Content

Disclaimer

This whitepaper does not constitute any investment advice or recommendation by EXCAVO, its officers, directors, managers, employees, agents, advisors or consultants on the merits of purchasing CAVO or EXCV tokens nor should it be relied upon in connection with any other contract or purchasing decision.

Introduction

Centralized exchanges (CEX) have been the major cryptocurrency marketplaces for years. They offer such advantages as fast settlement times, large trading volumes, and liquidity. However, this degree of centralization diverges from blockchain and cryptocurrency ideology. On the other hand, decentralized exchanges (DEX) do not require a third party or custodians to facilitate trading.

The main reason why DEXs did not become as popular as CEX is due to the inherent limitations of blockchain technology. Thus, it has been a challenge to build DEXs that meaningfully compete with their centralized counterparts.

Many researchers, developers and crypto enthusiasts have been thinking about the new ways of building a decentralized exchange. One of the recent successful examples of such project is Uniswap. As the result of this innovation, Uniswap itself and Uniswap-like DEXs became one of the most popular platforms as part of the Decentralized Finance (DeFi) movement.

Protocol Overview

EXCAVO platform is an Ethereum-based on-chain system of smart contracts. It implements an automated market maker mechanism based on the constant product formula. Each EXCAVO platform trading pair stores and provides liquidity to pooled reserves of two tokens, maintaining their constant value.

At the moment, there are two types of pools: either with ETH or USDC quote currencies.

Users can create their own liquidity pools (with several exceptions).

Traders pay a 0.4% fee on trades, which adds to liquidity pools.

Liquidity providers contribute to the liquidity pools with two types of tokens of the same value calculated with current pool’s price. They receive liquidity tokens which represent their share in pool’s liquidity. Liquidity tokens can be redeemed at any moment. Therefore, liquidity providers may withdraw their liquidity with an additional surplus from trading fees.

Platform provides users with two additional types of tokens to farm – EXCV and CAVO. The EXCV token allows liquidity providers to have shares in many pools simultaneously without contributing to all of them. The CAVO token provides traders with lower fee percentages while being staked.

EXCAVO platform relies on the non-upgradeable smart contracts due to security reasons.

Theory

An automated market maker (AMM) operates similarly to an ordinary market maker. It “holds a certain number of securities in its inventory with the purpose of being able to sell them to an interested buyer, or to buy securities from a seller selling securities in the market.” (1)

Below we will describe some crucial features of Uniswap-like AMMs that recently became very popular within the crypto industry. For those who are interested to learn more about the principles and jargons we suggest consulting the sources 1 through 5.

Inventory Management

In order to stay profitable market makers ought to manage their inventories by trying to keep them at some target level. As mentioned in sources (1) and (2) “Target inventories are the positions that dealers want to hold” and “If dealers allow their inventories to get too far out of balance, they will not have enough capital to finance their purchases or secure their short sales”.

The same rules apply to automated market makers. AMMs are passive traders. They do not choose when to trade and do so when other trades want to. Moreover, these trades are the only reliable source of the current market conditions. Thus, AMMs need to use this information to adjust pricing and keep the inventory balanced. To accomplish these goals EXCAVO platform utilizes Uniswap-like constant product formula to regulate its inventory:

$$Q_A \cdot Q_B = \text{const}$$

Q_A and Q_B -- is the amount of A and B type tokens in the pool. The same formula applies to each pool with its own token pair. The graphical representation of constant product formula is given below.

Pool's liquidity k_{AB} can be defined as follows:

$$k_{AB} = \sqrt{Q_A Q_B}$$

The reasoning behind this definition:

1. In the absence of trading fees traders cannot change the pool's liquidity. Thus, all liquidity changes are influenced by the liquidity providers;
2. Easy to track and calculate. Higher gas prices limit the complexity of formulas used by smart contracts.

Fee

Exchanges typically charge fees for their services (3). In addition, market fee is the only source of profit for Uniswap-like AMMs. Each trader is charged a certain fee, collected from input tokens. Thus, if a trader buys token B in exchange for token A he or she would pay a fee in token A and vice versa. In other words, one may distinguish between two cases:

1. Sell side, $dQ_A > 0$ and $dQ_B < 0$
2. Buy side, $dQ_A < 0$ and $dQ_B > 0$

For the sell side an infinitesimal amount of tokens A is divided into two parts:

$$dQ_A = \gamma dQ_A + (1-\gamma)dQ_A$$

Similarly, for the buy side:

$$dQ_B = \gamma dQ_B + (1-\gamma)dQ_B$$

γ -- is the fee. All collected fees are used to increase the pool's liquidity. In practice γ percentage of tokens is added immediately on top of the liquidity pool and the rest $(1-\gamma)$ is swapped and returned to the trader.

