562F – Tech Driven Transformation

Part III:

DeFi Deep Dive

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Part III:

DeFi Deep Dive

2. Decentralized Exchange

(i) Uniswap

(a) What is Uniswap?

Decentralized exchange: Uniswap

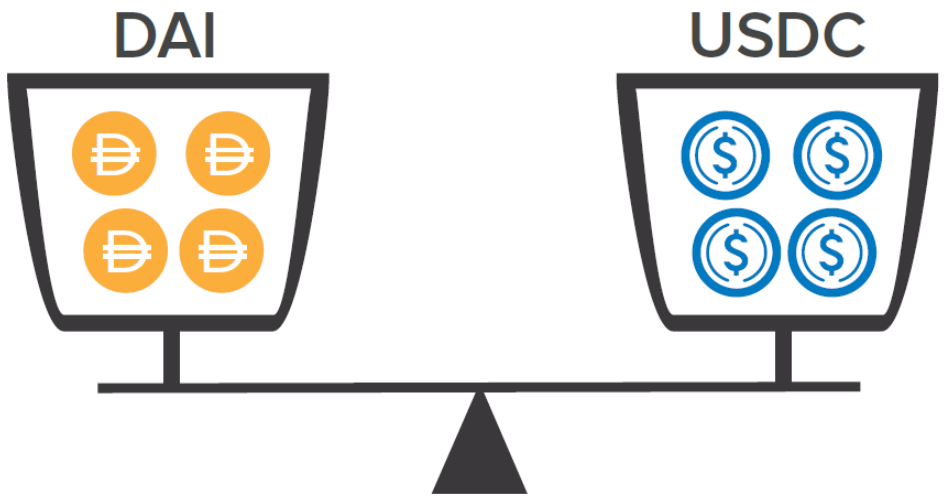
What is Uniswap?

- Prime example of Automated Market Maker on Ethereum
- Constant product rule, k=x*y where where *x* is the balance of asset *A*, and *y* the balance of asset *B*.
- Focus on Uniswap v2 but highlight advantages of v3
- The product *k* is the *invariant* and is required to remain fixed at a given level of liquidity.
  - To purchase (withdraw) some *x*, some *y* must be sold (deposited). The implied price is *x*/*y* and is the *risk-neutral* price, because the contract is equally willing to buy or sell at this rate as long as invariant *k* is constant.

Decentralized exchange: Uniswap

Example

- Investor in the Uniswap USDC/DAI market has 4 DAI (Asset A) and 4 USDC (Asset B). This sets the instantaneous exchange rate at 1 DAI:1 USDC and the invariant at 16 (= $x*y$).



