DeFi Lending

The Pawn Shop on the Blockchain

BSc Blockchain, Crypto Economy & NFTs

Digital Finance Program

Follow Priya as she discovers how to borrow money without a credit score.

What you will learn:

Over-collateralization and LTV ratios
Health factor and liquidation mechanics
Interest rate models (the kink curve)
Oracles, flash loans, and what went wrong on Black Thursday

Spring Semester 2026

Contents

1 Meet Priya

Priya's Story

Priya is a third-year BSc Economics student in Mumbai. She won a spot at a blockchain conference in Singapore, but the registration and flights cost $5,000. She goes to her bank.
"We would need proof of income, a credit score, and a co-signer," the loan officer says. "Processing takes two to four weeks."
Priya has no income—she is a student. No credit history. No co-signer available on short notice. The conference is in three weeks.
But Priya has 5 ETH, currently worth $10,000, that she bought during her first blockchain course. She does not want to sell it—she expects ETH to rise. What she needs is a **loan against her ETH**.

2 The Story: The Oldest Lending Model

Priya's Story

Priya's professor suggests an analogy: "Think of a pawn shop. You leave your gold watch as collateral, get cash, and reclaim the watch when you repay. DeFi lending works the same way—except the pawn shop is a smart contract, the watch is your ETH, and the cash is a stablecoin."
Five minutes later, Priya is on Aave. She deposits 5 ETH, borrows 6,000 USDC, and receives the funds in her wallet. No paperwork. No credit check. No waiting.
But Priya notices a number on her dashboard: **Health Factor: 1.33**. "What does that mean?" she wonders. "And what happens if it drops below 1?"

Definition: Over-Collateralization

Over-collateralization means a borrower must deposit collateral worth *more* than the amount borrowed. If the collateral-to-debt ratio falls below a threshold, the position is liquidated. This replaces credit scoring: the protocol does not care who you are, only what you pledge.

Explain Like I'm 5

Leave $1.50 to borrow $1. If your collateral drops to $1.20, the pawn shop sells some of it to cover the loan before you owe more than you pledged.

Definition: Loan-to-Value (LTV)

LTV is the maximum percentage of collateral value that can be borrowed.
For ETH on Aave: LTV = 75%. Deposit $10,000 of ETH → borrow up to $7,500.

Definition: Health Factor (HF)

The **health factor** measures how safe a position is:

$$\text{HF} = \frac{\text{Collateral Value} \times \text{Liquidation Threshold}}{\text{Total Debt}}$$

- HF > 1: position is safe.
- HF $= 1$: position is at the liquidation boundary.

- HF < 1: position can be liquidated.

For ETH on Aave: liquidation threshold = 80%.

3 Key Concepts

3.1 Why Credit Scores Fail for Strangers

Before diving into mechanics, Priya writes a short note about why her bank could not help her.

Definition: The Credit Paradox

Traditional banks use **credit scoring** to assess borrower risk: income, employment, credit history, assets. But:

- Young borrowers have no history to score.
- Students and freelancers have irregular income.
- Cross-border borrowers' records are not portable.
- Underbanked populations are excluded entirely.

The credit system, optimized for a narrow definition of "prime" borrowers, excludes billions of people globally. DeFi lending bypasses the scoring problem by requiring collateral—but this creates a different exclusion: it helps only those who already have crypto assets.

Explain Like I'm 5

A bank asks "who are you?" before lending. A DeFi protocol asks "what can you leave as security?" Neither question works for everyone. DeFi lending helps people who are *asset-rich but income-poor*; banks help people who are *income-rich with good reputation*.

3.2 Over-Collateralization in Practice

Worked Example: Priya's Loan

Parameter	Value
Collateral	5 ETH at \$2,000 = \$10,000
LTV (ETH on Aave)	75%
Max borrow	\$10,000 × 0.75 = \$7,500
Priya borrows	\$6,000 USDC (conservative)
Liquidation threshold	80%
Health factor	(\$10,000 × 0.80)/\$6,000 = 1.33

Priya borrows less than the maximum to keep a safety buffer.

3.3 Health Factor Deep Dive

Worked Example: What Happens When ETH Falls?

Priya's position: 5 ETH collateral, \$6,000 USDC debt.

ETH Price	Collateral	HF	Status
\$2,000	\$10,000	1.33	Safe
\$1,800	\$9,000	1.20	Caution
\$1,500	\$7,500	1.00	Liquidation boundary
\$1,200	\$6,000	0.80	Liquidated

At \$1,500/ETH, Priya's HF hits 1.00 and liquidators can seize part of her collateral.

