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Understanding Central Bank Digital Currencies (CBDCs)

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CAS in Blockchain
Zurich, 28th September 2024



Agenda

1. Introduction
2. Retail CBDC (rCBDC)
3. Wholesales CBDC (wCBDC)
4. Current Trends



Institutional Adoption and Central Bank Experiments

Central bank digital currency (CBDCs) is a digital currency issued by a central bank

BlackRock's BUIDL Crosses \$500 Million in Tokenized Treasuries

BlackRock's tokenized treasury fund is the first of its kind to reach the \$500 million market cap milestone.



BIS and Central Banks of France, Singapore and Switzerland Successfully Test Cross-Border CBDC Using DeFi



Jai Pratap

Last updated: 28 September 2023 at 10:08 CEST | 1 min read



≡ Bloomberg

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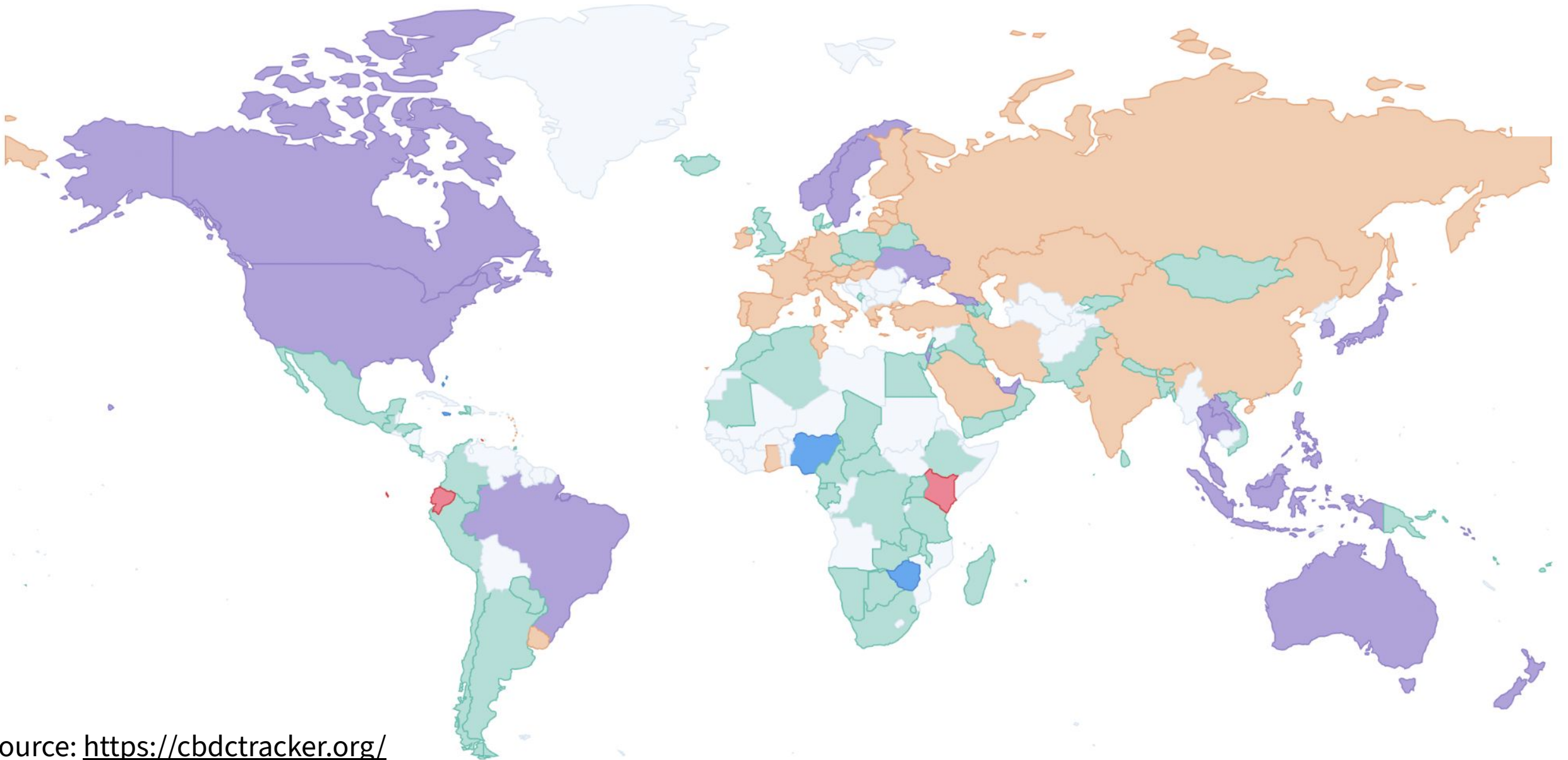


Industries | Finance

JPMorgan Is Exploring Blockchain-Based Deposit Token for Payments, Settlements

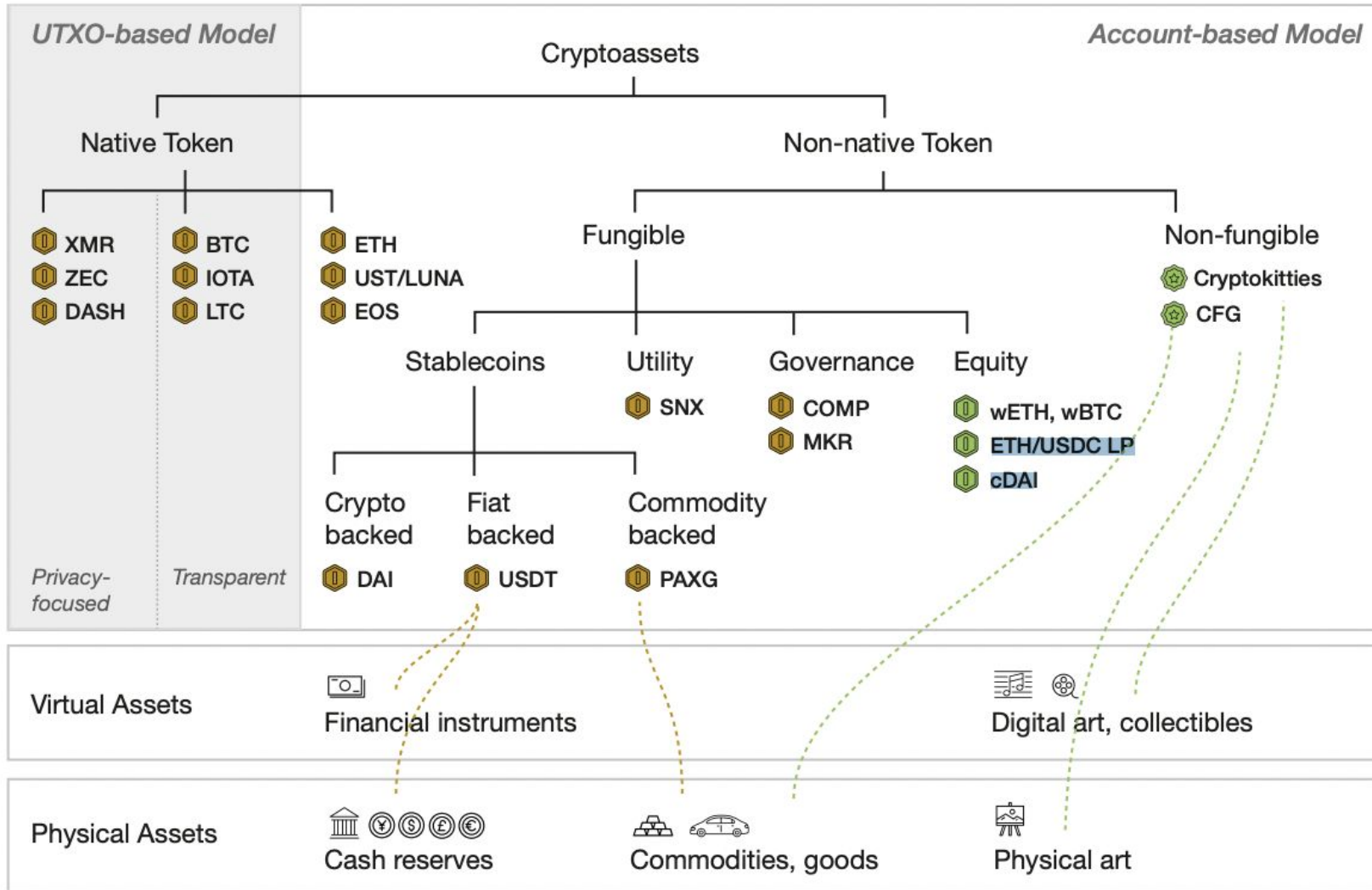
- If approved by regulators, token could speed up transactions
- Effort would mark expansion of JPMorgan's blockchain push

Today's CBDCs



Source: <https://cbdctracker.org/>

The Digital Currency Landscape



Native tokens are integral part of the blockchain.

