Monetary Economics of Digital Currencies

L02: Money Theory Meets Cryptocurrency

Can Bitcoin replace the dollar? What monetary theory tells us.

Economics of Digital Finance

BSc Course

Lesson Overview

Today's Topics

1. Functions of money revisited
2. Quantity theory in digital age
3. Cryptocurrencies as money
4. Stablecoin economics
5. Currency substitution

Learning Objectives

- Apply monetary theory to digital currencies
- Assess crypto against money functions
- Analyze stablecoin stability mechanisms
- Understand Gresham's Law ("bad money drives out good") and its implications

Monetary economics provides rigorous framework for evaluating digital currencies

Functions of Money: Economic Analysis

Medium of Exchange

Economic rationale:

- Eliminates barter inefficiency
- Reduces search and matching costs (time and effort to find trading partners)
- Transaction cost $= c_b - c_m$ where $c_m \ll c_b$ (where $\ll$ means "much less than")
  (Transaction cost with barter minus cost with money; money makes trading much cheaper)

  Example: If barter costs \$5 per trade (c_b) but using money costs \$0.50 (c_m), the saving is \$5 − \$0.50 = \$4.50 per trade.

Requirements:

- Acceptability (network effect)
- Divisibility (can be split into small amounts for any transaction size)
- Portability (easy to carry or transfer)

Unit of Account

Economic rationale:

- Reduces cognitive costs (mental effort to compare prices)
- With n goods: $\frac{n(n-1)}{2} \to n - 1$ prices
  (With n goods, barter needs n(n-1)/2 exchange rates; money needs only n-1 prices)

  Example: With 4 goods, barter needs $4 \times 3/2 = 6$ exchange rates. With money, you need only $4 - 1 = 3$ prices.
- Enables economic calculation

Store of Value

Requirements:

- Stable purchasing power
- Low volatility: the volatility of money's purchasing power should be low relative to the goods it buys
  (If money's value fluctuates more than the things you buy, it fails as a reliable store of value)
- Inflation protection

These functions matter because digital currencies must satisfy all three to replace traditional money effectively

Quantity Theory of Money in Digital Age

Classical Equation of Exchange

$$MV = PY$$

(Money supply times velocity equals price level times real output—how money flows through economy)

- M = Money supply
- V = Velocity of circulation
- P = Price level
- Y = Real output

Implications

- If V stable: $\Delta M \rightarrow \Delta P$
  (If velocity is stable, increasing money supply leads to higher prices—more money chasing same goods)

  Example: If M=\$100, V=2, Y=100 units, then $P = MV/Y$ = \$2. If M doubles to \$200, P doubles to \$4.
- Seigniorage = $\frac{\dot{M}}{P}$, where $\dot{M}$ denotes the rate of change of M over time
  (Rate of money creation divided by price

Digital Currency Complications

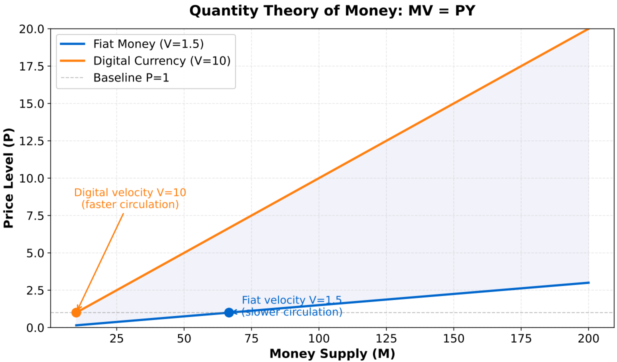
Bitcoin example:

- M fixed at 21 million (deflationary—since supply cannot grow, prices in Bitcoin would fall over time, discouraging spending)
- V highly volatile and hard to measure
- Which P? (Crypto priced in fiat)

Velocity Puzzle

- Traditional money: M2 (cash + savings + money market) $V \approx 1.5$; M1 (cash + checking accounts) velocity is higher at 5–7
- Bitcoin: V varies 2-20+—this unpredictable velocity makes quantity theory unreliable for crypto
- Stablecoins: Very high turnover (velocity), meaning each stablecoin changes hands many times per year

