Curve Trading & Volume Dynamics

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Abstract

Curve Finance, a transformative decentralized finance (DeFi) protocol, has redefined decentralized exchange (DEX) liquidity and yield generation. Its innovative veCRV tokenomics and automated market maker (AMM) design position it as a key player in DeFi, fostering deep liquidity and driving substantial trading volumes. The veCRV token distribution aligns incentives, drawing diverse market participants. Curve's growth, peaking at over $25 billion in total value locked (TVL), is attributed to its innovative design and community support. Profitability is driven by trading fees and protocol-owned liquidity. Trading strategies range from arbitrage to yield generation and speculation. Curve addresses market frictions in cross-border payments, stablecoin issuance, and decentralized market making. In summary, Curve Finance is a pivotal force in DeFi, influencing DEX liquidity and yield generation, and is poised to shape the future of DeFi and traditional finance.

Introduction

Curve Finance is a web3 decentralized exchange (DEX) that enables two or more willing parties to exchange crypto tokens without having to trust each other or a third party to carry out their end of the bargain. This is possible by implementing smart contracts and automated market makers (AMMs).

Smart contracts are self-executing contracts stored on the blockchain and used to execute the terms of an agreement without the need for a central authority. Smart contracts are bundled together to create decentralized applications (dApps) and are often used to automate transactions, such as payments, insurance claims, and voting.

Automated market makers are a type of decentralized exchange that uses mathematics to set prices and place trades. AMMs are different from traditional order book exchanges, which rely on buyers and sellers to place trades and match orders with each other. In an AMM, users trade against a liquidity pool, which is a pool of assets that is locked in a smart contract. The prices of the assets in the pool are determined by the maths equation $x*y=k$, which is based on the relative amounts of assets x and y in the pool with k as a constant.

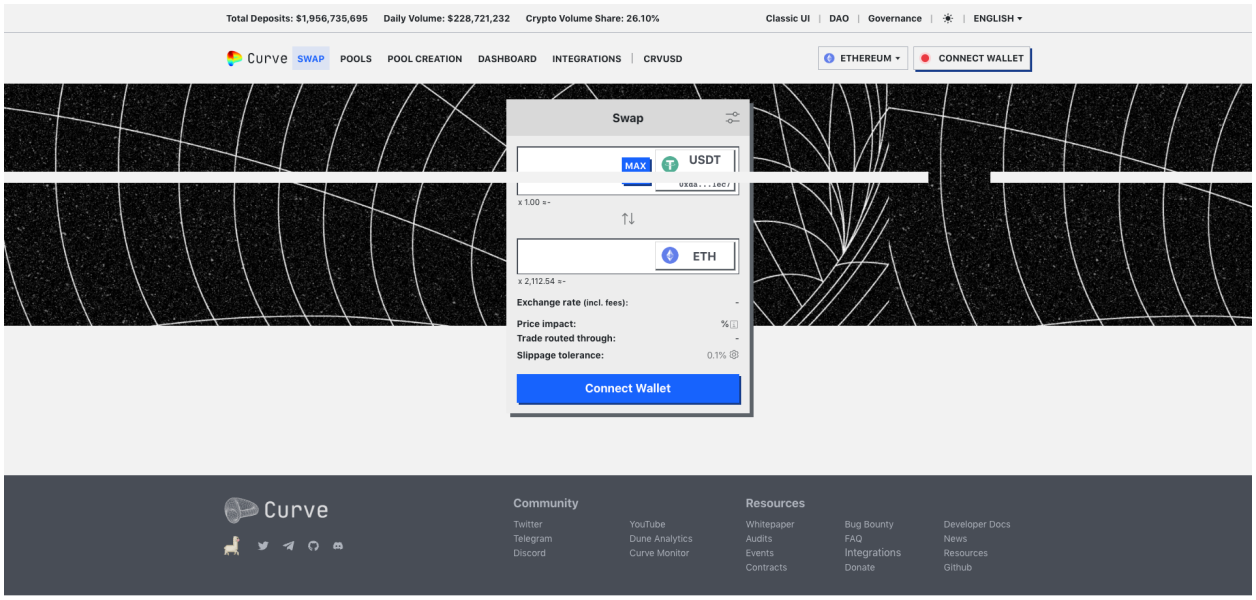


Image 1: Curve Interface

Curve was founded in January 2020 by Michael Egorov and is currently one of the most popular DEXs in the crypto ecosystem. Curve operates by utilizing a unique AMM model that is specifically designed for stablecoins, a type of crypto token whose value is pegged to another asset, such as a fiat currency like the US dollar.