Uniswap USDC/DAI Market

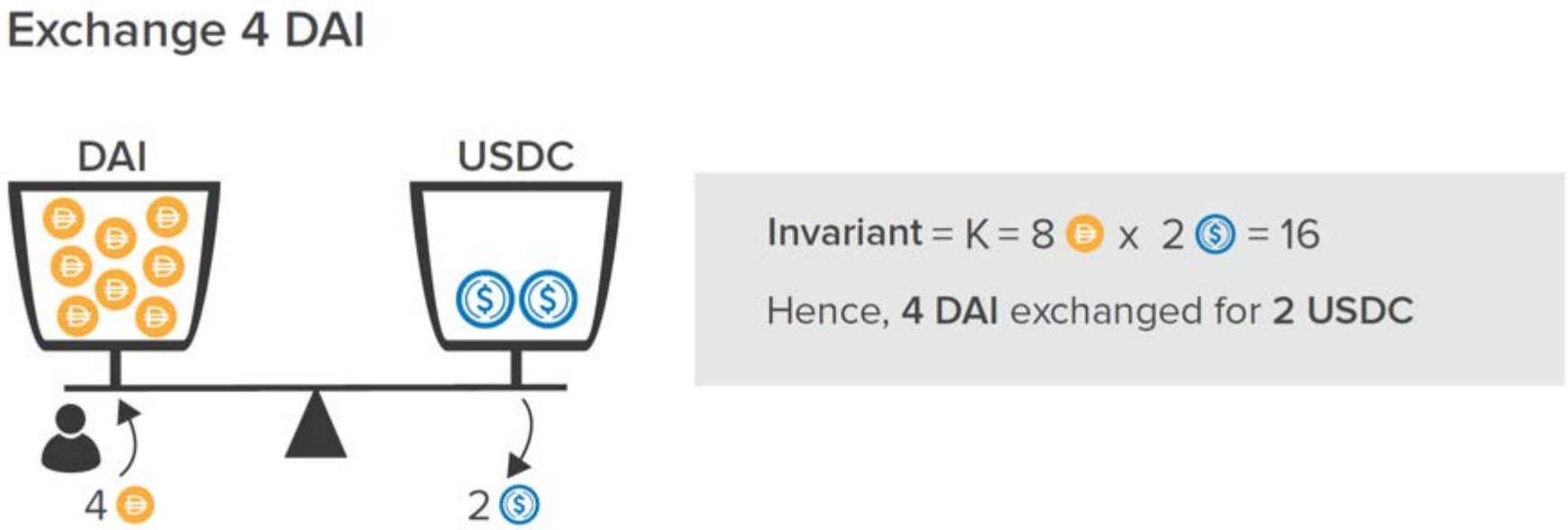
Instantaneous exchange rate = 1 Ð = 1 $

Invariant (K) = 4 Ð x 4 $ = 16

Decentralized exchange: Uniswap

Example

- To sell 4 DAI for USDC, the investor deposits 4 DAI to the contract and withdraws 2 USDC. Now the USDC balance is 4 – 2 = 2 and the DAI balance is 4 + 4 = 8. Invariant remains at 16.



Decentralized exchange: Uniswap

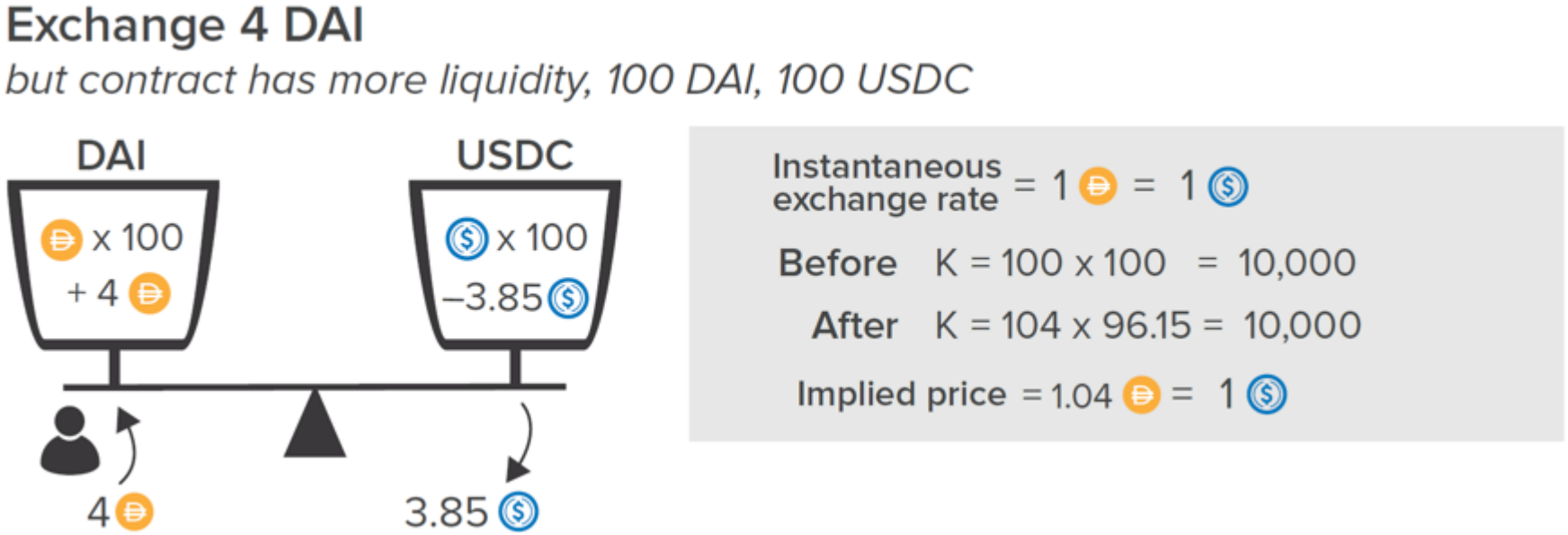
Example

- Notice that the effective exchange rate was 2 DAI: 1 USDC.
- The change in the exchange rate is due to slippage because of the low level of liquidity in the market.
- The magnitude of the invariant determines the amount of slippage.

