L37: Lending Protocols

Module E: DeFi Ecosystem

Blockchain & Cryptocurrency

December 2025

Learning Objectives

- Explain how DeFi lending protocols work (Aave, Compound)
- Analyze overcollateralization and its necessity
- Calculate health factors and liquidation thresholds
- Explore interest rate models (utilization-based)
- Compare DeFi lending to traditional finance

The Problem: How do we lend without credit scores?

The Challenge
How can we create a lending system without banks, credit scores, or identity verification? Traditional finance relies on centralized institutions to assess borrower creditworthiness and enforce repayment through legal systems.

Why It Matters

- Without credit infrastructure, billions are excluded from lending markets
- Traditional lending requires KYC, credit history, geographic presence, and legal recourse

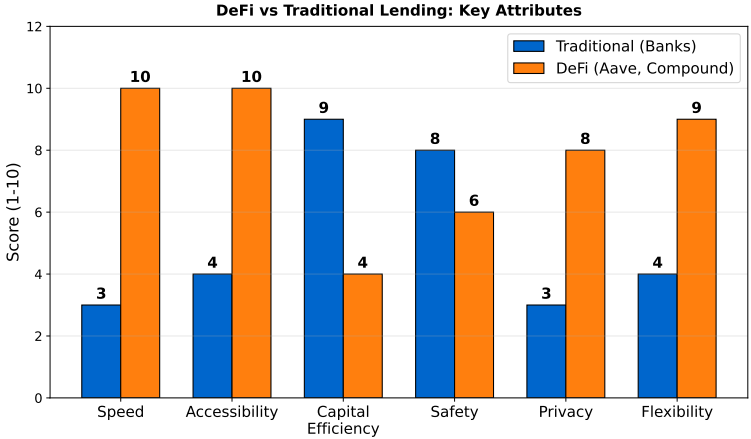
What We Need

- System that eliminates default risk without identity
- Automated liquidation mechanism that doesn't rely on courts
- Algorithmic interest rates that balance supply and demand

The Cryptoeconomics Question
Creating systems with desired properties: How do we align incentives so borrowers never default?

Today's lesson: How overcollateralized lending protocols address this challenge

DeFi vs Traditional Lending



DeFi trades capital efficiency for accessibility and speed

Traditional vs DeFi Lending

Traditional Lending

- Credit checks, KYC required
- Undercollateralized possible
- Long approval process
- Geographic restrictions

DeFi Lending

- No credit checks
- Overcollateralized only
- Instant approval
- Global access, 24/7

Key Trade-off: DeFi accessibility vs. capital efficiency (must lock more than you borrow).

How DeFi Lending Works

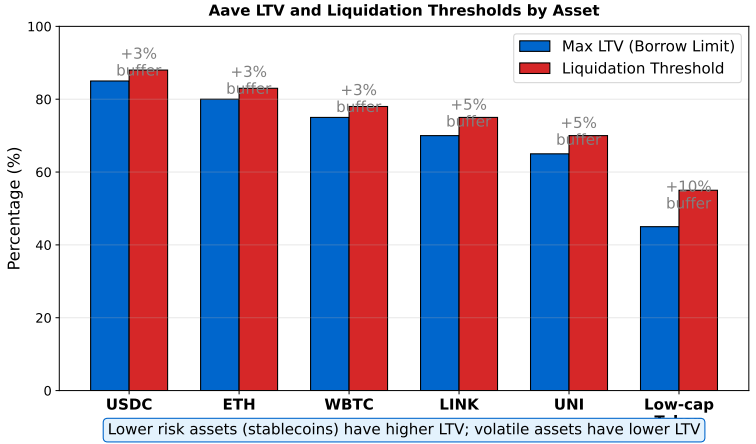
Core Mechanism:

1. **Lenders (Suppliers):** Deposit assets, earn interest (APY varies)
2. **Borrowers:** Deposit collateral, borrow up to LTV%, pay interest
3. **Protocol:** Matches via smart contracts, manages liquidations