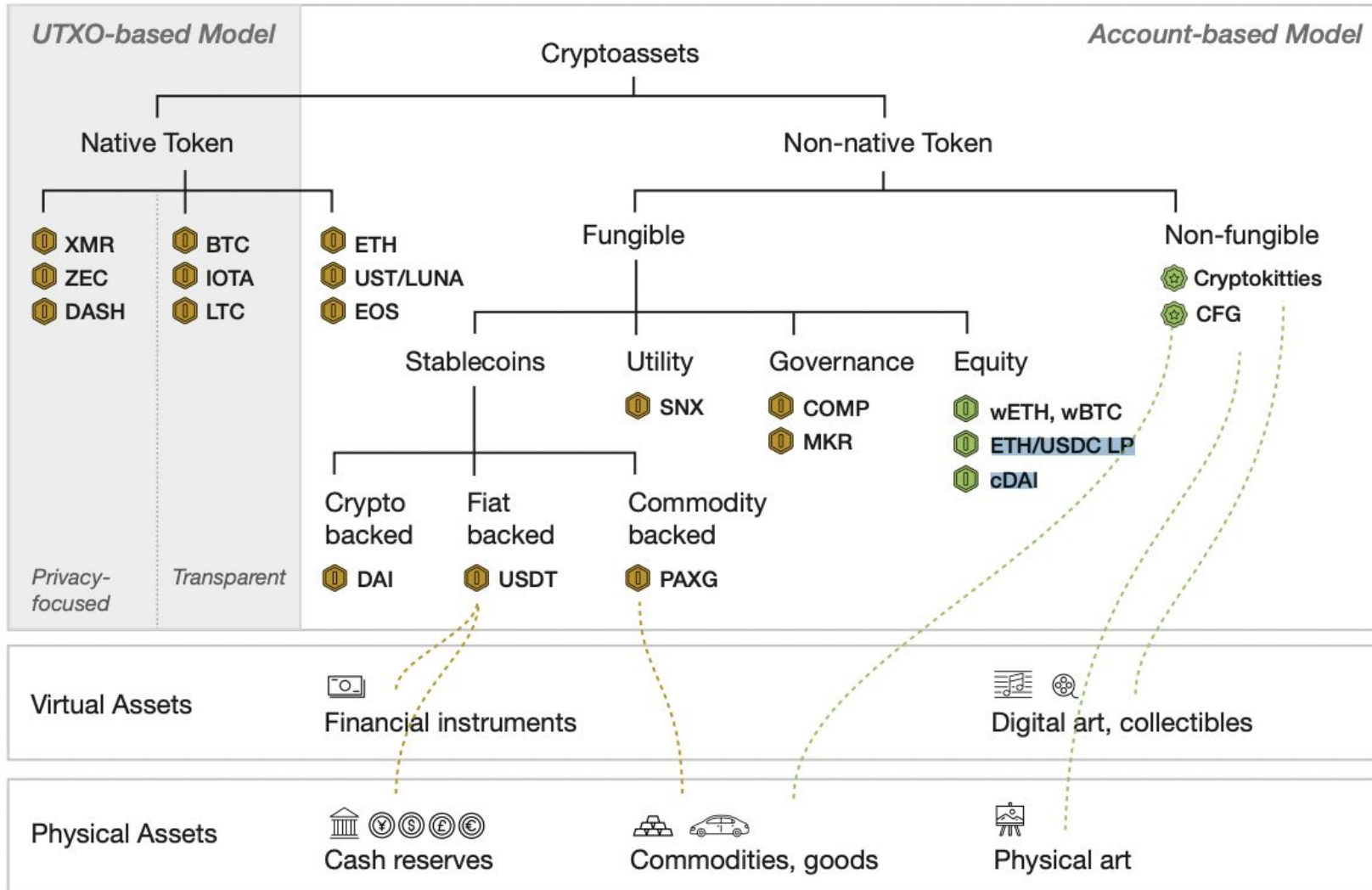
- They are used to pay gas fees

Non-native tokens are enabled by smart contracts. Typically they are

- ERC-20 (fungible)
- ERC-721 (non-fungible)

Thanks to smart contracts, tokens can have many properties and functionalities.

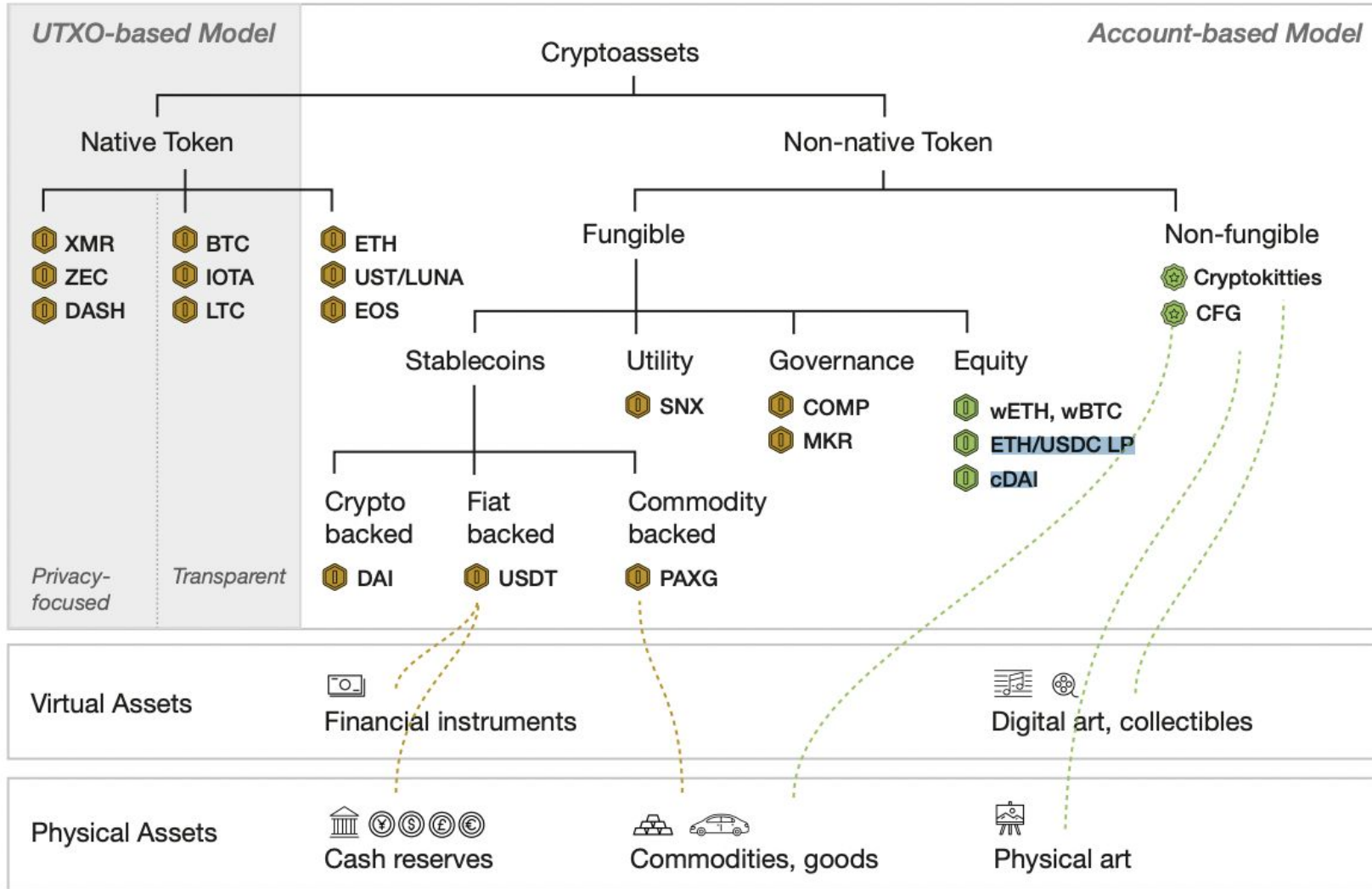
The Digital Currency Landscape



Difference between cryptocurrencies, stablecoins, tokenized deposits, CBDCs

- **Crypto-currency** tokens like ETH or BTC are very volatile
- **Stablecoins** are special tokens, which values is always pegged to fiat money (e.g 1 USD or 1 CHF)
- **CBDCs** are also pegged to fiat money, but they are issued by central banks only

The Digital Currency Landscape



Stablecoins, like USDT or USDC, make significant profits thanks to their cash reserves

Tokenized Deposits, like BUILD (BlackRock), are the latest trend in institutional DLT.

- They are similar to stablecoins and have value of 1 USD
- They pay daily/monthly rewards from deposits to the token holders on-chain in the form of extra new tokens

Defining CBDC

Central bank digital currency (CBDCs) is a digital currency issued by a central bank

There are two types of CBDCs, each with its own pros and cons:

- **Retail CBDCs** - for general public use
- **Wholesales CBDCs** - restricted for banks and institutions

CBDCs does not have to be issued on DLT, but **the application of blockchain allows for the fundamental transformation of the financial system.***

- Blockchain ensures atomic transaction execution with almost instantaneous finality, resolving challenges related to Delivery vs Payment (DvP) settlement.
- Smart contracts can offer compliance assurance and further value-adding services.

