# Role of CBDC, Digital Real in Brazil Relative to Existing and Planned Infrastructure Alternatives

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# Outline of the talk

❖ Smart, programmable contracts
  ➢ Definitions and designs, various options for Brazil, and a potential role for some kind of central bank infrastructure platform, including the possibility of CBDC

❖ Delegation to the private sector: innovation

❖ Imperfect competition: Public sector has an active role when there are IO concerns, including CBDC coins and smart contracts as competition for DeFi

❖ Blueprints: Needed for the design of the financial system, a plan

❖ Database: Data management as part of optimal financial system design

❖ Regulation: By the public sector using smart contracts, encryption and CBDC

❖ Money and monetary policy: The natural domain, and gain, from CBDC

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# Smart Contracts: Programming Code

❖ Mechanism design problem
  ➤ Max weighted sum of utilities of agents, participants
  ➤ Subject to resource constraints, information incentive constraints, limited commitment constraint, participation constraints

❖ Consequence
  ➤ Internalizes incentives to "tell the truth"
  ➤ And to take specified actions, follow the recommended plan, consistently

❖ 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, go with CBDC, it is optional

❖ Cryptography
  ➤ Privacy for incoming messages, outgoing messages with signatures, and generates commitment
  ➤ Prime example: "Trustless" escrow service (hashed timelock contract)

❖ Consequence
  ➤ Dealing with strangers, no need for trusted third parties, e.g., for financial access
  ➤ More efficiency, flexibility, and potential to reduce rent extraction

# Schemata for Designs, Examples
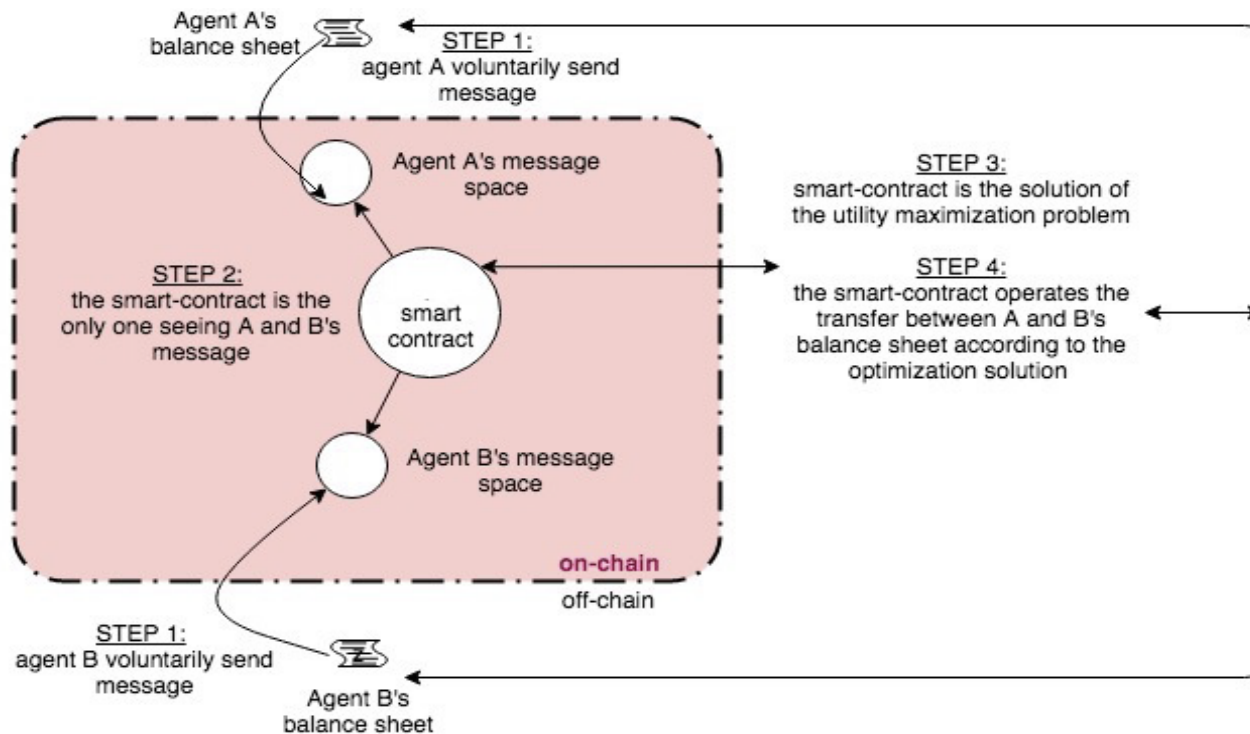


❖ Auctions with more privacy settings concerning bids and no trusted third party

❖ 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)

