Central Bank Digital Currencies (CBDCs)

L03: The Economics of Public Digital Money

Why 130+ countries are racing to digitize money—and what it means for you

Economics of Digital Finance

BSc Course

Lesson Overview

Today's Topics

1. CBDC design choices and trade-offs
2. Monetary policy transmission
3. Bank disintermediation risk
4. Financial inclusion economics
5. International currency competition

Learning Objectives

- Analyze CBDC design trade-offs
- Assess how CBDCs could change how central banks control the economy
- Evaluate disintermediation risks (the danger that people move money out of banks into CBDC)
- Understand global CBDC landscape

CBDCs represent central banks' response to private digital currencies

Background: The Banking System

Central Bank vs. Commercial Bank
Central bank (e.g., ECB, Federal Reserve):

- The government's bank
- Creates the national currency
- Sets interest rates for the economy
- Lender of last resort (providing emergency loans when no one else will) in crises

Commercial bank (e.g., Deutsche Bank, Chase):

- Private companies where you have accounts
- Accept deposits, make loans
- Can fail (unlike central banks)
- Must hold reserves (money banks must keep at the central bank) at central bank

Key Point: Your savings account is at a commercial bank. The central bank is the bank for banks.

Understanding this distinction is essential for CBDC analysis

Background: How Banks Work

Money Creation Through Lending

Banks don't lend from a vault of cash:

- When a bank lends you 100 EUR, it *creates* 100 EUR in your account
- Most money in modern economies is created this way
- This is called **fractional reserve banking**

Why Deposits Matter to Banks

- Banks borrow from depositors at low rates (e.g., 1%)
- Banks lend at higher rates (e.g., 5%)
- The difference is their profit

Bank Runs

A **bank run** occurs when:

- Many depositors withdraw simultaneously
- They fear the bank will fail
- Banks don't keep all deposits as cash
- Mass withdrawal causes collapse

Why Interest Rates Affect Spending

- Lower rates = cheaper loans
- Mortgages at 3% vs 6% = more homebuyers
- Cheap business loans = more investment

These mechanics explain why CBDCs could disrupt traditional banking

What is a Central Bank Digital Currency?

Definition
A CBDC is a digital form of central bank money:

- Direct liability of central bank (a legal obligation—the central bank owes you that value)
- Digital (not physical)
- Widely accessible to the public (retail) or restricted to banks and financial institutions (wholesale)

Not a CBDC

- Bank reserves (money banks hold at the central bank—like a bank's own bank account) are already digital
- Commercial bank money *(Your bank deposit is a promise from your bank, which can fail. CBDC is a promise from the central bank, backed by the state—it cannot fail.)*
- Stablecoins (private liability—can collapse, as Terra/UST did in 2022 losing $40B+)

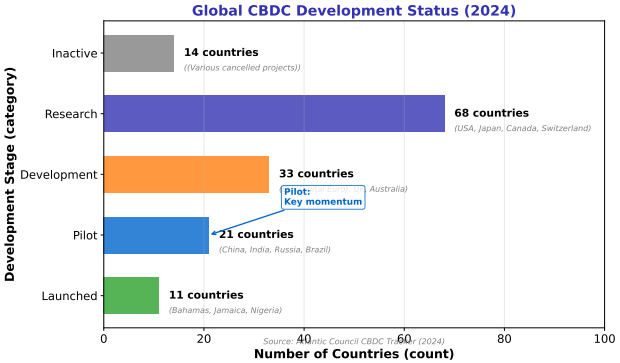
Motivations
Central banks cite multiple goals:

- Maintain monetary sovereignty—without it, a country cannot fight recessions independently (like Greece in 2010, which couldn't devalue its currency)
- Improve payment efficiency
- Promote financial inclusion
- Counter private digital currencies—if citizens abandon national currency for Bitcoin or stablecoins, the central bank loses its ability to stabilize the economy

Key Economic Question
Does public benefit exceed costs and risks?

CBDC = digital cash issued by central bank; distinct from existing digital money

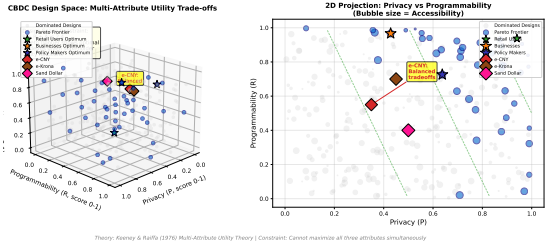
Global CBDC Development Status



- As of 2024, 147 countries (representing 98% of global GDP) are exploring or have launched CBDCs
- Colors indicate development stage: from early research to live deployment
- China's e-CNY (digital yuan) is the most advanced large-economy pilot; the Bahamas and Nigeria have fully launched