Example: Borrowing on Aave

- Deposit 10 ETH ($20,000), receive aETH tokens
- ETH has 80% LTV: max borrow = $16,000
- Borrow $10,000 USDC (safe margin)
- Pay 5% APY on debt, earn 2% on collateral

LTV and Liquidation Thresholds



Buffer between LTV and liquidation threshold protects against immediate liquidation

Loan-to-Value (LTV) Explained

Definition:

$$\text{LTV} = \frac{\text{Borrowed Value}}{\text{Collateral Value}} \times 100\%$$

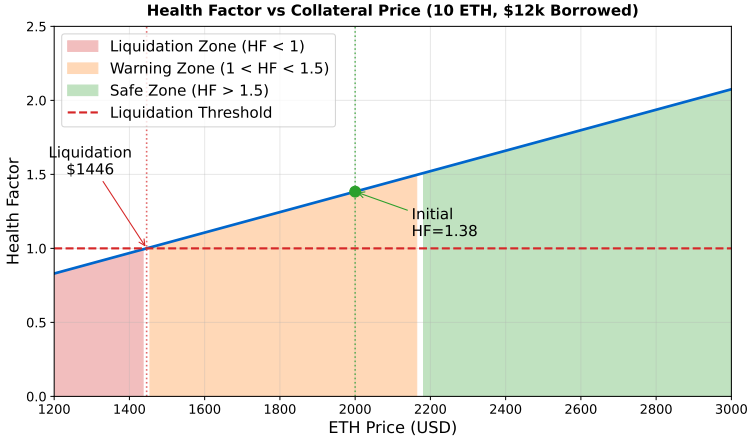
Why Different LTVs?

- Volatile assets = lower LTV (more buffer for price swings)
- Stable assets = higher LTV (minimal price risk)

Example Calculation:

- Collateral: 10 ETH at \$2,000 = \$20,000
- Borrowed: \$12,000 USDC
- LTV: $\frac{12{,}000}{20{,}000} = 60\%$ (safe, under 80% max)

Health Factor Dynamics



Health factor must stay above 1; monitor closely during volatility

Health Factor Calculation

Formula (Aave):

$$\text{Health Factor} = \frac{\text{Collateral Value} \times \text{Liquidation Threshold}}{\text{Borrowed Value}}$$

Interpretation:

- HF ¿ 1.5: Safe (comfortable buffer)
- HF 1.0-1.5: Warning zone
- HF ¡ 1: Liquidation occurs

Example:

- Collateral: $20,000 (ETH), Borrowed: $12,000
- Liquidation threshold: 83%
- HF $= \frac{20{,}000 \times 0.83}{12{,}000} = 1.38$ (safe)

Liquidation Process

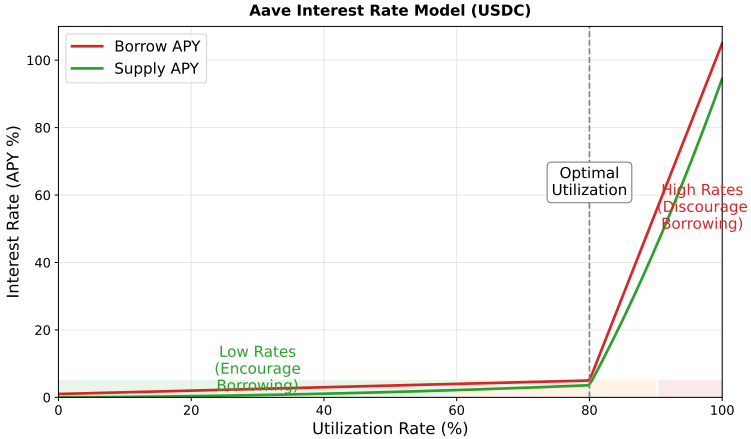
When Health Factor ¡ 1:

1. **Liquidator Bot Detects** unhealthy position
2. **Liquidator Repays** portion of debt (up to 50%)
3. **Liquidator Receives** equivalent collateral + 5-10% bonus
4. **Borrower Loses** liquidation penalty

Example:

- Debt: $12,000, Collateral: $14,460
- Liquidator repays 50% ($6,000), receives $6,300 in ETH
- Borrower loses $300 penalty (5%)

Interest Rate Model



High utilization triggers steep rate increase to prevent liquidity crises

Utilization-Based Interest Rates

Utilization Rate:

$$U = \frac{\text{Total Borrowed}}{\text{Total Supplied}}$$

Rate Behavior:

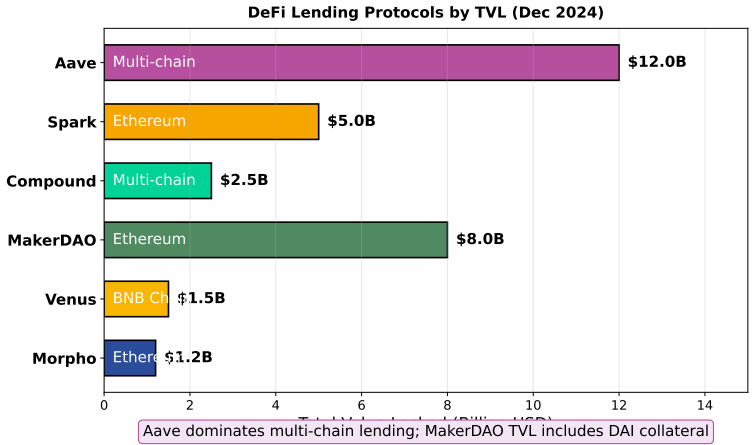
- Low utilization (0-60%): Low rates (encourage borrowing)
- Optimal (80%): Moderate rates (balanced)
- High (¿90%): Very high rates (discourage borrowing)

Supply APY Formula:

$$\text{Supply APY} = \text{Borrow APY} \times U \times (1 - \text{Reserve Factor})$$

Key Insight: Supply APY always lower than borrow APY.

Lending Protocol Market Share



Aave leads through multi-chain expansion; Compound pioneered the model

Aave vs Compound

Aave

- Flash loans (no collateral)
- Stable/variable rate choice
- Credit delegation
- E-Mode for correlated assets
- $31B TVL (Dec 2025), 60%+ DeFi lending market share

Compound

- cTokens (interest-bearing)
- Simpler, fewer features
- Pioneered DeFi lending
- COMP governance token
- $2.5B TVL

Historical Note: Compound launched 2018, Aave 2020. Compound's COMP mining sparked "DeFi Summer" 2020.

Flash Loans

Definition: Borrow any amount without collateral, repay in same transaction.

How It Works:

1. Borrow $1M USDC from Aave
2. Use for arbitrage, collateral swap, or liquidation
3. Repay $1M + 0.09% fee
4. All atomic (succeeds or reverts entirely)

Use Cases:

- Arbitrage across DEXs
- Collateral swaps without closing position
- Self-liquidation to avoid penalty

Risk: Used in many DeFi exploits (oracle manipulation attacks).

Risks in DeFi Lending

1. **Smart Contract Risk**
   - Bugs or exploits (Rari Capital, Cream Finance hacks)
2. **Liquidation Risk**
   - Volatile markets, network congestion prevents adding collateral
3. **Oracle Risk**
   - Price feed manipulation, stale prices
4. **Liquidity Risk**
   - High utilization prevents withdrawals

2022 Lesson: CeFi lenders (Celsius, BlockFi) collapsed; DeFi protocols survived.

Future: Undercollateralized Lending

Current Limitation: Overcollateralization is capital inefficient.