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# Implementation of Programmed Contracts in Brazil: A Choice of Designs

❖ The limitations of CBDC on distributed ledgers
  ➤ Validation on decentralized distributed ledgers does not scale up easily
  ➤ Solutions include better algorithms, e.g., Federated Byzantine, Algorand, etc., not Ethereum
  ➤ Or trusted centralized party running the ledgers, including partitioned ledgers, as with Corda
  ➤ Data storage and calls on the data: A scaling problem for transactions processing if not done correctly
  ➤ Potential solutions in the code itself or as hybrids off-chain

❖ PIX: Debit and credit balance sheets, not on distributed ledger
  ➤ Current option: Build on top of PIX, as with open banking
    o Buyer/seller with shipping, invoice financing and hence change of recipient of funds, DvP for real assets such cars, real estate, interface with other digital authentication platforms
    o However multi-party is more difficult, plus this path is one application at a time, may have limits

❖ Open platform as infrastructure, providing tools to write any contract
  ➤ Example: EvryNet, no connection to central bank, BOT

❖ Options for Brazil
  ➤ A public provision of such an open platform
    o Not involved with the contracts per se, let the private sector do that part
    o Multiple private sector platforms which are in principle interoperable (as evidenced by hashed timelock) but not yet clear how robust this is
  ➤ In principle separate from CBDC, but could do both, with fiat as legal tender for the object transferred, but not necessary to suffer from costly validation routines

❖ Domestic CBDC has other, additional rationales, described in the subsequent slides

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# More on Decentralized, Delegation to Private Sector

❖ Price competition for commodities or assets among platforms, broker-dealers as go-betweens, calling out terms of trade and trying to attract customers
  ➢ Works well
  ➢ Especially taking the limit as the number of providers increases

❖ Extends to mechanism design contracts with flexible options, pooling across large numbers
  ➢ Mutualization and securitization

❖ Increasing returns are not necessarily a problem
  ➢ Finite number of clusters, with internal intermediation

❖ Externalities as in two-sided markets also not necessarily a problem
  ➢ Payment cards, crypto currencies
  ➢ Problem of scaling up means increasing marginal costs, limits size, fixed costs not an issue

# Industrial Organization Issues When There Are Few Providers: Another Public Sector Role

❖ Imperfect competition in the provision of financial contracts is an issue

❖ Small numbers problem, profits vs. welfare
  - Tradeoffs: Lower obstacles may give counter-intuitive results
  - Can hurt the public and help banks that extract more rent

❖ Identifying which frictions hurts the most
  - Joaquim, Townsend and Zhorin (2020)
  - Artificial product differentiation creates rents for financial providers, there is a large gain to getting rid of this
  - Lowering spatial costs as with digital banking
  - Both provide larger gain relative to increasing number of physical bank branches

❖ Public sector as providing competition for private sector
  - Assuncao, Mityakov and Townsend (2021)
  - Commercial banks provide insurance, credit, and savings
  - Private sector banks act to preempt others in order to capture rents
  - Role for public bank that cares not only about its own profit but also about public welfare

❖ CBDC provision to ensure competition
  - Public infrastructure
  - Ensuring a healthy market in decentralized finance, DeFi
    - NFTs, machine learning, credit scoring, customized contracts, new sources of collateral
  - Making sure the benefits of private intermediation accrue to the public by competition from CBDC coins and direct or indirect programmability

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# Even with Competition, Need Rules, Need Blueprint, Design of Financial System

❖ Ex ante competition is good, ex post competition is bad, undercuts mechanism design incentives

❖ (Below, as time permits)

❖ Design remedies for pecuniary externalities, fire sales
  ➢ As in Kilenthong and Townsend (2021)
    o Do not need government involvement via restrictions on saving, portfolios, taxes
    o As in Stein (2013), auction for future Fed reserves, create market and price
    o Here fees for joining ex ante security exchanges for assets with commitment to unwind these in corresponding spot exchange at pre-designated price
    o Intuition: Type-specific fees are incorporating contributions to excess demand (or supply) which influences the price

❖ Intermediaries can be key
  ➢ As in Townsend and Xandri (2021)
    o Fixed costs/minimum scale leaving aggregate risk
    o Firms and households required to go through intermediaries
    o Stretching to extend number of projects means ex post funding is not balanced

❖ Coordination in innovation: Not the usual regulatory categories

# Database as Part of Optimal Financial System Design (as time permits)

❖ Rules for credit registry
  ➢ Immorlica, Sztutman, Townsend (2021)
  ➢ Adverse selection
  ➢ Optimal designs of credit registries with AI and commitment
  ➢ It may be optimal to be constrained in information provided to investors to prevent market from unraveling, plus need to prevent new entrants from undercutting

