

Lesson 48: CBDCs and Future of Digital Finance

Module 4: Traditional Digital Finance

Digital Finance Course

2025

- Understand Central Bank Digital Currency (CBDC) design principles and architectures
- Analyze Digital Euro project and global CBDC landscape
- Examine retail vs wholesale CBDC models
- Evaluate programmable money and smart contract integration
- Assess future trends in traditional digital finance

What is a CBDC?

Definition:

Central Bank Digital Currency (CBDC) is a digital form of central bank money, distinct from balances in traditional reserve or settlement accounts.

Key Characteristics:

- **Central Bank Liability:** Direct claim on central bank (like cash)
- **Digital:** Electronic, not physical currency
- **Legal Tender:** Government-backed, accepted for payments
- **Programmable:** Potential for conditional payments
- **Account-Based or Token-Based:** Identity vs bearer instrument

CBDC vs Other Digital Money:

- **Commercial Bank Deposits:** Bank liability, deposit insurance
- **Cryptocurrencies:** Decentralized, volatile, no legal tender status
- **Stablecoins:** Private issuers (Tether, USDC), reserves backing

Motivation for CBDCs:

Policy Goals:

- **Payment Efficiency:** Faster, cheaper cross-border payments
- **Financial Inclusion:** Access for unbanked populations
- **Monetary Sovereignty:** Counter private stablecoins (Libra/Diem threat)
- **Cash Decline:** Digital alternative as physical cash usage drops
- **Innovation Platform:** Programmable money, smart contracts

Risks and Concerns:

- **Bank Disintermediation:** Flight to CBDC during crises
- **Privacy:** Central bank surveillance potential
- **Cybersecurity:** Attractive target for attacks
- **Cross-Border Capital Flows:** Bypass capital controls
- **Operational Complexity:** 24/7 availability, scalability

Retail vs Wholesale CBDCs

Retail CBDC (General Purpose):

Users:

- Households and businesses
- Direct access to central bank money
- Digital cash alternative

Use Cases:

- Everyday payments (groceries, bills)
- P2P transfers
- E-commerce
- Government disbursements (stimulus, benefits)

Design Considerations:

- Distribution model (direct vs two-tier)
- Anonymity vs AML compliance
- Interest-bearing vs non-interest
- Holding limits (caps to prevent bank runs)
- Offline capability (resilience)

Wholesale CBDC (Limited Access):

Users:

- Banks and financial institutions
- Authorized payment service providers
- No public access

Use Cases:

- Interbank settlements (RTGS enhancement)
- Securities settlement (DVP)
- Cross-border payments (FX vs payment)
- Central bank operations (repo, monetary policy)

Advantages:

- Less disruptive to banking system
- Lower technology scaling requirements
- Easier privacy/AML balance
- Building block for retail later

Most advanced projects: Wholesale (e.g., Project Jura, Aber) vs retail still exploratory (Digital Euro, e-CNY pilot)

Digital Euro: Design and Timeline

ECB Digital Euro Timeline:

2020-2021: Investigation Phase

- Report on digital euro (October 2020)
- Public consultation (8000+ responses)
- Decision to launch investigation (July 2021)

2021-2023: Investigation

- 24-month investigation phase
- Design choices and technology exploration
- Prototypes and proof-of-concepts
- Rulebook drafting

2023-2025: Preparation Phase (Current)

- Scheme development (rules, standards)
- Technology provider selection
- Legislative framework (EU Digital Euro Regulation)

2025-2027: Implementation (Planned)

- Platform development and testing
- Pilot programs
- Potential launch decision

Key Design Choices (ECB Announcements):

1. Two-Tier Distribution:

- ECB issues, supervised intermediaries distribute
- Banks and PSPs provide wallets and services
- No direct ECB customer relationship

2. Privacy-Preserving:

- Offline payments: Full anonymity (like cash)
- Online payments: Privacy from merchants, AML compliance
- ECB does not track individual transactions

3. Holding Limits:

- Caps on digital euro holdings (proposed EUR 3,000-4,000)
- Prevent bank disintermediation
- Higher amounts: tiered remuneration (negative interest)

4. Offline Capability:

- Works without internet (NFC, Bluetooth)
- Resilience during outages
- Privacy benefit (no central server involved)

