



UNIVERSITY *of* NICOSIA

Session 3.2

# Decentralized Lending and Borrowing

BLOC 611: Introduction to Decentralized Finance

### Objectives

- Learn how lending and borrowing differs in a centralized and decentralized setting
- Become acquainted with some of the basic concepts of decentralized lending and borrowing, i.e, overcollateralized loans, liquidations, and more
- Understand the main decentralized lending and borrowing use-cases
- Become familiar with the novel concept of flash loans and their use-cases

Disclaimer: As usual, the inclusion of any particular blockchain project or organisation is for educational purposes only. This should not be construed as an endorsement or investment advice.

# Agenda

1. Lending and Borrowing
2. Popular Decentralized Lending/Borrowing Protocols
3. Flash Loans
4. Conclusions
5. Further Reading

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# **1. Lending and Borrowing**

# Disintermediating commercial banking

- Lending & borrowing were the among the first DeFi applications to gain popularity.
- Decentralized lending and borrowing platforms are simply **smart contracts that let users lend or borrow cryptocurrencies at a fixed or variable interest rate.**
  - In other words, they offer (in principle) exactly what commercial banks offer through deposits and loans.
  - Naturally, since DeFi is open, public, and permissionless, there is **no central authority** to decide who participates and mediate the whole lifecycle of lending and borrowing.
  - There is no need for credit history or other financial records.
  - Anyone can lend their assets and earn interest or deposit some collateral and borrow a percentage of its value.
  - Users can collectively reap the benefits of lending and borrowing.
- Removing the intermediaries aims at enhancing the efficiency of capital allocation, cutting costs, eliminating exclusion and increasing economic privacy and freedom.

# Lending and Borrowing in DeFi vs TradFi

Feature	DeFi	TradFi
Creditor	Anyone including smart contracts	Banks or appointed institutions
Debtor	Anyone including smart contracts	Vetted individuals or businesses
Interest rate	Set algorithmically by the protocol	Set by central bank, financial institutions, and lenders
Collateral	(mostly) Overcollateralized	Undercollateralized or unsecured debt
Maturity	Fixed or Undefined	Fixed
Risk to lender	Platform risk, protocol risk, volatility, governance risk, rug pulls	Default risk, systemic risks
Risk to borrower	Liquidation/loss of collateral	Bankruptcy, loss of financial flexibility

# Loans and Collateral

Loans are a form of debt between two parties, the **lender** and the **borrower**. What is stopping the borrower from defaulting on their loan? Let's find out!

- In exchange for providing loans, lenders, usually require:
  - **Some reward**: normally in the form of interest rate – which also reflects the risk assumed or cost of money.
  - **Some insurance**: that the money will be repaid. This comes in many forms usually but almost always in the form of **collateral**. A very common form of collateral loan are **mortgages**. It is also worth mentioning that the interest rate (or reward) can also reflect the creditworthiness of the debtor.
- Centralized institutions (banks and other credit providers) have a plethora of ways of assessing a borrower's ability to repay debt. Those include:
  - **Know your customer** (KYC)
  - **Credit history**
  - **Collateral**
- They also have ways of making borrowers repay – by law and even by force
- For those reasons, centralized institutions can get away with **undercollateralized** or **unsecured loans** – meaning loans where the value of the collateral is less than the value of the loan.
- But what about blockchain-based systems with no police force or courts?