3.4 Liquidation

Definition: Liquidation

When HF < 1, anyone can repay a portion of the borrower's debt and receive the corresponding collateral *plus a bonus* (the liquidation penalty). On Aave, the penalty for ETH is 5%. This incentivizes liquidators to act quickly, keeping the protocol solvent.

Important Caveat

Liquidation is not partial debt forgiveness—it is an emergency sale of your collateral at a discount. The borrower loses the 5% penalty and may still owe remaining debt.

3.5 Oracles

Definition: Price Oracle

A **price oracle** is an external data feed that tells the smart contract the current market price of an asset. DeFi lending protocols use oracles (primarily Chainlink) to calculate collateral values and health factors in real time.

Explain Like I'm 5

A smart contract cannot browse the internet. The oracle is the messenger who runs to the market, checks the price of ETH, and reports back. If the messenger lies—or is slow—the whole system breaks.

3.6 Interest Rate Model (The Kink Curve)

Definition: Kink Interest Rate Model

DeFi lending protocols use a two-slope interest rate model based on **utilization** (the percentage of deposited funds currently borrowed):

- **Below the kink** ($U < U_{\text{optimal}}$): rates rise slowly to encourage borrowing.
- **Above the kink** ($U > U_{\text{optimal}}$): rates spike sharply to discourage borrowing and attract new deposits.

Typical kink point: $U_{\text{optimal}} = 80\%$.

Worked Example: Interest Rates at Different Utilizations

Utilization	Borrow Rate	Supply Rate
20%	1.5%	0.3%
50%	3.0%	1.5%
80% (kink)	5.0%	4.0%
90%	25.0%	22.5%
95%	50.0%	47.5%

Above the kink, rates escalate rapidly. This mechanism prevents the pool from being fully drained.

3.7 Cross-Collateral and Multi-Asset Positions

Definition: Cross-Collateral

Cross-collateral mode allows borrowers to pledge multiple asset types simultaneously. The protocol calculates a weighted health factor across the entire position. Aave, Compound V3, and Morpho all support variations.

Worked Example: Priya's Cross-Collateral Position

Priya deposits:
- 5 ETH ($10,000, LTV 75%, threshold 80%)
- 20,000 USDC ($20,000, LTV 85%, threshold 90%)

Effective max borrow: $(10{,}000 \times 0.75) + (20{,}000 \times 0.85) = \$7{,}500 + \$17{,}000 = \$24{,}500$.
She borrows $15,000 DAI. Weighted health factor:

$$\text{HF} = \frac{(10{,}000 \times 0.80) + (20{,}000 \times 0.90)}{15{,}000} = \frac{8{,}000 + 18{,}000}{15{,}000} = 1.73$$

Cross-collateral is more capital efficient than single-asset lending but requires understanding multi-asset risk.

3.8 Supply-Side Risks

Definition: Supplier Risks

Users who *supply* assets to a lending pool also bear risks:
- **Smart contract risk** – bug in protocol code.
- **Liquidity risk** – if utilization is 100%, you cannot withdraw until borrowers repay.
- **Bad debt risk** – if liquidations fail (Black Thursday style), the protocol may have bad debt absorbed by suppliers.
- **Interest rate risk** – rates fluctuate; the yield you signed up for may not last.

Important Caveat

Suppliers often focus on headline APY but ignore liquidity risk. In 2022, many Celsius users could not withdraw because the platform had lent their funds out without maintaining sufficient reserves for redemptions. DeFi protocols cannot "freeze withdrawals"—but during high utilization, they can simply have no liquidity available.