Decentralized exchange: Uniswap

Example

- Assume balance is 100 DAI and 100 USDC; k=10,000
- If investor sells 4 DAI for USDC, now 3.85 USDC can be withdrawn so much lower slippage at an effective rate of 1.04 DAI: 1 USDC.



Decentralized exchange: Uniswap

Importance of liquidity

- Deep liquidity helps minimize slippage.
- Therefore, Uniswap incentivizes depositors to supply capital to a given market.
- Anyone can become a liquidity provider by supplying assets on both sides of a market at the current exchange rate.
- A liquidity provider adds to both sides of the market, thereby increasing total market liquidity. If a user exchanges one asset for another, the total liquidity of the market as measured by the invariant does not change.

Decentralized exchange: Uniswap

Importance of liquidity

- Supplying both sides increases the product of the amount of assets held in the trading pair (i.e., increases the invariant).
- Higher invariants lead to lower slippage and therefore an increase in effective liquidity.
- The invariant is a direct measure of liquidity.
- In summary, liquidity providing increases the invariant with no effect on price, whereas trading against a market impacts the price with no effect on the invariant.

Decentralized exchange: Uniswap

Importance of liquidity

- Each trade in a Uniswap market has an associated 0.3% fee that is paid back into the pool.
- Liquidity providers earn these fees based on their pro rata contribution to the liquidity pool.
- They therefore prefer high-volume markets.
- This mechanism of earning fees is identical to the *cToken* model of Compound. The ownership stake is represented by a similar token called a *Uni* token. For example, the token representing ownership in the DAI/ETH pool is Uni DAI/ETH.

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Part III:

DeFi Deep Dive

2. Decentralized Exchange

(i) Uniswap

(b) Impermanent Loss

Decentralized exchange: Uniswap

Impermanent loss

- Liquidity providers in Uniswap essentially earn passive income in proportion to the volume on the market they are supplying.
- Upon withdrawal, however, the exchange rate of the underlying assets will almost certainly have changed.
- This raises the possibility of impermanent loss.

Decentralized exchange: Uniswap

Impermanent loss

- Impermanent loss is the amount of money the liquidity provider would have made if she just held the pair rather than invested in Uniswap pool.
- The fees earned from trading volume must exceed impermanent loss in order for liquidity providing to be profitable.
- Consequently, stablecoin trading pairs such as USDC/DAI are attractive for liquidity providers because the high correlation of the assets minimizes the impermanent loss.

Decentralized exchange: Uniswap

Pair correlation

- Uniswap's $k = x*y$ pricing model works well if the correlation of the underlying assets is unknown.
- The model calculates the exact same slippage at a given liquidity level for any two trading pairs. In practice, however, we would expect much lower slippage for a stablecoin trading pair than for an ETH trading pair, because we know by design that stablecoin's price should be close to $1.

Decentralized exchange: Uniswap

Pair correlation

- The Uniswap pricing model leaves money on the table for arbitrageurs on high correlation pairs such as stablecoins, because it does not adjust default slippage lower, as would be expected; the profit is subtracted from the liquidity providers.
- For this reason, competitor AMMs, such as Curve, that specialize in high-correlation trading pairs may cannibalize liquidity in these types of Uniswap markets.

Decentralized exchange: Uniswap

Any ERC-20 pair is possible on Uniswap

- Anyone can start an ERC-20/ERC-20 or ETH/ERC-20 trading pair on Uniswap, if the pair does not already exist, by simply supplying capital on both sides.
- ETH, although fungible, is not an ERC-20 token.
- Many platforms, including Uniswap, instead use WETH, an ERC-20-wrapped version of ETH to get around this.
- Uniswap allows a user to directly supply and trade with ETH and it converts to WETH behind the scenes.