Digital Euro Technology Architecture

Technical Approach:

Centralized Ledger vs DLT:

- ECB leaning toward centralized database
- DLT explored but performance concerns
- Hybrid possible: Central ledger + DLT for settlement

Core Components:

① Settlement Layer (ECB):

- Central ledger of all digital euro balances
- Final settlement authority
- Reconciliation and oversight

② Distribution Layer (Intermediaries):

- Customer onboarding (KYC/AML)
- Wallet provision (mobile, hardware)
- Payment initiation and routing
- Customer service and dispute resolution

③ Interface Layer:

- APIs for merchants and developers
- POS integration, e-commerce plugins
- Peer-to-peer transfer protocols

Offline Payment Technology:

Hardware Wallets:

- Secure element (e.g., SIM card, smart card)
- Store digital euro locally (encrypted)
- NFC for proximity payments (contactless)
- Bluetooth for device-to-device transfers

Offline Protocol:

- Cryptographic signatures verify authenticity
- Double-spending prevention (local nonce tracking)
- Periodic online synchronization
- Limits on offline value (EUR 100-500)

Privacy Architecture:

- Blind signatures or zero-knowledge proofs
- Pseudonymous identifiers (rotate frequently)
- ECB sees aggregates, not individual transactions
- Intermediaries handle AML checks

Key challenge: Balance privacy (citizen demand) with AML compliance (regulatory requirement)

Digital Euro Stakeholder Perspectives

Central Bank (ECB) Goals:

- Monetary sovereignty (counter BigTech stablecoins)
- Ensure access to central bank money (cash declining)
- Support European payment autonomy (reduce Visa/Mastercard dependence)
- Platform for innovation (programmable euro)

Commercial Banks Concerns:

- **Disintermediation:** Customers move deposits to CBDC
- **Funding Costs:** Higher deposit rates to compete
- **Profitability:** Lower payment fee revenue
- **Mitigation:** Two-tier model, holding limits, no interest on CBDC

Banks' Requested Safeguards:

- Low holding caps (EUR 3,000 or less)
- No interest or negative rates (unattractive for savings)
- Compensation for distribution services
- Gradual rollout with monitoring

Citizens and Businesses:

Potential Benefits:

- Free or low-cost payments (no card fees)
- Instant settlement (vs T+1 bank transfers)
- Privacy for small transactions (cash-like)
- Pan-European acceptance (vs fragmented schemes)

Concerns:

- Privacy vs surveillance fears
- Complexity (another payment method)
- Holding limits (restrictive for some)
- Transition costs for merchants (POS upgrades)

Payment Providers (Visa, Mastercard):

- Competitive threat (direct ECB payment rail)
- Opportunity: Provide infrastructure services
- Push for open standards and interoperability

Political dimension: 2024 EU elections, Digital Euro Regulation debate (data protection, privacy, holding limits)

CBDC Projects Worldwide

Live CBDCs (As of 2024):

Bahamas - Sand Dollar (2020):

- First retail CBDC globally
- Blockchain-based (private, permissioned)
- Focus: Financial inclusion (islands)
- Limited adoption (competition with USD)

Eastern Caribbean - DCash (2021):

- 7 island nations, ECCB-issued
- Blockchain (Hyperledger Fabric)
- Challenges: Merchant acceptance, tech issues

Nigeria - eNaira (2021):

- Africa's first CBDC
- Over 1M wallets (low active usage)
- Push for financial inclusion

Jamaica - JAM-DEX (2022):

- Retail CBDC for unbanked
- Gradual adoption, government incentives

Advanced Pilots:

China - e-CNY (Digital Yuan):

- Largest retail CBDC pilot (2020+)
- 260M+ wallets, \$250B+ transactions (cumulative 2024)
- Two-tier: PBOC issues, banks distribute
- Controlled rollout (Beijing, Shenzhen, 26+ cities)
- Goals: Domestic efficiency, internationalizing RMB
- Concerns: Surveillance, government control

Sweden - e-Krona:

- Investigation since 2017 (cash usage ↓ 10%)
- Pilot ended 2022, no launch decision yet
- R3 Corda DLT platform tested

India - Digital Rupee:

- Retail pilot (2022): 5M users (2024)
- Wholesale pilot (2022): Interbank settlements
- Hyperledger Fabric blockchain

Cross-Border CBDC Projects

Multi-CBDC Platforms (mCBDC):

Project mBridge (BIS Innovation Hub):

- Participants: China, Hong Kong, Thailand, UAE, Saudi Arabia
- Wholesale CBDC for cross-border payments
- DLT platform (custom blockchain)
- Live transactions (2023): \$22B+ in pilots
- Goals: 24/7 settlement, FX vs payment, reduce correspondent banking

Project Jura (2021):

- Switzerland (SNB), France (Banque de France), BIS
- Wholesale CBDC for CHF-EUR FX settlement
- R3 Corda platform
- Proof-of-concept completed, no production plan

Project Aber (2020):

- Saudi Arabia, UAE
- Dual-issued wholesale CBDC (SAR-AED)
- Hyperledger Fabric
- Successful POC, exploring expansion

Dunbar (Australia, Malaysia, Singapore, South Africa):

- Multi-currency shared platform
- Atomic settlement (DVP, PVP)
- Quorum blockchain (2022 POC)

Benefits of mCBDC:

- **Speed:** Instant cross-border settlement (vs 2-5 days SWIFT)
- **Cost:** Lower fees (no correspondent chains)
- **Transparency:** Real-time tracking and finality
- **FX Integration:** Atomic swap capabilities

Challenges:

- Governance (who controls shared platform?)
- Legal harmonization (different jurisdictions)
- Capital controls (easier to bypass with instant settlement)
- Technology standards (interoperability)
- Geopolitical tensions (China-led vs US-led initiatives)

CBDC Status by Major Economies (2024)

United States - Digital Dollar:

- **Status:** Research phase, no pilot
- **Fed Position:** Cautious, awaiting Congressional authorization
- **Concerns:** Privacy, need unclear (stablecoins, private innovation)
- **Political:** Divided (Republicans skeptical, Democrats open)
- **Alternatives:** FedNow instant payments (2023 launch)

United Kingdom - Bitcoin:

- Consultation phase (2021-2023)
- Design work ongoing (BoE + HM Treasury)
- Potential launch: 2028-2030 (if approved)
- Two-tier model similar to Digital Euro

Japan - Digital Yen:

- Pilot phase (2023-2024)
- BoJ testing with banks and retailers
- No launch decision, monitoring global developments

Canada - Digital Canadian Dollar:

- Research and consultation (ongoing)
- Contingency planning (if cash declines or stablecoins dominate)
- No immediate need identified

Brazil - Digital Real (DREX):

- Pilot launched 2024
- Focus: Programmable payments, tokenized assets
- DLT-based, targeting 2025 launch

Global Statistics (BIS, IMF, Atlantic Council 2024):

- **130+ countries:** Exploring CBDCs (98% of global GDP)
- **11 countries:** Fully launched CBDCs
- **20+ countries:** Pilot phase (including China, India)
- **G7 Principles:** Endorsed CBDC principles (2021) - privacy, no programmability for surveillance

Programmable CBDC Features

Programmability Concept:

Ability to attach conditions and logic to money itself, enforced automatically.

Use Cases:

1. Conditional Payments:

- Pay only if delivery confirmed (IoT integration)
- Escrow automatically released on milestone
- Salary paid only to authorized accounts

2. Time-Locked Funds:

- Stimulus funds spendable only at local businesses
- Budget allocations released monthly (automatic)
- Pension payments on specific dates

3. Targeted Fiscal Policy:

- COVID relief usable only for essentials (food, rent)
- Expiring money to encourage spending (negative interest)
- Carbon credits embedded in payments

4. Atomic Transactions (DVP/PVP):

- Securities delivery only if payment received (simultaneous)
- Cross-currency swaps (no settlement risk)
- Supply chain: Pay on confirmed delivery (IoT sensors)

Implementation Approaches:

Smart Contract Layer:

- CBDC on blockchain with smart contract capability
- E.g., Ethereum-like execution environment
- Challenges: Complexity, security audits

API-Based Programmability:

- Centralized ledger with programmable payment rules
- Simpler, more controllable
- Example: Brazil DREX design

