems
  - A hybrid borrowing/lending insurance scheme, with privacy and no need for trusted third party
    - Example of central bank providing CBDC ledgers and letting private sector do the contracting