Example of non-blockchain CBDC:

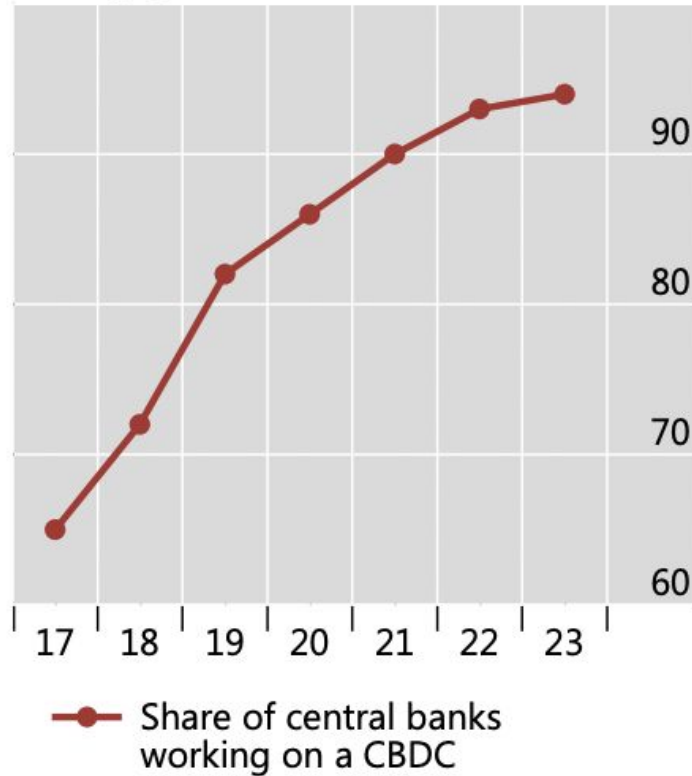
- Hungary's central bank, the Magyar Nemzeti Bank (MNB), launched its first retail CBDC pilot project in September 2020 to support digital financial inclusion of students.



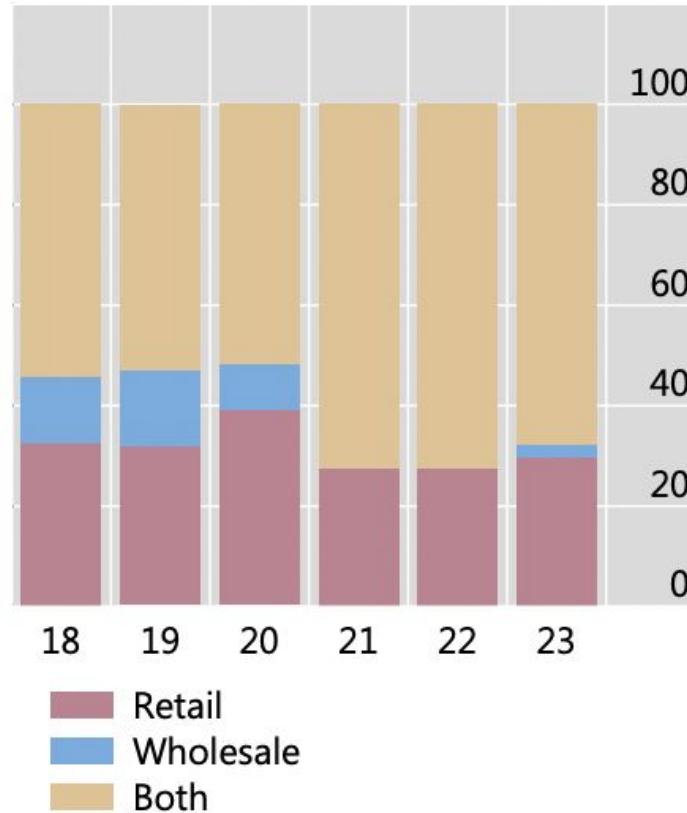
Central Bank Involvement in CBDCs

Over 90 central banks work on CBDCs initiatives. The focus shifts towards wholesale CBDCs

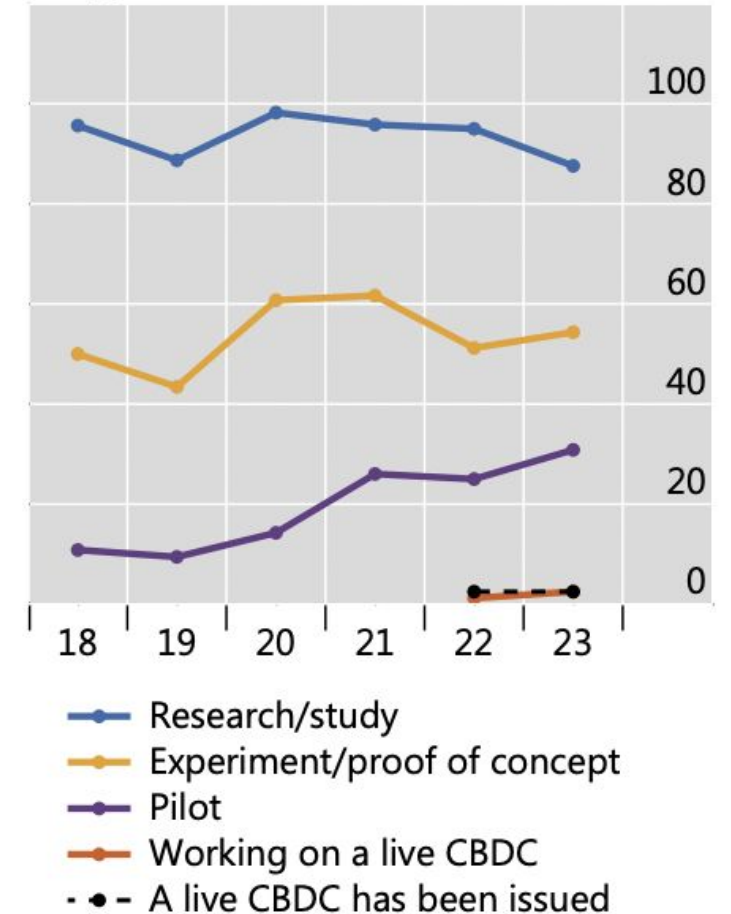
A. Engagement in CBDC work



B. Focus of work²



C. Type of work²



Retail CBDCs



Motivation for Retail CBDCs

CBDCs increase the household welfare according to the models

Will CBDCs Overpower Stablecoins?

The research by Jonathan Chiu from the **Bank of Canada**, have explored the potential co-existence of CBDCs (central bank digital currencies) and stablecoins.

According to these findings, whether CBDCs will overshadow stablecoins largely depends on two key factors:

- ▶ Level of CBDC Surveillance
- ▶ Interest Rates

Money Creation for Distributed Ledgers: Stablecoins, Tokenized Deposits, or Central Bank Digital Currencies?

Jonathan Chiu
Bank of Canada

Cyril Monnet*
University of Bern
Study Center Gerzensee

September 15, 2023

Abstract

Should a central bank digital currency (CBDC) or tokenized deposits be issued to facilitate decentralized finance (DeFi) within the crypto space? Would their introduction be a curse or a blessing for stablecoins and illicit transactions? This paper presents a general equilibrium monetary model where money creation is susceptible to moral hazard problems. The impacts of issuing a CBDC or tokenized deposits hinge upon their utilization as a means of payment or as collateral assets in the DeFi sector. In instances where surveillance is low and the interest rate remains moderate, these tokenized currencies tend to be used as a means of payment, thereby crowding out stablecoins. Conversely, when the associated interest rate and surveillance level are high, tokenized currencies tend to serve as collateral, leading to the crowding-in of stablecoins. In terms of social welfare, CBDCs generally outperform tokenized deposits. In some cases, it becomes necessary to prohibit the creation of tokenized deposits in order to implement the optimal CBDC design. Furthermore, it is deemed optimal to apply the lowest level of surveillance to a CBDC to prevent its utilization as collateral by stablecoin issuers, thus preserving the scarcity of collateral assets.



Challenges for Retail CBDCs

- ▶ Low Surveillance & Moderate Interest Rates: Tokenized currencies tend to be used as a means of payment, potentially crowding out stablecoins.
- ▶ High Surveillance & High Interest Rates: Tokenized currencies are more likely to be used as collateral, leading to the crowding-in of stablecoins.

Social Welfare Implications:

- ▶ CBDCs vs. Tokenized Deposits: Generally, CBDCs outperform tokenized deposits in terms of social welfare.

Optimal Design Considerations:

- ▶ Prohibiting the creation of tokenized deposits might be necessary to implement an optimal CBDC design.
- ▶ Applying the lowest level of surveillance to CBDCs can prevent their use as collateral by stablecoin issuers, maintaining the scarcity of collateral assets.