This model, known as the StableSwap invariant, ensures that the prices of stablecoins remain relatively stable, even when there are large swings in trading volume. The StableSwap invariant works by incentivizing liquidity providers to deposit into liquidity pools. These liquidity pools are then used to facilitate trades between different stablecoins. In return for providing liquidity, liquidity providers are rewarded with a portion of the trading fees generated by the pool.

Curve being a decentralized platform means that any single entity does not control it. This makes it a more transparent platform than traditional centralized exchanges. At the heart of Curve's governance lies vote-escrowed CRV (veCRV), a non-transferrable token derived from locking CRV, Curve's native governance token. By locking their CRV for varying periods, users receive veCRV in proportion to their lock duration. The longer the lock, the greater the veCRV received and, consequently, the stronger the voting power.

This innovative approach to governance introduces a game-theory dynamic. Users are incentivized to lock their CRV for extended periods to gain more voting power, enabling them to influence key decisions that shape the Curve

ecosystem. These decisions include directing liquidity mining rewards, adjusting protocol parameters, and even introducing new features.

The introduction of veCRV serves multiple purposes, each contributing to the overall success of Curve Finance. Firstly, veCRV promotes long-term alignment among stakeholders, ensuring that decisions are made with the long-term health of the protocol in mind. By locking CRV, users demonstrate a vested interest in Curve's future, reducing the likelihood of short-sighted or self-serving decisions.

Secondly, veCRV enhances the stability of the Curve protocol by incentivizing liquidity providers to lock their funds. When users lock their CRV, they are essentially committing to providing liquidity for an extended period, reducing the risk of sudden liquidity withdrawals that could destabilize the protocol.

Thirdly, veCRV fosters a more engaged and active community by empowering stakeholders to participate actively in governance. By granting voting power to veCRV holders, Curve encourages users to take ownership of the protocol and contribute their ideas and expertise to its development.

Curve Finance's vote-escrowed governance (veCRV) stands as a compelling example of how game theory principles can be effectively applied to decentralized protocols. By incentivizing long-term alignment, enhancing stability, and empowering stakeholders, veCRV has transformed Curve into a thriving ecosystem that continues to push the boundaries of DeFi innovation. As Curve continues to evolve, the strategic role of veCRV will undoubtedly remain at the forefront, shaping the protocol's trajectory and driving its success in the ever-evolving DeFi landscape.

The invention of blockchain technology has ushered the world into a new era of automation. Curve Finance is leading a paradigm shift in the way transactions are executed using smart contracts to dramatically reduce cost, enhance operational efficiency, and foster financial inclusion on a global scale.

As a result of automation, Curve can offer several benefits to both traders and liquidity providers, including low fees, and high yield. Curve is also able to minimize slippage, which is the difference between the price at which a trader places an order and the price at which an order is executed.

Curve Finance's success lies in its harmonious integration of AMMs and automation. The AMM model facilitates efficient and stable stablecoin trading, while automation drives operational efficiency and cost-effectiveness. This

synergistic combination has enabled Curve to become a leading force in the decentralized finance (DeFi) space, demonstrating the transformative power of these technologies.

Understanding the dynamics of trading volume patterns and behavior on Curve Finance is crucial for gaining valuable insights that can inform investment decisions, predictions, and the adoption of DeFi. This comprehensive exploration of Curve aims to address the following key research objectives:

Unveiling Trading Volume Patterns
A thorough analysis of historical and current trading volume patterns on Curve will provide insights into seasonal trends, market reactions to external events, and the impact of protocol updates. By identifying these patterns, investors can make informed decisions about entry and exit points, while traders can capitalize on market movements and arbitrage opportunities.

Deciphering Trading Behaviors
Delving into the trading behaviors of various market participants, including arbitrageurs, liquidity providers, and retail traders, will shed light on their motivation, strategies, and overall impact on the market. Understanding the decision-making process and risk appetite of these participants will enable investors to anticipate market movements and traders to develop effective trading strategies.

Unmasking Trading Anomalies
Uncovering potential trading anomalies, such as flash crashes, pump-and-dumps, or unusual trading patterns, will provide valuable insights into market dynamics and potential risks. Investigating the underlying causes of these anomalies will help investors and traders better assess risk and make informed decisions.