Part III:

DeFi Deep Dive

2. Decentralized Exchange

(i) Uniswap

(c) Flash Swaps

Decentralized exchange: Uniswap

Flash swap

- In a flash swap, the contract sends the tokens *before* the user pays for them with assets on the other side of the pair.
- A flash swap unlocks many opportunities for arbitrageurs.
- The user can deploy this instant liquidity to acquire the other asset at a discount on another exchange before repaying it; the corresponding amount of the alternate asset must be repaid in order to maintain the invariant.

Decentralized exchange: Uniswap

Flash swap

- This flexibility in a flash swap is different from the provision in a flash loan, which requires that repayment occur with the same asset.
- A key aspect of a flash swap is that all trades must take place during a single Ethereum transaction and that the trade must be closed with the corresponding amount of the complementary asset in that market.

Decentralized exchange: Uniswap

Example

- Consider this example in the DAI/USDC market with a supply of 100,000 each.
- This implies a 1:1 exchange rate and an invariant of 10 billion.
- A trader who has no starting capital spots an arbitrage opportunity to buy DAI on a DEX for 0.95 USDC.

Decentralized exchange: Uniswap

Example

- The trader can capitalize on this arbitrage via a flash swap by withdrawing 950 USDC of flash liquidity (liquidity derived from a flash loan) from the DAI/USDC market, purchase 1,000 DAI via the described arbitrage trade, and repay 963 DAI for a profit of 37 DAI—all consummated with no initial capital.
- The figure of 963 is calculated as 960 (with rounding for ease of illustration) to maintain the 10 billion invariant, and to account for some slippage, plus a 0.30%*960 = 3 DAI transaction fee.

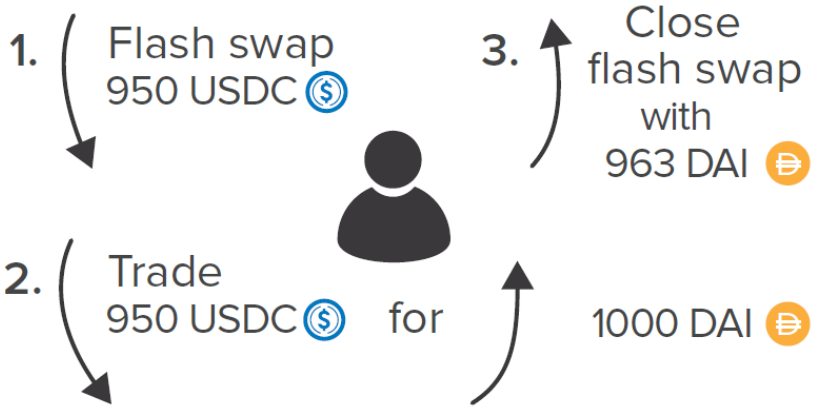
Decentralized exchange: Uniswap

Example

- The 30bp fee is paid into the pool owned by the liquidity providers.

Uniswap
USDC/DAI
implied price

1 USDC = 1 DAI



Alternative DEX
USDC/DAI
price

0.95 USDC = 1 DAI

Slippage = 10 DAI, so 960 DAI
Fee = .003 x 960 = 3 DAI
Swap done at 960 + 3 = 963 DAI
Profit = 1000 – 963 = 37 DAI

Part III:

DeFi Deep Dive

2. Decentralized Exchange

(i) Uniswap

(d) Governance and Uniswap v3

Decentralized exchange: Uniswap

Governance

- Lastly, an important point about Uniswap is the release of a governance token in September 2020 called UNI.
- Like COMP, the Compound governance token, UNI is distributed to users to incentivize liquidity in key pools including ETH/USDC and ETH/DAI.

Decentralized exchange: Uniswap

Governance

- The UNI governance even has some control over its own token distribution because 43% of the supply will be vested over four years to a treasury controlled by the UNI governance.
- Importantly, each unique Ethereum address that had used Uniswap before a certain cutoff date (over 250,000 addresses) was given 400 UNI tokens as a free airdrop.
- At the same time as the airdrop, UNI was released on Uniswap and the Coinbase Pro exchange for trading.

