DeFi Ecosystem

AMMs, Lending, Stablecoins, and Risk

Prof. Dr. Jörg Osterrieder

Blockchain, Crypto Economy & NFTs

Learning Objectives:

1. Explain how AMMs replace order books using the constant product formula (*Apply*)
2. Calculate impermanent loss for a given price change (*Analyze*)
3. Compare the three stablecoin designs and their failure modes (*Evaluate*)
4. Identify systemic risks in DeFi: smart contract bugs, oracle attacks, and contagion (*Evaluate*)

What Is DeFi? — Traditional Finance vs. Decentralized Finance

Definition

Decentralized Finance (DeFi) is an ecosystem of financial applications built on public blockchains that replaces intermediaries with smart contracts.

Core principle:
Anyone with a wallet can access lending, trading, and insurance — no bank account, no credit check, no permission needed.

Criterion	TradFi	DeFi
Permission	KYC / AML required	Permissionless wallet only
Hours	Mon–Fri 9am–5pm	24/7/365 always on
Custody	Bank holds your funds	Self-custody your keys
Fees	2–5% spread + commissions	0.01–0.3% swap fee
Access	1.4B unbanked excluded	Global access internet only

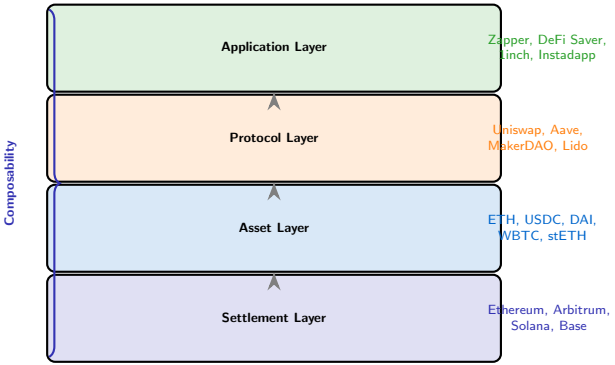
DeFi recreates every financial service — but replaces trust in institutions with trust in code.

The DeFi Stack: Four Layers

DeFi is composable: each layer builds on the one below, like Lego blocks. Protocols combine freely — this is called **"money Legos."**

Layer breakdown:

- **Settlement:** the base blockchain that executes transactions and guarantees finality
- **Asset:** tokens that represent value — native coins, stablecoins, wrapped assets
- **Protocol:** smart contract logic — AMMs, lending pools, derivatives
- **Application:** user-facing interfaces that aggregate protocols



Composability is DeFi's superpower: a flash loan can borrow, swap, lend, and repay in a single transaction.

AMMs: The Constant Product Formula

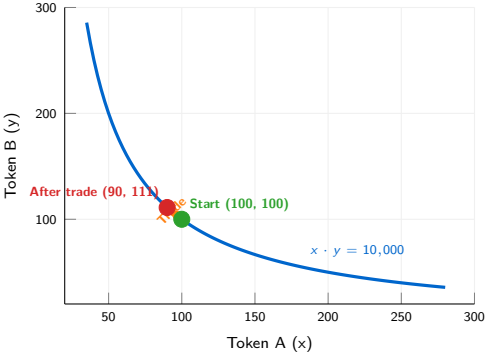
How Uniswap works:
No order book. Liquidity providers (LPs) deposit two tokens into a pool. The price is set by a formula:

$$\underbrace{x}_{\text{Token A}} \times \underbrace{y}_{\text{Token B}} = \underbrace{k}_{\text{constant}}$$

Worked example:

- Pool starts: 100 ETH × 100 USDC = 10,000
- Trader buys 10 ETH → pool has 90 ETH
- New USDC: 10,000 / 90 = 111.1 USDC
- Cost: 11.1 USDC for 10 ETH
- **Slippage**: paid 1.11 per ETH vs 1.00 starting price

Larger trades → more slippage.



Uniswap V1/V2 use this formula. V3 added concentrated liquidity; V4 (Jan 2025) added hooks for custom logic.