Spot Price

In the context of this paper spot price is a specific price for the swap of infinitesimally amounts of tokens. One may define spot price as:

$$P_B = -\frac{dQ_A}{dQ_B}$$

P_B -- is a spot price of token B in terms of token A. The definition above considers that during the exchange one side of the pool would increase while the other would decrease. Thus, derivative should have a negative sign.

If the fee percentage γ is equal to 0 then the spot price is calculated according to its definition and the constant product formula:

$$P_B = \frac{Q_A}{Q_B}$$

In the $\gamma \neq 0$ case spot price has two values depending on the side of the trade. For the sell side spot price:

$$P_B^{ask} = -\frac{dQ_A}{dQ_B} = \frac{1}{1-\gamma} \cdot \frac{Q_A}{Q_B}$$

And for the buy side spot price:

$$P_B^{bid} = -\frac{dQ_A}{dQ_B} = (1-\gamma) \cdot \frac{Q_A}{Q_B}$$

Thus, the spot price on the sell side is higher and lower on the buy side in comparison to the $\gamma = 0$ spot price.

Market Impact

The spot price introduced in the previous subsection is determined by the amount of tokens in the inventory. Due to the size of inventory changing after each trade the spot price would change accordingly. Overall, traders move spot prices, thus creating market impact. Market impact can be defined as “... the expected price change conditioned on initiating a trade of a given size and a given sign.” (4).

Market impact on the ask side is equal to:

$$P_B^{ask} = -\frac{dQ_A}{dQ_B} = \frac{1}{1-\gamma} \cdot \frac{Q_A}{Q_B}$$

This leads to an ordinary differential equation:

$$\frac{dQ_A}{Q_A} + \frac{1}{1-\gamma} \cdot \frac{dQ_B}{Q_B} = 0$$

With a simple solution:

$$Q_A^{1-\gamma} Q_B = \text{const}$$

Thus, the best ask price P_B^{ask} AMM can offer is equal to:

$$P_B^{ask} = \frac{\text{const}}{1-\gamma} \cdot Q_B^{-\frac{2-\gamma}{1-\gamma}}$$

The relative ask price changes:

$$\frac{\Delta P_B^{ask}}{P_B^{ask}} = \left(1 - \frac{\Delta Q_B}{Q_B}\right)^{-\frac{2-\gamma}{1-\gamma}} - 1$$

Market impact on the bid side can be derived in a similar way. The final formula of the bid side is equal to:

$$\frac{\Delta P_B^{bid}}{P_B^{bid}} = 1 - \left(1 + \frac{\Delta Q_B}{Q_B}\right)^{-2+\gamma}$$

If fee percentage is small $\gamma \ll 1$ then relative price change can be reasonably approximated:

$$\frac{\Delta P_B^{ask}}{P_B^{ask}} \approx (2+\gamma) \cdot \frac{\Delta Q_B}{Q_B}$$

$$\frac{\Delta P_B^{bid}}{P_B^{bid}} \approx (2-\gamma) \cdot \frac{\Delta Q_B}{Q_B}$$

This leads to the conclusion:

1. Relative price changes approximately twice as much as the relative change in B tokens;
2. Relative price change has an approximate linear dependency on the size of γ .