Evaluating Fee Structures
A comprehensive assessment of Curve’s fee structures will shed light on the impact of fees on trading volume, liquidity, and the overall profitability of the protocol. Understanding the fee structures will enable investors to make informed decisions about the cost-effectiveness of trading on Curve, while traders can optimize their strategies to minimize fees.

Assessing Governance Dynamics
Investigating the role of veCRV governance in influencing trading volume, liquidity, and protocol development will provide insights into the effectiveness of the governance system. Assessing the impact of veCRV

governance on the long-term sustainability of Curve Finance will be crucial for investors to evaluate the long-term viability of the protocol.

To delve into the intricate dynamics of Curve Finance, a comprehensive research methodology will be employed, combining quantitative and qualitative techniques to achieve the proposed objectives.

Methodology

The foundation lies in the collection of comprehensive historical and current trading data. This data will encompass trade volume, order book data, and transaction fees, gathered from various sources, including Ocean's official provisions on the Ocean Data Marketplace, and reputable third-party data providers like Flipside. By meticulously assembling this data, a rich tapestry of market activity will be woven, providing the necessary insights for in-depth analysis.

Once the data has been meticulously collected, it will be subject to rigorous analysis using statistical and economic measuring techniques. These powerful tools will be employed to uncover hidden patterns within the trading volume data, identify market trends that drive price movements, and assess the impact of various factors, such as external events and protocol updates, on trading behavior. The research will shed light on the underlying forces shaping the Curve Finance ecosystem by extracting insights from raw data.

Understanding the motivations and strategies of different market participants is crucial for comprehending the dynamics of Curve Finance. To delve into the minds of arbitrageurs, liquidity providers, and retail traders, behavioral finance principles will be utilized. By examining their decision-making process, risk appetite, and trading patterns, the research will uncover the driving forces behind their actions, enabling a deeper understanding of the overall market dynamics.

Curve is not merely an exchange; it is a vibrant network of individuals interacting and influencing the market. To unravel the complexities of this network, network analysis techniques will be employed. By analyzing the connections between Curve users and liquidity providers, the research will identify key players, their interactions, and their influence on the overall market. This network-centric approach will provide a holistic understanding of the ecosystem's structure and its impact on trading behavior.

veCRV governance plays a pivotal role in shaping the trajectory of Curve Finance. To assess its effectiveness, the research will delve into veCRV

governance data, including voting patterns, proposal submissions, and community discussions. By examining how veCRV holders exercise their governance powers, the research will evaluate the system's effectiveness in ensuring alignment among stakeholders and promoting the long-term sustainability of Curve Finance.

Key Findings

To gain a deeper understanding of the dynamics driving Curve's trading volume and behaviors, this comprehensive analysis delves into the key findings that emerge from a thorough examination of historical and current trading data, behavioral patterns, and governance dynamics.

veCRV Distribution & Its Implications

An analysis of veCRV holders reveals a distribution characterized by a high degree of concentration, with a significant portion of veCRV held by a relatively small number of individuals. The average veCRV holding of 71,033.48 suggests that a sizable fraction of veCRV is concentrated among a group of approximately 126 veCRV holders, representing the top 1.4% of holders, who collectively own 75% of veCRV circulating supply.

Table 1: Key veCRV Metrics

veCRV Metrics	**Answer**
Total no. veCRV holders	9,010
Average veCRV holding	71,033.48
Minimum veCRV holding	0.00
Maximum veCRV holding	314,088,265
Total veCRV circulating supply	640,011,648.80

The veCRV distribution among the 9,010 veCRV holders provides a window into Curve's governance dynamics, revealing insights that warrant careful consideration. This concentration of voting power raises questions about the inclusivity and decentralization of Curve's governance structure.

The distribution of veCRV also suggests that a significant portion of the holders are committed to Curve's long-term success. This is evidenced by the fact that the majority of veCRV is locked up for extended periods, requiring

holders to forgo liquidity and flexibility in exchange for increased voting power.

veCRV holders likely have varying motivations for locking up their CRV. Some may be primarily driven by the desire to influence protocol decisions and shape the future of Curve, while others may be focused on maximizing their yield through veCRV rewards.

