

Cryptocurrency

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Blockchain and Cryptocurrencies

Lecture 6



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Definition of Cryptocurrency

Cryptocurrency is a type of digital or virtual currency that uses cryptography for security and operates on decentralized networks based on blockchain technology. Unlike traditional currencies such as the US dollar or euro, cryptocurrencies are not issued or controlled by a central authority like a government or central bank. Instead, they rely on distributed computer networks that record and verify transactions through a secure and transparent system.

The term “cryptocurrency” comes from two words: “crypto”, which refers to cryptography (the use of encryption techniques to secure information), and “currency”, which refers to a medium of exchange used to buy goods and services. Cryptography ensures that transactions are secure, prevents fraud, and controls the creation of new units of the currency.

Cryptocurrency was created primarily as a response to the systemic failures of the traditional financial system, exposed starkly by the 2008 Global Financial Crisis. Satoshi Nakamoto, Bitcoin's pseudonymous inventor, sought to build a decentralized, trustless alternative that empowers individuals over institutions, eliminates intermediaries, and enforces sound monetary principles through code rather than human oversight.

Trigger: The 2008 Financial Crisis

The crisis originated in the U.S. subprime mortgage collapse, leading to a cascade of bank failures, massive bailouts, and global recession. Governments injected trillions such as the U.S. TARP program (\$700 billion) to prop up "too-big-to-fail" banks, effectively transferring losses from reckless institutions to taxpayers via money printing and inflation. This bred widespread distrust: ordinary savers saw their purchasing power erode while elites were rescued.

Inflation and Debasement: Central banks print fiat at will, debasing currency value (e.g., USD lost 20% purchasing power post-2008). Bailouts amplified this "hidden tax" on savers. Centralization Risks: Single points of failure enable corruption, surveillance, and exclusion e.g., freezing accounts in politically unstable regions. These weren't abstract; 2008 proved banks could collapse overnight, yet wield unchecked power. Satoshi's solution: a system where "what's true is what achieves consensus," prioritizing math over authority.

Bitcoin (BTC)

Bitcoin, launched in 2009, holds over 50% market dominance as "digital gold" with a \$1.8 trillion cap (price ~\$90,000 in early 2026). Its fixed 21 million supply and Proof-of-Work consensus make it a scarce store of value, ideal for hedging inflation without intermediaries. Primarily used for long-term holding and cross-border transfers, BTC's halvings (next in 2028) drive cyclical price surges, attracting institutions via ETFs.

Ethereum (ETH)

Ethereum powers decentralized apps with \$370B cap (~\$3,100 price), shifting to Proof-of-Stake post-2022 Merge for 99% energy savings. Smart contracts via Solidity enable DeFi (\$150B+ TVL) and NFTs, processing 15-30 TPS base layer. Upgrades like Dencun (2024) slashed Layer-2 fees, boosting scalability to 100K TPS combined. (Word count: 402 distinct focus: ETH's EVM (Ethereum Virtual Machine) acts as a global computer, executing bytecode immutably think Turing-complete blockchain.

Stablecoins

Stablecoins like Tether (USDT, \$120B+ cap) and USDC peg 1:1 to USD via reserves (cash/T-bills), enabling frictionless trading and remittances at near-zero volatility. They process \$10T+ yearly volume, dominating 70% of exchange liquidity without crypto's price swings. (isolated depth: Issuers audit reserves quarterly (e.g., Circle's SOC2), mitigating depeg risks seen in UST's 2022 collapse)

Altcoins

Altcoins everything non-BTC span Solana (SOL, \$78B cap, 2K TPS via Proof-of-History for gaming/DeFi), Cardano (ADA, research-driven PoS at \$14B), and Avalanche (AVAX, subnets for custom chains). They innovate on speed (SOL), sustainability (ADA), or interoperability (AVAX). (non-overlapping: SOL's Gulf Stream mempool skips blocks for 50K TPS peaks, but outages (5+ in 2025) highlight centralization risks. ADA's Ouroboros PoS emphasizes peer-reviewed papers, slow-rolling to Hydra L2 (1M TPS).

Metric	Bitcoin (BTC)	Ethereum (ETH)	Stablecoins (USDT)	Solana (SOL) as Altcoin
Market Cap	\$1.8T	\$370B	\$120B+	\$78B
Primary Use	Store of Value	Smart Contracts	Trading/Stability	High-Speed DeFi
Consensus	PoW	PoS	N/A (Pegged)	PoH+PoS
TPS (Peak)	7 (L2:1M)	30 (L2:100K)	Chain-Dependent	2K+
Volatility	High	High	Low	Very High
2026 Strength	Institutional	dApp Ecosystem	Liquidity	Adoption Growth

Cryptocurrency's versatility extends far beyond speculation, enabling practical applications that redefine finance, ownership, and value exchange in a decentralized manner. By 2026, its uses span everyday transactions to sophisticated programmable ecosystems, with total value locked (TVL) exceeding \$500B across protocols and daily volumes surpassing traditional payment networks in speed and cost-efficiency.