### Over-collateralized loans

- In such systems (pseudonymous, permissionless, open) it would be reasonable to assume that if the value of the collateral fell below the value of the loan, there would be no incentive to pay back the debt. **Moral Hazard!**
- To mitigate this, DeFi loans are typically **over-collateralized**, meaning that a user can only borrow less money than the value of their collateral.
  - This eliminates a scenario where a user defaults on their debt **simply because the value of the collateral has fallen below the loan value**. In such case, **the collateral would be liquidated**, meaning sold to prevent any losses. Thus, no Moral Hazard, and no need for laws or police.
- One might naturally ask: why would someone want to borrow money (and pay interest), when the value of the loan is less than the collateral they already possess?
  - **The answer is that borrowers post as collateral assets whose value varies (e.g., Ether).**
  - If someone possesses an asset the value of which they believe **would appreciate** in the future, but, at the same time, **need liquidity**, there is a rational incentive to deposit the asset as collateral and borrow part of its value.
  - In this way, if the prediction is correct, the user receives liquidity, while continuing to capture the increase of the locked asset's value. They can even use that liquidity to buy more of the provided asset for multiplicative returns.
  - However, if the prediction is incorrect and the value of the collateral decreases, the DeFi lending protocol will start liquidating part of the collateral, as it approaches the value of the loan, in order to repay it or maintain an acceptable loan-to-collateral ratio.



# Using DeFi for leverage

- To demonstrate why someone may be willing to borrow even if their collateral is worth more than the loan, consider the following scenario (assuming no interest, transaction costs, or [slippage](#)):
  - Suppose that I hold 1 ETH, which is valued at \$1,500. I can deposit my 1 ETH as loan collateral to platform X, which has a collateral to loan ratio of 150%.
  - So, I will be able to borrow up to \$1,000 worth of DAI (stablecoin).
  - I can then proceed to swap my \$1,000 DAI for 0.666 ETH at current prices (\$1,500).
  - I now own 1.666 ETH (worth \$2,500), of which 1 ETH is loan collateral and 0.666 in my wallet.
  - If the price of ETH were to increase by 10% the total value of my holdings would be \$2,750 (minus \$1,000 which I must repay to the protocol).
  - **My profit is \$250, meaning \$100 more than if I simply held my 1 ETH**
  - If the price of ETH decreased by 10%, I would lose \$250, instead of \$100 (in practice my losses would be higher since my collateral would be liquidated due to the value decrease beyond the collateralization ratio)
- I have effectively used **leverage to multiply my potential profits (and losses)**
  - Leverage is the use of debt to amplify returns (and losses) from an investment.
  - I can even redeposit my ETH, to borrow more DAI and swap it for ETH to increase my leverage and profit (losses).
  - The money lego nature of DeFi even allows [other dApps that do this automatically for me](#).

# Other reasons for DeFi Lending/Borrowing

- You can calculate the potential profit or loss with the following equation

$$Profit/Loss = \left[ Collateral\ Value + \left( \frac{Collateral\ Value}{Collateral\ to\ Loan\ Ratio} \right) \right] \times \%Change\ of\ Collateral\ Value - (Fees + Interest)$$

- Besides leverage there are other reasons for lending/borrowing in DeFi
  - Lenders and borrowers maintain exposure to the funds they lend or use as collateral
  - Lenders receive interest on the funds they lend
  - Lenders and borrowers may receive additional rewards in the form of governance tokens that can be sold in the market
  - Depending on the jurisdiction, users might avoid or delay paying capital gains taxes through lending/borrowing

### On collaterals and liquidation

- As we have established, liquidation is the selling of loan collateral to avoid losses for the lender
- Some important concepts you should know:
  - **Liquidation threshold** (a.k.a close factor): The percentage at which a loan is defined as undercollateralized. This is determined by a **health factor** set by the protocol. For example, in the case of AAVE the health factor is the following ( $H_f < 1$  means the position can be liquidated):

$$H_f = \frac{\sum \text{Collateral}_i \text{ in ETH} \times \text{Liquidation Threshold}_i}{\text{Total Borrows in ETH} + \text{Total Fees in ETH}}$$

- **Liquidation incentive:** The premium (part of the collateral) given to liquidators as an incentive for liquidating the position. If the premium is 1.1, liquidators receive an extra 10% of the borrower's collateral. Another way of thinking about this, is that the liquidator receives the collateral at a discount.
- In practice liquidation is highly competitive and is usually performed by bots.
- The above are known as **fixed liquidations**. But there are also **auction liquidations** (as in the case of Maker)