❖ Trade reporting rules
  ➢ With 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 re-balance
  ➢ Post trade disclosure and third party platforms: Restrictions to 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 and not to price it

❖ Atomic swaps are not a panacea
  ➢ With Lee, Martin and Townsend (2021)
  ➢ Atomic swaps limit reneging and the limited commitment problem
  ➢ But to prevent information leakage, trades are limited, not contingent
  ➢ Illustrative of a problem with partial innovation
  ➢ Rather than the design of entire system, the latter recommended here as the ideal

# Regulation Using Smart Contracts, Distributed Ledgers, and/or CBDC

❖ Financial stability concerns: Bank (market) runs have a solution with smart contracts, in particular with cryptography and commitment
  ➢ Deal with problem directly through evolving caps on withdrawal and history dependence
  ➢ Green-Lin solution to Diamond-Dybvig bank run problem
    o Townsend Advanced Macroeconomics II lecture notes
  ➢ Multi-lateral smart contracts deal with financial stability concerns
  ➢ Yet this alone is not an argument for CBDC per se

❖ Related Idea: Suggested caps on CBDC with withdrawal
  ➢ Related to the runs problem in the sense of programmable money

❖ US repo market: Direct use of a wholesale CBDC
  ➢ Broker-dealer contract with clients, then trade in inter-dealer market
  ➢ Problems of coordination (multiple equilibria) and overly-binding liquidity ratios, US
  ➢ Solved with multi-agent smart contract on treasury and central bank ledgers for reserves, hence CBDC

❖ Digital assets on distributed ledgers, a regulatory smart contract
  ➢ Tokens as claims on intermediary returns, backed by data access
  ➢ A good thing for the economy, expect more
  ➢ But with multiple high velocity debts there can be a coordination problem
  ➢ Information at some nodes of exchange is key to implementation
  ➢ Easy to implement on distributed partitioned ledgers, or interoperable ledgers, like hash timelock, with much private but some public info

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# 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 on top
  ➢ bank deposit, debit and credit cards
  ➢ Multiple means of payment per se not a problem

❖ With CBDC, another option: Paper replaced by digital currency, may potentially enhance monetary policy, e.g., interest earned on the coin

❖ By analogy to the above, fully fiat-backed stable coins, backed by CBDC
  ➢ Much like ideal commercial bank accounts
  ➢ With monitoring of the backing, narrow banks

❖ Conclusion: Public and private money can co-exist, fiat alone leaves gaps with private sector layered on top can help fill, both can be valuable

❖ Open up to DeFi environment, sandbox idea
  ➢ Coins attempting stable values via algorithmic, programmed money
  ➢ CBDC tokens exchanged for private coins, which are sold to investors who want claims on physical asset purchases
  ➢ Secondary market in such DeFi coin
  ➢ 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.
  ➢ Analogy to having an economy with multiple assets and varying prices, which is not a new problem for central banks

❖ Corollary: The future has arrived
  ➢ Financial system will continue to evolve with desirable innovations, and so the role for CBDC and central bank will evolve, but think ahead and get ready now

❖ Solution for central banks
  ➢ Map of the financial system with tracking, put in cryptography, MPC and FHE for privacy, automate parts of monetary policy with programmable money

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# Example of Revised Monetary Policy

❖ In the US, COVID crisis relief transfers (micro) and ad hoc special facilities (macro financial)

- ➤ Neither very successful
- ➤ How to get to supply chains: Relationship banking though SBA was a problem
- ➤ 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
  - o Executed in Thai villages successfully, shows up in implicit consumption premium
  - o In the US, existing regulatory data is not enough (back to the point about needed data infrastructure)

# Conclusions

❖ Role of public sector in design of open platform infrastructure, including programmability, potentially through a version of CBDC

❖ Private sector competing on top, which works robustly (including returns, externalities)

❖ Public sector has a role in providing countervailing competition in the public interest – in coins and smart contract provision

❖ Public sector has a role in overall blueprints for the design of financial system

❖ Need public database infrastructure for tracking, regulation, and policy
  ➢ It too needs to be designed, there are surprises

❖ Public sector should use new technologies in regulation
  ➢ Bank runs, coordination problem in wholesale markets, and for trade in digital assets as high velocity circulating private debt tokens

❖ Private and public monies can be complements, but distinct roles should be clear conceptually
  ➢ Do not have to fix exchange rate across all media, not the job of central bank through CBDC

❖ Strongest argument for CBDC is as fiat money, improved monetary policy in an innovative financial economy

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