Week 7: Digital Assets & Market Analysis

Learning Objectives

- Explain cryptocurrency fundamentals and blockchain technology basics
- Analyze crypto market structure, price formation, and liquidity
- Assess volatility characteristics and risk properties of digital assets
- Evaluate financial inclusion claims for cryptocurrencies critically
- Implement crypto data analysis using APIs and Python
- Discuss regulatory approaches and policy challenges

Note on terminology: We call these "digital assets" not "digital currencies" because, as we'll demonstrate, they've failed as currencies but function as speculative assets.

The Central Puzzle

Bitcoin has existed for 15 years, yet remains marginal as actual currency:

- **Virtually nobody** prices goods in Bitcoin
- **Few merchants** accept it for payment
- **Transaction volumes** tiny compared to traditional payments (Visa ~2,000× more than Bitcoin)
- **Primary use**: Speculative trading, not currency

This contradicts the original vision:

Satoshi Nakamoto's 2008 whitepaper promised "*peer-to-peer electronic cash*" without financial institutions. The technology works: but adoption as currency has failed.

Instead: Bitcoin became a volatile speculative asset (20-30% monthly swings), unsuitable for currency functions

Agenda

Part I : Cryptocurrency fundamentals and blockchain basics
Part II : Market structure, exchanges, and price formation
Part III : Volatility, risk characteristics, and correlations
Part IV : Financial inclusion claims vs evidence
Part V : Hands-on: Crypto data analysis and market behavior

What is a Cryptocurrency?

Core definition:

Digital currency using **cryptography** for security, operating on **decentralised networks** based on **blockchain** technology.

How it differs from traditional electronic money:

- **Traditional** (bank transfer): Trusted central authority (bank) maintains ledger
- **Crypto**: Distributed network of computers maintains ledger via consensus
- **Goal**: Transfer value A $\rightarrow$ B without trusted intermediaries

Why this matters:

No bank can block your account, no government can shut it down (in theory)

Cryptocurrency: The Ideal Properties

Five key properties (as designed):

1. **Decentralisation** : No central authority controls the network
2. **Pseudonymity** : Transactions public, but users pseudonymous
3. **Immutability** : Historical transactions cannot be altered
4. **Censorship resistance** : No authority can block transactions
5. **Limited supply** : Fixed maximum supply (e.g., Bitcoin: 21M)

The promise:

Digital cash that no government controls, no bank can freeze, and no inflation can devalue

Reality Check: Gaps Between Ideal and Practice

The spectrum of decentralisation:

- **Bitcoin**: Substantial decentralisation (15K+ nodes, distributed mining)
- **Altcoins**: Many effectively centralised (Ripple/XRP, Binance/BNB)
- **User practice**: Most use centralised exchanges (Coinbase, Binance)

Result: Intermediaries reintroduced despite technology's promise

Other reality gaps:

- **Pseudonymity**: Blockchain analysis can trace transactions to identities
- **Immutability**: 51% attacks possible; hard forks can reverse history
- **Censorship resistance**: Miners can filter transactions; ISPs can block
- **Limited supply**: Rules can change via hard forks (social convention, not law)

Pseudonymity vs Anonymity

The privacy illusion:

- **What users see**: Anonymous addresses (“1A1zP1...”)
- **What blockchain reveals**: Complete transaction history, forever public
- **Blockchain forensics**: Chainalysis, Elliptic, CipherTrace track transactions

Cybercrime realities (Cong et al. 2022):

- **33.5% of FTC fraud reports** involve cryptocurrency ($728.8M in 2022)
- **BUT**: Organized ransomware operations successfully tracked and dismantled
- **Permanent public record** makes crypto potentially less private than cash

Privacy coins (Monero, Zcash) enhance privacy but face:

- Regulatory pressure over money laundering concerns
- Exchange delistings
- Limited adoption

Key insight: Cryptocurrency is pseudonymous, not anonymous: and blockchain forensics increasingly effective

The Platform Coordination Problem

The chicken-and-egg dilemma:

New platforms face a critical challenge: **users won't join unless others are already there**

Example: Launching a new messaging app

- **You alone**: App is worthless (nobody to message)
- **100 users**: Still limited value (most contacts not on platform)
- **Everyone joins**: Maximum value (can message anyone)

The coordination failure:

- Everyone would benefit if everyone joined (social optimum)
- But individually rational to wait and see if others join first
- Result: Platform never reaches critical mass, even though it's valuable

Traditional solution: Subsidize early adopters (Uber's discounts, referral bonuses)

Problem: Expensive, temporary, attracts free-riders who leave when subsidies end

Why Do Tokens Have Value? Tokenomics

The puzzle: Most tokens generate no cash flows, pay no dividends, grant no ownership rights. So why do they trade for positive prices?