### Liquidation examples

- The following examples are provided by popular lending protocol AAVE:

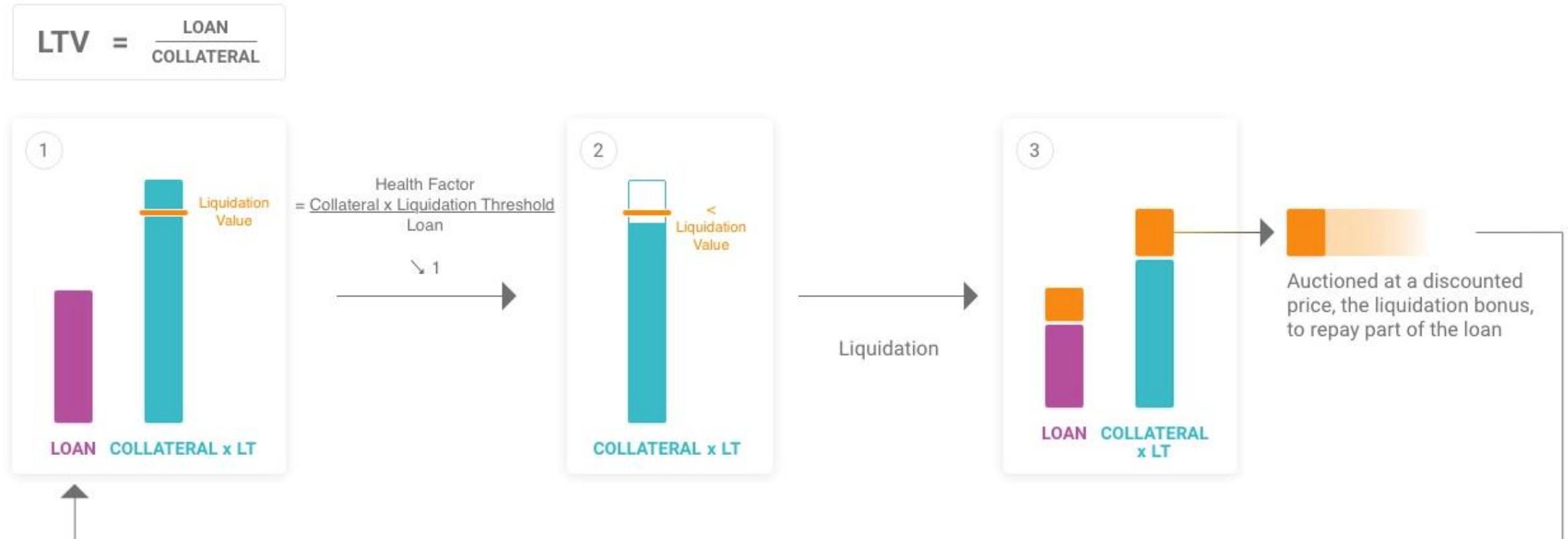
#### Example 1

- Bob deposits 10 ETH and borrows 5 ETH worth of DAI. If Bob's Health Factor drops below 1 his loan will be eligible for liquidation. A liquidator can repay up to 50% of a single borrowed amount (2.5 ETH worth of DAI in this example). In return, the liquidator can claim a single collateral which is ETH (5% bonus). The liquidator claims  $2.5 + 0.125$  ETH for repaying 2.5 ETH worth of DAI.

#### Example 2

- Bob deposits 5 ETH and 4 ETH worth of YFI, and borrows 5 ETH worth of DAI. A liquidator can repay up to 50% of a single borrowed amount. In return, the liquidator can claim a single collateral. As the liquidation bonus is higher for YFI (15%) than ETH (5%), the liquidator chooses to claim YFI. The liquidator claims  $2.5 + 0.375$  ETH worth of YFI for repaying 2.5 ETH worth of DAI.