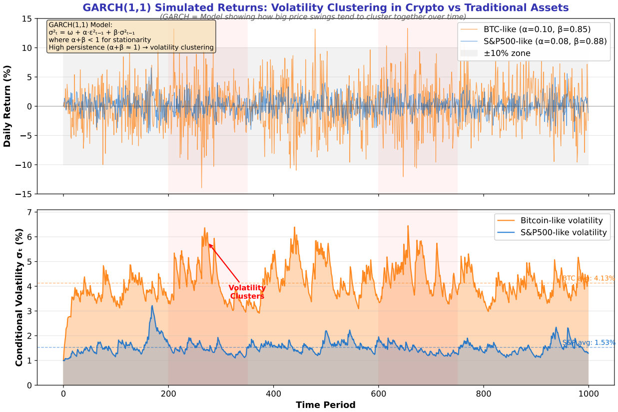
Quantity Theory: Fiat vs. Digital Velocity



- Using $P = MV/Y$: higher velocity (orange, V=10) means the same money supply produces much higher prices than fiat velocity (blue, V=1.5).
- Digital currencies circulate faster, so fewer coins are needed to support the same level of economic activity.
- The shaded gap shows the "inflation pressure" created by higher velocity at every money supply level.

Chart uses the Fisher equation $MV = PY$ with fixed real output Y=100; higher velocity amplifies money's impact on prices

Bitcoin as Money: The Volatility Problem



- **Note:** This chart is a **GARCH(1,1) statistical simulation** mimicking Bitcoin-like volatility patterns—not actual Bitcoin price data.
- **Volatility clustering:** Big price swings tend to cluster together (shaded regions), then calm periods follow.
- **Annualized volatility** of 50–85% means Bitcoin's value can roughly double or halve within a single year.
- Bitcoin-like returns (orange) swing far wider than stock-market-like returns (blue).

High volatility (50-85% annually) makes Bitcoin impractical as a unit of account—imagine if the dollar's value changed 50% per year

Cryptocurrencies as Money: Economic Assessment

Medium of Exchange: Grade C-

- Limited merchant acceptance
- High transaction costs (at times)
- 10-60 min confirmation times
- Scalability trilemma (must sacrifice one of: decentralization (no single controller), security (resistant to attacks), or speed (fast transactions))

Unit of Account: Grade F

- Extreme volatility
- "Menu cost" (cost of constantly repricing goods) of repricing
- No contracts denominated in BTC (Bitcoin's ticker symbol)

Store of Value: Grade C

- Long-term appreciation (but volatile)
- Digital gold narrative (the claim that Bitcoin, like physical gold, is a scarce store of value)
- Moves in sync with risk assets (tends to fall when stocks fall)—this undermines the "digital gold" claim since it doesn't protect portfolios during crashes

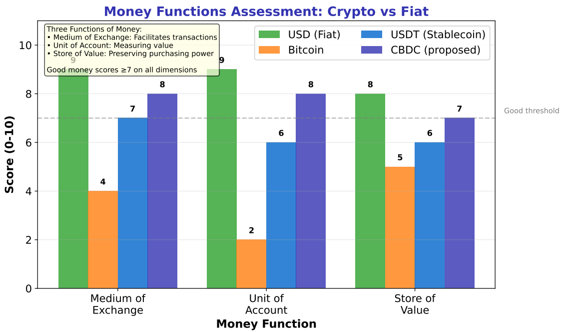
Yermack (2015) Conclusion

"Bitcoin behaves more like a speculative investment than a currency"

- Low correlation with major currencies
- High correlation with tech stocks
- Driven by speculation, not trade

These poor grades matter because they explain why Bitcoin hasn't replaced traditional money despite 15+ years of existence

Money Functions: Comparative Assessment



- Scores are **illustrative assessments** based on current properties, not measured data.
- **CBDC scores are projections** based on design goals—no major retail CBDC has been fully deployed yet.
- Traditional fiat excels as unit of account; Bitcoin scores poorly due to volatility; stablecoins trade off decentralization for stability.