Decentralized exchange: Uniswap

Governance

15	Uniswap UNI	$11.52	▲ 2.86%	▲ 23.65%	$3,275,199,138
16	Aave AAVE	$252.80	▲ 1.75%	▲ 33.65%	$3,071,258,380

https://coinmarketcap.com/

Decentralized exchange: Uniswap v3

Main innovation

- On May 5, 2021, Uniswap v3 is launched
- Liquidity providers can allocate funds to a custom range (the range in the CFMM is not limited and potentially infinite).
- This creates individualized price curves and traders interact with the aggregation of the liquidity of all of these curves.
- Given the ability to specify a range, v3 is somewhat analogous to a limit order system.

Decentralized exchange: Uniswap

Summary

- Uniswap is critical infrastructure for DeFi applications; it is important to have exchange operational whenever it is needed.
- Uniswap offers a unique approach for generating yield on users' assets by being a liquidity provider.
- The platform's flash swap functionality aids arbitrageurs in maintaining efficient markets and unlocks new use cases for users. Users can access any ERC-20 token listed, including creating completely new tokens through an IDO.

Decentralized exchange: Uniswap

Traditional Finance Problem	**Uniswap Solution**
Centralized Control: Exchanges that control which trading pairs are supported.	Allows anyone to create a new trading pair if it does not already exist and automatically routes trades through the most efficient path if no direct pair exists.
Limited Access: The best investment opportunities and returns from liquidity providing are restricted to large institutions.	Anyone can become a liquidity provider and earn fees for doing so. Any project can list its token on Uniswap to give anyone access to an investor.
Inefficiency: Trades generally require two parties to clear.	An AMM that allows constant access for trading against the contract.
Lack of Interoperability: Ability to exchange assets on one exchange is not easily used within another financial application.	Any token swap needed for a DeFi application can utilize Uniswap as an embedded feature.
Opacity: Unknown if the exchange truly owns all user's entire balance.	Transparent liquidity levels in the platform and algorithmic pricing.

Part III:

DeFi Deep Dive

2. Decentralized Exchange

(ii) Balancer

Decentralized Exchange: Balancer

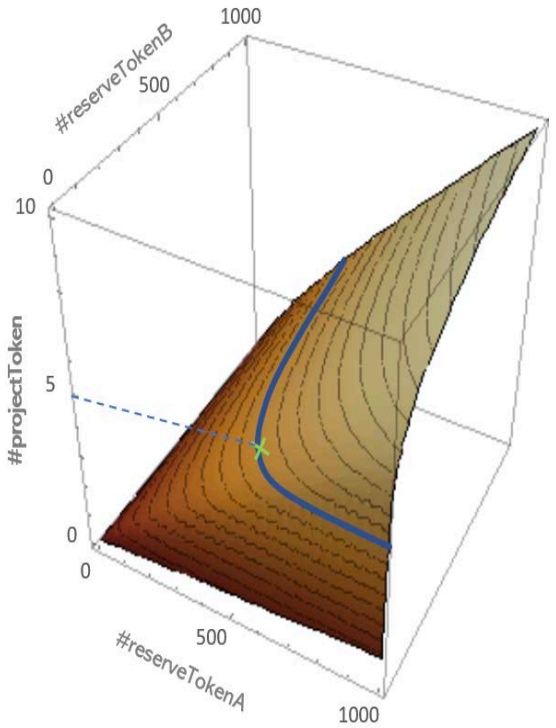
Overview

- Balancer is a decentralized exchange with an Automated Market Maker and is similar to Uniswap
  - Up to 8 assets (ERC-20 Tokens or ETH) can be supported in a single liquidity pool
  - Assets can be weighed arbitrarily and do not need to be weighted 50:50 in value like in Uniswap
  - Liquidity pool controller (creator) sets transaction fees
  - Liquidity pools can be finalized (public), controlled (private), or smart (controlled by a smart contract

Decentralized Exchange: Balancer

Bonding Surfaces

- To allow up to 8 assets in a single Liquidity pool, Balancer uses bonding surfaces, which generalizes Uniswap's x*y=k formula to n dimensions
- The Bonding Surface is given by V = $\prod_{t=0}^{n} B_t^{W^t}$
  - V is the value function (analogous to k in a bonding curve)
  - n is the number of tokens in the pool
  - B is the balance of token t in the pool
  - W is the normalized weight of token t



https://medium.com/balancer-protocol/bonding-surfaces-balancer-protocol-ff6d3d05d577