Impermanent Loss: The Hidden Cost of Providing Liquidity

What is impermanent loss (IL)?
When you provide liquidity, price changes cause your position to underperform simply holding the tokens.

Formula:

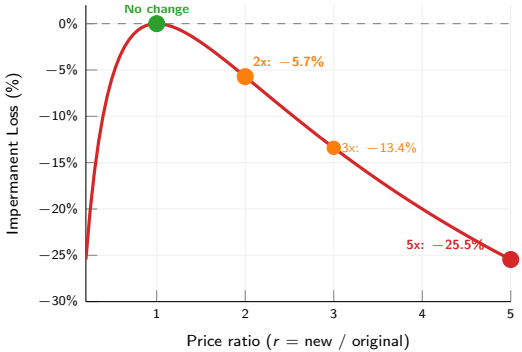
$$\text{IL} = \frac{2\sqrt{r}}{1+r} - 1$$

where r = price ratio (new price / original price).

Key thresholds:

- Price doubles ($r = 2$): IL $= -5.7\%$
- Price triples ($r = 3$): IL $= -13.4\%$
- Price 5x ($r = 5$): IL $= -25.5\%$

"Impermanent" because IL reverses if price returns to the original ratio. LP fees must exceed IL for profit.



LPs earn trading fees (0.3% per swap on Uniswap V2) to compensate — but in volatile markets, IL often exceeds fees.

DeFi Lending: Collateral, Health Factor, and Liquidation

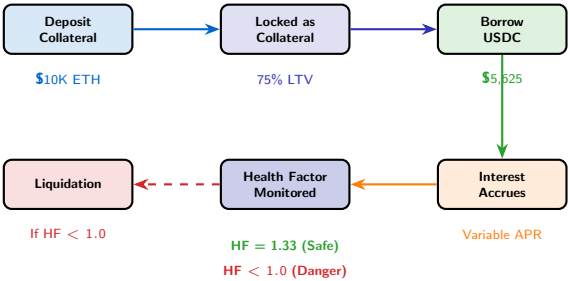
How DeFi lending works:
Borrow against crypto collateral. No credit score needed — the protocol liquidates you if collateral drops too low.

Key formula:

$$\text{Health Factor} = \frac{\overbrace{\text{Collateral} \times \text{LTV}}^{\text{borrowing power}}}{\underbrace{\text{Debt}}_{\text{amount owed}}}$$

Worked example:

- Deposit: \$10,000 ETH collateral
- LTV threshold: 75%
- Borrow: \$5,625 USDC
- HF = (\$10K $\times$ 0.75) / \$5,625 = **1.33**
- Liquidation when HF $<$ 1.0



Aave and Compound are the largest lending protocols. Overcollateralization is the price of trustless lending.

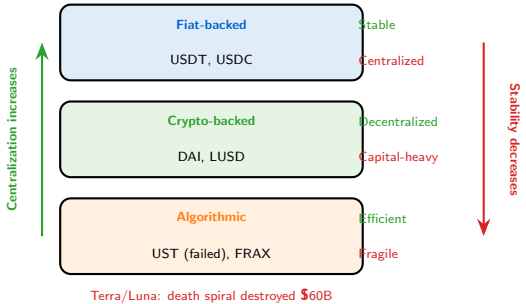
Stablecoins: Three Designs and the Terra/Luna Collapse

Three stablecoin models:

1. **Fiat-backed** (USDT, USDC)
   Stable but centralized. Issuer can freeze funds.
   Market share: $\sim$90%.
2. **Crypto-backed** (DAI, LUSD)
   Decentralized but capital-heavy.
   Requires 150%+ overcollateralization.
3. **Algorithmic** (UST, FRAX)
   Capital-efficient but fragile.
   Uses mint/burn mechanics to maintain peg.

Terra/Luna Collapse (May 2022)

\$60B destroyed in 72 hours. UST depegged $\rightarrow$ LUNA hyperinflated from **\$**80 to **\$**0.0001. Anchor's 20% APY was funded by reserves, not revenue. Death spiral: redemptions $\rightarrow$ more minting $\rightarrow$ more selling.