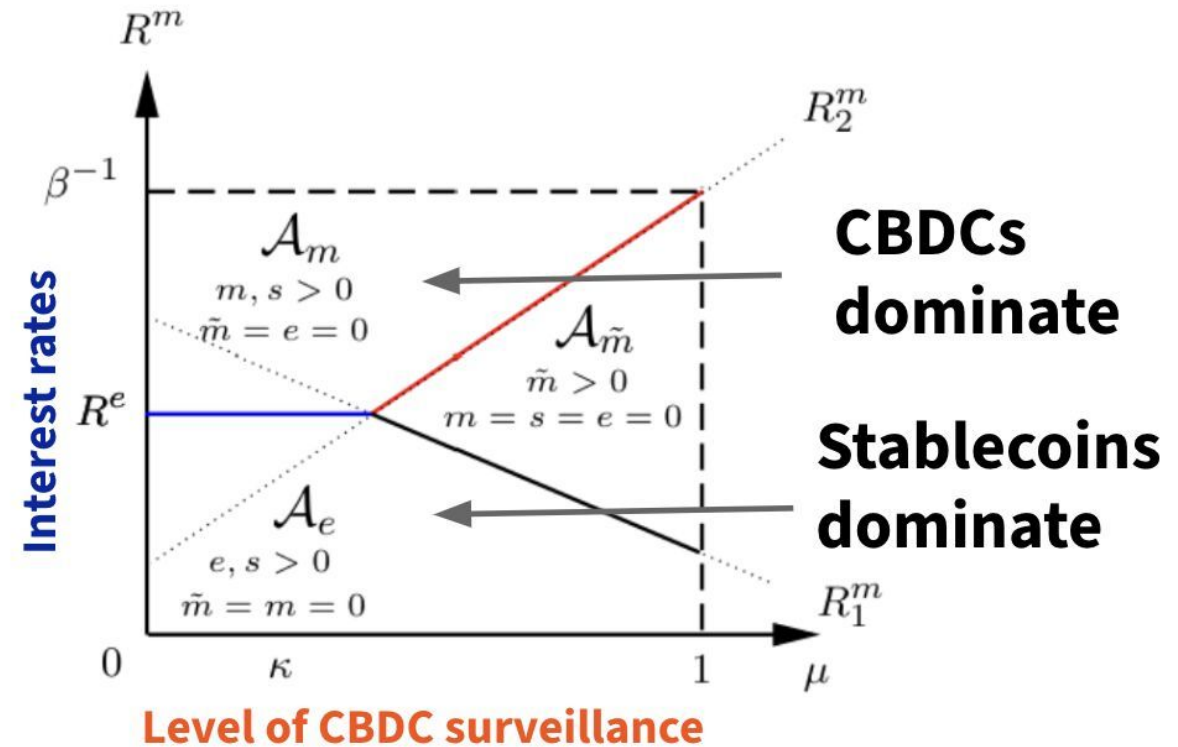
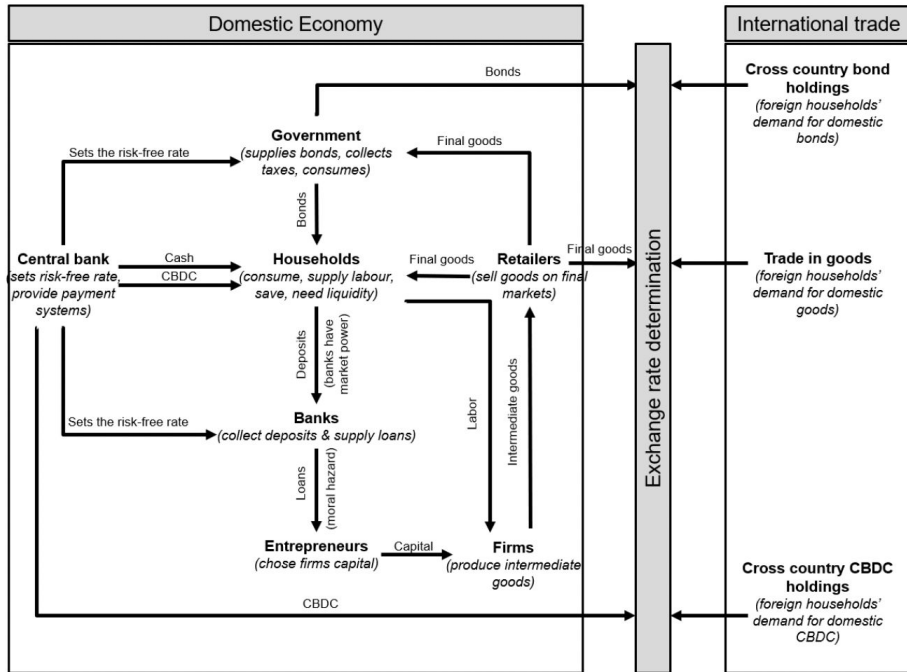


Figure 4: Distribution of Equilibria in the (R^m, μ) space

Retail CBDC's Impact on Commercial Banks

With CBDCs, the power of banks may be reduced, and some banks could face liquidity issues. How can we manage the transition to CBDCs effectively?



The introduction of central bank digital currencies (CBDCs) poses significant challenges and opportunities, particularly concerning the power dynamics and liquidity issues faced by banks.

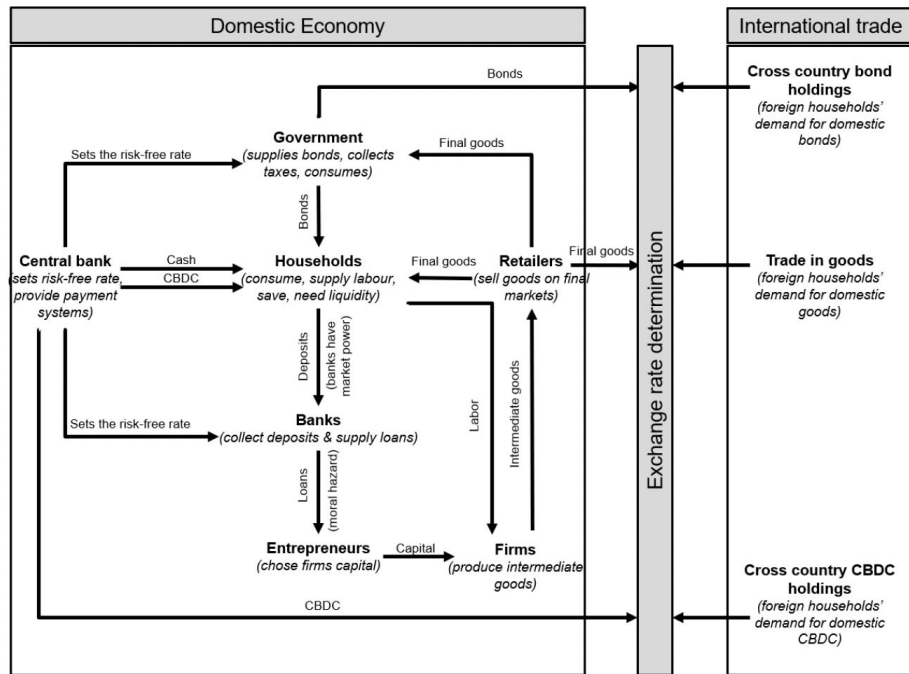
In this two-country model, researchers from the **European Central Bank** study the financial frictions during the transition from a steady state without a CBDC to one where the home country issues a CBDC.

Working Paper Series

Katrin Assenmacher, Massimo Ferrari Minesso, Arnaud Mehl, Maria Sole Pagliari
Managing the transition to central bank digital currency

Retail CBDC's Impact on Commercial Banks

With CBDCs, the power of banks may be reduced, and some banks could face liquidity issues. How can we manage the transition to CBDCs effectively?



1 Gradual Implementation:

- ▶ Phased Rollout: Introduce the CBDC gradually to allow banks and other financial institutions to adapt. This phased approach can help mitigate sudden shocks to the banking sector.
- ▶ Pilot Programs: Start with limited pilot programs to test the CBDC in controlled environments before full-scale implementation.

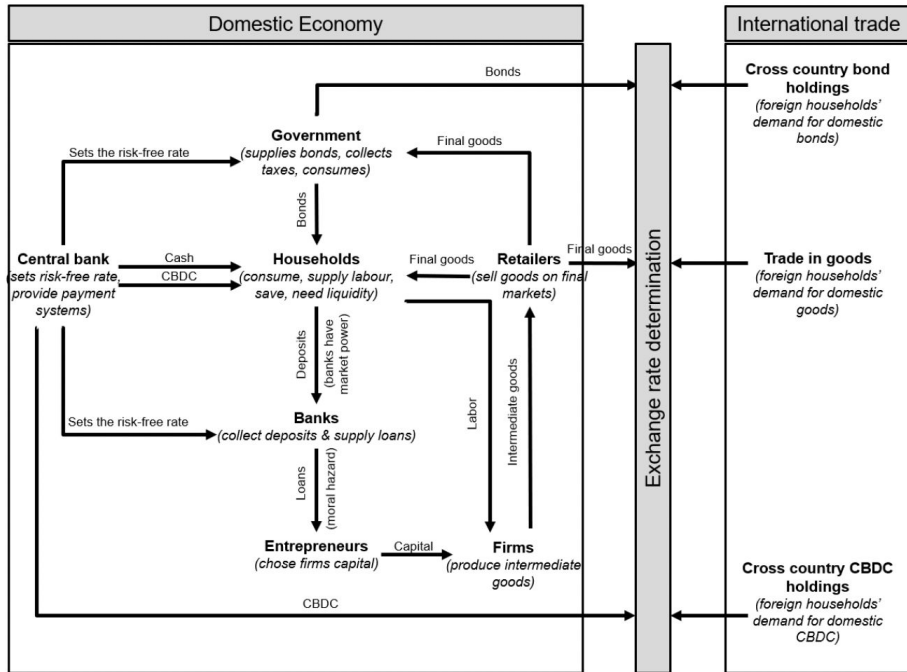
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2 Policy Interventions:

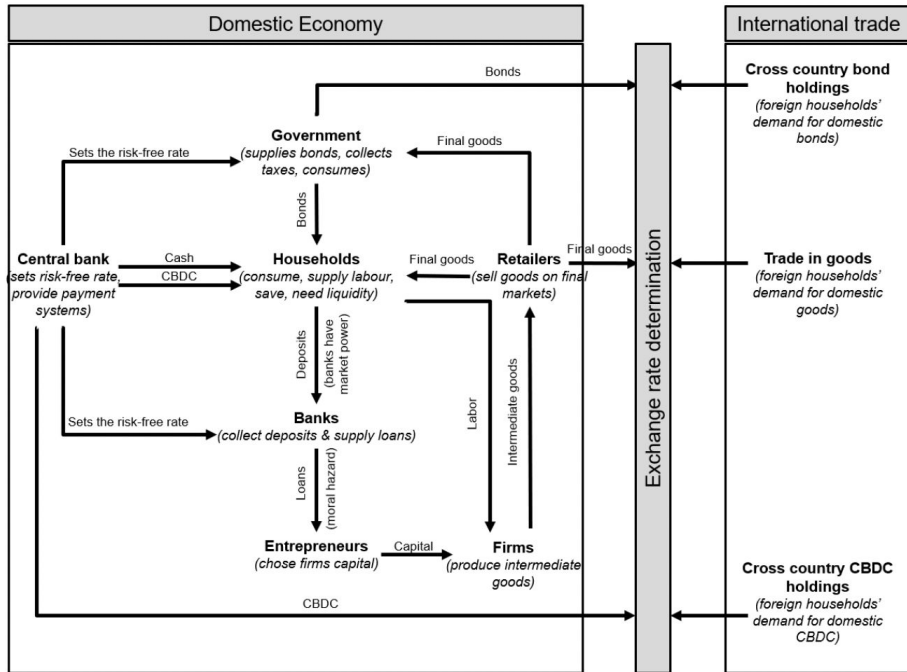
- ▶ **Binding Caps:** Implement caps on the amount of CBDC individuals and businesses can hold. An optimal cap around 40% of steady-state CBDC demand can reduce disintermediation and output losses.
- ▶ **Tiered Remuneration:** Apply different interest rates to varying levels of CBDC holdings to manage demand and prevent excessive shifts away from bank deposits.