Source: Atlantic Council CBDC Tracker. The pace of exploration has accelerated sharply since 2020

CBDC Design Space: Key Choices



- Each axis represents a design goal (e.g., privacy, efficiency, control). No single design can maximize all goals simultaneously
- The Pareto frontier (curved surface) shows the *best achievable* trade-offs—improving one dimension requires sacrificing another
- Dominated designs (dots below the frontier) are inferior: another design is better in *every* dimension

Pareto frontier: named after economist Vilfredo Pareto. Think of it as the "best you can do" boundary—you cannot move closer to one goal without moving away from another

Retail vs. Wholesale CBDCs

Retail CBDC

For general public use:

- Replaces/complements cash
- Consumer payment instrument
- Requires distribution network *(Unlike wholesale CBDC which uses existing bank infrastructure, retail CBDC needs new channels to reach every citizen.)*

Economic considerations:

- High operational costs
- Privacy vs. AML (Anti-Money Laundering—criminals using untraceable money enables drug trafficking, terrorism financing, and tax evasion) trade-off
- Competition with banks

Wholesale CBDC

For financial institutions:

- Interbank settlement (transferring money between banks)
- Securities transactions (buying/selling stocks and bonds between institutions)
- Cross-border payments

Economic considerations:

- Lower operational burden
- Efficiency gains clearer
- Less disruptive to banking

Most advanced economies focus on retail; wholesale offers clearer near-term benefits

Token-Based vs. Account-Based CBDCs

Token-Based

Like digital cash:

- Verify the instrument, not holder
- Can enable anonymity
- Offline transactions possible *(This matters because rural areas and developing countries may lack reliable internet—offline capability ensures universal access.)*

Economic implications:

- Lower transaction costs
- Privacy preserving
- Harder to implement AML

Account-Based

Like bank accounts:

- Verify the identity of holder
- Full transaction records
- Programmable features possible—e.g., stimulus payments that can only be spent at small businesses, or rent subsidies that can only pay landlords

Economic implications:

- Interest-bearing feasible *(Because account-based systems track balances, they can calculate and pay interest—token-based systems cannot easily distinguish one holder's balance from another.)*
- Targeted policies possible
- Privacy concerns

Most designs are hybrid: token-like for small values, account-like for large

Monetary Policy Transmission with CBDCs

Traditional Channels
Interest rate channel:

$$i_{\text{policy}} \rightarrow i_{\text{deposit}} \rightarrow C, I$$

(When the central bank changes its policy rate (i_{policy}), banks adjust deposit rates ($i_{deposit}$), affecting consumption (C) and investment (I).)

- Works through bank intermediation
- Banks pass rate changes to customers
- Time lags in transmission (months can pass before rate changes affect consumer behavior)

CBDC Impact
If CBDC is interest-bearing:

$$i_{\text{CBDC}} \rightarrow i_{\text{deposit}}$$

(If CBDC pays 2% interest, banks must match or exceed this to keep deposits—CBDC rate sets a floor.)

- Direct transmission to public
- Floor on deposit rates

Example: Suppose CBDC pays 2% and your bank pays 0.5% on savings. You would move money to CBDC. To keep your deposits, the bank must raise its rate to at least 2%. This is the "floor" effect.

CBDC could strengthen monetary policy by providing a direct channel to households

Enhanced Policy Options with CBDCs

New Policy Tools

Interest-bearing CBDC enables:

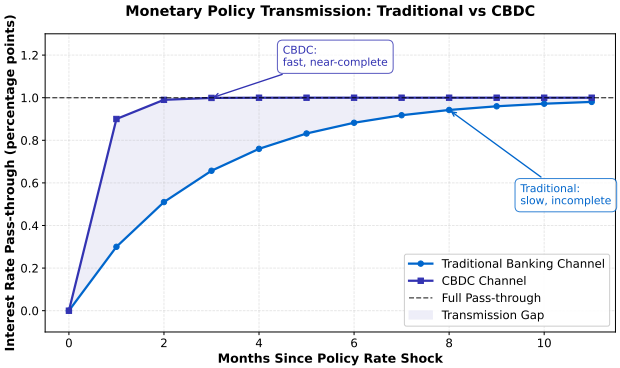
- Negative interest rates (charging people to hold money, to encourage spending)
- Helicopter money (direct cash from central bank to citizens—named for the image of dropping money from helicopters)
- Time-limited money—e.g., China's Chengdu pilot gave citizens digital yuan that expired in 3 months, forcing spending to boost local businesses