CBDCs designed to achieve high scores across all functions; stablecoins compromise on decentralization

Stablecoin Economics: Design and Mechanisms

Types by Collateral

1. Fiat-backed (USDT/Tether, USDC/USD Coin)

- 1:1 reserve in bank accounts
- Trust in issuer and audits
- Redemption guarantee

2. Crypto-backed (DAI/MakerDAO)

- Over-collateralized (150%+)
  (e.g., deposit $150 in ETH (Ether) to borrow $100 in DAI)
- Smart contract enforcement (automated rules coded into the blockchain that execute without human intervention)
- Liquidation mechanisms (forced sale when collateral value drops)

3. Algorithmic (failed: UST/TerraUSD)

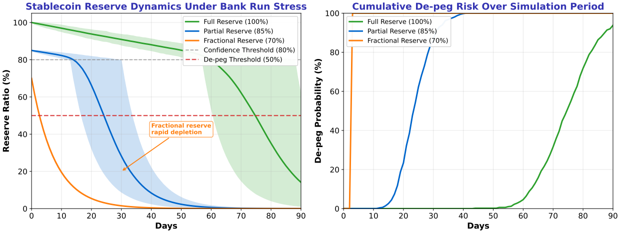
- No collateral backing
- Arbitrage-based (relying on profit-seekers to keep prices aligned) stability
- Prone to death spirals (falling price triggers more selling, which pushes price lower still—a self-reinforcing collapse)

Economic Trade-offs

- Capital efficiency (getting maximum lending from minimum reserves) vs. safety
- Centralization vs. transparency
- Scalability vs. collateral needs

Terra/UST collapse (2022) showed algorithmic designs are inherently fragile

Stablecoin Reserve Dynamics Under Stress



Based on Diamond & Dybvig (1983) bank run model

- **Reserve ratio** = how much real money backs each stablecoin (100% = fully backed; below 100% = fractional reserve).
- Based on the **Diamond & Dybvig (1983)** bank-run model, which explains how rational depositors can cause collapses by all trying to withdraw at once.
- When reserves drop below a critical threshold, de-peg probability spikes—just like a traditional bank run.

The Terra/UST collapse in May 2022 showed algorithmic stablecoins can fail catastrophically when confidence breaks ($40B+ lost)

Gresham's Law and Currency Substitution

Gresham's Law

"Bad money drives out good"

- When two currencies circulate at a fixed exchange rate
- Undervalued ("good") currency is hoarded
- Overvalued ("bad") currency is spent

  Note: Gresham's Law strictly requires a fixed exchange rate. In crypto, there is no fixed rate, but the **analog** *is similar: users spend stablecoins (whose value doesn't rise) and hoard Bitcoin (hoping it appreciates).*

Digital Application

- Bitcoin hoarded ("HODL"—crypto slang for "hold," originally a famous typo)
- Stablecoins used for transactions
- Self-fulfilling (outcomes that occur because people expect them): reduces velocity

Currency Substitution

Dollarization analogy:

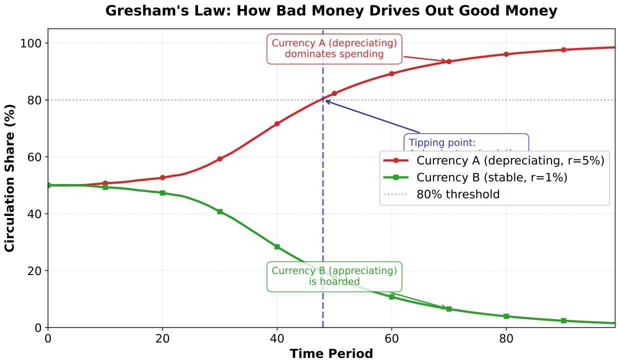
- Weak local currency replaced
- "Crypto-ization" in high-inflation countries
- Argentina, Venezuela, Turkey cases
  (countries where high inflation drove citizens to hold USD or crypto instead of local currency; e.g., Argentina had 5+ million crypto users (∼10% of population) with inflation exceeding 100% in 2023)