Digital Payments

Cryptocurrency facilitates borderless, instant digital payments without banks, leveraging stablecoins and Layer-2 solutions for everyday viability. In 2026, platforms like Strike and Cash App process millions of remittances daily, slashing fees from 6-7% (Western Union average) to under 1%, with settlement in seconds versus days. Bitcoin's Lightning Network scales to 1M+ TPS at near-zero cost, enabling micropayments for content (e.g., podcasts tipping sats per listen) or machine-to-machine IoT billing think 5G sensors auto-paying for data relay in smart cities.

Investment and Trading

As a high-volatility asset class, cryptocurrency drives investment via spot holding, futures, and yield strategies, with \$3T+ market cap drawing institutions. BTC/ETH ETFs (approved 2024) onboarded \$100B+ AUM, treating crypto as "digital gold" or growth tech. Retail traders use DEXs like Uniswap for 24/7 liquidity, while perps on Binance/Bybit offer 100x leverage \$5T derivatives volume yearly.

Strategies diversify: HODLing BTC for halvings (2028 next), DCA into ETH amid upgrades, or altcoin season plays on SOL/ADA. Staking yields 4-10% APY lock \$50B+ ETH, generating passive income without custody risk via non-custodial wallets. Venture exposure via funds (a16z Crypto) targets 100x moonshots in AI-blockchain hybrids.

Smart Contracts

Smart contracts are self-executing code on blockchains like Ethereum, automating agreements without lawyers triggered by conditions (e.g., pay if shipment arrives).

Real-world: MakerDAO's DAI mints via collateralized debt positions; prediction markets like Augur settle on outcomes

AI integration: ML oracles (e.g., Witnet) feed models for dynamic pricing rental contracts adjust rent via occupancy data. Zero-knowledge proofs enable private execution (zk-SNARKs hide inputs).

Development: Remix IDE deploys testnets free; OpenZeppelin libraries standardize ERC-20/721. Gas optimization (e.g., assembly opcodes) cuts costs 50%. 2026 trend: account abstraction (ERC-4337) makes wallets smart, batching txs. Risks: oracle manipulation, but decentralized feeds mitigate.

Advantages and Disadvantages of Cryptocurrency

Cryptocurrency has emerged as one of the most transformative financial innovations of the 21st century. Built on blockchain technology and secured through advanced cryptographic techniques, cryptocurrencies represent a decentralized form of digital money that operates independently of traditional banking systems. Since the launch of Bitcoin in 2009, the cryptocurrency ecosystem has expanded rapidly, introducing thousands of digital assets and new financial models that challenge conventional methods of payment, investment, and economic participation.

One of the key reasons cryptocurrencies have gained global attention is their ability to reshape financial systems by offering faster transactions, lower costs, and greater accessibility. Unlike traditional financial services that rely heavily on centralized institutions such as banks and payment processors, cryptocurrencies enable peer-to-peer transactions directly between users.

At the same time, cryptocurrencies have introduced new opportunities for individuals who were previously excluded from the formal financial system. In many parts of the world, millions of people lack access to bank accounts due to geographic limitations, high banking fees, or strict identification requirements. Cryptocurrency networks offer an alternative by allowing anyone with internet access to store value and participate in digital transactions.

Despite these benefits, the rapid growth of cryptocurrency markets has also highlighted several challenges and risks. Digital assets are often characterized by high price volatility, making them unpredictable as a store of value. Security concerns such as hacking, fraud, and wallet theft remain significant issues for users and investors. In addition, the environmental impact of certain blockchain systems, particularly those that rely on energy-intensive mining processes, has sparked debate among policymakers, environmentalists, and industry leaders.

Benefits of Cryptocurrency

One of the most widely recognized advantages of cryptocurrency is its ability to facilitate efficient, secure, and decentralized financial transactions. Unlike traditional financial systems that rely on banks and payment processors, cryptocurrency networks operate on decentralized blockchain infrastructures. This structure allows users to send and receive funds directly without requiring a trusted third party to verify or process the transaction.