### Liquidation examples (continued)



Source: AAVE

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## **2. Popular Decentralized Lending/Borrowing Protocols**

### Maker



- The first popular DeFi lending/borrowing platform in the market was **Maker**, a protocol that initially allowed users to deposit ETH and receive 50% of its value as loan denominated in an algorithmic stablecoin called **DAI**, which was issued (minted) after a user deposited the ETH collateral.
  - DAI's circulating supply is algorithmically regulated based on the overall value of locked collaterals, the demand for loans and their repayment.
  - Nowadays, Maker has evolved to offer a variety of assets to deposit as collateral, beyond ETH.
  - It is also governed in a decentralized way (more on that on week 5).
  - Its TVL in October 2021 stands at over \$15 bn.
  - We also explored MakerDAO in session 1 of this week.

# Maker Growth

### Total Value Locked (USD) in Maker



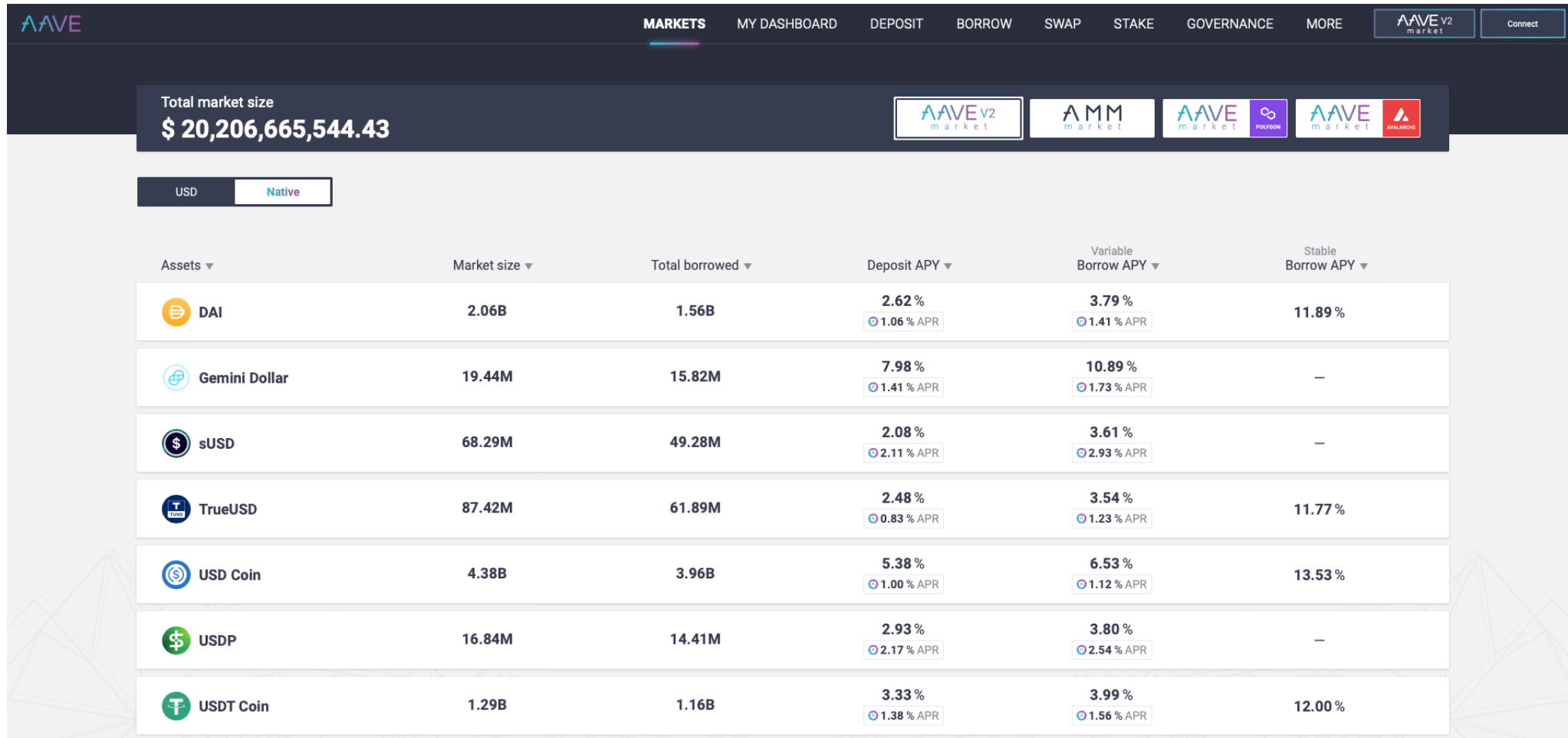


# AAVE








- **Aave**, another important project of the space, begun as **EthLend** during the ICO era in 2017.
  - AAVE started as a peer-to-peer platform, meaning that a user who wanted a loan had to find another user to take the other side of the loan and mutually agree on the specific terms.
  - That was an inefficient model and the resulting use of the platform was limited.
  - Success came after the shift to a model of a **pool of funds**. Users were then interacting with a smart contract and not directly with other users. Funds from lenders were gathered into a common pool, which had specific predetermined rules. Borrowers under this model had immediate access to loans, provided that the pool had enough liquidity.
  - AAVE also were the first to introduce the revolutionary idea of **flash loans**, where someone can borrow funds with zero collateral, under specific circumstances and for a limited amount of time.