Economic Consequences

- Loss of monetary policy autonomy—countries cannot fight recessions or control inflation independently
- Seigniorage transfer abroad—foreign entities profit from money creation that should benefit the local economy
- Financial stability risks

Currency competition creates both opportunities and risks for monetary systems

Gresham's Law: Simulation of Currency Substitution



- **Agent-based simulation:** 1,000 agents choose which currency to spend each period. Currency A depreciates faster ("bad money").
- As more people spend Currency A, others follow (positive feedback), creating an S-curve tipping point around period 40–50.
- After the tipping point, Currency B ("good money") almost disappears from circulation—it is hoarded, not spent.

Simulation uses a logit feedback model (Selgin, 1996); parameters calibrated to show tipping dynamics, not real currency data

Money Demand for Digital Currencies

Traditional Money Demand

$$M^d/P = L(Y, i)$$

(Real money demand depends on income Y (positive) and interest rate i (negative))

- $L_Y > 0$: higher income → hold more money (transaction motive)
- $L_i < 0$: higher interest rate → hold less money (opportunity cost of keeping cash instead of earning interest)
- Baumol-Tobin (a model of optimal cash holding) inventory model

Example: If your monthly income is \$3,000 and rates are 5%, you might hold \$500 in cash. If rates rise to 10%, you reduce cash to \$300 (since the cost of not earning interest is higher).

Portfolio Approach

$$M^d = f(W, r_m, r_b, \pi^e, \sigma)$$

Crypto Money Demand
Additional factors:

- Speculative motive dominates (people hold crypto mainly hoping the price will rise, not for everyday purchases)
- Network effects matter
- Regulatory risk premium (extra return demanded due to regulatory uncertainty)

Empirical Challenges

- What is "crypto money supply"?
- How to measure crypto velocity?
- Multiple exchanges, prices

Seigniorage in Digital Currency Systems

Traditional Seigniorage

$$S = \frac{\dot{M}}{P} = \frac{\Delta M}{M} \cdot \frac{M}{P}$$

(Seigniorage = growth rate of money times real money balances—how much value the money issuer extracts)

Example: If money supply grows 5% ($\Delta M/M = 0.05$) and real balances are $M/P = \$100\text{B}$, seigniorage $= 0.05 \times \$100\text{B} = \$5\text{B}$.

- Revenue from money creation
- Accrues to central bank/government
- Inflation tax on money holders

Bitcoin "Seigniorage"

- Block rewards to miners (computers that validate transactions and earn new coins)
- Declining over time (halvings: events that cut mining rewards in half every ∼4 years)
- Dissipated in mining costs (electricity and hardware expenses consume most of the reward)

Stablecoin Seigniorage

- Interest on reserves kept by issuer
- Tether earns billions annually
  (Tether holds user deposits in Treasury bonds (government debt securities) earning 4–5% interest, keeping the yield for itself)
- Users bear opportunity cost

Policy Implications

- Who captures monetary rents (profits earned simply from controlling money creation)?
- Private vs. public money trade-offs
- CBDC: Returns seigniorage to public

Stablecoin issuers capture seigniorage that would otherwise accrue to governments

Monetary Policy Implications

Transmission Mechanism Risks

How it works: Central banks raise/lower interest rates → banks adjust lending rates → businesses and consumers borrow more or less → economy speeds up or slows down. If people hold crypto instead of bank deposits, this chain weakens:

- Crypto reduces the money multiplier (the process by which bank lending amplifies deposits into a larger money supply—e.g., $100 deposited can support $1,000 in loans)
- Interest rate channel (how central bank rate changes affect borrowing) weakened
- Bank reserves less relevant

Financial Stability

- Pro-cyclical (amplifying booms and busts) crypto prices
- Contagion from crypto crashes
- Interconnection with TradFi (traditional finance)

Central Bank Responses

- CBDC development (defensive) *(central banks developing CBDCs to prevent private stablecoins from undermining monetary control)*
- Stablecoin regulation
- Reserve requirements for crypto banks

Long-term Questions

- Can crypto coexist with fiat?
- Optimal regulatory perimeter?
- International coordination needs?