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3 Liquidity Support for Banks:

- ▶ Central Bank Lending Facilities: Establish facilities to provide liquidity to banks facing shortfalls due to the transition.
- ▶ Reserve Requirements Adjustments: Modify reserve requirements to give banks more flexibility in managing their liquidity.

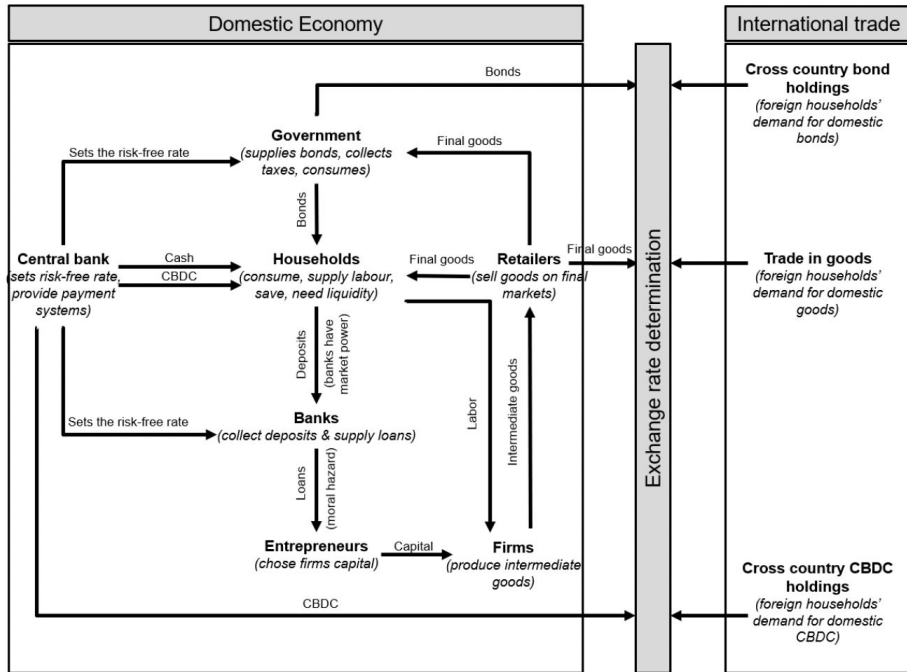
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4 Regulatory Adjustments:

- **Surveillance and Compliance:** Ensure robust monitoring and compliance frameworks are in place to prevent illicit use and manage financial stability risks.
- **Interbank Cooperation:** Foster collaboration among banks, central banks, and other financial entities to share best practices and ensure a coordinated approach.

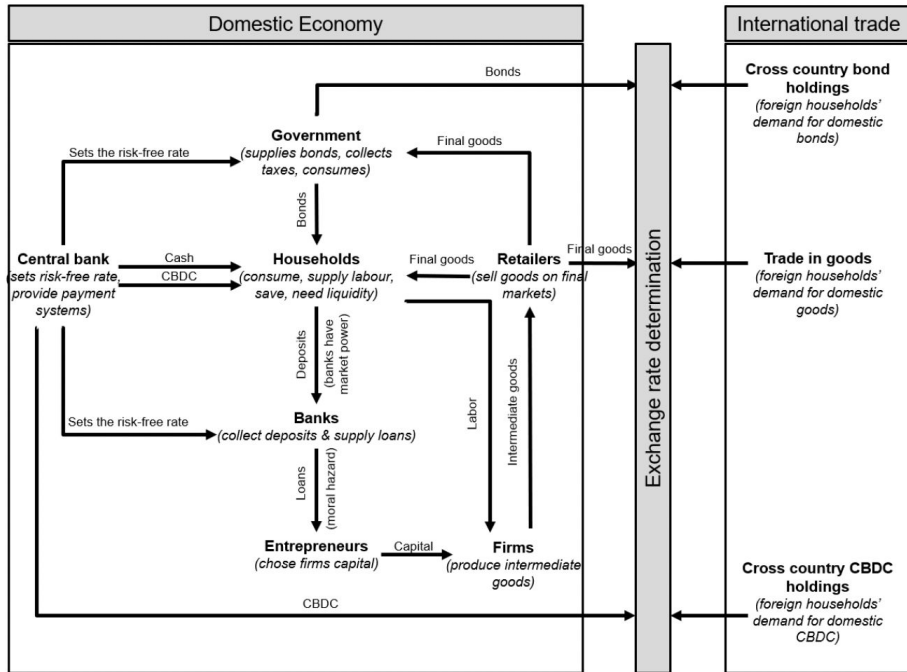
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- 5) Public Communication and Education:
- Transparent Communication: Clearly communicate the benefits and operational details of the CBDC to the public to build trust and understanding.
 - Educational Campaigns: Launch educational campaigns to help consumers and businesses understand how to use CBDCs effectively.

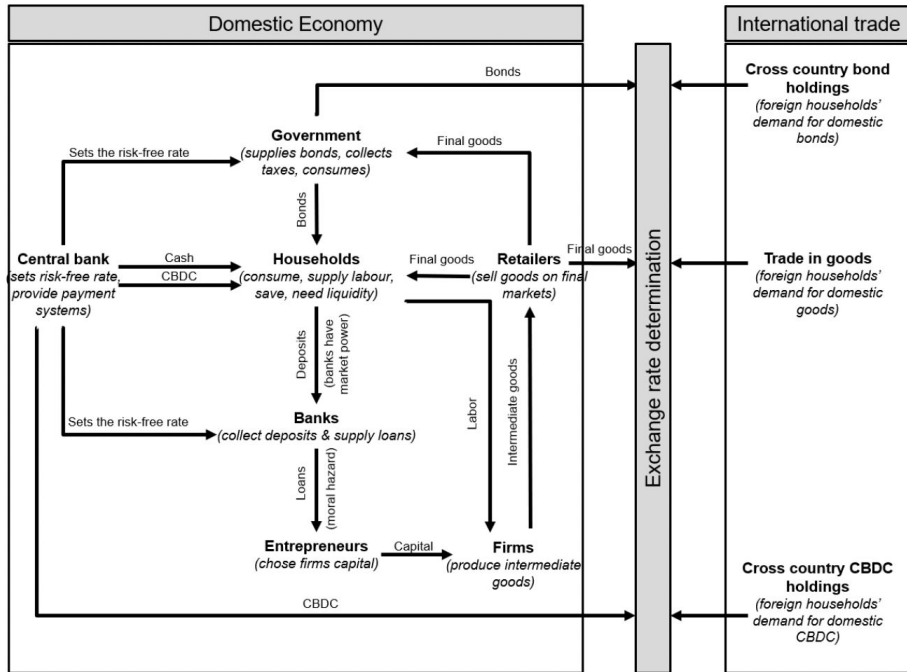
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- 6 Central Bank Asset Purchases:
- Stabilization Measures: Use central bank asset purchases to stabilize the economy during the transition period, supporting investment and consumption.

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CBDC Pilots in Switzerland

	Domestic use case	Cross-border use case
Wholesale CBDC	Helvetia I Helvetia II Helvetia Pilot (ongoing)	Jura Mariana Agora (ongoing)
Retail CBDC	Tourbillon	

Source: Swiss National Bank

- Wholesale CBDC are restricted to banks or financial intermediaries.
 - Retail CBDC would be open to the general public.
- At the moment, there is no use case for retail CBDC in Switzerland. Focus on wholesale CBDC.

Wholesales CBDCs

3



Decentralized Finance (DeFi) Protocols

DeFi protocols are smart contracts that provide financial services. Consequently, there are no intermediaries and no counterparty risk.