A major benefit of this system is the reduction of transaction costs. Traditional financial transfers especially international payments often involve multiple intermediaries such as banks, clearing houses, and payment networks. Each of these institutions may charge processing fees and introduce delays. Cryptocurrency transactions, on the other hand, are processed directly on the blockchain network, which can significantly lower costs and increase transaction speed, particularly for cross-border transfers.

Cryptocurrencies also offer greater financial autonomy for users. In traditional banking systems, individuals must rely on financial institutions to manage their funds and authorize transactions. Cryptocurrency users maintain direct control over their digital assets through private keys, which function as secure access credentials. This ownership model reduces dependence on centralized authorities and allows individuals to manage their finances independently.

Another advantage is the speed and availability of transactions. Cryptocurrency networks typically operate continuously, allowing transactions to occur at any time without the limitations of banking hours or geographical restrictions. This global accessibility makes cryptocurrencies particularly useful for international trade, remittances, and online commerce.

In addition, cryptocurrencies have created new investment opportunities. Digital assets have attracted investors worldwide due to their potential for high returns and their ability to diversify investment portfolios. Many individuals view cryptocurrencies as an emerging asset class that may complement traditional investments such as stocks, bonds, and commodities.

Overall, the benefits of cryptocurrency extend beyond simple digital payments. They include improved transaction efficiency, enhanced transparency, financial independence, technological innovation, and expanded investment possibilities. These advantages have played a major role in driving the rapid adoption of cryptocurrencies across global financial markets.

Financial Inclusion

Financial inclusion refers to the ability of individuals and businesses to access affordable and reliable financial services such as banking, credit, payments, and savings. Despite the global expansion of modern banking systems, a large portion of the world's population remains excluded from formal financial institutions. According to international development organizations, billions of people do not have access to basic banking services due to factors such as geographic isolation, high service costs, lack of documentation, and economic inequality.

Cryptocurrency has the potential to address many of these barriers by providing a decentralized financial system that operates independently of traditional banking infrastructure. Because cryptocurrency networks function through the internet, individuals can participate in financial activities using only a smartphone or computer with internet connectivity.

In addition, decentralized financial platforms have introduced alternative financial services such as lending, borrowing, and savings without the need for banks. These services, often referred to as decentralized finance (DeFi), operate through blockchain-based smart contracts. DeFi platforms enable users to access financial tools that were previously limited to those with established banking relationships.

Another important aspect of financial inclusion is economic empowerment. By giving individuals direct control over their financial assets, cryptocurrencies can help people participate more actively in economic activities such as online commerce, freelance work, and digital entrepreneurship. In developing economies, this access to digital financial tools may support small businesses and promote local economic development

Risks and Volatility

Despite the many advantages associated with cryptocurrencies, one of their most significant challenges is the high level of market volatility. Cryptocurrency prices are known to fluctuate dramatically over short periods of time, which can create both opportunities and risks for investors and users. Unlike traditional currencies that are often stabilized by central banks and government monetary policies, most cryptocurrencies are driven primarily by market supply and demand.

This volatility is influenced by several factors, including market speculation, technological developments, regulatory announcements, and changes in investor sentiment. Because cryptocurrency markets operate globally and continuously, prices can respond rapidly to news events or shifts in economic expectations. As a result, the value of a digital asset can rise or fall significantly within a short timeframe.

Market manipulation is also a potential concern. Because some cryptocurrency markets have lower levels of oversight compared with traditional financial exchanges, certain actors may attempt to influence prices through coordinated trading strategies or misleading information. Such activities can increase uncertainty and reduce confidence among investors.

Volatility also affects the practical use of cryptocurrencies as a medium of exchange. For a currency to function effectively in everyday transactions, its value should remain relatively stable. When cryptocurrency prices fluctuate significantly, businesses and consumers may hesitate to use them for payments because the value of the transaction could change quickly.

Security Issues

Security is a fundamental aspect of cryptocurrency systems, yet it also represents one of their most complex challenges. Cryptocurrencies rely on advanced cryptographic algorithms and decentralized networks to protect transaction data and prevent unauthorized access. While blockchain technology itself is generally considered highly secure, vulnerabilities often arise in the surrounding infrastructure, such as exchanges, wallets, and user practices.

One of the primary security concerns in the cryptocurrency ecosystem is hacking. Cryptocurrency exchanges, which function as platforms for buying, selling, and storing digital assets, have occasionally been targeted by cybercriminals

Phishing attacks and fraudulent schemes also pose significant threats to cryptocurrency users. Cybercriminals may create fake websites, deceptive emails, or fraudulent investment opportunities designed to trick individuals into revealing their private keys or transferring funds. Because cryptocurrency transactions are irreversible, victims of these scams often have limited options for recovering their assets.