Decentralized Exchange: Balancer

Token Price and Pool Value

- The effective price between a single pair of tokens is given by the ratio of the token balances normalized by their weights: $EP_y^x = \frac{A_y}{A_x}$
  - Where A_x is the amount of token x being bought and A_y is the amount of token y being sold

Decentralized Exchange: Balancer

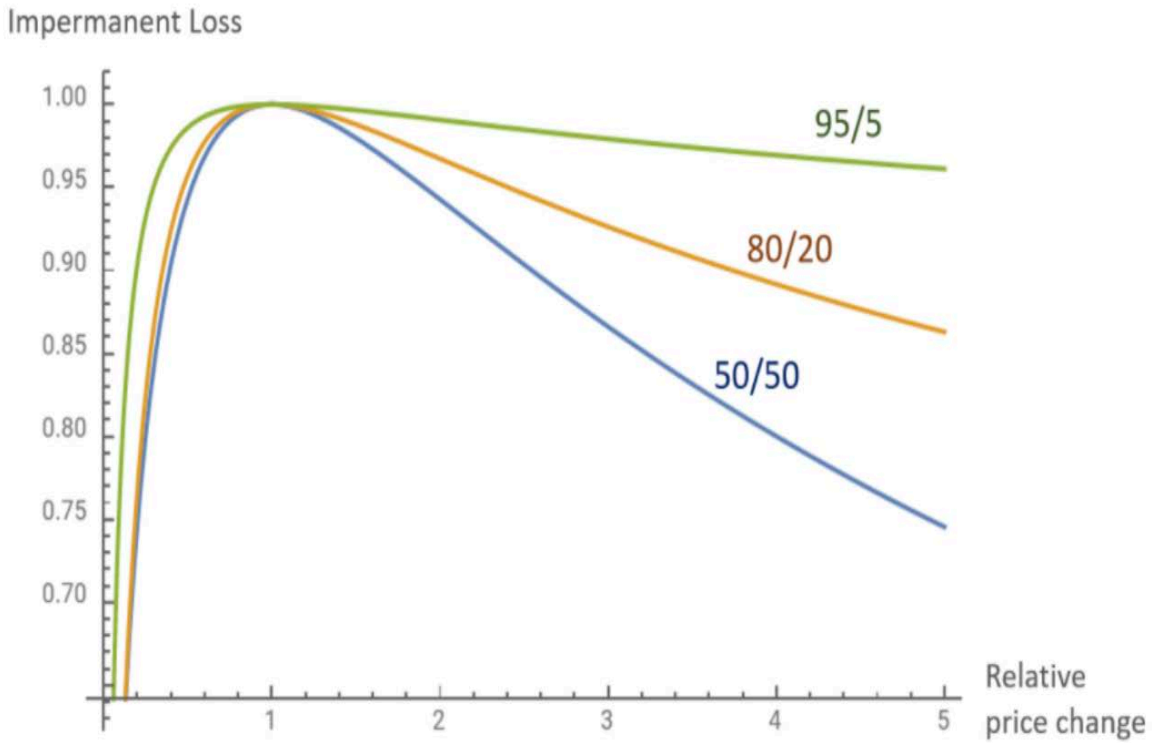
Swap Fees and Limits

- A user can only swap in up to 50% of the current balance of a token *into* a pool
- A user can swap out up to 33.3% of the current balance of a token *out* of a pool
- Liquidity pool controllers set transaction fees between 0.0001% and 10%

Decentralized Exchange: Balancer

Impermanent Loss

- Impermanent loss can be higher or lower in Balancer depending on the weighting of tokens
- Two tokens weighted 50/50 and a 5x increase in the token valuation results in an impermanent loss of 25.5%. However, two tokens weighted 95/5 and the same increase results in an impermanent loss of just 3.88%
- If a pool creator is confident in a token, they can create more uneven pools to offer themselves selective exposure and earn transaction fees



Impermanent Loss for different combinations of Balancer pool weights

https://balancer.finance/2020/03/16/80-20-balancer-pools/

Decentralized Exchange: Balancer

Slippage and Smart Order Router

- Equal token weights in a pool have the lowest slippage, while uneven pools have higher slippage, which disincentivizes traders from using the pool and results in less trading volume and lower transaction fees generated for the pool
- Smart Order Router (SOR) is an off-chain price optimizer that searches across all Balancer pools to find the best price