Other DeFi advantages:

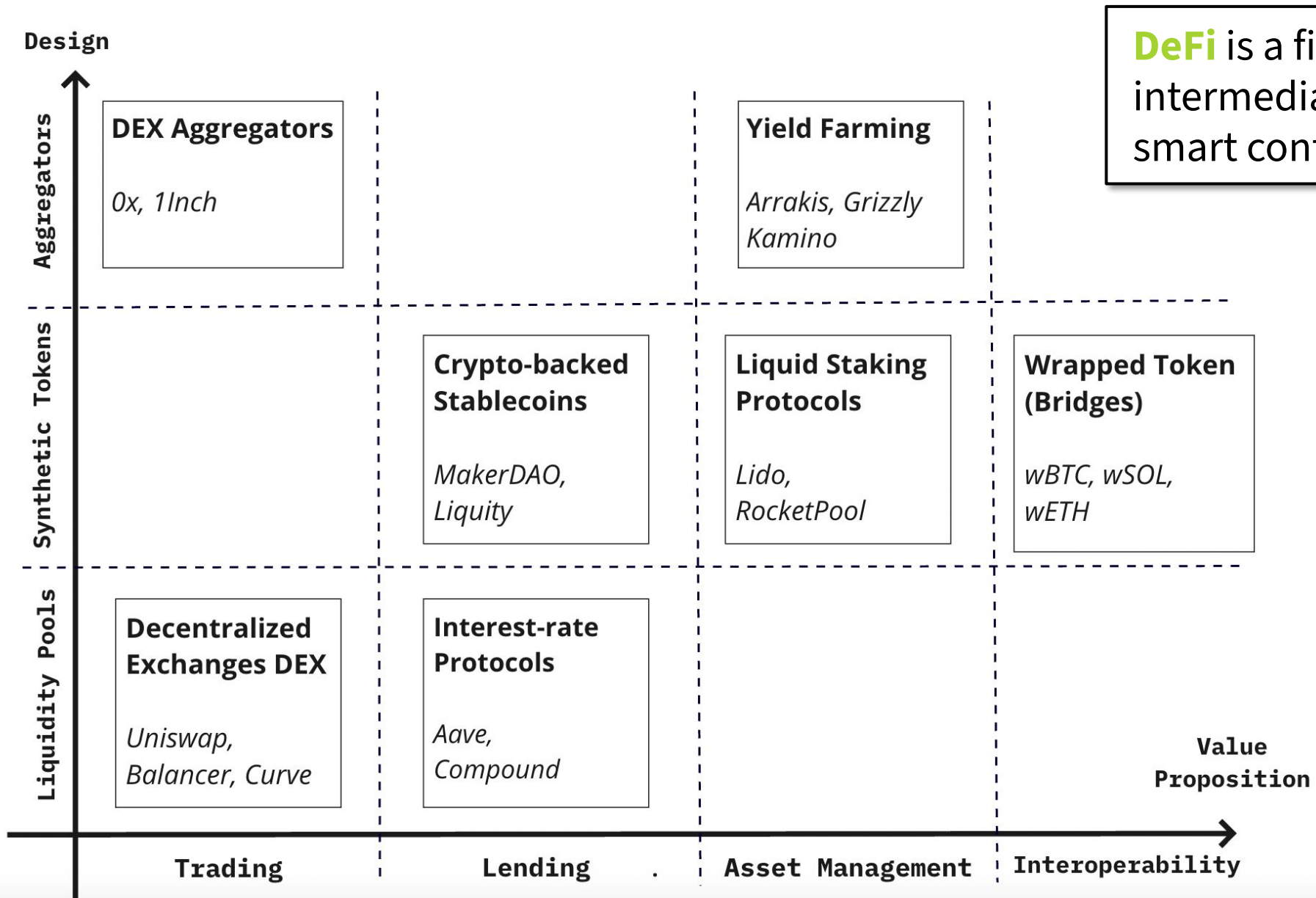
- permissionless (anyone can create or use financial products),
- transparent (“code is the law”),
- fast,
- low cost (L2s),
- open 24/7.

Application of wCBDcs with DeFi smart contracts can lead to **80%** costs reduction of financial services

Source: PYMNTS Report, Can Blockchain Solve the Cross-Border Puzzle, (2024)



What is Decentralized Finance (DeFi)?



DeFi is a financial ecosystem without intermediaries, using blockchain and smart contract.

Source: Gogol et al (2023). SoK: Decentralized Finance (DeFi) -- Fundamentals, Taxonomy and Risks. arXiv preprint arXiv:2404.08967

Application of Wholesales CBDCs

Central Bank and BIS Pilot Initiatives of wCBDCs:

1. Settlement for Tokenized Assets:

Tokenization of Illiquid Assets: tokenization makes illiquid assets (e.g., SME bonds, real estate, fine art) tradeable, by bringing them on-chain and listing at AMM-based DEXs.

Project Helvetia: Settlement with digital CHF

Project Agora: Unified ledger for settlements of tokenized assets.

2. Repo Agreements:

Project Guardian: DeFi lending protocols with Real-World-Asset (RWA) as collateral for repurchase agreements.

3. FX Market:

Project Mariana: Decentralized Exchanges (DEXs) facilitate foreign exchange markets through wholesales CBDCs.



Use-case: Project Guardian and Repo

3.1



Project Guardian: Repo Agreements

What is a Repo Agreement?

- A repo (repurchase) agreement is a short-term loan arrangement, typically overnight, between two banks.
- One bank borrows capital from another by providing bonds as collateral.
- The global repo market sees a daily volume of approximately €3 trillion.

What are DeFi Lending Protocols?

- Smart contracts that automate the borrowing and lending of digital assets.
- They automatically manage interest rates, loan terms, and handle liquidation processes without intermediaries.

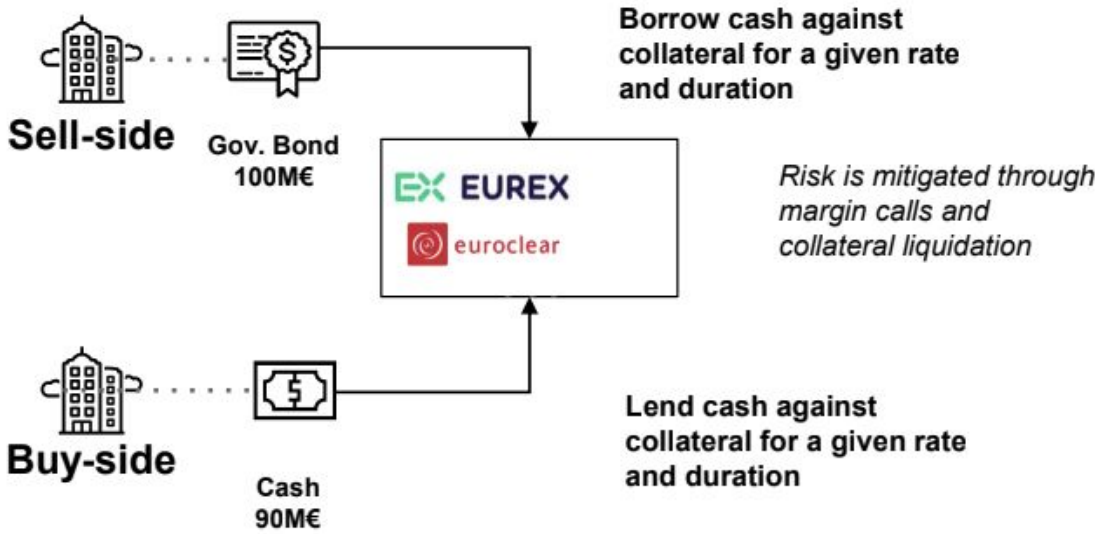
DeFi Lending for Repo

- In a DeFi-based repo, a bank provides tokenized government or commercial bonds as collateral.
- DeFi lending protocol calculates the loan amount and interest rate.
- The loan is issued in wholesale CBDCs, which were previously supplied to the lending protocol by the lender bank.

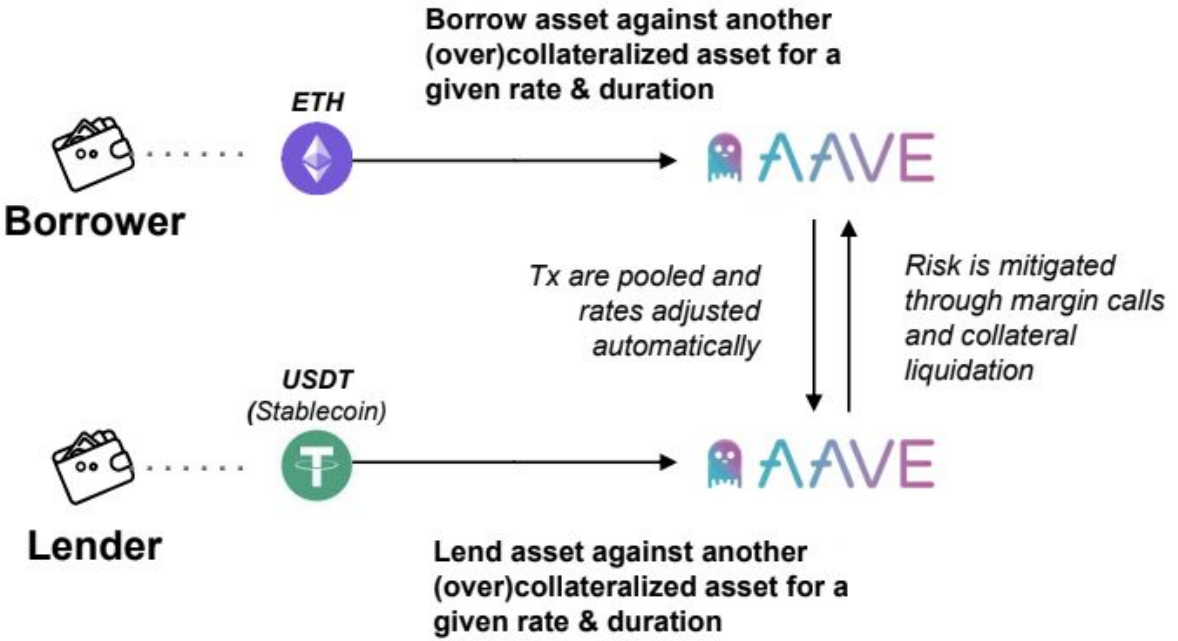


Project Guardian: Repo Agreements

TRADITIONAL FINANCE Repos & Reverse Repos



DECENTRALIZED FINANCE Lending & borrowing protocols



- **Project Guardian:** BIS, Bank of France, University of Zurich
- DeFi lending protocols automate repurchase (repo) agreements

Advantages of DeFi Lending for Repo

Key Advantages of DeFi Lending in Repo Markets

- **Greater Efficiency:** Smart contracts streamline processes, minimizing paperwork and speeding up settlement times.
- **Expanded Access:** DeFi protocols open the repo market to a wider range of participants, including smaller institutions
- **Improved Transparency:** Decentralized networks offer clearer insights into market activity and transactions.
- **Cost Reduction:** Lower operational expenses create savings for both lenders and borrowers.
- **Advanced Risk Management:** DeFi protocols introduce innovative risk tools, such as automated margin calls and collateral liquidation mechanisms.