Concerns:

- Privacy erosion (surveillance capitalism)
- Government overreach (social credit systems)
- Complexity and bugs (financial system risk)
- Financial exclusion (conditions disadvantage some)

Tokenized Deposits and Synthetic CBDCs

Tokenized Deposits (Private Sector):

Concept:

- Commercial bank deposits on blockchain
- Programmable, interoperable with smart contracts
- Bank liability (not central bank money)

Examples:

- **JPMorgan JPM Coin:** Tokenized USD deposits for institutional clients (\$1B+ daily volume, 2024)
- **SocieteGenerale EURCV:** Euro-denominated stablecoin
- **HSBC, Standard Chartered:** Pilots for trade finance

Advantages over CBDC:

- Faster to market (no central bank coordination)
- Programmability without government control
- Integrate with DeFi and tokenized assets

Disadvantages:

- Not risk-free (bank default risk)
- Fragmented (each bank's token different)
- Regulatory uncertainty

Synthetic CBDC (sCBDC):

Concept (BIS Model):

- Private stablecoins fully backed by central bank reserves
- Central bank provides infrastructure and oversight
- No public CBDC issuance needed

Architecture:

- ① Private entities issue stablecoins
- ② 100% reserve backing at central bank
- ③ Real-time auditability by central bank
- ④ Interoperability via central bank platform

Benefits:

- Leverages private sector innovation
- Central bank avoids operational burden
- Competition drives better user experience
- Faster deployment than full CBDC

Example: Project Aurum (Hong Kong):

- Two-tier sCBDC architecture
- Banks issue e-HKD backed by reserves at HKMA
- POC completed 2022

Convergence: TradFi, DeFi, and CBDCs

Interoperability Visions:

Unified Ledger Concept (BIS):

- Single platform for CBDC, tokenized deposits, tokenized assets
- Atomic settlement across money and assets
- Programmable financial contracts
- Central bank oversight with private innovation

Project Guardian (Singapore MAS):

- Industry collaboration (DBS, JPMorgan, SBI)
- DeFi protocols on institutional blockchain
- Asset tokenization (bonds, funds) + CBDC settlement
- Live pilots: FX swaps, fixed income trading (2023-2024)

Project Agorá (BIS, Central Banks, Banks):

- Cross-border wholesale CBDC platform
- Focus: FX trading and settlement
- 7 central banks (Fed, ECB, BoJ, BoE, BoK, SNB, Banque de France)
- Target: 2025-2026 proof-of-concept

Instant Payments vs CBDCs:

FedNow (US, 2023):

- 24/7/365 instant payments
- Real-time settlement
- Competes with need for retail CBDC
- Over 300 banks participating (2024)

EU Instant Payments Regulation (2025):

- Mandatory instant SEPA credit transfers
- 10-second settlement
- May reduce urgency for Digital Euro (retail)

Scenario: Coexistence

- **Cash:** Declines but persists (privacy, resilience)
- **Bank Deposits:** Remain dominant for savings
- **Instant Payments:** Everyday transactions (P2P, bills)
- **CBDC:** Niche use (cross-border, programmable, government payments)
- **Stablecoins:** DeFi and crypto ecosystems

1. Tokenization of Real-World Assets:

- Real estate, private equity, commodities on blockchain
- Fractional ownership, 24/7 trading
- Settlement in CBDC or tokenized deposits
- Market size projection: \$10T+ by 2030 (BCG estimate)

2. AI in Finance:

- **Trading:** Reinforcement learning, alternative data
- **Risk:** Real-time credit scoring, fraud detection
- **Compliance:** Automated regulatory reporting, AML
- **Advisory:** Personalized wealth management (robo 2.0)
- **Operations:** Document processing (NLP), reconciliation

GenAI Applications (2024+):

- Code generation for trading strategies
- Natural language interfaces to financial systems
- Synthetic data for model training (privacy-preserving)
- Regulatory document interpretation

3. Quantum Computing Threat and Opportunity:

Threats:

- Break current encryption (RSA, ECC) in 10-15 years
- Risk to digital signatures, payment security
- CBDC and blockchain vulnerable

Response:

- Post-quantum cryptography (NIST standards 2024)
- Migration timeline: 5-10 years
- CBDC designs incorporating quantum-resistant algorithms