  - AAVE was originally deployed on Ethereum but has recently also launched on **Polygon** as well.
  - Its TVL in October 2021 stands at \$16 bn.

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### Aave front-end



The screenshot displays the Aave front-end interface. At the top, the Aave logo is on the left, and navigation links for MARKETS, MY DASHBOARD, DEPOSIT, BORROW, SWAP, STAKE, GOVERNANCE, and MORE are in the center. On the right, there are buttons for AAVE v2 market and Connect. Below the navigation bar, a dark banner shows the 'Total market size' as '\$ 20,206,665,544.43'. To the right of this banner are logos for AAVE v2 market, AMM market, and AAVE market on Polygon and Avalanche. Below the banner, there are tabs for 'USD' and 'Native'. The main content is a table with columns: Assets, Market size, Total borrowed, Deposit APY, Variable Borrow APY, and Stable Borrow APY. The table lists seven assets: DAI, Gemini Dollar, sUSD, TrueUSD, USD Coin, USDP, and USDT Coin, each with its respective market size, total borrowed, and APY rates.

Assets ▾	Market size ▾	Total borrowed ▾	Deposit APY ▾	Variable Borrow APY ▾	Stable Borrow APY ▾
 DAI	2.06B	1.56B	2.62 % <small>1.06 % APR</small>	3.79 % <small>1.41 % APR</small>	11.89 %
 Gemini Dollar	19.44M	15.82M	7.98 % <small>1.41 % APR</small>	10.89 % <small>1.73 % APR</small>	—
 sUSD	68.29M	49.28M	2.08 % <small>2.11 % APR</small>	3.61 % <small>2.93 % APR</small>	—
 TrueUSD	87.42M	61.89M	2.48 % <small>0.83 % APR</small>	3.54 % <small>1.23 % APR</small>	11.77 %
 USD Coin	4.38B	3.96B	5.38 % <small>1.00 % APR</small>	6.53 % <small>1.12 % APR</small>	13.53 %
 USDP	16.84M	14.41M	2.93 % <small>2.17 % APR</small>	3.80 % <small>2.54 % APR</small>	—
 USDT Coin	1.29B	1.16B	3.33 % <small>1.38 % APR</small>	3.99 % <small>1.56 % APR</small>	12.00 %