Concerns

- Political resistance to negative rates *(Why accept losing money? Without physical cash, people cannot escape—some see this as coercive.)*
- Privacy implications of targeting
- Complexity of implementation

These tools are powerful but raise fundamental questions about government control over spending

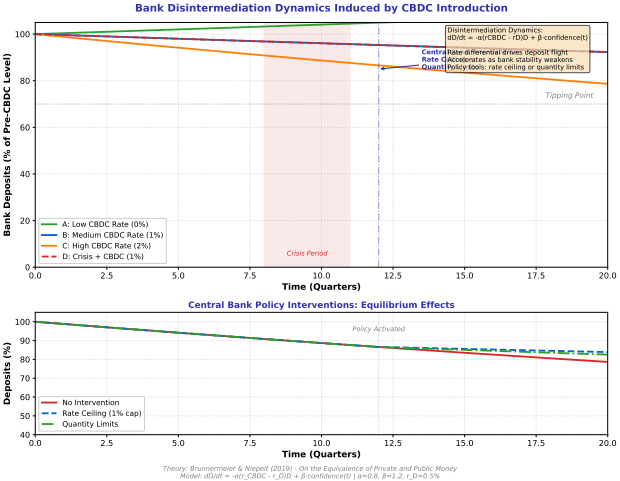
How Fast Does CBDC Transmit Policy?



- The chart compares how quickly a central bank rate change reaches consumers through traditional banks vs. through CBDC
- Traditional banking passes rate changes slowly (months of delay); CBDC transmits almost instantly
- Faster transmission means monetary policy becomes more powerful—but also more disruptive

Impulse response model based on Bindseil (2020). CBDC pass-through rate exceeds traditional banking channel

Bank Disintermediation Risk



- Each scenario shows how bank deposits evolve over time as CBDC becomes available
- Steeper decline = more deposits moving to CBDC = greater stress on banks
- The key variable is CBDC attractiveness: higher interest or better features accelerate deposit flight

Economics of Disintermediation

The Concern
If CBDC is attractive:

- Deposits migrate to CBDC
- Banks lose cheap funding
- Credit supply (total loans available) may contract

Example: If 20% of deposits move to CBDC, banks must borrow elsewhere at higher rates, meaning fewer or costlier loans.

Andolfatto (2021), an economist at the Federal Reserve Bank of St. Louis, modeled this:

- CBDC gives depositors a credible alternative: if your bank offers poor rates, you can switch to CBDC, forcing banks to compete
- Forces competitive deposit rates
- Net welfare effect ambiguous (welfare = total well-being of society—economists cannot agree if everyone is better or worse off overall)

Mitigation Strategies
Design features to limit migration:

- Holding limits (e.g., 3000 EUR)
- Tiered remuneration (different rates for different amounts—e.g., 0% up to 3000 EUR, negative above)
- No interest on CBDC

Financial Stability

- Digital bank runs faster—in 2023, Silicon Valley Bank lost $42 billion in 24 hours via mobile apps; traditional runs took days as people queued at branches
- Flight to safety amplified (the rush to safe assets is faster when transfers are instant)
- Requires careful design

Design constraints trade off CBDC usefulness against banking system stability

Financial Inclusion Economics

The Unbanked Problem
Globally 1.4 billion unbanked adults:

- Lack documentation for accounts
- Live far from bank branches
- Cannot afford minimum balances

CBDC Potential

- Lower KYC (Know Your Customer) requirements for small values (e.g., open account with just a phone number for transactions under 500 EUR)
- Mobile-based access
- No minimum balance required

Economic Analysis
Benefits:

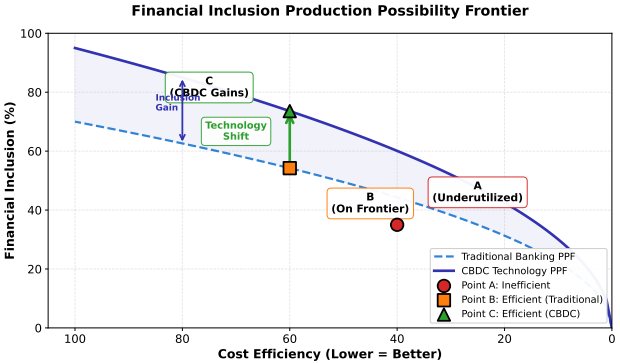
- Lower transaction costs
- Entry to formal finance
- Government transfer efficiency *(Example: During COVID, US paper stimulus checks took weeks. Direct CBDC transfers could reach citizens in seconds at near-zero cost.)*

Challenges:

- Digital divide (gap between those with and without internet access) persists *(Example: In India, 300 million people lack smartphones—CBDC only on phones would exclude them, worsening inequality.)*
- Infrastructure requirements
- Financial literacy needs