3.9 Flash Loans

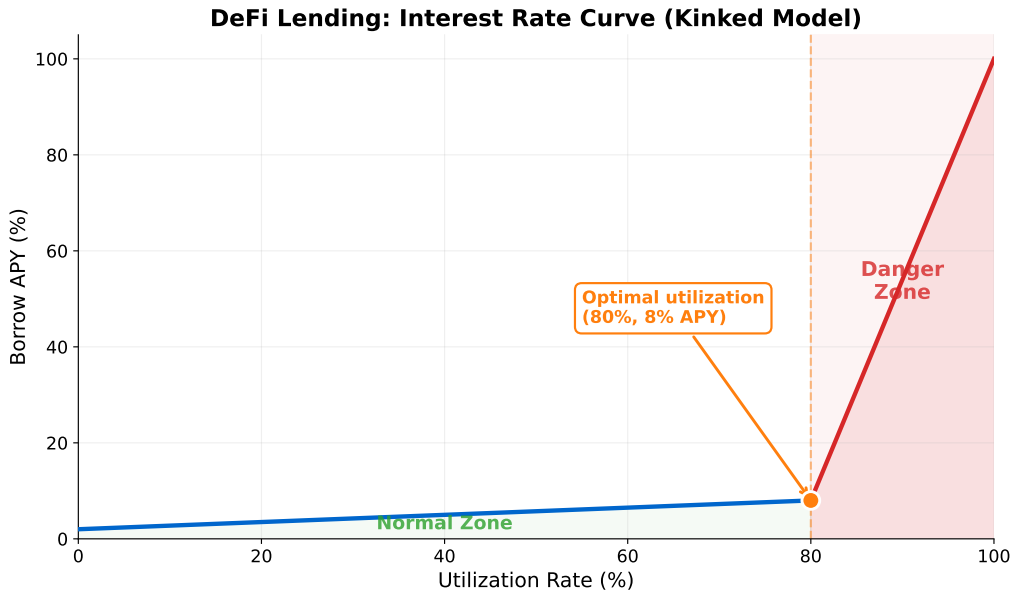
Definition: Flash Loan

A **flash loan** is an uncollateralized loan that must be borrowed and repaid within a *single blockchain transaction* (roughly 12 seconds on Ethereum). If the borrower cannot repay, the entire transaction reverts as if it never happened.

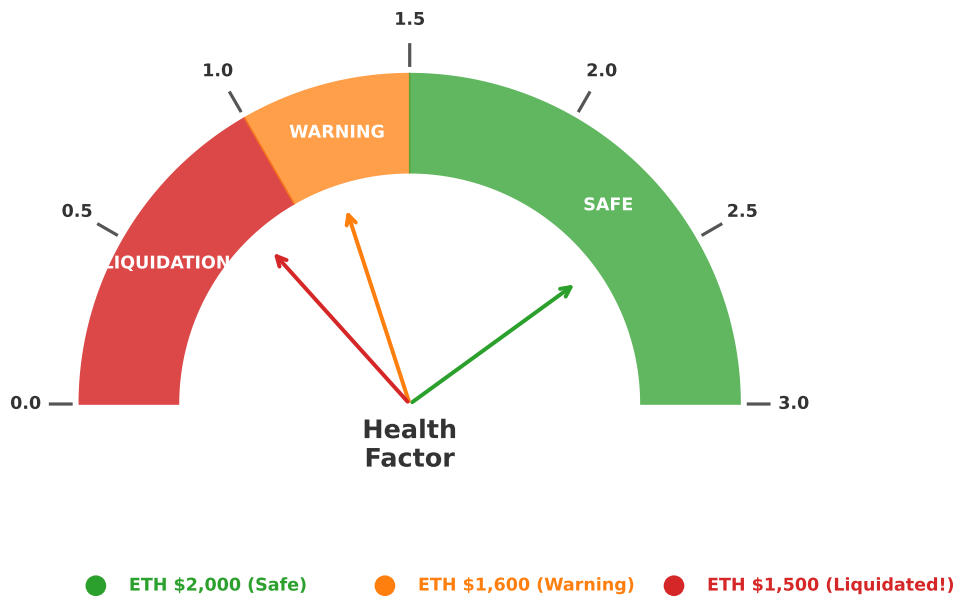
Explain Like I'm 5

Borrow millions of dollars for 12 seconds. If you cannot pay it back by the end of those 12 seconds, time rewinds and nothing happened. The blockchain's atomic transactions make this possible.

Lending Interest Rate Curve (Kink Model)



Health Factor Visualization



Self-Assessment Checkpoint

Can you calculate the health factor for a given position? Can you find the ETH price at which liquidation triggers? Can you explain why the kink exists in the interest rate model? If all three: continue.

4 How It Works: The Math

Priya's Story

Priya wants to understand the exact numbers behind her loan so she can set price alerts on her phone.

4.1 Core Formulas

Formula: Maximum Borrow Amount

$$\text{Max Borrow} = \text{Collateral Value} \times \text{LTV}$$

For Priya: $\$10{,}000 \times 0.75 = \$7{,}500$.

Formula: Health Factor

$$\text{HF} = \frac{\text{Collateral Value} \times \text{Liquidation Threshold}}{\text{Total Debt}}$$

For Priya at deposit: $\frac{\$10{,}000 \times 0.80}{\$6{,}000} = 1.33$.

Formula: Liquidation Price

Solving HF = 1 for the ETH price P:

$$P_{\text{liq}} = \frac{\text{Debt}}{\text{ETH Amount} \times \text{Liquidation Threshold}}$$

For Priya: $P_{\text{liq}} = \frac{\$6{,}000}{5 \times 0.80} = \$1{,}500$.