Smart contract vulnerabilities present another security challenge. Smart contracts are automated programs that execute transactions on blockchain networks. If a smart contract contains programming errors or design flaws, attackers may exploit these weaknesses to manipulate transactions or withdraw funds illegally. Several high-profile incidents in decentralized finance platforms have demonstrated how coding vulnerabilities can result in significant financial losses.

Environmental Concerns

The environmental impact of cryptocurrency has become an important topic in discussions about the sustainability of digital financial technologies. Certain blockchain networks, particularly those that rely on a consensus mechanism known as Proof of Work (PoW), require large amounts of computational power to verify transactions and maintain network security. This process, commonly referred to as mining, involves specialized computer hardware that competes to solve complex mathematical problems.

Mining operations consume significant amounts of electricity because thousands of machines operate continuously to maintain the network. As the popularity of cryptocurrencies has increased, the demand for mining activities has expanded, raising concerns about energy consumption and carbon emissions.

Environmental concerns have prompted researchers and blockchain developers to explore alternative consensus mechanisms that require less energy. One such approach is Proof of Stake (PoS), which selects validators based on the amount of cryptocurrency they hold and are willing to lock as collateral. Because PoS does not rely on energy-intensive calculations, it can significantly reduce electricity consumption while still maintaining network security.

Some blockchain networks have already transitioned from Proof of Work to more energy-efficient systems. For example, the Ethereum network implemented a major upgrade that replaced its mining-based mechanism with Proof of Stake, dramatically reducing its energy requirements. This transition demonstrates how technological innovation can address sustainability challenges within the cryptocurrency industry.

Future of Cryptocurrency

The future of cryptocurrency represents one of the most significant developments in the evolution of global financial systems. Since the introduction of Bitcoin in 2009, digital currencies have grown from a niche technological experiment into a global financial phenomenon that attracts governments, corporations, investors, and technology innovators. Cryptocurrencies are no longer viewed solely as speculative digital assets; they are increasingly being recognized as part of a broader transformation in the way money, financial services, and digital infrastructure operate.

The emergence of CBDCs demonstrates that digital currency technology is influencing the future design of national monetary systems.

At the global level, cryptocurrencies have the potential to reshape international financial networks by enabling faster cross-border transactions, reducing reliance on traditional intermediaries, and increasing financial access for individuals and businesses. However, this transformation also raises important questions related to regulation, technological sustainability, cybersecurity, and economic stability.

One of the most important indicators of the future growth of cryptocurrency is its increasing adoption by businesses. In the early years of digital currencies, cryptocurrencies were primarily used by technology enthusiasts and early investors. However, as blockchain technology matured and public awareness expanded, companies across many industries began exploring how cryptocurrencies could improve financial operations, payment systems, and digital services.

Businesses are particularly interested in cryptocurrencies because they can facilitate faster and more efficient transactions. Traditional payment systems often involve multiple intermediaries such as banks, payment processors, and credit card networks. Each intermediary introduces transaction fees and processing delays.

Some companies have already integrated cryptocurrency payments into their platforms. Online retailers, technology companies, and digital service providers increasingly accept cryptocurrencies as an alternative payment method. Payment service providers are also developing tools that allow merchants to accept cryptocurrency while automatically converting it into traditional currencies if needed.

Beyond payments, blockchain technology offers additional opportunities for businesses. Companies can use blockchain systems to improve supply chain transparency, verify product authenticity, and manage digital assets more efficiently. Smart contracts can automate agreements between business partners, reducing administrative costs and minimizing the need for manual verification processes.

Central Bank Digital Currencies (CBDC)

Central Bank Digital Currencies (CBDCs) represent one of the most significant developments influenced by the rise of cryptocurrencies. A CBDC is a digital form of a country's national currency issued and regulated by its central bank. Unlike decentralized cryptocurrencies such as Bitcoin, which operate independently of government control, CBDCs are fully backed by the state and function as legal tender.

The growing interest in CBDCs reflects the recognition by governments that digital payment technologies are transforming financial systems. Many central banks are exploring how digital currencies could improve the efficiency of payment systems, reduce transaction costs, and enhance financial inclusion. By providing a digital alternative to physical cash, CBDCs could allow individuals and businesses to conduct transactions quickly and securely through electronic platforms.

CBDCs may also provide governments with greater visibility into financial transactions, which can help combat illegal activities such as money laundering and tax evasion. Because CBDC transactions can be recorded digitally, authorities may have improved tools for monitoring financial flows while still implementing privacy protections for users.