Three sources of value:

1. **Transactional demand** : Must hold token to use platform (Cong, Li, and Wang 2021)
2. **Network effects** : More users $\rightarrow$ higher value to each user
3. **Speculative demand** : Early buyers anticipate future adoption

Key insight: Tokens solve the coordination problem we just saw: and do it better than subsidies

Token Value Mechanism: Transactional Demand

How platforms create token value:

- **Requirement**: Users must hold tokens to access platform services
- **Feedback loop**: Better platform $\rightarrow$ more users $\rightarrow$ higher token demand $\rightarrow$ price increases
- **Differs from equity**: Value from transaction necessity, not profits

Example: Cloud storage platform

- More users join $\rightarrow$ must buy tokens to use storage
- Token price rises $\rightarrow$ signals future value $\rightarrow$ attracts early adopters
- Early adopters profit from appreciation $\rightarrow$ validates platform

Critical point: Platform can lose money but have valuable tokens (if usage grows)

How Tokens Solve the Coordination Problem

Remember the problem: Early adopters bear risk but don't capture the value they create for later users

The token solution:

- Early users buy tokens to access platform (requirement)
- As more users join → token price rises (network effects)
- Early users profit from token appreciation → they captured the value!

The magic: Turns early adopters into investors with skin in the game

Research finding (Cong, Li, and Wang 2021):

- **Tokenized platforms**: Can achieve 100% adoption (social optimum)
- **Tokenless platforms**: Reach only 40-60% potential (coordination failure)

Why? Token creates self-fulfilling expectations:

- "If others join, token price rises"
- "So I'll join early to profit"
- Everyone thinks this → everyone joins → token price rises → expectations

Tokens vs Traditional Subsidies

Traditional platform subsidies (Uber model):

- Require external venture capital (dilutive)
- Terminate when funding depletes
- Create free-riding (join for subsidy, leave after)

Token mechanism advantages:

- No external funding needed (sell tokens to early users)
- Appreciation rewards early adopters automatically
- Users committed (token holders want platform to succeed)
- Liquid exit (sell to later adopters)

Research finding: Traditional subsidies require >100% of transaction value to match token adoption: literally impossible

The catch: Only works with credible path to adoption. Many ICO failures = tokens for platforms without viable value propositions

Blockchain Technology Basics

```
Block N-1          Block N            Block N+1

  Prev Hash        Prev Hash        Prev Hash
  Timestamp          Timestamp          Timestamp
  Nonce              Nonce              Nonce
  Txns               Txns               Txns
    • Tx1              • Tx5              • Tx9
    • Tx2              • Tx6              • Tx10
    • Tx3              • Tx7              • Tx11
    • Tx4              • Tx8              • Tx12
  Hash               Hash               Hash
```

Key concepts:

- **Block**: Container of transactions with metadata
- **Hash**: Cryptographic fingerprint linking blocks
- **Proof-of-Work**: Miners compete to find valid nonce

Major Cryptocurrencies

Cryptocurrency	Market Cap	Consensus	Key Features	Launched
Bitcoin (BTC)	~$500B	Proof-of-Work	Digital gold??, fixed supply (21M), store of value narrative	2009
Ethereum (ETH)	~$200B	Proof-of-Stake	Smart contracts, DeFi ecosystem, programmable	2015
Stablecoins (USDT/USDC)	~$150B	Varies	Pegged to USD, used for trading/settlement	2014/2018
Binance Coin (BNB)	~$35B	Proof-of-Staked Authority	Exchange token, BSC network	2017
Others	~$300B	Varies	Thousands of altcoins, many	-

Bitcoin: Digital Gold or Digital Speculation?