4.2 Full Worked Scenario

Worked Example: From Deposit to Liquidation

Step 1: Deposit. Priya deposits 10 ETH at \$2,000/ETH = \$20,000 collateral.
Step 2: Borrow. She borrows \$12,000 USDC.
HF = (\$20,000 × 0.80)/\$12,000 = 1.33.
Step 3: Price drops to \$1,500.
Collateral = 10 × \$1,500 = \$15,000.
HF = (\$15,000 × 0.80)/\$12,000 = 1.00. Liquidation boundary.
Step 4: Liquidation. A liquidator repays 50% of debt (\$6,000) and receives:

$$\text{Collateral seized} = \frac{\$6{,}000}{P_{\text{ETH}}} \times (1 + 0.05) = \frac{\$6{,}000}{\$1{,}500} \times 1.05 = 4.2 \text{ ETH}$$

After liquidation: Priya has 5.8 ETH collateral, \$6,000 remaining debt.
New HF = (\$8,700 × 0.80)/\$6,000 = 1.16. Position is stable again, but Priya lost 4.2 ETH (the 5% penalty cost her 0.2 ETH).

Key Takeaway

DeFi lending replaces credit scores with collateral. The health factor is your lifeline. Know your liquidation price. Set alerts. The protocol is merciless—it liquidates at HF = 1 regardless of your intentions.

4.3 The Liquidator Economy

Definition: Liquidator Bot

A **liquidator** is an automated bot that monitors DeFi lending positions and executes liquidations the instant a position's health factor drops below 1. Liquidators compete on speed: the first bot to submit a valid liquidation transaction wins the penalty bonus.

Worked Example: Liquidator Profit

A position becomes liquidatable with \$100,000 of debt and \$101,000 of collateral (liquidation threshold crossed).

- Liquidator repays 50% of debt = \$50,000.
- Receives collateral + 5% bonus = \$52,500 worth of ETH.
- Swaps ETH back to stablecoin on Uniswap (may lose 0.3% to slippage): \$52,340.
- Gas cost for the transaction: \$50–\$500 depending on congestion.
- Gross profit: \$52,340 − \$50,000 − \$200 = \$2,140.

Liquidators must outbid each other on gas. During a cascade, they can pay \$5,000+ in gas per

transaction, bidding via **priority fees**.

Definition: Liquidation Auction

Some protocols (MakerDAO/Sky) use **auction-based liquidations** instead of direct seizure. The collateral is auctioned to the highest bidder. This is more capital-efficient but slower—during Black Thursday, auctions failed because no bidders appeared.

4.4 Interest Rate Mechanics

Formula: Supply APY from Borrow APY

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

The reserve factor (typically 10–25%) is the protocol's cut of interest income.

Worked Example: Supply Rate Calculation

A pool has 80% utilization, 5% borrow APY, and a 20% reserve factor.

$$\text{Supply APY} = 5\% \times 0.80 \times (1 - 0.20) = 5\% \times 0.80 \times 0.80 = 3.2\%$$

Suppliers earn 3.2% while borrowers pay 5%. The 1.8% spread is divided between the protocol treasury (20%) and idle liquidity (20% of the pool is not earning).

4.5 Variable vs. Stable Rates

Definition: Variable vs. Stable Rates

Aave offers two borrowing modes:

- **Variable rate** – The interest rate changes every block based on utilization. Cheaper on average but unpredictable.
- **Stable rate** – The rate is fixed at the time of borrow but can be "rebalanced" by the protocol if market conditions diverge significantly. Predictable but typically higher.

Worked Example: Mode Comparison

Priya borrows $10,000 for 6 months.

- **Variable mode:** Rate ranges from 3% to 8%. Average 5%. Cost: $250.
- **Stable mode:** Fixed at 6.5%. Cost: $325.

Variable is cheaper if utilization stays low; stable is safer if Priya expects a liquidity crunch that would spike variable rates above 6.5%.

5 Real-World Cases

5.1 Leveraged Strategies (and their dangers)

Definition: Recursive Borrowing (Looping)

Recursive borrowing ("looping") amplifies exposure by repeatedly using borrowed assets as new collateral. Deposit ETH, borrow DAI, swap DAI to more ETH, re-deposit, borrow more DAI—repeat. Each loop increases both yield and liquidation risk.