Decentralized Exchange: Balancer

Governance

- BAL is the Balancer Governance Protocol Token
- Total supply of BAL is capped at 100M BAL
  - 25M to founders, advisors, and investors
  - 5M to Balancer Ecosystem Fund and 5M to fundraising fund
  - 65M to liquidity providers with 145,000 BAL per week distributed to providers
  - The community will have to decide if token distribution should end before the cap is reached
- BAL is distributed to liquidity miners as a function of the total amount of liquidity contributed relative to the total liquidity on Balancer

Part III:

DeFi Deep Dive

2. Decentralized Exchange

(iii) Rehypothecation

Decentralized exchange: Rehypothecation

Collateralization ratios enforced by keepers

- In traditional finance, the method is different. Archegos (hedge fund) example:

Once you know the right amount of collateral, and you call up the hedge fund to tell it to post more collateral, and the hedge fund says “I’m busy today let’s talk tomorrow,” and you call them tomorrow and they say “hey this week got away from me but send me an email,” and you send them an email summarizing your collateral demand and call them next week and they say “oh I haven’t had a chance to look at your email yet but I will very soon,” and meanwhile the right amount of collateral keeps ticking up … what do you do about that? There is a theoretical and contractual answer, which is, if the client doesn’t post the collateral you want then you terminate the swap, but you are a person and the hedge fund does sound really busy and surely it can’t hurt to talk to them tomorrow? Plus if you terminate the swap you lose their business, and your whole job is about doing more business. Matt Levine, Bloomberg Opinion, July 29, 2021

Decentralized exchange: Rehypothecation

What is rehypothecation?

- In traditional finance, hypothecation is simply pledging collateral for debt
- Rehypothecation is a practice whereby banks or brokerages use assets posted by their clients for their own trading (e.g., bank using the client collateral as their collateral to take out a loan – which is a derivative asset)
- It is sometimes called “re-pledging” or “re-use”.
- In traditional finance, the amount of rehypothecation is regulated (see, for US, Fed Regulation T and SEC Rule 15c3-3)

Decentralized exchange: Rehypothecation

Total Locked Value (TLV)

- TLV is a measure of the usage of DeFi protocols
- When you add liquidity (for example into MakerDAO, Compound, Aave, or Uniswap), this value is referred to as the “locked” value.
- “Locked” is misleading because you can easily repatriate in DeFi
- We might assume that the collateral assets that are pledged are locked in the context of the particular application
- However, this is not necessarily the case because the equity tokens (representing the share of the LP) are a type of derivative asset that rehypothecates the collateral

Decentralized exchange: Rehypothecation

Money multiplier

- A similar situation exists in CeFi
- You deposit $100 at a bank. The bank must set aside 10% at the Federal Reserve and then lends out $90.
- A borrower gets the $90 and deposits at another bank. The second bank sends $9 as the required reserve to the Fed an loans out $81.
- This process continues and induces a money multiplier. The original $100 deposit generates much more than $100 in loans.
- The multiplier is 1/(reserve ratio)

Decentralized exchange: Rehypothecation

DeFi multiplier example

- User deposits $1500 of WETH into Maker and gets a loan of 1,000 DAI (this implies a 150% collateralization ratio)
- User deposits the borrowed 1,000 DAI along with 1,000 USDC into a Uniswap v2 DAI-USDC pool. The user's total investment is $2,500 (WETH + USDC).
- Uniswap issues DAI-USDC LP tokens that represent $2,000
- User could redeposit the LP tokens into Maker to get another loan of 1,960 DAI (collateralization ratio = 102%)

Decentralized exchange: Rehypothecation

DeFi multiplier example

- Let's calculate the TLV
  - WETH = $1,500 backing Maker loan
  - Liquidity added to Uniswap v2 (USDC) = $1,000
  - Liquidity added to Uniswap v2 (DAI) = $1,000
  - Uniswap DAI-USDC LP tokens backing new loan at Maker = $2,000

Total = $5,500 – yet only $2,500 pledged. Note we could get an even higher number if we repeat the process with the new 1,960 DAI loan!

- Multiplier formula more complicated because of different "reserve" ratios