The narrative evolution:

- **2009-2013**: "Peer-to-peer electronic cash" (Satoshi's whitepaper)
- **2013-present**: "Digital gold" / "store of value" (scaling limitations emerged)

The digital gold argument:

- Fixed supply (21M cap) creates scarcity
- Easily divisible, portable, verifiable
- Censorship-resistant, no government control

The empirical challenges:

- Gold: millennia of value; Bitcoin: 15 years
- Gold: stable purchasing power; Bitcoin: 60-80% annual volatility
- Gold: uncorrelated with equities; Bitcoin: increasingly correlated (0.3-0.4)
- Deflation spiral risk if widely adopted (fixed supply $\rightarrow$ hoarding)

Yet Bitcoin persists: Survived hacks, crashes, regulatory crackdowns, 80%+ drawdowns. BlackRock ETF (2024) legitimizes asset class.

Ethereum: Programmable Money and Smart Contracts

Beyond simple value transfer:

Ethereum (2015) = "World computer" executing arbitrary code via **smart contracts**

Smart contracts = Programs on blockchain that execute automatically when conditions met

What this enables:

- **DeFi**: Lending, trading, derivatives without banks
- **NFTs**: Digital ownership certificates
- **DAOs**: Decentralised governance organisations
- **Dapps**: Applications running on blockchain

The Merge (Sept 2022): Proof-of-Work $\rightarrow$ Proof-of-Stake

- 99% energy reduction
- Changed from inflation to potential deflation
- Increased centralisation concerns (Lido, Coinbase, Binance control majority stake)

Ongoing challenges: Scalability (~15 TPS), complexity, regulatory uncertainty

Stablecoins: The Cryptocurrency Paradox

The ironic admission:

Cryptocurrencies supposedly free users from government fiat, **yet the most-used cryptocurrencies are pegged to the US dollar**

What are stablecoins?

Tokens pegged 1:1 to fiat currency (usually USD), used for crypto trading/settlement

- **Tether (USDT)**: ~$90B market cap
- **USD Coin (USDC)**: ~$25B market cap
- Combined: More than most cryptocurrencies except Bitcoin/Ethereum

Three types:

1. **Fiat-collateralized** (USDT, USDC): Backed by cash/treasuries, centralised issuers
2. **Crypto-collateralized** (DAI): Backed by ETH with over-collateralization
3. **Algorithmic**: Maintain peg through incentives: **most failed catastrophically**

Terra/UST collapse (May 2022): $40B algorithmic stablecoin death spiral in 48 hours

The Altcoin Universe: Innovation or Exploitation?

Beyond Bitcoin and Ethereum: Thousands of alternative cryptocurrencies ("altcoins")

Some legitimate experiments:

- **Cardano**: Peer-reviewed academic development
- **Solana**: High throughput (65K TPS target) at cost of centralisation
- **Monero**: Privacy-focused (fungible, untraceable)

But massive fraud at scale:

- **ICO boom (2017-18)**: Raised billions, most projects failed or were scams
- **Pattern repeats**: IEOs, IDOs, NFT drops, play-to-earn, DeFi "food tokens"
- **Common scams**: Pump-and-dump, Ponzi tokenomics, rug pulls

The information asymmetry problem:

- **Founders know**: Code quality, tokenomics, true intentions
- **Retail investors see**: Marketing materials, price charts, FOMO

Lack of investor protections:

Cryptocurrency Exchanges

Centralized exchanges (CEX):

- Coinbase, Binance, Kraken, etc.
- Hold customer funds (custody risk)
- Order book matching
- Fiat on/off ramps
- Regulated (varying degrees)

Decentralized exchanges (DEX):

- Uniswap, SushiSwap, PancakeSwap
- Users retain custody
- Automated market makers (AMMs)
- Limited fiat access
- Regulatory uncertainty

Key issues:

Fragmentation, price discrepancies, arbitrage opportunities, custody risk, regulatory gaps

Research Evidence: Arbitrage and Manipulation

Arbitrage opportunities (Makarov and Schoar 2020):

- **Cross-border spreads 3-15%**: US-Europe (3%), Japan-US (10%), US-Korea (15-40%)
- **Within-country <1%**: Price consistency within same jurisdiction
- **"Kimchi premium"**: Korean prices peaked 40% above US (2017-18)
- Reflects genuine frictions (transfer times, capital controls, regulatory barriers)
- Spreads have narrowed over time (<0.5% now vs. 5-10% earlier)

Manipulation evidence (Griffin and Shams 2020):

- **Tether used to systematically purchase Bitcoin** during price declines
- Prices on suspicious exchanges diverge from regulated venues
- Not all price discrepancies represent genuine arbitrage opportunities