Inclusion requires complementary policies; technology alone is insufficient

Financial Inclusion: The Technology Shift



- The production possibility frontier (PPF) shows the best achievable trade-off between cost and inclusion
- CBDC technology shifts the frontier outward: more inclusion is achievable at the same cost
- The gap between the two curves represents the efficiency gain from digital infrastructure

PPF model: traditional banking (inner curve) vs. CBDC-enabled inclusion (outer curve). Based on World Bank Findex data framework

International Currency Competition

Currency Competition
CBDCs could intensify:

- Cross-border CBDC use
- Challenge to dollar dominance *(The US gains immense power from dollar dominance: ability to sanction enemies, borrow cheaply, and export inflation. Challengers want these privileges.)*
- Regional currency blocs (groups of countries sharing or linking their currencies)

China's Strategy

- e-CNY for domestic use
- mBridge (a multi-CBDC platform connecting central banks) for wholesale cross-border
- Reduce dependence on SWIFT (the global interbank messaging system)

US Response Dilemma

- Digital dollar slower to develop
- Privacy concerns prominent
- Risk of losing first-mover advantage (the benefit of being first to market)

Economic Implications

- Seigniorage redistribution *(If people worldwide use digital yuan instead of dollars, China earns the profit from money creation that previously went to the US.)*
- Sanctions effectiveness (the ability to economically punish other nations)
- Monetary policy spillovers (when one country's policy unintentionally affects others—e.g., US rate hikes cause capital flight from emerging markets)

CBDCs add new dimension to international monetary system competition

Cross-Border CBDC Applications

Current Pain Points

- High costs (average 6%)
- Slow settlement (2-5 days)
- Limited transparency
- Correspondent banking (international payments through intermediary banks)

Example: A worker sending $200 home may lose $12 in fees and wait 3 days.

Wholesale CBDC Solution

- Direct central bank settlement
- Atomic swap (both sides of exchange happen together, or neither happens)
- 24/7 operation possible

Multi-CBDC Projects

- mBridge (China, UAE, HK, Thailand)—Asia-Middle East corridor, largest pilot
- Project Dunbar (Singapore, Australia)—ASEAN focus, tests multi-currency settlement
- Project Icebreaker (Nordic countries)—Nordic corridor, explores retail cross-border

Economic Benefits

- Reduced Foreign Exchange (FX) settlement risk
- Lower remittance costs
- Faster trade finance (loans and guarantees for international commerce)

Wholesale CBDCs show clearer efficiency gains for cross-border payments

Privacy vs. Policy Control Trade-off

Privacy Concerns

- Government surveillance potential
- Transaction tracking
- Political control over spending

Design Options

- Tiered privacy (small = anonymous)
- Zero-knowledge proofs (proving you meet a requirement without revealing your data)
- Third-party anonymity services (companies that act as privacy shields, similar to how a VPN hides internet activity)

Policy Control Benefits

- AML/CFT (Combating the Financing of Terrorism) compliance
- Tax enforcement
- Targeted stimulus *(Example: Instead of giving everyone $1000, programmable CBDC could give $2000 only to unemployed workers, or restrict spending to domestic goods.)*

Economic Framework

The core trade-off in practice:

- Full anonymity: 0% tax enforcement, easy money laundering
- Full transparency: 100% tax compliance, but citizens lose all financial privacy
- Most designs aim for a middle ground (e.g., anonymous below 500 EUR, identified above)
- Social preferences vary by country—no one-size-fits-all design

Privacy preferences differ: Germany (with Stasi memories) values privacy; China's social credit system reflects different norms

Case Study: The Digital Euro

ECB (European Central Bank) Design Principles

- Complement to cash, not replacement
- Privacy by design (building privacy protections into the system from the start) (small payments)
- Holding limits (˜3000 EUR proposed)
- No interest initially

Timeline

- Investigation phase: 2021–2023
- In October 2023, the ECB decided to move to the preparation phase
- Preparation phase: 2023–2025
- Potential launch: 2027–2028

Economic Rationale

- Strategic autonomy (not dependent on Visa, Mastercard, or US tech giants)
- Payment system resilience (if Visa goes down or a foreign company exits, CBDC ensures people can still pay)
- Declining cash usage—if cash disappears, citizens lose their only form of public money; all transactions would go through private banks or card companies who charge fees and track purchases

Criticisms

- Banks lobby (companies trying to influence politicians) against disintermediation
- Privacy advocates concerned
- Unclear consumer demand

Digital Euro reflects European values: privacy, strategic autonomy, bank coexistence

Key Takeaways

Main Conclusions

1. CBDC design involves fundamental trade-offs
2. Disintermediation risk requires mitigation
3. Monetary policy transmission could improve
4. International competition is intensifying

Economic Framework

- Retail vs. wholesale scope
- Token vs. account architecture
- Privacy vs. policy control
- Inclusion vs. stability

Core Insight

CBDCs are not simply "digital cash"—they require careful economic analysis of trade-offs between competing objectives. No design satisfies all goals simultaneously. Example: the Digital Euro proposes a ~3000 EUR holding limit to balance usefulness against bank disintermediation risk.