Opportunities:

- Portfolio optimization (quadratic speedup)
- Derivatives pricing (Monte Carlo acceleration)
- Machine learning (quantum ML models)

4. Decentralized Identity (DID):

- Self-sovereign identity (users control data)
- Verifiable credentials (KYC once, use anywhere)
- Integration with CBDC wallets
- Standards: W3C DID, EU Digital Identity Wallet (eIDAS 2.0)

Regulatory Evolution and Global Coordination

Global Standards and Coordination:

BIS Innovation Hub:

- Coordinate CBDC research (mBridge, Dunbar, etc.)
- Technology experimentation and best practices
- Hubs: Switzerland, Hong Kong, Singapore, London, Toronto

IMF and World Bank:

- CBDC guidance for developing economies
- Financial inclusion focus
- Technical assistance programs

FSB (Financial Stability Board):

- Stablecoin regulation (2023 framework)
- Cross-border payment roadmap
- Crypto-asset regulatory standards

G20 Priorities:

- Cross-border payment efficiency (target: 5x faster, 50% cheaper by 2027)
- CBDC interoperability principles
- Stablecoin oversight harmonization

Emerging Regulatory Themes:

1. Embedded Finance Regulation:

- Non-banks offering financial services (BigTech)
- Same activity, same risk, same regulation
- Data privacy and competition concerns

2. AI Governance in Finance:

- Model risk management (SR 11-7 updates)
- Explainability requirements
- Bias and fairness testing
- EU AI Act implications (2024)

3. Climate Finance and ESG:

- Mandatory climate risk disclosure (SEC, ISSB)
- Green CBDC concepts (incentivize low-carbon spending)
- Carbon credit tokenization

4. Open Banking and Data Portability:

- PSD3 (EU, 2024): Expand open banking scope
- US: CFPB Open Banking Rule (2024)
- Data sharing standards (FAPI, CIBA)

Strategic Implications for Financial Institutions

Banks: Adapt or Disintermediate

Threats:

- CBDC reduces need for commercial bank money
- BigTech and fintechs capture customer relationships
- Margin compression (instant payments, CBDC)
- Regulatory burden increases (AI, climate, crypto)

Opportunities:

- Distribution partners for CBDC (two-tier model)
- Tokenized deposit issuers (programmable banking)
- Custodians for digital assets
- Data analytics and AI services
- Embedded finance (BaaS - Banking as a Service)

Strategic Responses:

- Invest in technology (cloud, APIs, blockchain)
- Partner with fintechs (acquire or collaborate)
- Focus on high-value services (advisory, complex products)
- Regulatory technology (RegTech, SupTech)

Asset Managers and Investors:

New Asset Classes:

- Tokenized real assets (real estate, art, private equity)
- CBDC and stablecoin strategies (yield farming)
- Digital securities (tokenized bonds, equities)

Operational Changes:

- 24/7 markets (tokenized assets never close)
- Instant settlement ($T+0$ becomes standard)
- Fractional ownership (lower minimums, broader access)
- Programmable compliance (automatic reporting)

Fintechs and Innovators:

Opportunities:

- Build on CBDC infrastructure (wallets, apps)
- DeFi bridges to traditional finance
- Niche services (cross-border, remittances)
- AI-driven personalized finance

Risks:

- Regulatory capture (licensing barriers)
- Competition from incumbent banks
- Funding challenges (higher interest rates)

Scenarios for 2030-2035

Scenario 1: CBDC-Dominant World

Characteristics:

- Major economies launch retail CBDCs (Digital Euro, e-CNY, Digital Pound)
- Cash usage ↓ 5% of transactions
- Cross-border mCBDC platforms replace SWIFT for most B2B
- Commercial banks focus on lending, wealth management

Implications:

- Central banks gain powerful monetary policy tools (negative rates, direct stimulus)
- Privacy concerns intensify (calls for regulation)
- Financial inclusion improves (unbanked access CBDC)
- Geopolitical fragmentation (CBDC blocs: US-led, China-led)

Scenario 2: Private Stablecoin Dominance

Characteristics:

- Regulated stablecoins (USDC, EURC) become standard
- CBDCs limited to wholesale use
- BigTech wallets (Apple Pay, Google Pay) integrate stablecoins
- DeFi grows to \$5T+ TVL (vs \$100B 2024)

Implications:

- Central banks lose monetary policy leverage
- Regulatory arbitrage (offshore stablecoin issuers)
- Innovation thrives (private sector experimentation)
- Financial stability risks (stablecoin runs)

Scenario 3: Hybrid Coexistence (Most Likely)

Characteristics:

- Mix of CBDCs (some countries), stablecoins, instant bank payments
- Interoperability via standards (ISO 20022, mCBDC protocols)
- Tokenization mainstream for assets, niche for money
- Traditional finance absorbs blockchain selectively

Summary and Key Takeaways

CBDC Fundamentals:

- Digital central bank money, distinct from deposits and crypto
- Retail (public access) vs wholesale (banks only)
- Goals: Payment efficiency, financial inclusion, monetary sovereignty
- Risks: Bank disintermediation, privacy, cybersecurity

Digital Euro:

- Preparation phase (2023-2025), potential launch 2025-2027
- Two-tier distribution (ECB + intermediaries)
- Privacy-preserving (offline anonymity, online pseudonymity)
- Holding limits (EUR 3-4k) to prevent bank runs
- Centralized ledger (DLT explored but not chosen)

Global Landscape:

- 130+ countries exploring (98% global GDP)
- 11 live (Bahamas, Nigeria, Jamaica, etc.)
- China e-CNY: 260M+ wallets, \$250B+ cumulative
- mCBDC: mBridge (\$22B+ pilots), Jura, Dunbar
- US cautious (FedNow alternative), UK/Japan in design

Programmable Money:

- Conditional payments, time locks, atomic DVP/PVP
- Use cases: Targeted stimulus, supply chain, fiscal policy
- Concerns: Privacy erosion, government overreach
- Tokenized deposits (JPM Coin \$1B+ daily) vs synthetic CBDC

Future Trends (2025-2035):

- Tokenization: \$10T+ real-world assets by 2030
- AI in finance: Trading, risk, compliance, advisory
- Quantum threat: Post-quantum crypto migration (5-10 years)
- Decentralized identity: Self-sovereign KYC
- Regulatory evolution: AI governance, climate finance, open banking

Strategic Implications:

- Banks: CBDC distributors, tokenized deposit issuers, BaaS
- Asset managers: 24/7 markets, T+0 settlement, fractional ownership
- Fintechs: Build on CBDC infrastructure, DeFi bridges
- Likely outcome: Hybrid coexistence (CBDCs + stablecoins + instant payments)

Course Conclusion: Traditional Digital Finance

Module 4 Journey:

Lessons 37-39: Foundations

- Financial markets infrastructure (exchanges, clearinghouses)
- Core banking systems (CBS, digital banking)
- Payment rails (ACH, wires, real-time, cards)

Lessons 40-42: Trading and Risk

- Electronic trading and HFT (market microstructure)
- Risk management systems (VaR, stress testing, model risk)
- RegTech and compliance (Basel III, IFRS 9, EMIR)

Lessons 43-45: Markets and Derivatives

- Capital markets technology (OMS, EMS, PMS, T+1)
- Derivatives technology (pricing, CCPs, EMIR, SOFR)
- Wealth management systems (robo, hybrid, direct indexing)

Lessons 46-48: Data and Future

- Financial data vendors (Bloomberg, LSEG, FactSet, alternative data)
- CBDCs and future (Digital Euro, e-CNY, programmable money, scenarios)

Key Themes Across Module:

- ① **Digitalization:** Paper → Electronic → Real-time → Programmable
- ② **Automation:** Manual → STP → AI/ML → Autonomous
- ③ **Integration:** Siloed systems → APIs → Platforms → Ecosystems
- ④ **Regulation:** Reactive → Proactive → RegTech → Embedded compliance
- ⑤ **Convergence:** TradFi ↔ Fintech ↔ DeFi ↔ CBDCs

Looking Ahead:

The future of digital finance is not a replacement of traditional systems but an evolution—integrating the stability and trust of central banks with the innovation of technology, creating a hybrid ecosystem where efficiency, inclusion, and sovereignty coexist.