Implication: Markets are not just inefficient: they're partially manipulated

24/7 Trading & Thin Liquidity

Continuous trading creates unique dynamics:

- **24/7/365 markets**: No close, no circuit breakers, global access
- **Time-zone effects**: Volume peaks during US-Europe overlap (1-9pm London)
- **Weekend volatility**: Crashes can occur when traditional markets closed
- **News anytime**: Elon tweets, hacks, regulations: no pause for digestion

Thin order books create price impact:

- **$10M Bitcoin order**: Moves price 0.5-1%
- **$10M Apple order**: Moves price 0.01%
- **Small altcoins**: Entire order book might be $10K-$100K

Liquidity hierarchy:

Bitcoin/Ethereum (deep) $>$ Major altcoins (moderate) $>$ Small-caps (virtually none)

Manipulation opportunities: Spoofing, layering, whale moves

Market Manipulation: Wash Trading

The volume fabrication problem:

70-90% of reported trading volume on unregulated exchanges may be **fake**

Why fake volume?

- Exchanges compete for users and listings
- Higher volume attracts traders and projects
- Creates false liquidity impression

Bitwise (2019) analysis for SEC:

- Analyzed 81 exchanges
- **Only 10 had genuine volume**
- 71 showed patterns consistent with wash trading

Implications:

- Market cap rankings misleading
- Liquidity assumptions false
- Research using volume data compromised

Market Manipulation: Tether & Price Intervention

Griffin and Shams (2020) forensic evidence:

Tether Limited issued USDT and used it to purchase Bitcoin during downward price pressure

The mechanism:

1. Bitcoin price falling $\rightarrow$ negative sentiment
2. Tether issues new USDT stablecoins
3. Uses USDT to purchase Bitcoin (absorbing supply)
4. Bitcoin price stabilizes/recovers despite bad news

Why this works:

- Tether is dominant stablecoin for crypto trading
- Sellers accept USDT instead of fiat
- Large purchases absorb supply and support prices

The concerns:

- Tether lacks transparency about USD backing (limited audits)

Technical Trading & Market Efficiency

Why technical analysis dominates:

No fundamental valuation anchor: what is Bitcoin "worth"?

- No cash flows to discount
- No assets backing tokens
- No financial statements
- Price becomes its own signal

Self-fulfilling dynamics:

- Traders believe 200-day MA is support → **becomes support** (they buy there)
- Momentum works → traders chase trends → **reinforces momentum**
- Resistance levels matter → traders sell there → **creates resistance**

Market structure creates patterns that technical analysis exploits

Research evidence (mixed):

- Momentum, mean reversion, predictable patterns exist
- Markets incorporate major news quickly

Bitcoin Volatility: The Numbers

Historical volatility metrics:

- Daily volatility: 3-5% (vs. 1-1.5% for equities)
- Annual volatility: 60-80% (vs. 15-20% for S&P 500)
- Maximum drawdown: 80-85% in bear markets
- Skewness: Slightly negative (large downside moves)
- Kurtosis: High (fat tails, extreme events common)

Implications:

- Unsuitable as currency (purchasing power instability)
- Challenges for portfolio allocation
- High margin requirements, liquidation risks
- Options pricing difficult (model assumptions violated)

Bitcoin Price History: Extreme Volatility in Action

Key observations:

- **Multiple 50%+ crashes** within 5 years (2020 Covid, 2022 bear market)
- **Daily moves of $\pm$5%** occur regularly (red lines on returns chart)
- **80-85% peak-to-trough drawdowns** make long-term holding psychologically difficult
- Compare to S&P 500: Largest crash since 2020 was ~35% (Covid), recovered within months

Return Distribution: Fat Tails Everywhere

Statistical evidence:

- **Kurtosis**: `{python} f'{kurt:.2f}'` (normal $=$ 3.0) $\rightarrow$ Fat tails
- **Skewness**: `{python} f'{skew:.2f}'` (normal $=$ 0.0) $\rightarrow$ Slightly negative (crash risk)
- **±5% daily moves**: `{python} extreme_events` events in `{python} total_days` days (`{python} f'{100*extreme_events/total_days:.1f}'`%)
- **Normal distribution predicts**: <1% probability of ±5% moves
- **Reality**: `{python} f'{100*extreme_events/total_days:.0f}'`$\times$ more frequent than normal distribution

Q-Q plot interpretation: Systematic deviation from diagonal $=$ non-normal distribution