Spread size

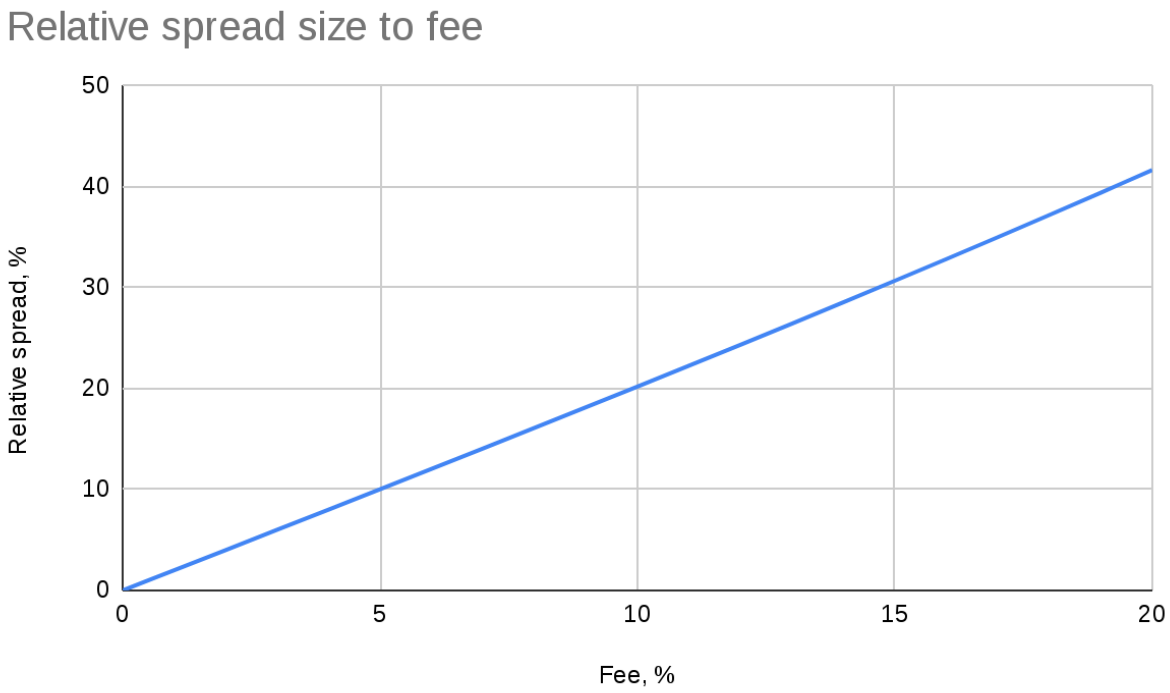
As it was shown in the “Spot price” subsection there are two different spot prices for seller and buyer accordingly. Thus, if a user buys and then immediately sells tokens he would lose a

certain amount of tokens twice. This occurs due to the positive price difference between bid and ask prices. Difference between the best prices is called spread (2) and can be calculated as:

$$\Delta P_B^{spr} = P_B^{ask} - P_B^{bid} = \frac{\gamma(2-\gamma)}{1-\gamma} \cdot \frac{Q_A}{Q_B}$$

Thus, there is almost a linear dependency between the relative spread and fee size. Relative spread can be approximated in case of small percentage fee $\gamma \ll 1$:

$$\frac{\Delta P_B^{spr}}{P_B} = 2\gamma \left(1 + \frac{\gamma}{2} + O(\gamma^2)\right)$$



Returns

As mentioned in the “Fee” subsection, collected fees are added directly to the liquidity pool.

$$k_{AB}^2 = Q_A Q_B$$

Thus:

$$\frac{dk_{AB}}{k_{AB}} = \frac{1}{2} \cdot \frac{d(Q_A \cdot Q_B)}{Q_A \cdot Q_B} = \frac{1}{2} \cdot \left(\frac{dQ_A}{Q_A} + \frac{dQ_B}{Q_B} \right)$$

Pool's liquidity k_{AB} will increase after each trade by design in accordance with the formula:

$$\frac{dk_{AB}}{k_{AB}} = \gamma \left(1 - \frac{\gamma}{2}\right) \cdot \left| \frac{dP_B}{P_B} \right|$$

Where the spot price P_B is defined as:

$$P_B = \frac{Q_A}{Q_B}$$

Thus, one may derive time dependent ordinary differential equation:

$$\frac{\dot{k}_{AB}}{k_{AB}} = \gamma \left(1 - \frac{\gamma}{2}\right) \cdot \left| \frac{\dot{P}_B}{P_B} \right|$$

With solution:

$$k_{AB}(t) = k_{AB}(0) \exp \left(\gamma \left(1 - \frac{\gamma}{2}\right) \int_0^t \left| \frac{\dot{P}_B}{P_B} \right| d\tau \right)$$

From this result one may conclude that:

1. The power in the formula above can be positive if $\gamma > 0$ or equal to zero if $\gamma = 0$ or price $P_B(\tau)$ has not changed over time period t ;
2. Liquidity k_{AB} may either increase exponentially or stay constant depending on its exponent;
3. Liquidity growth depends on fee percentage γ , frequency of price movements and its relative size. Thus, the more trades with large amounts of tokens occur over a unit of time, the more the liquidity grows.