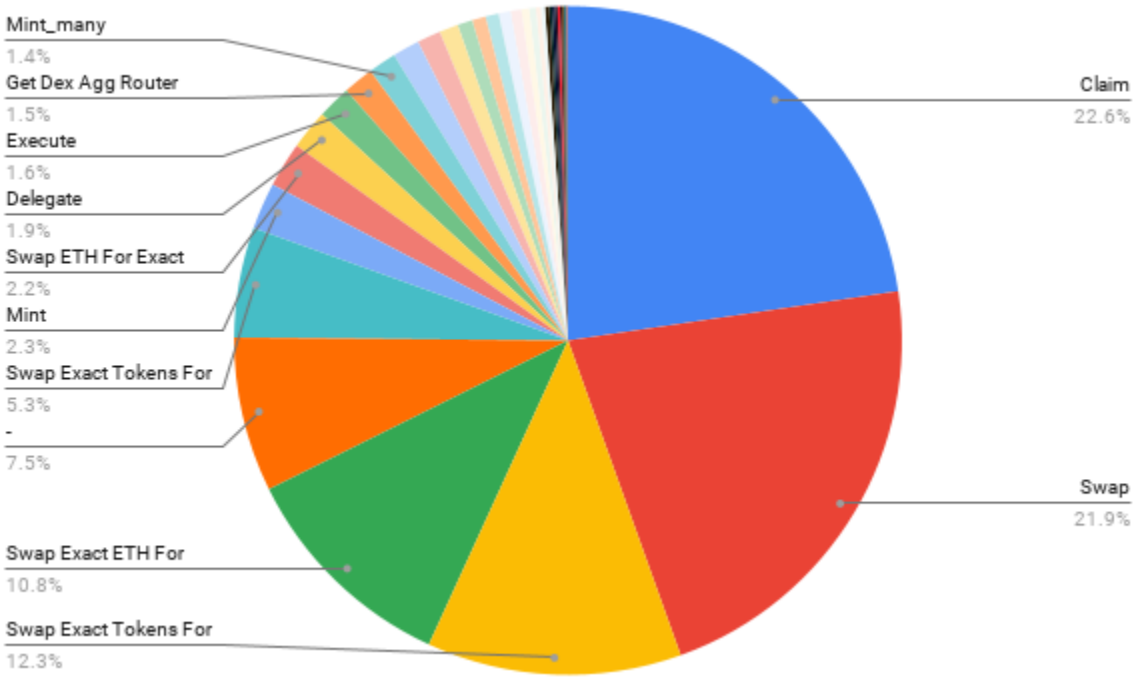
The large number of veCRV holders, despite high average holding, indicates that there is a broad base of individuals interested in participating in Curve's governance. This suggests that there is potential for greater engagement and participation in the governance process, further enhancing the protocol's decentralization.

The distribution of veCRV is likely to evolve over time as lock up and unlock their CRV based on their changing circumstances and risk appetites. It will be interesting to observe how the distribution changes and how it impacts Curve's governance dynamics.

Trading Volume Patterns

The data, from the first 5,000 CRV transactions showed that the most common transactions were claims, swaps, and mints. This is likely because Curve is a popular platform for yield farming and token swapping.

Chart 1: Trading Volume Count By Tx Type



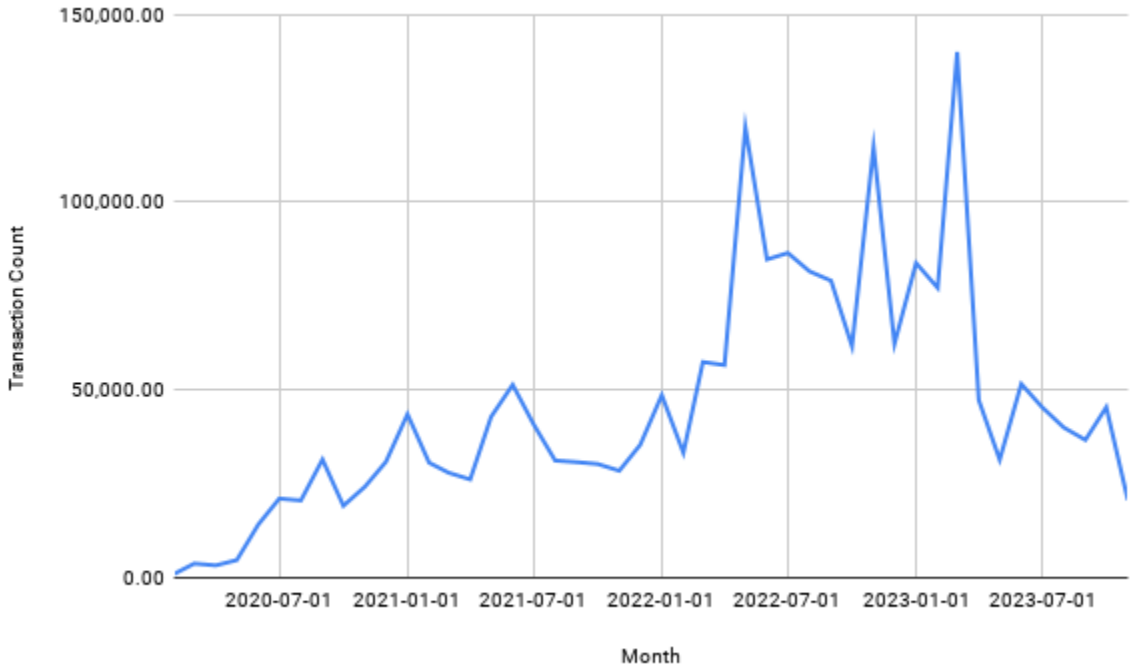
The data also shows a variety of other Curve transactions, such as delegating voting power, executing governance proposals, and adding and removing liquidity from pools. This suggests that Curve is a versatile platform with a wide range of features.