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# AAVE Growth

### Total Value Locked (USD) in Aave

[TVL \(USD\)](#) | [ETH](#) | [BTC](#) | [DAI](#)

[All](#) | 1 Year | 90 Day | 30 Day



### ETH Locked in Aave

TVL (USD) | [ETH](#) | [BTC](#) | [DAI](#)

[All](#) | 1 Year | 90 Day | 30 Day



# Compound



- **Compound** is another large lending/borrowing project that has also introduced some innovative concepts, which helped the whole DeFi lending space to evolve.
  - The **liquidity mining** mechanism that Compound implemented is a mechanism that was later copied and extended by many other projects and attracted many users to DeFi lending.
  - The mechanism introduced extra incentives to lenders and borrowers to use their platform, in the form of distributing the platform's native **COMP token** to the users.
  - That led to the creation of the notion of **yield farming**, which describes the situation of users being incentivized to switch back and forth between lending and borrowing, among different tokens, in order to achieve the best yield possible.
  - Compound's TVL stands at around \$10 bn.

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### Compound front-end

The screenshot displays the Compound front-end dashboard. At the top, there's a navigation bar with the Compound logo, 'Dashboard' (active), 'Vote', and a 'Connect Wallet' button. The main area shows three large circular gauges: 'Supply Balance' at \$0, 'Net APY' at an unspecified rate, and 'Borrow Balance' at \$0. Below these is a 'Borrow Limit' progress bar at 0%. The dashboard is divided into two main sections: 'Supply Markets' and 'Borrow Markets'. Each section contains a table of assets with their respective APY, wallet balance, and collateral/liquidity status.

Supply Markets				Borrow Markets			
Asset	APY	Wallet	Collateral	Asset	APY	Wallet	Liquidity
Aave Token	0.24%	0 AAVE	<input type="checkbox"/>	Aave Token	4.29%	0 AAVE	\$5.35M
Basic Attention ...	0.58%	0 BAT	<input type="checkbox"/>	Basic Attention ...	6.55%	0 BAT	\$73.17M
Compound Gov...	0.81%	0 COMP	<input type="checkbox"/>	Compound Gov...	6.72%	0 COMP	\$0k
Dai	3.05%	0 DAI	<input type="checkbox"/>	Dai	4.59%	0 DAI	\$876.26M
Ether	0.09%	0 ETH	<input type="checkbox"/>	Ether	2.79%	0 ETH	\$5,874.79M
ChainLink Token	0.29%	0 LINK	<input type="checkbox"/>	ChainLink Token	4.60%	0 LINK	\$134.46M

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# Compound TVL

### Total Value Locked (USD) in Compound

[TVL \(USD\)](#) | [ETH](#) | [BTC](#) | [DAI](#)

[All](#) | 1 Year | 90 Day | 30 Day



### ETH Locked in Compound

TVL (USD) | [ETH](#) | [BTC](#) | [DAI](#)

[All](#) | 1 Year | 90 Day | 30 Day



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# **3. Flash Loans**

# Introduction to Flash Loans

- Remember when we talked about how loans on DeFi are overcollateralized? – **We Lied.**
- There are two forms of unsecured loans – regular unsecured loans and **flash loans**.
- Regular unsecured loans are essentially very restricted versions of what we described earlier, allowing for use of the borrowed funds only with specified smart contracts. Funds also remain under custody of the original smart contract at all times. **Flash loans are more special.**
- In Week 1, section 1, we mentioned that DeFi imitates, and then extends TradFi concepts
- Flash loans are an example of an application that exists in DeFi but not TradFi
  - That is, because they rely on the deterministic nature of blockchains. This means that an action either occurs entirely as it was described or does not occur at all. There is no in-between state.