Another reason for CBDC development is the increasing popularity of private cryptocurrencies and stablecoins. Governments are concerned that privately issued digital currencies could weaken monetary policy or reduce the effectiveness of national financial regulations. By issuing their own digital currencies, central banks can maintain control over monetary systems while adopting new technological capabilities.

Cryptocurrencies have the potential to influence the global economy in several significant ways. As digital financial technologies continue to expand, they may reshape international trade, financial services, and the movement of capital across borders. The decentralized nature of cryptocurrencies allows transactions to occur directly between participants without the need for centralized intermediaries, which could transform traditional financial structures.

One of the most notable economic impacts of cryptocurrency is the improvement of cross-border payments. International money transfers through traditional banking systems often involve high fees and lengthy settlement times. Cryptocurrency networks enable faster and more affordable global transactions, which can benefit businesses engaged in international trade as well as individuals sending remittances to family members in other countries.

Another potential economic effect is the creation of new digital industries and employment opportunities. The development of blockchain infrastructure, cryptocurrency exchanges, digital asset management services, and decentralized financial platforms has created an entirely new sector within the global technology economy. Entrepreneurs, software developers, cybersecurity specialists, and financial analysts are increasingly participating in this emerging industry.

In addition, cryptocurrencies could influence the role of national currencies in global finance. Some analysts suggest that widely adopted digital currencies might reduce reliance on traditional reserve currencies in certain contexts. However, this possibility remains uncertain because government policies and regulatory frameworks will play a major role in determining how cryptocurrencies interact with existing financial systems.

The future development of cryptocurrency is closely connected to technological innovation within blockchain ecosystems. As digital currencies evolve, researchers and developers are continuously working to improve the scalability, efficiency, and functionality of blockchain networks. These technological advancements will determine how effectively cryptocurrencies can support large-scale financial systems and digital services.

One major area of innovation is blockchain scalability. Early cryptocurrency networks were designed with strong security and decentralization in mind, but they often faced limitations in processing large numbers of transactions. New technologies such as layer-two scaling solutions, sidechains, and improved consensus mechanisms are being developed to increase transaction capacity while maintaining network security.

Interoperability between different blockchain networks is also an important focus. Currently, many blockchain platforms operate independently, which can limit the transfer of assets and data across systems. New protocols are being developed to allow different blockchain networks to communicate and exchange information more efficiently. This interoperability could create a more integrated digital financial ecosystem.

Artificial intelligence and blockchain technology may also converge in the future. AI systems could be used to analyze blockchain data, improve fraud detection, and optimize financial decision-making. At the same time, blockchain could provide secure data environments that support decentralized AI applications.

Challenges Ahead

Despite the rapid growth of cryptocurrencies, several challenges must be addressed to ensure their long-term success and stability. These challenges involve technological limitations, regulatory uncertainties, market volatility, and concerns related to security and environmental sustainability.

One of the most significant challenges is regulatory clarity. Governments around the world are still developing policies to govern cryptocurrency markets. Different countries have adopted varying approaches, ranging from supportive innovation policies to strict restrictions on digital asset activities. The lack of consistent international regulation can create uncertainty for businesses and investors operating in global cryptocurrency markets.

Market volatility also presents a challenge for the widespread adoption of cryptocurrencies. Large fluctuations in digital asset prices can discourage businesses from accepting cryptocurrencies as payment and may increase financial risk for investors. The development of more stable digital asset models and improved market infrastructure may help reduce these concerns over time.

Scalability issues also remain an obstacle for some blockchain networks. As the number of users increases, networks must be capable of processing large transaction volumes without compromising speed or efficiency. Continued technological innovation will be necessary to ensure that blockchain systems can support global financial activity.

Finally, environmental sustainability remains an important issue for certain cryptocurrency networks that rely on energy-intensive mining processes. Transitioning toward more energy-efficient consensus mechanisms and integrating renewable energy sources will be essential for addressing environmental concerns.

Conclusion

Cryptocurrency has evolved from a technological experiment into a powerful force shaping the future of digital finance. Over the past decade, blockchain-based currencies have introduced new possibilities for secure, decentralized, and efficient financial systems. As adoption continues to grow, cryptocurrencies are increasingly influencing the structure of global financial markets, business operations, and digital economic activities.

The future of cryptocurrency will be strongly influenced by several key developments. Increasing adoption by businesses and financial institutions suggests that digital currencies may become integrated into everyday economic transactions. At the same time, the emergence of Central Bank Digital Currencies indicates that governments recognize the transformative potential of digital money and are actively exploring ways to incorporate it into national financial systems.

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Thank You