Empirical Evidence: Returns and Risk Factors

Liu and Tsyvinski (2021) comprehensive analysis (2011-2018):

Frequency	Mean Return	Std Dev	Sharpe Ratio
Daily	0.46%	5.46%	0.08
Weekly	3.44%	16.50%	0.21
Monthly	20.44%	70.80%	0.29

Annualized volatility: ~167% (vs. 15-20% for stocks)

Extreme events occur frequently:

- **-20% daily loss**: 0.48% probability (once every 200 days, ~2x/year)
- **+20% daily gain**: 0.9% probability (almost 2x as often as crashes)
- **High kurtosis, fat tails**: Standard risk models systematically underestimate tail risk

Key insight: Sharpe ratios competitive with equities at monthly horizon, but extraordinary volatility and tail risk make standard portfolio theory inadequate

Correlation Patterns: Limited Diversification

Within-crypto correlations:

- Bitcoin-altcoin correlation: 0.5-0.7 (high)
- Most altcoins highly correlated with Bitcoin
- "Bitcoin dominance" drives market
- Diversification within crypto limited

Cross-asset correlations:

- Bitcoin-equity: 0.2-0.4 (time-varying, increasing)
- Bitcoin-bonds: ~0.0 (no relation)
- Bitcoin-gold: ~0.0 to 0.1 (weak "digital gold" support)
- During stress: correlations increase ("flight to liquidity")

Diversification: Limited within crypto; modest cross-asset benefits

Correlation Visualization: Crypto as “Risk-On” Asset

Key findings:

- **Bitcoin-Ethereum: 0.85** → Diversifying across crypto provides minimal benefit
- **Bitcoin-S&P 500: Increasing** from 0.15 (early) to 0.45 (recent) → “Digital gold” narrative weakens
- **Bitcoin-Gold: 0.10** → Very weak, contradicts “digital gold” marketing
- **Bitcoin-Bonds: -0.03** → No relationship, neither diversifier nor risk asset behavior

Implication: Bitcoin increasingly behaves as risk-on asset (like tech stocks), not safe haven

Volatility Comparison: Crypto vs Traditional Assets

Stark differences:

- **Bitcoin volatility**: `{python} f'{vol_btc:.0f}'`% → ~4× higher than S&P 500
- **Ethereum**: `{python} f'{vol_eth:.0f}'`% → Even more volatile than Bitcoin
- **S&P 500**: `{python} f'{vol_sp500:.0f}'`% → Baseline equity volatility
- **Gold**: `{python} f'{vol_gold:.0f}'`% → True "safe haven" behavior
- **Bonds**: `{python} f'{vol_bonds:.0f}'`% → Lowest volatility, capital preservation

Portfolio implication: 1% Bitcoin allocation contributes more volatility than 20% equity allocation

Modeling Crypto Volatility: Statistical Tests

Before modeling, test for key properties:

1. Autocorrelation in squared returns (Ljung-Box test) - Tests if volatility clusters (today's volatility predicts tomorrow's) - H_0: No autocorrelation | H_1: Volatility clustering exists

2. Normality of returns (Jarque-Bera test) - Tests if returns are Gaussian (normal distribution) - H_0: Normal distribution | H_1: Fat tails, skewness

Typical results for Bitcoin: - **Ljung-Box**: p $< 0.001 \rightarrow$ Strong evidence of volatility clustering - **Jarque-Bera**: p $< 0.001 \rightarrow$ Reject normality (fat tails)

GARCH Models: Capturing Volatility Clustering

Connection to Week 3 foundations:

Volatility **clusters**: high volatility today $\rightarrow$ high volatility tomorrow. Standard deviation assumes constant volatility (wrong for crypto!).

GARCH(1,1) model: (Week 3, §3.4)

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$

- ω: Long-run variance baseline
- α: News impact (yesterday's shock)
- β: Persistence (yesterday's variance)
- **Persistence**: $\alpha + \beta$ (close to $1 =$ highly persistent)

Connection to Ch 03, §3.4: GARCH Models

GARCH models **time-varying volatility**: volatility today depends on recent shocks and past volatility. This captures volatility clustering observed in Bitcoin returns.