Risks and Potential Losses

As demonstrated in the previous subsection "Returns", the liquidity growth strictly depends on the price movements. Therefore, the more price changes the higher the profit of the liquidity provider is. Usually, this statement is true but as it turns out, the increase in liquidity does not always lead to the appropriate increase of its market value. The author of article (5) points this out: "...But after a few days with their liquidity in the pool, some liquidity providers are looking at the value of their stake in the liquidity pool and finding it's worth less than what they put in, when measured in either ETH or the ERC-20 token on the exchange."

This is the so-called impermanent loss which is the major risk of providing liquidity to Uniswap-like exchanges. We recommend consulting the article (5) for more detailed information on this subject.

Participants

Participants benefitting from using EXCAVO protocol are traders and liquidity providers. Although there is a developer team that directly affects smart contracts. Overall, interactions between these users create a positive feedback loop, fueling digital economies by defining a common marketplace through which tokens can be pooled, traded and earned.

Traders

Traders are users engaged in exchanging the assets in the token market represented by token pools.

One may differentiate several types of traders with different roles and goals:

1. Arbitrageurs or speculative traders. Their goal is to profit from the price difference between the EXCAVO token pools and exogenous markets (other DEXs, exchanges, etc). It has been proven that CPMM (6) prices tend to closely follow global prices. This is possible due to arbitrage opportunities that incentivize speculative traders to move price in the right direction.

2. Common traders. They are profitting off the DAPP users (those that receive payments in crypto, etc) rather than from price differences.

Each trade via the EXCAVO protocol has some costs. These costs are gas usage, spread and slippage (7). They are charged mostly implicitly though slippage can be regulated to some extent.

Gas usage is inevitable because it is the fee one needs to pay for submitting transactions to the Ethereum network.

Slippage occurs when average delivery price differs from the spot price. The sole reason for slippage is the inventory management mechanism. It is highly dependent on the pool's liquidity and it falls when liquidity increases.

Spread emerges from fees charged on an input amount of trader's tokens. Currently fee is equal to 0.3% but can be reduced under some conditions. EXCAVO protocol reduces the spread's width for those who farm CAVO bonus tokens. The rules are provided below:

1. Traders burn CAVO tokens to reduce or remove fees from the single trade.

2. Traders stake CAVO tokens to remove fees permanently (as long as the tokens are staked).

Liquidity Providers

EXCAVO DEX is a dealer market meaning that traders do not directly interact with each other. They interact with the so-called liquidity pools filled with tokens. Token suppliers for these liquidity pools are called liquidity providers. One may become a liquidity provider by adding two types of tokens (one type is ETH or USDC) of equal value to both sides of the liquidity pool. Liquidity provider's goal is to participate in liquidity mining (8). Liquidity mining can be explained as a process similar to lending. DEX borrows assets from liquidity providers and pays back with its native tokens called liquidity tokens. These tokens act as bonds without a fixed interest rate. They can be redeemed at any time and the interest is payed as soon as they are redeemed. Spread fees traders pay is the source of liquidity providers' potential income.

The main drawback for liquidity providers might be the so-called impermanent losses (5) due to large price movements (see "Risks and Potential Losses"). Thus, one should keep this in mind while developing his or her investment strategy. The platform tries to mitigate the negative effects of impermanent losses by rewarding liquidity providers with several farming opportunities (see the "Tokenomics" section). Briefly speaking, a liquidity provider owns part of a continuously growing supply of EXCV tokens as long as he participates in at least one of the liquidity pools. One may claim his or her part at any time and sell it or add to ETH/EXCV liquidity pool to farm CAVO tokens. CAVO tokens can then be sold to traders. The demand for CAVO tokens is influenced by their trading perks.

Developer Team

The Developer Team is neither involved in trading nor in liquidity providing, however they support and maintain the whole project. They monitor the security, improve and upgrade protocol's smart contracts. By design The Developers Team does not receive any income from EXCAVO platform.

Operations

Users such as traders and liquidity providers can interact with the EXCAVO platform in the following ways. They can swap tokens, provide the liquidity, redeem the liquidity tokens and claim the rewards.

Token Swap

Similar to other DEXs like Uniswap (9), token swaps (10) are a simple way to exchange one ERC-20 token for another.