### Flash Loans

- Flash loans essentially allow anyone, at any time, and with a minimal (theoretically even zero) cost, to borrow any amount of money (provided it is available in the protocol), for whatever reason, without requiring collateral, and without exposing the parties involved to counterparty risk.
- This is possible due to the **atomic deterministic nature of smart contract-enabled payments**.
- However, it is worth pointing out that, **while counterparty risk is eliminated, other novel forms of risks exist**. Flash loans have also introduced **new forms of attacks**.

### Flash Loans use cases

- Flash loans are used today for:
  - **Arbitrage** – with a side effect of creating a more efficient market
  - **Collateral swaps** – to avoid high fees and multiple transactions when collateralizing positions
  - **Self-liquidation** – to gain access to locked collateral and to avoid liquidation fees ([see MakerDAO vaults](#)) in light of market swings
  - **Speculation**, through the **exploitation of various vulnerabilities** of decentralized systems (mostly legally)
- **Flash loan attacks** rely on an attacker's ability to manipulate market mechanisms and forces. They include:
  - **Pump and dump arbitrage**
  - **Oracle manipulation**
- Naturally, none of the above are ethical/legal practices.

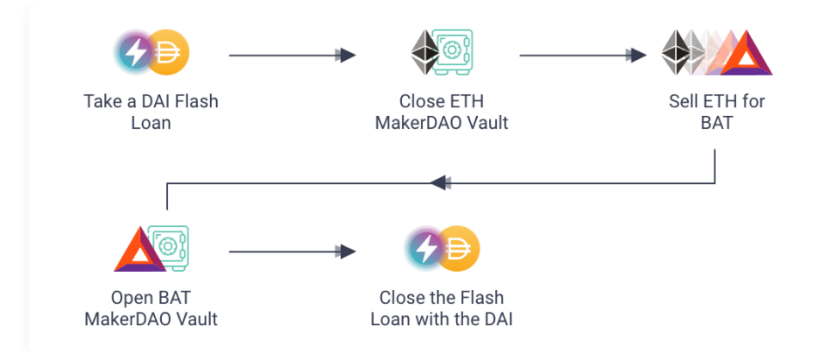
# Indicative flash loan use case examples

- **Arbitrage**

- The price of 1 wBTC = 10 ETH in DEX1 and 12 ETH in DEX2
- A user gets a flash loan of 100 ETH
- They buy 10 wBTC on DEX1 and exchange them for 120 ETH on DEX2
- They buy back the loan of 100 ETH and keep the 20 ETH profit – fees and interest aside

- **Collateral Swap**

- User has a loan on MakerDAO using ETH as collateral to get DAI.
- User wants their ETH back, for whatever reason
- They can get a flash loan in DAI, use it to close the ETH Vault, receive their ETH, sell (part of) it for BAT, open a BAT Vault to collateralize their original loan, and close the DAI flash loan.
- All this happens in a single transaction – or not at all.



Flash Loan use case: Collateral swap of a MakerDAO Vault

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## **4. Conclusions**

### Conclusions

- In this session, you have learned about how decentralized lending and borrowing works as well as its similarities and differences with centralized lending
- We looked into the use cases for over-collateralized lending and borrowing
- We investigated the concepts of collateral, liquidation and their specifics
- Finally, we explored the novel concept of flash loans and their use cases.

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## **5. Further Reading**

### Further Reading

- Some popular flash loan enablers are More on flash loans
  - [AAVE documentation](#)
  - [Compound documentation](#)
- More on flash loans and attacks
  - [Finematics Flash Loans Explained](#)
  - [What is arbitrage?](#)
  - [Flash Loans 101: Features, Types, and How To Prevent Flash Loan Attacks](#)
  - [Flash Loan attacks](#)
  - [Flash loans and the importance of tamper-proof oracles](#)
- Popular flash loan enablers
  - [Aave](#)
  - [DxDy](#)
  - [Uniswap](#)
  - [Eurocombo](#)

Tip: Clicking while pressing Ctrl key opens a new tab in Chrome browser on non-Apple devices



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## Questions?

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