Worked Example: A Looping Strategy

Priya starts with 10 ETH ($20,000). She wants amplified ETH exposure.
- Loop 1: Deposit 10 ETH, borrow $15,000 (75% LTV), buy 7.5 ETH. Now has 17.5 ETH.
- Loop 2: Deposit 7.5 more ETH, borrow $11,250 more, buy 5.6 ETH. Now has 23.1 ETH.
- Loop 3: Deposit 5.6 more ETH, borrow $8,400 more, buy 4.2 ETH. Now has 27.3 ETH.

Total exposure: 27.3 ETH on $20,000 of initial capital. Leverage: 2.73x.
Risk: A 10% ETH drop now produces a 27% loss on Priya's equity. A 25% drop triggers cascading liquidations that can wipe out her entire position.

Important Caveat

Leverage cuts both ways. Looping strategies were responsible for many individual blowups in 2022 as ETH fell from $3,500 to $900. Never loop more than you can afford to lose entirely.

Historical Case Study: Black Thursday (March 12, 2020)

On March 12, 2020, ETH crashed 43% in 24 hours (from $194 to $111). The MakerDAO system (which uses ETH collateral to back the DAI stablecoin) was overwhelmed:
- Ethereum network congestion caused oracle price updates to lag.
- Liquidation auctions ran with zero bids because keepers could not get transactions through.
- A liquidator won $8.32M of collateral for $0 (zero-bid liquidations).
- MakerDAO had to mint and auction MKR tokens to cover the shortfall.

Lesson: Liquidation mechanisms depend on network capacity. If the blockchain is congested, the entire system can seize up.

Historical Case Study: Mango Markets Oracle Attack (Oct 2022)

Avraham Eisenberg manipulated the price oracle of Mango Markets (a Solana-based lending protocol):
- He bought a large MNGO perpetual position, then artificially pumped the MNGO spot price.
- The inflated oracle price made his collateral appear more valuable.
- He borrowed $117M against the inflated collateral and withdrew it.
- Eisenberg argued it was "a profitable trading strategy." He was later arrested and convicted of fraud.

Lesson: Oracle security is paramount. A single manipulable price feed can drain an entire protocol.

Historical Case Study: Euler Finance (March 13, 2023)

An attacker exploited a logic flaw in Euler Finance's donation mechanism using flash loans:
- Borrowed $30M via flash loan.
- Used a "donate" function to create an artificial bad debt.
- Exploited the accounting error to extract $197M.
- Euler had been audited multiple times prior to the attack.
- The attacker later returned the funds after negotiations.

Lesson: Audits reduce risk but cannot guarantee safety. Novel interactions between features create unexpected attack surfaces.

6 What Can Go Wrong

Priya's Story

Priya reads about Black Thursday and sets three price alerts on her phone: at HF = 1.5, 1.2, and 1.05. She never wants to be caught off guard.

Important Caveat

Liquidation cascades. When many positions are liquidated simultaneously, the sold collateral drives prices down further, triggering more liquidations. This positive feedback loop can crash asset prices far below fundamental value.

Important Caveat

Oracle failure. If the oracle reports a stale or manipulated price, positions may be liquidated unfairly (or not liquidated when they should be). Oracle attacks have caused hundreds of millions in losses across DeFi.

Common Misconception: "DeFi lending is like a savings account"

Supplying assets to a lending pool earns interest, but it is *not* a savings account. There is no deposit insurance. If the protocol is hacked, your deposits can be lost. The interest rate fluctuates with utilization. And in extreme congestion, you may not be able to withdraw immediately.

Common Misconception: "You cannot lose money if you borrow less than your collateral"

You can absolutely lose money. If your collateral drops in value and you are liquidated, you lose the liquidation penalty (5%) plus any remaining debt. If ETH falls 50% and you are liquidated, you could end up with significantly less value than if you had simply sold the ETH at the start.

7 The Cryptoeconomics Lens

Before applying the six questions, Priya thinks about the human side of collateralized lending.

Definition: The Skin-in-the-Game Principle

DeFi lending's core insight is the **skin-in-the-game principle**: if a borrower stands to lose more (the collateral) than the lender stands to lose (the loan), both parties' incentives align. The borrower has strong motivation to repay and avoid liquidation. The lender has the collateral as a fallback.

This principle is ancient—pawn shops have used it for centuries. DeFi's innovation is automating it. No physical custody, no human judgment, no hours of operation. A smart contract enforces the principle 24/7 for anyone with an internet connection.

Explain Like I'm 5

In traditional banking, the bank takes the risk because the borrower has no stake. In DeFi, the borrower has all the stake (their collateral), and the protocol just follows rules. The rules have no emotions, no favoritism, and no flexibility—which is both a strength and a weakness.