Estimating GARCH(1,1) for Bitcoin

Fit GARCH to Bitcoin returns:

Key insight: GARCH captures **volatility spikes** (2018 crash, 2020 COVID, 2021 bull run)

Persistence $+$ 0.98: Volatility shocks decay **very slowly** (half-life ~35 days)

Asymmetric Volatility: GJR-GARCH

Problem: GARCH(1,1) treats good/bad news equally. Reality: **Bad news increases volatility more** (leverage effect)

GJR-GARCH model: (Week 3, §3.4.2)

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \gamma\epsilon_{t-1}^2 \mathbb{I}_{\epsilon_{t-1}<0} + \beta\sigma_{t-1}^2$$

- γ: **Asymmetry parameter** (extra impact if $\epsilon_{t-1} < 0$, i.e., negative shock)
- If $\gamma > 0$: Bad news hits harder than good news

Key insight: -5% Bitcoin drop increases volatility ~**1.5× more** than +5% rally

! Connection to Ch 03, §3.4.2: Asymmetric GARCH

Leverage effect: Negative returns increase volatility more than positive returns. Why? - **Risk aversion**: Bad news triggers panic selling → more volatility - **Leverage**: Price drops → debt/equity ratio rises → perceived risk increases
GJR-GARCH's **news impact curve** shows this asymmetry visually.

Volatility Forecasting and Out-of-Sample Validation

Question: Does GARCH predict future volatility accurately?

Test: Rolling-window forecast + **Mincer-Zarnowitz regression** (Week 1, §0.6)

$$\text{Realized Vol}_t = \alpha + \beta \times \text{Forecast Vol}_t + \epsilon_t$$

- If $\alpha = 0$ and $\beta = 1$: **Unbiased forecast**
- If R^2 high: **Accurate forecast**

Key insight: GARCH forecasts Bitcoin volatility reasonably well (R^2 ~0.5-0.7), but **underestimates** during extreme events

Connection to Week 1, §0.6: Out-of-Sample Validation

Mincer-Zarnowitz tests forecast unbiasedness: - $\alpha = 0, \beta = 1$: Forecast is unbiased - High R^2: Forecast explains realized volatility well
This is **honest evaluation**: forecast on past data, test on future data (no look-ahead bias).

Structural Breaks vs GARCH Persistence

Key question: Is Bitcoin's high GARCH persistence ($+ \quad 0.98$) **real** or an **artifact of regime shifts**?

Two interpretations:

1. **True persistence:** Volatility shocks decay slowly (GARCH is correct model)
2. **Structural breaks:** Volatility shifts between **regimes** (calm vs turbulent), GARCH mistakes this for persistence

Test: Compare **full-sample GARCH** vs **sub-period GARCH** models

If persistence **drops** in sub-periods → regime shifts, not true persistence

> **!** Connection to Ch 03, §3.5: Structural Breaks
>
> **Structural breaks**: Volatility regime changes (calm → turbulent → calm). GARCH fitted to full sample can **confuse regime shifts with persistence**.
> **Key concepts:** - **Chow test**: Test if parameters differ across periods - **Rolling volatility**: Visual regime identification - **Model comparison** (AIC/BIC): Does

Regime Identification: Rolling Volatility

Visual inspection: Plot rolling 30-day volatility to identify regimes

Key insight: Bitcoin alternates between **calm** ($<$30% vol) and **turbulent** ($>$60% vol) regimes

Sub-Period GARCH: Testing for Regime Stability

Test: Fit GARCH separately to first half vs second half of sample

If persistence (+) **similar** → true persistence
If persistence **different** → regime shifts

Typical result: Sub-period persistence **varies** (0.90 vs 0.96) → evidence of regime shifts

Implication: GARCH Persistence is Partly Spurious

If persistence differs across sub-periods, **full-sample GARCH overestimates** true persistence by confusing regime shifts with gradual mean reversion.
Better models: Markov-switching GARCH, regime-dependent volatility, threshold models
Practical impact: Risk models using full-sample GARCH will **overestimate** volatility persistence → wrong hedging ratios, wrong VaR estimates

Summary: Volatility Modeling for Cryptocurrency

What we demonstrated:

1. **Statistical tests** (Ljung-Box, Jarque-Bera): Bitcoin has volatility clustering, fat tails
2. **GARCH(1,1)** (Week 3, §3.4): Models time-varying volatility, high persistence ($+ \quad 0.98$)
3. **GJR-GARCH** (Week 3, §3.4.2): Asymmetric: bad news increases vol $1.5\times$ more than good news
4. **Volatility forecasting** (Week 1, §0.6): Mincer-Zarnowitz test shows decent accuracy ($R^2 \sim 0.6$)
5. **Structural breaks** (Week 3, §3.5): High persistence is **partly spurious**: regime shifts matter!