Use-case: Project Mariana and FX Market

3.2



Project Mariana: FX Market

Project Set-up

- Central banks of Switzerland, France and the Monetary Authority of Singapore issued wholesales CBDCs (wCBDCs): digital Franc, digital Euro and digital Singaporean Dollar.
- AMM-DEX (Automated Market Maker-based Decentralized Exchange) was used to exchange these three CBDCs among each other. The AMM-DEX used was a fork of Curve v2 - the exchange operating on Ethereum with cryptocurrencies.

What are AMM-DEX?

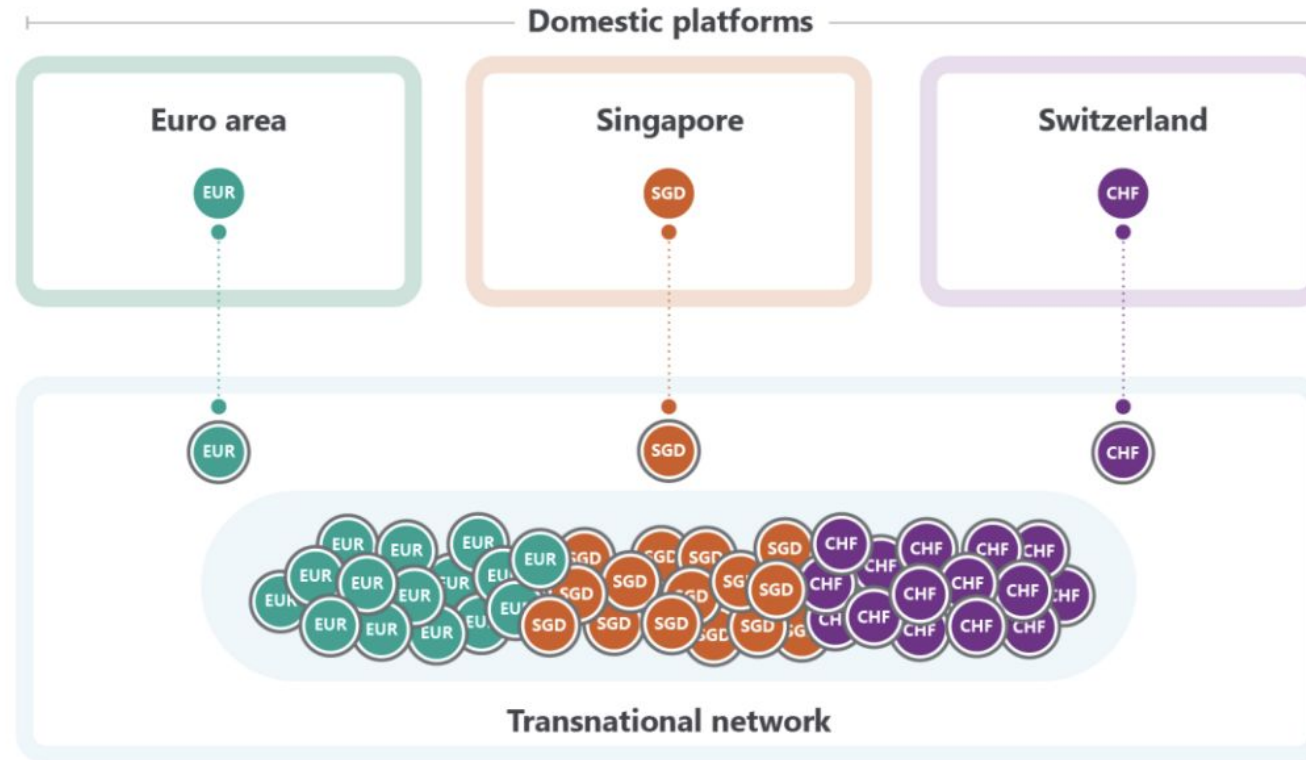
- Smart contracts that automate the exchange of cryptocurrencies / tokens among each other.
- Unlike the traditional exchanges that employ order books, AMMs determine the exchange price between two tokens based on the token reservers (called liquidity pools).

AMMs for FX Market

- A liquidity pool with three wCBDCs is set with digital Euro, Franc and Singaporean Dollar.
- Traders trade against AMMs smart contract.
- Arbitrageurs equal the prices between various trading venues.



Project Mariana: FX Market



- Project Mariana: BIS and Central Banks of Switzerland, France and Singapore
- AMM-DEX optimizes foreign exchange markets through wholesales CBDCs.

Advantages of AMM-DEX for FX Market

Pros of Automated Market Makers (AMMs) for wCBDCs:

- **Atomic Settlement:** All swaps are fully on-chain, eliminating counterparty risk.
- **Lower Trading Fees:** independence of market makers to facilitate trading activities
- **Predictable Transaction Costs:** Price impact and transaction costs are known in advance, offering transparency for traders.
- **Independence from the US Dollar:** AMMs enable global trade without relying on the US dollar, promoting greater financial sovereignty.

Cons of AMMs:

- The cost of providing liquidity to pools (token reserves) isn't always compensated by trading fees, potentially resulting in losses for liquidity providers (LPs).

The same benefits extend to tokenized real-world assets (RWAs).



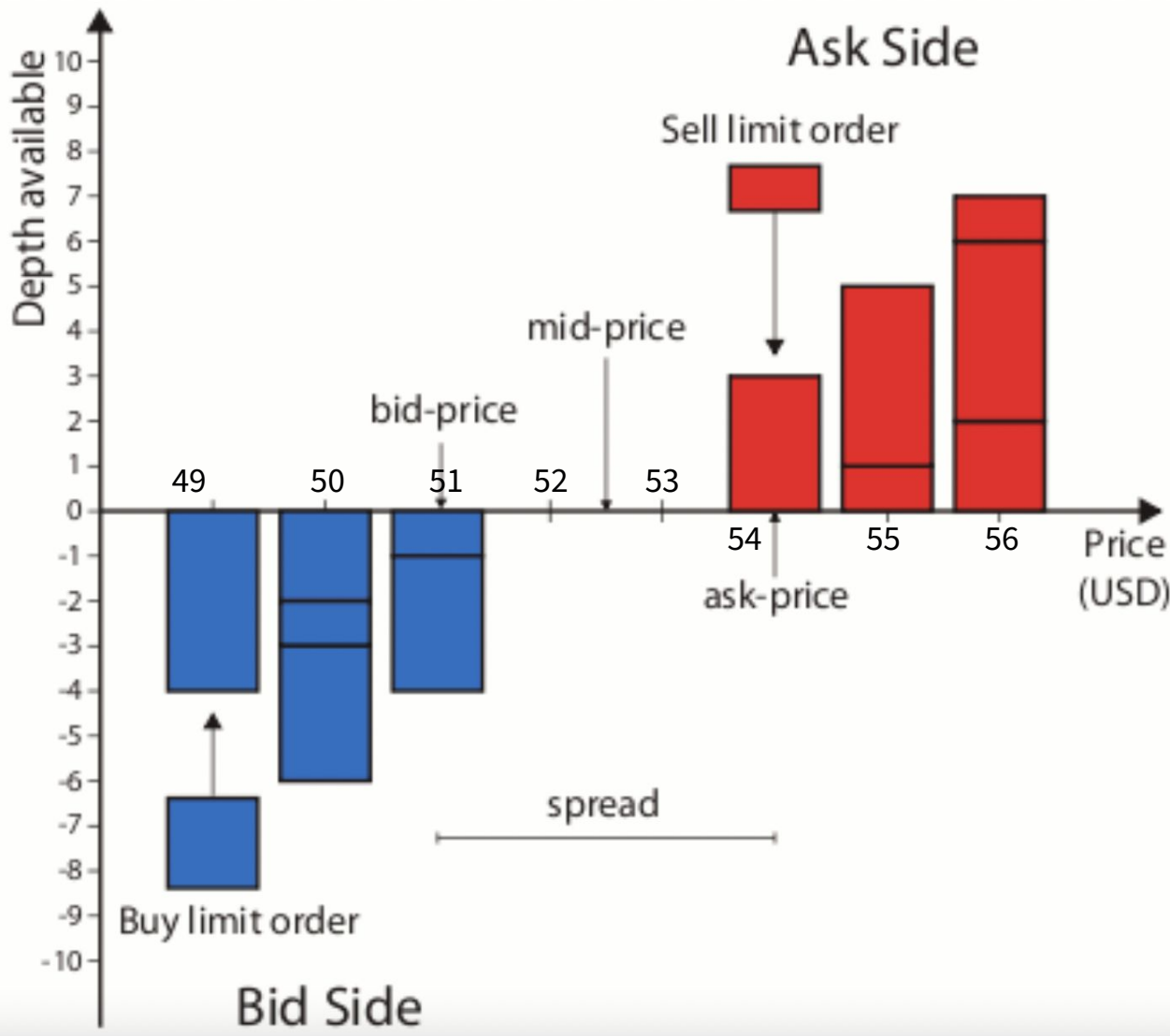
CLOB vs AMMs

Centralized Exchanges use the **Central Limit Order Book (CLOB)** to match buyers and sellers.