Cryptoeconomics Lens

Apply the six cryptoeconomics questions to DeFi lending:

1. **PROBLEM:** Traditional lending requires credit scores, identity verification, and intermediaries. DeFi replaces all three with over-collateralization and smart contracts.
2. **INCENTIVES:** Lenders earn interest (supply rate). Borrowers pay interest but access liquidity without selling assets. Liquidators earn a 5% bonus for keeping the system solvent. Each participant acts in self-interest, yet the system remains healthy.
3. **BENEFITS / COSTS:** Borrowers gain instant, permissionless loans; they pay interest and IL risk. Lenders earn yield; they bear smart contract risk. Liquidators earn penalties; they bear execution risk.
4. **FAILURE MODE:** Black Thursday showed cascading liquidations during congestion. Mango Markets showed oracle manipulation. Euler showed that even audited code can be exploited. The system assumes liquid markets, functional oracles, and bug-free code—all of which can fail simultaneously.
5. **DESIGN:** Fixed-rate vs. variable-rate lending, single-asset vs. cross-collateral, pool-based (Aave) vs. peer-to-peer (Morpho). Each design choice trades off capital efficiency, risk, and complexity.
6. **ALTERNATIVES:** Under-collateralized lending with reputation (TrueFi), real-world asset tokenization (Centrifuge), and credit delegation could expand DeFi lending beyond crypto-native users.

8 Deep Dive: Risk Management for Borrowers

Priya wants a practical framework for managing her position. She develops a step-by-step risk management protocol.

8.1 Step 1: Set Your Liquidation Price

Worked Example: Liquidation Price Worksheet

Item	Priya's Position
Collateral (ETH)	5
Deposit price	\$2,000/ETH
Liquidation threshold	80%
Debt (USDC)	\$6,000
Liquidation price	\$1,500/ETH
Buffer to liquidation	25%

Rule of thumb: a 25% buffer is risky in volatile markets. A 50% buffer is comfortable. A 100% buffer is ultra-safe but capital-inefficient.

8.2 Step 2: Set Alerts at Three Thresholds

Definition: Three-Alert System

Effective position monitoring uses three alerts:
- **Green alert** at HF = 1.5: "Watch closely."
- **Yellow alert** at HF = 1.2: "Consider reducing position or adding collateral."
- **Red alert** at HF = 1.05: "Act immediately or accept liquidation."

8.3 Step 3: Choose a Mitigation Strategy

Worked Example: Mitigation Options When HF Drops

Strategy	Description
Repay debt	Return part of the borrowed amount. Reduces debt, increases HF.
Add collateral	Deposit more ETH. Increases collateral, increases HF.
Swap collateral	Move to a less volatile asset (ETH → stablecoin collateral).
Close position	Repay all debt, withdraw collateral. Accept the realized loss.
Accept liquidation	Do nothing. Lose 5–13% penalty but retain remaining equity.

8.4 Step 4: Understand Tail Risk

Important Caveat

Black Thursday (March 2020) showed that a normal 25% buffer can be insufficient during extreme events. ETH fell >40% in 24 hours. Positions with <40% buffers were liquidated en masse, often at unfavorable prices due to network congestion.

8.5 Step 5: Portfolio Construction

Worked Example: Risk-Based Position Sizing

Priya divides her $10,000 crypto portfolio into three risk buckets:

- **Safe bucket ($5,000):** Stablecoins earning 3–5% via Aave supply.
- **Balanced bucket ($3,000):** ETH collateral, conservative 30% LTV borrow, used for stablecoin yield.
- **Speculative bucket ($2,000):** Pure ETH, willing to lose entirely.

This structure limits the damage of any single failure. A lending protocol exploit affects only the $5,000 safe bucket. A price crash affects the speculative bucket most.

8.6 Pro Strategies: Advanced Lending Use Cases

Definition: Common Advanced Strategies

- **Self-repaying loans.** Deposit collateral, borrow stablecoins, deposit stablecoins into a yield farm. If farm yield exceeds borrow rate, the loan pays itself off.
- **Short positions via lending.** Borrow a token you expect to decrease, immediately sell it, buy back at a lower price to repay.
- **Yield arbitrage.** Borrow where rates are low, supply where rates are higher (across chains or protocols).
- **Tax deferral.** Borrow against appreciated collateral instead of selling. In many jurisdictions, borrowing is not a taxable event.

9 Practice Problems

Discovery Exercise 1

Max borrow. You deposit 8 ETH at $2,500/ETH. LTV is 75%. What is the maximum you can borrow in USDC?