Central banks view crypto growth as potential challenge to monetary sovereignty

Key Takeaways

Main Conclusions

1. Bitcoin fails core money functions due to volatility
2. Stablecoins are "money-like" but carry risks
3. Quantity theory applies but needs adaptation
4. Seigniorage distribution is policy issue

Economic Framework

- Money functions: Medium of Exchange (MoE), Unit of Account (UoA), Store of Value (SoV)
- Quantity theory: $MV = PY$
- Gresham's Law and hoarding
- Currency substitution dynamics

Core Insight

Monetary economics reveals why cryptocurrencies struggle as money: they optimize for speculation, not monetary functions. Stablecoins address some issues but create new ones.

Next lesson: Central Bank Digital Currencies (CBDCs)

Key Terms (1/3): Money Fundamentals

Medium of Exchange Money's function as accepted payment for transactions.

Unit of Account Money's function as standard measure for pricing.

Store of Value Money's function preserving purchasing power over time.

Barter Direct goods exchange without money; requires double coincidence of wants.

Velocity of Money Rate at which money circulates in economy.

Quantity Theory of Money $MV = PY$ relationship linking money, velocity, prices, output.

Seigniorage Profit from issuing money; face value minus production cost.

Inflation Tax Hidden tax reducing purchasing power when government prints money.

Deflationary Prices falling over time; fixed-supply currencies trend deflationary.

Opportunity Cost Value of next best alternative foregone when choosing.

Menu Cost Cost of changing prices (like reprinting menus); frequent repricing is expensive.

Master these terms before proceeding to subsequent lessons

Key Terms (2/3): Stablecoins & Market Mechanics

Stablecoin Cryptocurrency maintaining stable value, typically pegged to fiat.

Fiat-Backed Stablecoin Stablecoin backed 1:1 by fiat reserves.

Algorithmic Stablecoin Stablecoin using supply adjustments without full collateral.

Collateral Assets pledged as security for loan or stablecoin.

Over-collateralization Pledging more collateral than loan value for safety.

Capital Efficiency Getting maximum output from minimum capital; over-collateralization is capital-inefficient.

Liquidation Forced sale of collateral when value drops below threshold.

Arbitrage Profiting from price differences; maintains stablecoin pegs.

Death Spiral Self-reinforcing collapse where falling prices trigger more selling.

Risk Assets Investments that can lose value (stocks, crypto); opposite of safe assets like government bonds.

Scalability Trilemma Trade-off where blockchains can achieve only two of three: decentralization, security, or speed.

Master these terms before proceeding to subsequent lessons

Key Terms (3/3): Monetary Policy & Crypto

Gresham's Law "Bad money drives out good"; overvalued currency circulates, undervalued hoarded.

HODL Hold despite price drops; crypto slang resisting sales.

Dollarization Country adopting foreign currency instead of own.

Money Multiplier Bank lending amplifies deposits into larger money supply.

TradFi Traditional Finance; conventional banks versus DeFi.

Monetary Policy Autonomy A country's ability to set its own interest rates and control money supply.

Transmission Mechanism How central bank decisions (like rate changes) affect the real economy.

Pro-cyclical Moving with economic cycles—booms get bigger, busts get worse.

Contagion When problems in one market spread to others, like a disease.

Master these terms before proceeding to subsequent lessons

Further Reading

Academic Papers

- Yermack (2015): "Is Bitcoin a Real Currency?"
- Gorton & Zhang (2023): "Taming Wildcat Stablecoins"
- Brunnermeier et al. (2019): "The Digitalization of Money"

Policy Analysis

- BIS (2022): "The Future Monetary System"
- IMF (2023): "Elements of Effective Crypto Policies"
- ECB (2022): "Stablecoin Assessment"

All readings available on course platform