Although there is a way to call smart contracts' methods directly (11), EXCAVO platform provides users with a convenient and intuitive UI. It is compatible with most popular Ethereum wallets. Thus, if a trader wants to exchange his or her tokens it is quite simple. There is a small list of steps they need to take:

1. Connect your wallet to EXCAVO platform;

2. Specify the liquidity pool by choosing input token and output token symbols;
3. Specify an input amount;
4. Look at the amount of tokens this operation provides;
5. Accept or reject execution;
6. If the swap conditions are accepted, then protocol executes and sends output tokens immediately.

To improve the trades and user experience EXCAVO DEX UI provides traders with analytics which updates regularly with the latest spot prices, slippage control, etc.

Adding Liquidity

EXCAVO platform can function properly as a reliable marketplace if and only if there is enough liquidity in the platform's pools. The liquidity providers are the sole source of market's liquidity. There are no restrictions on who can or cannot become a liquidity provider or registration restrictions. Thus, the basic mechanics of the platform allows its users to be anonymous.

There are two scenarios of adding liquidity to the pool:

1. User creates liquidity pool. Because he or she is the first liquidity provider the price can be set to the arbitrary value depending on amount of tokens that are sent to both sides of the pool;
2. User adds liquidity to an already existing pool. In this case, the amount of tokens has to be equal to the current pool's exchange rate.

The general rule: To become a liquidity provider one has to add tokens to both sides of the chosen pool. In the second case the amount of tokens ΔQ_A and ΔQ_B liquidity provider adds to the pool and amount of liquidity tokens $\Delta Q_{¿}$ that he or she receives are based on the formula:

$$\frac{\Delta Q_{LT}}{Q_{LT}} = \frac{\Delta Q_A}{Q_A} = \frac{\Delta Q_B}{Q_B}$$

Q_A and Q_B -- are amounts of A and B tokens inside the pool, and $Q_{¿}$ is the total amount of outstanding liquidity tokens. User specifies either ΔQ_A or ΔQ_B and the platform calculates the rest.

After tokens have been transferred to the liquidity pool the sender receives liquidity tokens of that pool. Liquidity tokens are minted to track the share of total reserves each liquidity provider has contributed. They are highly divisible and can be burned at any time to return a proportional share of the market's liquidity to the provider.

One may create a liquidity pool with arbitrary token pairs as long as one of the sides is either ETH or USDC though there is one exception. One may not create a liquidity pool with pEXCV (ETH/pEXCV and USDC/pEXCV pairs are restricted) tokens.

Removing Liquidity

The core mechanics of EXCAVO platform assures that k_{AB} would grow over time with each trade. Trading fees are added to total liquidity pools without minting new liquidity tokens(9). Thus, liquidity providers have an implicit income and they can withdraw their share from the pool at any time. To withdraw the share from the pool liquidity provider should transfer liquidity tokens to the EXCAVO platform. The exact amount of tokens liquidity provider would receive (7) is:

$$\Delta Q_A = \frac{\Delta Q_{LT}}{Q_{LT}} \cdot Q_A,\ \Delta Q_B = \frac{\Delta Q_{LT}}{Q_{LT}} \cdot Q_B$$

Q_A , Q_B and $Q_{¿}$ are taken at the moment of withdrawal and not at the moment of deposit. This has practical consequences -- the received $\Delta Q_A : \Delta Q_B$ ratio can differ from the original deposit's ratio due to price movements (see "Risks and Potential Losses" for details).

Reward Claiming

Two additional types of tokens that are minted on EXCAVO platform EXCV and CAVO can be claimed by burning pEXCV and pCAVO tokens. Details are explained in the "Tokenomics" section.

Tokenomics

Original Uniswap (9) does not provide users with any native tokens except for liquidity tokens. EXCAVO platform, however, offers unique type of tokens in addition to previously mentioned. These tokens are EXCV and CAVO. The economic reasoning behind this offering is to reward early adopters to raise liquidity and reduce price slippage. Similar ideas were used by the different DeFi protocols described in (12) and (13). Thus, a positive feedback loop would be formed: traders can reduce trading costs with reward tokens that can be bought from liquidity providers. This facilitates traders to trade more often and liquidity providers to add more liquidity to the pools.

More detailed information about ECXV and CAVO tokens is explained in the section below.