Emerging Solutions:

1. **On-Chain Credit Scores:** Track repayment history (Credora, ARCx)
2. **Real-World Identity:** KYC-linked, legal recourse (Goldfinch, TrueFi)
3. **Social Collateral:** Community vouching (Teller Protocol)

Trade-off: Undercollateralization requires identity or trust, reducing permissionlessness.

Problem Solved? Lending Protocols

The Original Problem

How do we lend without credit scores?

How Lending Protocols Solves It

- **Overcollateralization:** Borrowers deposit more value than they borrow, eliminating default risk entirely
- **Automated liquidation:** Smart contracts enforce liquidation when health factor ¡ 1, no courts needed
- **Algorithmic interest rates:** Utilization-based models adjust rates to balance supply/demand without central authority

Remaining Limitations

- **Capital inefficiency:** Must lock $150 to borrow $100 (vs traditional lending at 20-30% down payment)
- **Liquidation cascades:** Market volatility can trigger mass liquidations, amplifying price drops

Open Questions

- Can undercollateralized DeFi lending work without sacrificing permissionlessness?
- Risk: Identity-based credit systems (Goldfinch, TrueFi) reintroduce centralization and exclusion

Lending protocols solve trustless lending but trade capital efficiency for permissionless access

Summary

Key Takeaways:

- DeFi lending: permissionless but requires overcollateralization
- LTV ratios vary by asset risk (ETH 80%, low-cap 45%)
- Health factor must stay above 1 to avoid liquidation
- Interest rates adjust algorithmically based on utilization
- Flash loans enable zero-collateral borrowing within one tx
- Aave dominates ($31B TVL); Compound pioneered the model
- Future: undercollateralized lending via credit scoring

Next Lecture: Stablecoin Mechanisms.

Questions for Reflection

1. Calculate health factor: $30k collateral, $20k borrowed, 85% liq threshold.
2. Why is overcollateralization necessary in DeFi lending?
3. How do interest rates adjust to prevent bank runs?
4. What risks do flash loans pose to DeFi protocols?
5. Variable or stable rates for 1-year borrow?

Quiz Questions (1–5)

Q1. What is the main difference between traditional lending and DeFi lending?
A) Traditional requires KYC, DeFi doesn't B) Traditional is faster C) DeFi allows undercollateralized loans D) Traditional is 24/7
Answer: A – DeFi lending is permissionless with no KYC, while traditional requires credit checks and identity verification.

Q2. If you deposit 10 ETH worth $20,000 with 80% LTV, what is the maximum you can borrow?
A) $20,000 B) $16,000 C) $10,000 D) $25,000
Answer: B – Maximum borrow = Collateral Value $\times$ LTV = $20,000 $\times$ 0.80 = $16,000.

Q3. What happens when your health factor drops below 1?
A) Interest rate increases B) You get a warning email C) Your position gets liquidated D) Nothing happens
Answer: C – Health factor ¡ 1 triggers liquidation; liquidators repay debt and receive collateral plus a bonus.

Q4. Why do volatile assets like altcoins have lower LTV ratios than stablecoins?
A) Less popular B) Higher price volatility risk C) Lower liquidity D) Regulatory restrictions
Answer: B – Volatile assets need larger buffers (lower LTV) to protect against price swings and prevent immediate liquidations.

Q5. What is the health factor for $30,000 collateral, $20,000 borrowed, 85% liquidation threshold?
A) 1.00 B) 1.28 C) 1.50 D) 0.67
Answer: B – HF = (30,000 $\times$ 0.85) / 20,000 = 25,500 / 20,000 = 1.275 $\approx$ 1.28.

Quiz Questions (6–10)

Q6. What is the liquidation penalty received by liquidators on Aave?
A) 1-2% B) 5-10% C) 15-20% D) 25-30%
Answer: B – Liquidators receive a 5-10% bonus on top of the collateral they claim as incentive for maintaining protocol solvency.

Q7. How is the utilization rate calculated?
A) Total Supplied / Total Borrowed B) Total Borrowed / Total Supplied C) Total Borrowed - Total Supplied D) Interest Rate / LTV
Answer: B – Utilization Rate = Total Borrowed / Total Supplied, measuring what percentage of available liquidity is being used.