Key lessons:

- **GARCH works** for crypto: captures clustering, fat tails, asymmetry
- **But:** Single-regime GARCH **overestimates persistence** due to regime shifts
- **Better models**: Regime-switching GARCH, threshold models, DCC (dynamic correlation)

Systematic Return Predictors

Beyond volatility: Factor structure (Liu, Tsyvinski, and Wu 2022)

Three-factor model explains cross-sectional cryptocurrency returns:

1. **Market factor**: Overall crypto market movements
2. **Size factor**: Smaller coins outperform (liquidity premium, convenience yield trade-off)
3. **Momentum factor**: Past winners continue outperforming (attention-driven trading)

Key finding: 10 of 24 characteristics predict returns significantly
Implication: Not pure bubbles: systematic risk-return relationships exist

The Inclusion Narrative

Crypto advocates claim:

- Banking the unbanked (2B people without accounts)
- Reducing remittance costs (vs. Western Union 5-7%)
- Enabling censorship-resistant transactions
- Empowering individuals in oppressive regimes
- Financial services without permission or discrimination

Reality check questions:

- Who actually uses cryptocurrency?
- For what purposes?
- In which countries and demographics?
- What evidence supports welfare benefits?
- What barriers prevent mainstream adoption?

Crypto vs. Mobile Money: Evidence Comparison

Dimension	Mobile Money (M-Pesa)	Cryptocurrency
Target users	Poor, unbanked, rural	Unbanked (narrative)
Actual adoption	90%+ Kenyan adults, previously excluded	Wealthy, tech-savvy, male
Primary use	Payments, remittances, savings	Speculation
Welfare evidence	2pp poverty reduction (Suri and Jack 2016)	None (no causal studies)
Cost structure	~1% transaction fees	\$0.01-\$50+ (variable)
Technology	USSD on basic phones	Smartphone, internet required

Key findings from Auer et al. (2025):

- **5M owners (2016) → 220M (2021)**: Growth follows price momentum, not financial need
- **Retail pattern**: Enter when prices rise, exit when they fall (speculation)

Who Actually Uses Cryptocurrency?

Survey evidence contradicts inclusion narrative:

Demographics:

- **Income**: Ownership increases with wealth (5-15% in developed countries, 1-5% in developing)
- **Education**: Correlates with tech literacy and higher education
- **Gender**: 70-80% male users
- **Age**: Concentrated 18-40 years old

Geographic patterns:

- **Highest adoption**: US, EU, wealthy Asian countries (functioning banking systems)
- **Developing countries**: Lower absolute adoption despite need
- **Venezuela, Nigeria**: Some elevated interest, but stablecoins (USD access) not Bitcoin

Profile conclusion: "Risk-seeking tech enthusiasts" NOT "financially excluded seeking services"

Usage Patterns: Speculation Not Utility

Blockchain analytics reveal actual behavior:

Transaction volumes:

- **Bitcoin on-chain**: 200K-400K transactions/day
- **Exchange trading**: Billions in daily volume
- **Implication**: Most Bitcoin never leaves exchanges: traded, not used

Merchant acceptance:

- **Peak 2017-18**: BitPay processed for Microsoft, Overstock, Steam
- **Current**: Merchants dropping support (volatility, fees)
- **Result**: Minimal real-world payment utility

Ethereum gas fees:

- **Congestion periods**: \$50-100+ per transaction
- **Excludes poor users** by cost alone

Stablecoins show most utility (trading, some remittances) but users still mostly traders, not unbanked

Barriers to Inclusion: Technical Complexity

Infrastructure requirements:

- **Internet + smartphone**: Not universal in developing countries
- **M-Pesa comparison**: Works on basic phones via USSD
- **Immediate exclusion**: Hundreds of millions without required technology

Private key management: a critical vulnerability:

- **Requirement**: Securely store 12-24 word seed phrases
- **No recovery mechanism**: Lose seed phrase = lose funds permanently
- **Contrast**: Banks and M-Pesa have account recovery
- **Single mistake = permanent loss**

Transaction complexity:

- **Bitcoin sending**: Access wallet → generate address → verify address → wait 10-60 min → variable fees
- **M-Pesa sending**: Dial *334# → send → phone number → amount → PIN → instant
- **Usability gap is enormous**

Barriers to Inclusion: Knowledge Requirements

Cryptocurrency demands sophisticated financial literacy:

Must understand:

- Blockchain technology concepts
- Different cryptocurrency types and use cases
- Wallet types (hot, cold, custodial, non-custodial)
- Exchange mechanisms and order types
- Volatility, risk, and portfolio implications
- Tax treatment and reporting requirements
- Security threats (phishing, malware, rug pulls, smart contract risks)

The systematic exclusion problem:

- Financial literacy correlates with education and income
- **Lowest among populations crypto claims to serve**
- "Do your own research" (DYOR) effectively blames victims
- **Information asymmetry enables systematic scams**

Barriers to Inclusion: Institutional Gatekeeping

The on/off ramp paradox:

To use cryptocurrency, you typically need:

1. **Bank account** (to transfer fiat to exchange)
2. **KYC/AML verification** (ID, proof of address)
3. **Exchange account approval** (days to weeks wait)
4. **Minimum deposits** ($10-50, significant for poor)

If you're unbanked, you can't easily access cryptocurrency

Alternative on-ramps exist but:

- **Bitcoin ATMs**: 5-10% fees, urban concentration
- **Peer-to-peer trading**: High premiums, limited scale
- **Cash-for-crypto**: Geographic constraints

Merchant acceptance:

- Negligible even in developed countries
- Virtually nonexistent in developing countries (outside tourism)

Barriers to Inclusion: Economic Unsuitability

Volatility destroys savings function:

- Monthly salary \$100 $\rightarrow$ save \$20 in Bitcoin
- Next month: might be worth \$15 or \$25
- **Poor households cannot accept this savings risk**
- M-Pesa maintains stable value in local currency

Credit access impossible for target users:

- **DeFi lending**: Requires over-collateralization (deposit \$150 to borrow \$100)
- **Unbanked poor have no collateral** to begin with
- **Predatory crypto lending**: Worse terms than traditional options

No recourse for errors:

- Wealthy investor loses \$1K to scam: painful but not devastating
- Poor person loses month's savings: catastrophic
- **Irreversibility + anonymity = attacker-friendly, victim-hostile**
- Banks and M-Pesa provide fraud protection and recovery

Lab 7 Preview

Exercise 1: Accessing Crypto Market Data (30 min)

- CoinGecko/CoinMarketCap APIs
- Exchange APIs (Coinbase, Binance)
- Historical price data retrieval
- Order book and volume analysis

Exercise 2: Return and Volatility Analysis (40 min)

- Calculate returns across cryptocurrencies
- Measure and compare volatilities
- Identify tail risk and fat tails
- Correlation analysis

Exercise 3: Market Efficiency Testing (30 min)

- Autocorrelation and momentum
- Mean reversion tests
- Arbitrage opportunity detection
- Price prediction attempts

Summary and Key Takeaways

1. Cryptocurrencies use blockchain for decentralized transactions but face scalability and governance challenges

2. Markets are fragmented, volatile, and exhibit unique microstructure features (24/7, thin liquidity, manipulation)

3. Bitcoin volatility ($\sim$60-80% annualized) makes it unsuitable as currency and challenging as investment

4. Financial inclusion claims are not supported by evidence: adoption concentrates among wealthy speculators

5. Multiple barriers (technical, knowledge, institutional, economic) prevent mainstream adoption

6. Cryptocurrency data analysis reveals market inefficiencies and risk characteristics requiring careful management

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Core readings:

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- Böhme, R., Christin, N., Edelman, B., & Moore, T. (2015). "Bitcoin: Economics, Technology, and Governance," *Journal of Economic Perspectives*
- Vives (2019) : Digital disruption in banking (Chapter 4 on crypto)
- Makarov, I., & Schoar, A. (2020). "Trading and Arbitrage in Cryptocurrency Markets," *Journal of Financial Economics*
- Sockin, M., & Xiong, W. (2023). "A Model of Cryptocurrencies," Management Science (forthcoming)

Additional resources:

- CoinGecko/CoinMarketCap for market data
- Chainalysis/Elliptic for blockchain analytics reports
- BIS, IMF, World Bank reports on CBDCs and crypto financial stability
- Academic working papers on crypto market efficiency, volatility, adoption

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