The stablecoin trilemma: you can optimize for stability, decentralization, or capital efficiency — but not all three.

DeFi Market: Total Value Locked by Protocol

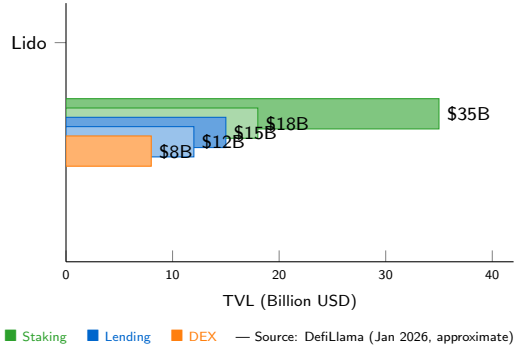
Total Value Locked (TVL) measures the dollar value of crypto deposited in DeFi protocols.

Key facts (Jan 2026):

- DeFi TVL: ∼$120B+
- Peak (Nov 2021): $180B
- Crash (Jun 2022): $30B
- Recovery driven by liquid staking and restaking

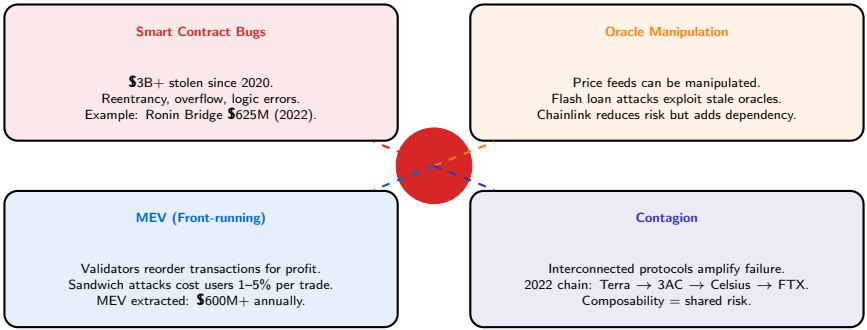
Protocol categories:

- **Staking**: Lido, EigenLayer
- **Lending**: Aave, Maker
- **DEX**: Uniswap, Curve



Liquid staking (Lido) and restaking (EigenLayer) now dominate DeFi TVL — a shift from the 2021 DEX-driven era.

DeFi Risk: Smart Contracts, Oracles, MEV, and Contagion

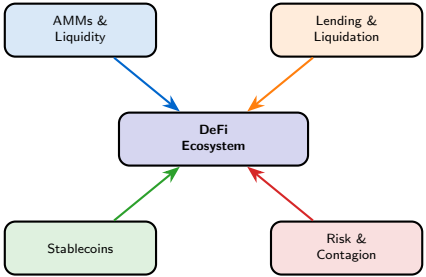


DeFi's permissionless nature is both its strength (innovation) and its weakness (no consumer protection, no bailouts).

Key Takeaways

Four Core Lessons

1. **DeFi replaces intermediaries with smart contracts** — permissionless, 24/7, self-custody, but no safety net. Code is law — bugs are unforgivable
2. **AMMs use $x \cdot y = k$ but LPs face impermanent loss** — providing liquidity is not risk-free yield. IL at 2x price change is already 5.7%
3. **Overcollateralization is the price of trustless lending** — no credit scores means protocols demand 150%+ collateral and liquidate ruthlessly
4. **If you cannot explain the yield source, you ARE the yield** — Terra's 20% APY had no revenue backing. Sustainable yield comes from real economic activity



DeFi is financial engineering at the speed of software — powerful, but errors compound just as fast.

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B – IL $= 2\sqrt{2}/(1+2) - 1 \approx -5.7\%$.

Answers reveal on click. Review any incorrect answers before proceeding.

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B – If yield has no real revenue source (fees, interest), it comes from new capital inflows — a structure that eventually collapses.

Score: 9–10 Excellent | 7–8 Good | 5–6 Review slides | <5 Re-watch lecture.