Next lesson: Payment Systems Economics

Key Terms (1/2)

CBDC (Central Bank Digital Currency) Digital cash issued by the central bank. If you hold 100 in CBDC, the central bank guarantees you that value—unlike bank deposits which depend on your bank staying solvent.

Retail CBDC CBDC available to the general public for everyday transactions.

Wholesale CBDC CBDC restricted to financial institutions for interbank settlements.

Token-Based CBDC CBDC where validity is verified by the instrument itself (like cash), enabling offline transactions.

Account-Based CBDC CBDC where validity requires verification of the holder's identity against an account.

Bank Disintermediation Risk that CBDC adoption draws deposits away from commercial banks, reducing their lending capacity.

Monetary Sovereignty A nation's ability to control its own money supply and monetary policy independently.

Seigniorage The profit a government earns from issuing currency—the difference between the face value of money and its production cost.

AML (Anti-Money Laundering) Laws and regulations designed to prevent criminals from disguising illegally obtained money as legitimate income.

KYC (Know Your Customer) The process of verifying the identity of customers, required by financial regulations.

Terms continued on next slide

Key Terms (2/2)

Correspondent Banking An arrangement where one bank provides services on behalf of another, commonly used for international payments.

Atomic Swap A technology enabling exchange of different currencies simultaneously—both transfers complete or neither does.

Wholesale Funding Money banks borrow from other financial institutions (rather than customer deposits) to fund operations.

Tiered Remuneration Different interest rates for different amounts held—e.g., 0% on first 3000 EUR, negative rates above.

Helicopter Money Direct cash transfers from central bank to citizens, bypassing banks—named for the image of dropping money from helicopters.

Negative Interest Rates A policy where depositors pay to keep money in accounts rather than earning interest—used to encourage spending.

Interbank Settlement The process by which banks transfer money between themselves to complete transactions.

Flight to Safety When investors move money from risky assets to safe ones during uncertainty—with CBDC, could mean moving from bank deposits to CBDC.

Financial Inclusion Ensuring all people have access to useful and affordable financial services.

Zero-Knowledge Proofs Cryptography that proves you meet a requirement without revealing your data—like proving you're over 18 without showing your birthdate.

CBDC design choices have profound implications for monetary policy and financial stability

Key Terms (3/3)

Liability (Finance) A legal obligation to pay—if you hold CBDC, the central bank owes you that value. Unlike an asset (what you own), a liability is what you owe.

Monetary Policy The central bank's decisions about interest rates and money supply to control inflation and support the economy. Examples: raising rates to fight inflation, cutting rates to boost growth.

Bank Reserves Money that commercial banks hold at the central bank—like a bank's own bank account. Required by regulation to ensure banks can meet withdrawals.

Credit Supply The total amount of loans banks can offer to businesses and people. When credit supply contracts, fewer loans are available, slowing economic activity.

Spillovers When one country's policy unintentionally affects other countries. Example: US interest rate hikes cause capital to leave emerging markets, weakening their currencies.

Trade Finance Loans and guarantees that help companies buy and sell goods internationally. Without trade finance, global commerce would be much slower and riskier.

CFT (Combating the Financing of Terrorism) Laws preventing terrorist groups from receiving money—often paired with AML (Anti-Money Laundering).

FX (Foreign Exchange) The exchange of one currency for another—e.g., converting dollars to euros.

First-Mover Advantage The benefit of being first to market—early CBDC adopters may set standards others must follow.

Sanctions Economic penalties imposed by governments—restricting trade or freezing assets of target countries.

Further Reading

Academic Papers

- Andolfatto (2021): "Assessing the Impact of CBDC on Private Banks"
- Brunnermeier & Landau (2022): "The Digital Euro"
- Auer et al. (2022): "CBDCs Beyond Borders"

Central Bank Publications

- ECB (2023): "A Stocktake on the Digital Euro"
- BIS – Bank for International Settlements (2021): "CBDCs: An Opportunity for the Monetary System"
- Fed – Federal Reserve (2022): "Money and Payments"

All readings available on course platform