Q8. What happens to borrow interest rates when utilization exceeds 90%?
A) They decrease B) They stay constant C) They increase steeply D) Protocol shuts down
Answer: C – High utilization triggers steep rate increases to discourage borrowing and encourage repayment, preventing liquidity crises.

Q9. Which protocol has the largest DeFi lending market share as of December 2025?
A) Compound B) MakerDAO C) Aave D) dYdX
Answer: C – Aave leads with $31B TVL and 60%+ market share through multi-chain expansion and innovative features.

Q10. What unique feature does Aave offer that Compound does not?
A) Interest-bearing tokens B) Flash loans C) Governance token D) Overcollateralized loans
Answer: B – Aave pioneered flash loans (uncollateralized borrowing within one transaction), which Compound does not offer.

Quiz Questions (11–15)

Q11. What must happen for a flash loan to succeed?
A) Collateral must be posted B) Loan must be repaid within same transaction C) Loan duration must be 1 block D) KYC verification
Answer: B – Flash loans are atomic: borrow, use, and repay (plus fee) must all happen in the same transaction or the entire transaction reverts.

Q12. What is the typical flash loan fee on Aave?
A) 0.09% B) 1% C) 5% D) 10%
Answer: A – Aave charges a 0.09% fee on flash loans, making them very capital-efficient for arbitrage and other single-transaction strategies.

Q13. Why is Supply APY always lower than Borrow APY in lending protocols?
A) Protocol keeps the difference as revenue B) Gas costs C) Reserve factor and utilization D) Regulatory requirements
Answer: C – Supply APY = Borrow APY $\times$ Utilization $\times$ (1 - Reserve Factor); the reserve factor and ¡100% utilization ensure supply rates are lower.

Q14. What tokens do lenders receive when depositing assets on Aave?
A) cTokens B) aTokens C) COMP tokens D) LP tokens
Answer: B – Aave issues aTokens (e.g., aETH, aUSDC) that accrue interest in real-time and represent the deposited assets plus earned interest.

Q15. Which event sparked "DeFi Summer" in 2020?
A) Aave launch B) Compound COMP mining C) Uniswap v2 D) Bitcoin halving
Answer: B – Compound's COMP token liquidity mining program in June 2020 sparked explosive DeFi growth known as "DeFi Summer."

Quiz Questions (16–20)

Q16. What is the main risk that flash loans pose to DeFi protocols?
A) High gas costs B) Oracle manipulation attacks C) Regulatory scrutiny D) Network congestion
Answer: B – Flash loans provide large capital for oracle manipulation attacks, allowing attackers to distort price feeds and exploit protocols.

Q17. What is Aave's E-Mode designed for?
A) Emergency shutdowns B) Higher LTV for correlated assets C) Lower gas costs D) Faster liquidations
Answer: B – E-Mode allows higher LTV ratios for highly correlated assets (e.g., ETH-stETH), improving capital efficiency for low-risk pairs.

Q18. What happened to CeFi lenders Celsius and BlockFi in 2022?
A) They merged B) They went public C) They collapsed D) They launched tokens
Answer: C – Both Celsius and BlockFi collapsed in 2022 due to mismanagement and contagion, while DeFi protocols remained operational.

Q19. What is needed for undercollateralized DeFi lending to work?
A) Higher interest rates B) Credit scores or identity systems C) Longer loan terms D) More liquidators
Answer: B – Undercollateralized lending requires reputation, on-chain credit scores, or KYC/identity to enable legal recourse.

Q20. What is the trade-off of introducing identity-based undercollateralized lending?
A) Higher fees B) Slower transactions C) Reduced permissionlessness D) Lower yields
Answer: C – Adding identity or credit requirements reduces DeFi's core benefit of permissionless access, trading accessibility for capital efficiency.