Discovery Exercise 2

Health factor. Using the position from Exercise 1, you borrow $12,000 USDC. Liquidation threshold is 80%. Calculate the health factor.

Discovery Exercise 3

Liquidation price. For the same position, at what ETH price does liquidation occur (HF = 1)?

Discovery Exercise 4

Liquidation penalty. ETH drops to $1,800 (below your liquidation price from Exercise 3). A liquidator repays 50% of your debt. How much ETH do they seize (including the 5% penalty)?

Discovery Exercise 5

Post-liquidation HF. After the liquidation in Exercise 4, calculate your remaining collateral, remaining debt, and new health factor at $1,800/ETH.

Discovery Exercise 6

Interest rates. A lending pool has $100M in deposits and $70M in borrows. What is the utilization? If the kink is at 80%, is the pool below or above the kink? What happens to rates if another $15M is borrowed?

Discovery Exercise 7

Flash loan mechanics. Explain why flash loans do not require collateral. What prevents a borrower from simply keeping the funds?

Discovery Exercise 8

Oracle attack. Describe step by step how the Mango Markets oracle attack worked. What oracle design change would have prevented it?

Discovery Exercise 9

Strategy comparison. Priya has 10 ETH at $2,000. Compare three strategies: (a) hold ETH, (b) sell for USDC, (c) deposit as collateral and borrow 50% LTV. If ETH goes to $3,000 in one year, which strategy performed best? If ETH drops to $1,200?

Discovery Exercise 10

System design. Why do DeFi lending protocols require over-collateralization instead of using credit scores? List two advantages and two limitations of this design.

10 Glossary of Lending Terms

aToken
Aave's interest-bearing receipt token. 1 aUSDC always represents 1 USDC plus accrued interest.

Aave
The largest DeFi lending protocol, with $57B TVL as of early 2026.

APY
Annual Percentage Yield. The annualized rate including compounding.

APR
Annual Percentage Rate. The annualized rate without compounding.

Bad debt
Debt that cannot be repaid due to collateral becoming insufficient. Absorbed by suppliers or protocol reserves.

Black Thursday
March 12, 2020. ETH crashed 43% in 24 hours; MakerDAO suffered $8.32M in losses from failed liquidations.

Borrow APY
The interest rate charged to borrowers.

cToken
Compound's interest-bearing receipt token, analogous to aTokens.

Chainlink
The dominant oracle network for DeFi, providing price feeds to most major protocols.

Collateral
Assets pledged to secure a loan. If the loan cannot be repaid, the collateral is seized.

Collateral factor
The percentage of collateral value that can be borrowed (synonym: LTV).

Compound
A pioneering DeFi lending protocol, less used today but historically significant.

Cross-collateral
The ability to pledge multiple asset types in a single position.

Debt
The amount owed by a borrower, including accrued interest.

Deposit
Funds supplied by a lender to the protocol, earning the supply APY.

Flash loan
An uncollateralized loan that must be borrowed and repaid in the same transaction.

Health factor (HF)
A measure of position safety. $HF > 1$ is safe; $HF < 1$ triggers liquidation.

Interest rate model
The function relating utilization to borrow rate. Typically a kink curve.

Kink
The utilization level at which the interest rate curve inflects upward sharply.

Liquidation
The forced sale of collateral when a position's health factor drops below 1.

Liquidation threshold
The percentage of collateral value at which liquidation can be triggered.

Liquidation bonus (penalty)
The discount granted to liquidators, typically 5% for ETH.

Liquidator
A bot that executes liquidations to earn the liquidation bonus.

Loan-to-Value (LTV)
The maximum percentage of collateral value that can be borrowed.

MakerDAO / Sky
The protocol behind DAI / USDS. Rebranded to Sky in August 2024.

Morpho
A DeFi lending protocol offering peer-to-peer matching on top of Aave/Compound.

Oracle
A service that provides off-chain data (primarily prices) to smart contracts.

Over-collateralization
Requiring collateral worth more than the borrowed amount.

Reserve factor
The percentage of interest income retained by the protocol treasury.

Stable rate
A fixed-for-now borrow rate that can be rebalanced if market conditions diverge.

Supply APY
The interest rate earned by lenders.

Utilization
The percentage of deposited funds that is currently borrowed.

Variable rate
A borrow rate that changes every block based on utilization.

Solutions

Exercise 1. Collateral = $8 \times \$2{,}500 = \$20{,}000$. Max borrow = $\$20{,}000 \times 0.75 = \$15{,}000$.