EXCV and pEXCV Tokens

EXCV is an Ethereum-based ERC20 token that can be earned by a liquidity provider in addition to their basic income. Its total supply is equal to 1 billion. Token represents the entire platform's liquidity. Because different pool's liquidities are measured in different units they need to be converted to a single unit $\sqrt{ETH/USDC}$. Thus, by owning pEXCV token each liquidity provider obtains a certain share of profit in all platform pools. Therefore, the function of

intermediate pEXCV token is similar to liquidity tokens and its amount increases proportional to in the ETH/EXCV liquidity pool.

To be more precise user has to:

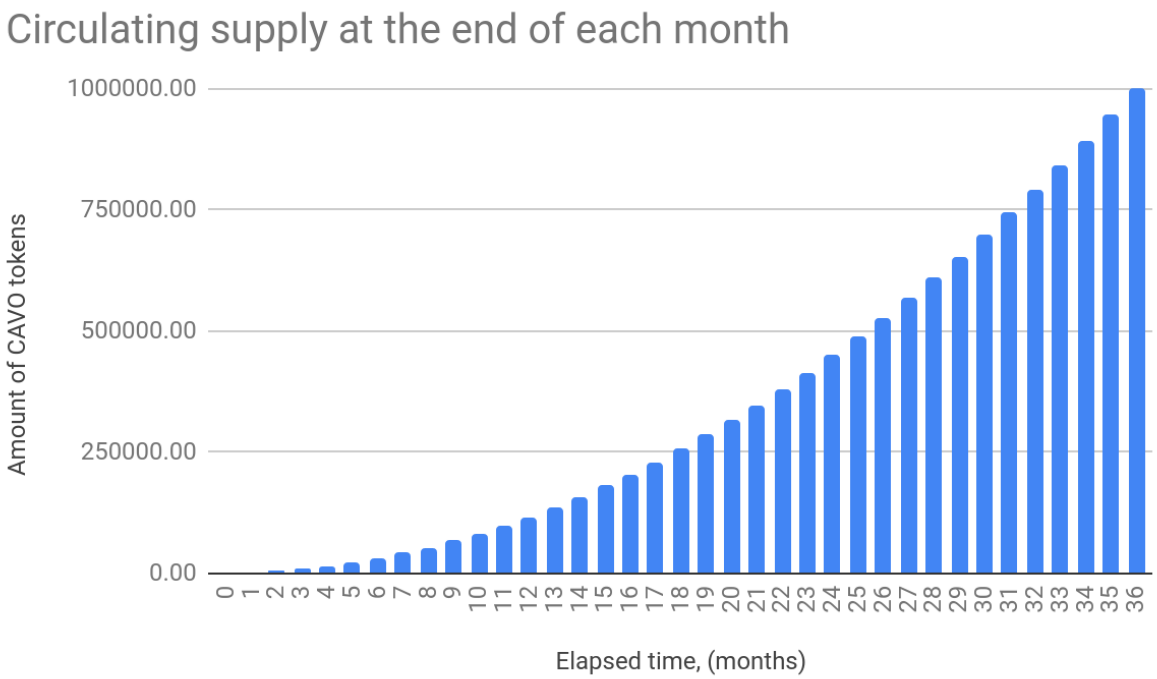
1. Add liquidity to one of the existing pools or create his or her own. Simultaneously he would receive liquidity tokens and pEXCV tokens;
2. Wait long enough for liquidity k to increase;
3. Claim EXCV by burning pEXCV.

Then EXCV can be sold at one of the EXCAVO pools or added to the EXCV/ETH liquidity pool.

Custom creation of pEXCV/ETH of pEXCV/USDC liquidity pools on the EXCAVO platform is forbidden.

CAVO and pCAVO Tokens

CAVO is an Ethereum-based ERC20 token. It is a synthetic asset that may adjust its supply depending on the price movements. Its total supply is equal to 1 million tokens. The circulating supply of CAVO tokens will be 0 (zero) when the EXCAVO platform launches. The entire token supply is expected to be distributed over the vesting period of 36 months (3 years). Each month is set to be 30 days long.



Daily token distribution depends on the CAVO price in the CAVO/ETH pool. If the price is lower than the threshold price no additional tokens would be minted and distributed that day. Threshold price can be derived as:

$$P^{tr} = \frac{N_t - N_0}{6500} \cdot 0.003 \quad \left[\frac{ETH}{CAVO}\right]$$

P^{tr} -- threshold price, N_t -- number of the current block, N_0 -- number of the block at the moment of smart contract's deployment. Thus, circulating supply of CAVO tokens would increase if and only if the inequality $P > P^{tr}$ holds during 6500 blocks.