Implementations of CLOB on the blockchain is not possible because of two reasons:

- expensive on-chain data storage ,
- security attacks (e.g Just-In-Time Liquidity MEV-attack).

This is why AMMs were introduced in 2018 by Uniswap!



Current Trends

4



Current Trends

1. **Shift towards pilots of wholesales CBDCs (wCBDCs)**

Mostly because of the privacy issues for retail CBDCs

2. **Application of DeFi for wCBDCs:**

Smart Contract have the potential to transform financial services. Most of DeFi smart contracts is developed in Solidity (programming language of Ethereum Virtual Machine)

3. **Dominant Permissionless Blockchain:**

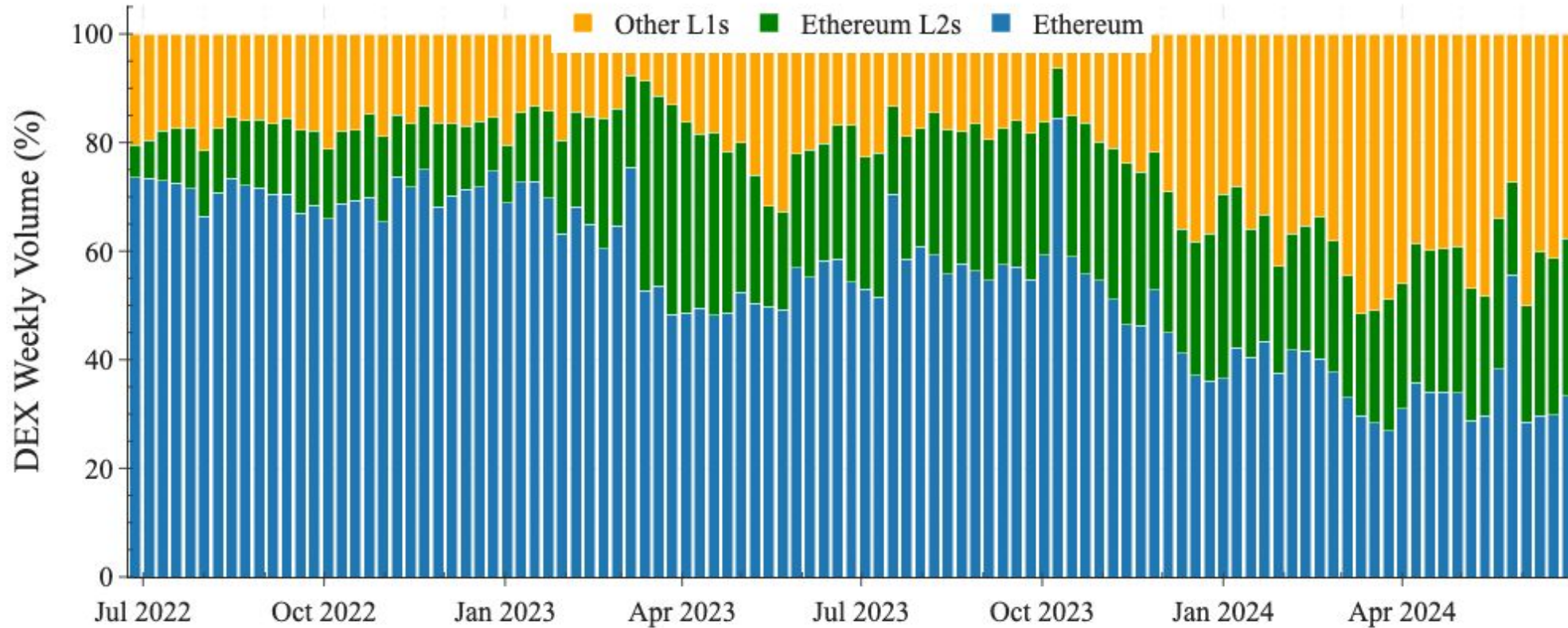
Ethereum will likely remain the primary blockchain for the financial industry's settlements and smart contracts.

4. **Layer-2 Solutions (Rollups):**

While leveraging the security and decentralization of public blockchains, mostly Ethereum, they can act as permissioned blockchain that supports Ethereum Virtual Machine.



Ethereum's Dominance

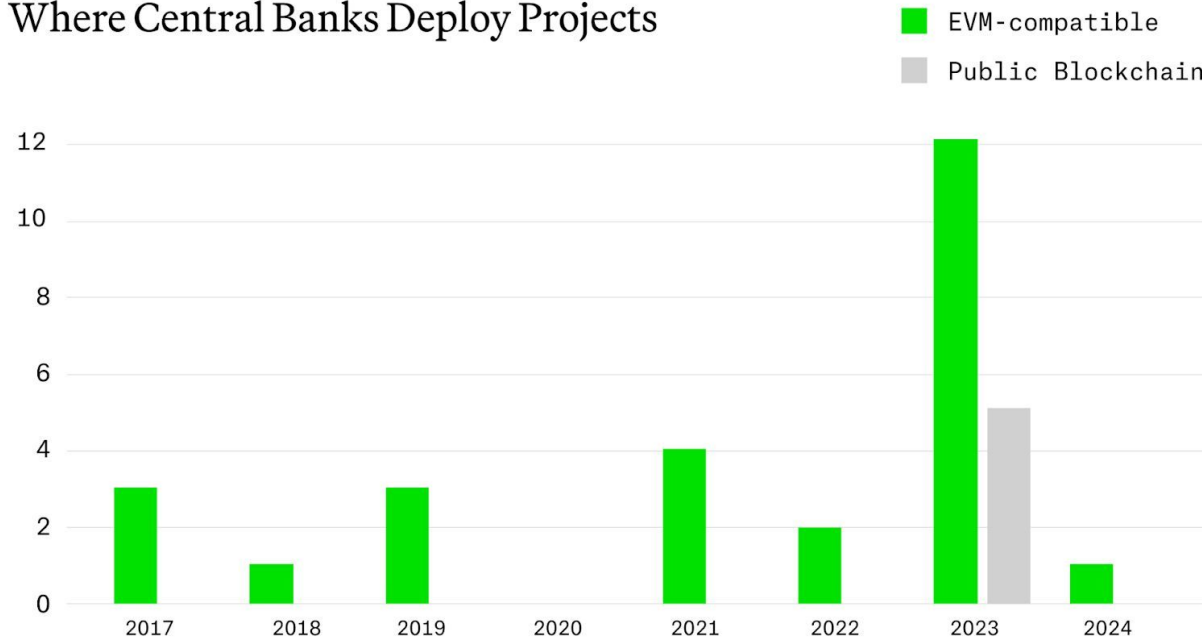


- Ethereum is the major blockchain for decentralized finance
- Trading activity and volume are moving from Ethereum to its L2 blockchains.

Where Central Bank Deploy Projects

Recent research by Paradigm reveals that nearly half of G20 central banks' blockchain experiments are now compatible with the Ethereum Virtual Machine (EVM).

Where Central Banks Deploy Projects



Diverse Applications: 47% of projects span CBDC to DeFi, leveraging Ethereum's technology stack.

Leading Projects: Project Mariana and Project Guardian showcase EVM's potential for finance.

Strong Developer Ecosystem: The shift to EVM is propelled by Ethereum's robust developer community and **open-source, secure infrastructure.**

Challenges to Overcome

Both public and permissioned blockchain pose challenges for CBDCs deployment.

Challenges for public blockchains:

- 1. Technical:** Blockchain finality and block production - 12s (Ethereum), 10min (Bitcoin), ca 1s (L2s)
Transaction per second (TPS) - 15 (Ethereum), 150 (L2s), vs 100'00 (Hyperledger)
- 2. Legal:** KYC and Whitelisting/Blacklisting enforcements, especially on public blockchains
Work only with selected validators/miner? Digital ID?

Challenges for permissioned blockchains:

- 3. Governance**
- 4. Lack of Ethereum Virtual Machine:** Without smart contract, DeFi applications are not possible.
- 5. Public and Private Sector Collaboration**



Conclusions

Mass adoption of blockchain, DeFi and CBDCs:

1. Not Cryptocurrencies:

While the mass adoption of blockchain and DeFi is inevitable, cryptocurrencies themselves may not be the central focus.

2. Traditional Finance (TradFi) Remains:

Banks, credit cards, and payment systems will still exist, but blockchain will handle the settlement, FX conversion, and interbank transfers with wholesale CBDCs .

3. Convergence of TradFi and DeFi:

Every financial transaction will be settled by blockchain-based smart contracts.





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Thank you

Krzysztof Gogol

University of Zurich



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- Auer, Frost, Gambacorta, Monnet, Rice, Shin, H.S.: Central bank digital currencies: motives, economic implications and the research frontier (2021),
- Chaum, Grothoff, Moser.: How to issue a central bank digital currency (2021)

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- Embracing diversity, advancing together – results of the 2023 BIS survey on central bank digital currencies and crypto
- Project Mariana <https://www.bis.org/about/bisih/topics/cbdc/mariana.htm>
- Project Guardian <https://www.mas.gov.sg/schemes-and-initiatives/project-guardian>
- Project Agora <https://www.bis.org/about/bisih/topics/fmis/agora.htm>