Exercise 2. HF = $(\$20{,}000 \times 0.80)/\$12{,}000 = \$16{,}000/\$12{,}000 = 1.33$.

Exercise 3. $P_{\text{liq}} = \$12{,}000/(8 \times 0.80) = \$12{,}000/6.4 = \$1{,}875$. If ETH falls below $1,875, the position can be liquidated.

Exercise 4. Liquidator repays 50% of $12,000 = $6,000. ETH seized = $(\$6{,}000/\$1{,}800) \times 1.05 = 3.333 \times 1.05 = 3.5$ ETH.

Exercise 5. Remaining collateral: $8 - 3.5 = 4.5$ ETH $= 4.5 \times \$1{,}800 = \$8{,}100$. Remaining debt: $\$12{,}000 - \$6{,}000 = \$6{,}000$. New HF = $(\$8{,}100 \times 0.80)/\$6{,}000 = \$6{,}480/\$6{,}000 = 1.08$. The position survived, but Priya lost 3.5 ETH.

Exercise 6. Utilization = $70M/$100M = 70%. This is below the 80% kink. If $15M more is borrowed, utilization = $85M/$100M = 85%, which is above the kink. Rates would spike sharply to encourage repayment and attract new deposits.

Exercise 7. Flash loans exploit blockchain atomicity: either the entire transaction succeeds (borrow + use + repay) or it all reverts. The borrower cannot keep the funds because the repayment is checked *within the same transaction*. If repayment fails, the borrow never happened.

Exercise 8. (1) Eisenberg took large MNGO perp positions. (2) He bought MNGO spot aggressively to inflate the price. (3) The oracle reported the inflated price to Mango Markets. (4) His collateral appeared more valuable; he borrowed $117M against it. (5) He withdrew the borrowed funds. Prevention: time-weighted average price (TWAP) oracles that resist short-term manipulation, or multi-source oracle aggregation (Chainlink-style).

Exercise 9. If ETH $\to$ $3,000: (a) Hold: $10 \times \$3{,}000 = \$30{,}000$. (b) Sell: $20,000 (missed the gain). (c) Borrow: 10 ETH worth $30,000, repay $10,000 + interest ($\sim$$500 at 5% APR), net $\approx$ $19,500 profit plus retained ETH. Strategy (a) is simplest; (c) gives exposure plus liquidity. If ETH $\to$ $1,200: (a) Hold: $12,000 (loss). (b) Sell: $20,000 (best). (c) Borrow: liquidation at $1,875, lose 5% penalty on seized ETH. Strategy (b) outperforms in the bear case.

Exercise 10. Advantages: (1) no identity or credit history required—anyone with collateral can borrow, (2) instant and automated—no manual underwriting. Limitations: (1) capital inefficient—depositing $1.33 to borrow $1 locks up excess capital, (2) excludes the unbanked who have no crypto assets to pledge.

Further Reading

Protocol documentation:

- Aave V3 Documentation (`docs.aave.com`) – Comprehensive technical reference.
- Compound V3 Documentation (`docs.compound.finance`) – Alternative lending architecture.
- Morpho Documentation (`docs.morpho.org`) – Peer-to-peer optimized lending.
- MakerDAO / Sky Documentation (`docs.makerdao.com`) – DAI/USDS vault mechanics.

Academic papers:

- Gudgeon, L., Perez, D., Harz, D., Livshits, B., & Gervais, A. (2020). "The Decentralized Financial Crisis." Analysis of Black Thursday.

- Qin, K., Zhou, L., Gamito, P., Jovanovic, P., & Gervais, A. (2021). "An Empirical Study of DeFi Liquidations." Data-driven analysis of liquidation mechanics.
- Kao, H.-T., Chitra, T., Chiang, R., & Morrow, J. (2020). "An Analysis of the Market Risk to Participants in the Compound Protocol."

Dashboards and tools:

- **DeBank** (`debank.com`) – Portfolio tracker with HF monitoring.
- **Instadapp** (`instadapp.io`) – Position management interface for Aave and Compound.
- **DeFiLlama Yields** (`defillama.com/yields`) – Compare lending rates across protocols and chains.
- **Parsec** (`parsec.finance`) – Advanced analytics for DeFi positions.

Priya's ongoing strategy:
After several months of using Aave, Priya settles into a simple routine: she supplies stablecoins for the conservative yield (earning 3–5% APR), occasionally borrows against her ETH for short-term liquidity needs, and monitors her position daily on DeBank. She never loops leverage, never chases exotic yields, and never borrows more than 50% LTV. Her lesson from all the case studies: *the safest lending strategies are the boring ones.*