Traders can reduce fee percentage (and trading costs) by burning CAVO tokens for a single trade. Staking reduces fee percentage as long as CAVO tokens stay staked. The value of reduced fee can be calculated according to formula:

$$Reduced\ fee = Discount \cdot 0.4\%$$

The numerical value of the discount is given in the table below:

Amount of tokens staked	Discount
1-5	0.9
6-10	0.8
11-20	0.7
21-50	0.6
51-100	0.5
>100	0.4

In order to farm CAVO tokens, one needs to become a liquidity provider for the EXCV/ETH liquidity pool.

To be more precise user has to:

4. Add liquidity to one of the EXCV/ETH liquidity pools. Simultaneously he would receive liquidity tokens and pCAVO tokens;
5. Wait long enough for CAVO circulating supply to increase;
6. Claim CAVO by burning pCAVO.

Next, user may sell CAVO on the platform to the traders to get a lower fee percentage.

Liquidity Tokens

EXCAVO platform's liquidity tokens represent a liquidity provider's share in the liquidity pool. They are Ethereum-based ERC20 tokens. Each liquidity pool has its own specific non-interchangeable liquidity tokens. They can be sold, purchased and transferred like any other ERC20 token. Each time a user adds liquidity to one of the pool he receives a certain amount of liquidity tokens, proportional to the liquidity he has deposited.

$$\frac{\Delta Q_{LT}}{Q_{LT}} = \frac{\Delta Q_A}{Q_A}$$

$$\frac{\Delta Q_A}{Q_A} = \frac{\Delta Q_A \cdot \sqrt{\Delta Q_B}}{Q_A \cdot \sqrt{\Delta Q_B}} = \frac{\Delta Q_A \cdot \sqrt{\Delta Q_B}}{Q_A \cdot \sqrt{\Delta Q_A \cdot \frac{Q_B}{Q_A}}} = \frac{\sqrt{\Delta Q_A \Delta Q_B}}{\sqrt{Q_A Q_B}} = \frac{\sqrt{\Delta Q_A \Delta Q_B}}{k_{AB}}$$

Thus, the amount of minted liquidity tokens is proportional to the outstanding amount of liquidity tokens:

$$\Delta Q_{LT} = \frac{Q_{LT}}{k_{AB}} \cdot \sqrt{\Delta Q_A \Delta Q_B}$$

We have to prove that the following equivalence holds:

$$\Delta k_{AB} = \sqrt{\Delta Q_A \Delta Q_B}$$

By definition:

$$\Delta k_{AB} \equiv \sqrt{(Q_A + \Delta Q_A)(Q_B + \Delta Q_B)} - \sqrt{Q_A Q_B}$$

One may use the equivalence from subsection "Adding liquidity":

$$\frac{\Delta Q_{LT}}{Q_{LT}} = \frac{\Delta Q_A}{Q_A} = \frac{\Delta Q_B}{Q_B}$$

Applying this formula to Δk_{AB} gives:

$$\Delta k_{AB} = \sqrt{Q_A Q_B}\left(\sqrt{1 + 2 \cdot \frac{\Delta Q_{LT}}{Q_{LT}} + \left(\frac{\Delta Q_{LT}}{Q_{LT}}\right)^2} - 1\right) = \sqrt{Q_A Q_B}\left(\sqrt{\left(1 + \frac{\Delta Q_{LT}}{Q_{LT}}\right)^2} - 1\right)$$

Finally:

$$\Delta k_{AB} = k_{AB} \cdot \frac{\Delta Q_{LT}}{Q_{LT}}$$

This final result convinces us that the amount of liquidity tokens liquidity providers receive is always proportional to the amount of liquidity added by them to the pool.

Conclusion

EXCAVO is an Ethereum-based exchange platform which allows traders to swap ERC20 tokens anonymously, without the involvement of any third party. Contrary to the traditional order-driven market system, EXCAVO platform has liquidity pools, represented by smart contracts and traders trade against these liquidity pools. Anyone can swap or add tokens to the pool to earn fees, or list a token at EXCAVO.

While still in development, EXCAVO platform offers its own advantages and new opportunities to both traders and liquidity providers.

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