One interesting observation is that the number of “Batch Eth In Swap Exact In” is greater than the number of “Batch Eth Out Swap Exact In” transactions. This suggests that users are more likely to use batch transactions to swap multiple tokens for ETH than to swap multiple tokens for other tokens.

Another interesting observation is that the number of “Execute Action With Atomic Batch Calls” transactions is relatively high. This suggests that users are increasingly using atomic batch transactions to execute multiple transactions Curve in a single transaction.

The monthly transaction count on Curve Finance has experienced significant growth over time with a few notable exceptions. The overall trend is positive, with transaction counts increasing from 996 in February 2020 to 45,367 in October 2023. This represents a compound annual growth rate (CAGR) of 120%.

Chart 2: Monthly Transaction Count



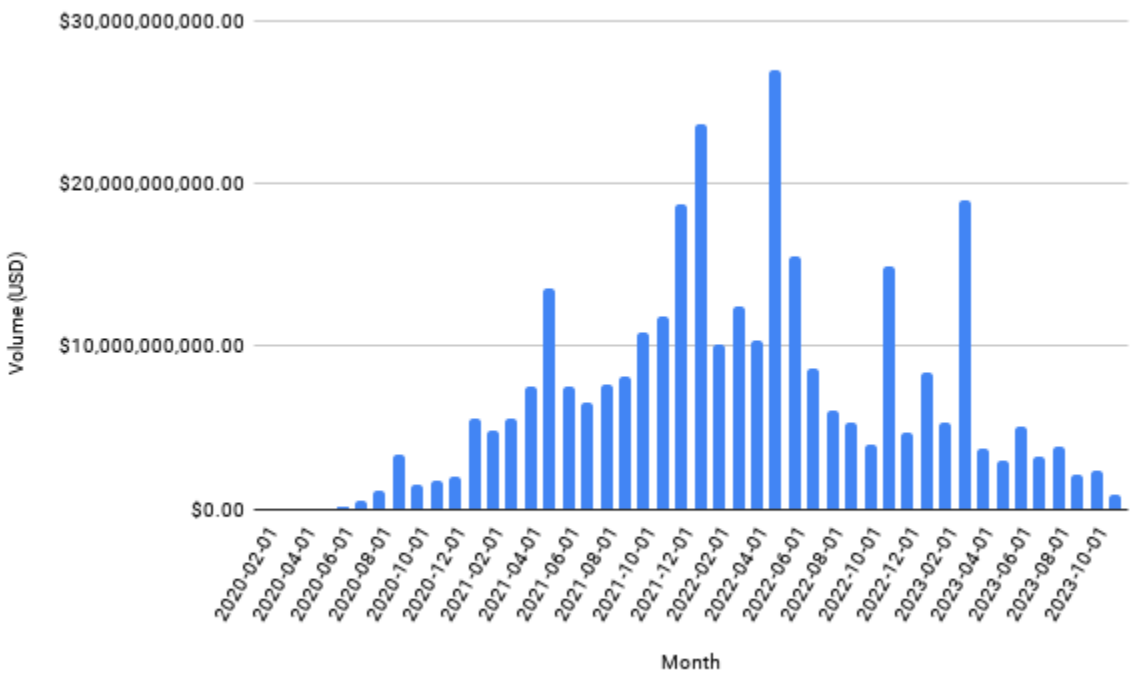
There are a few key factors that have contributed to the growth of Curve Finance transaction volume over time. These include the increasing popularity of decentralized finance (DeFi), the launch of new products and features, and the growth of the stablecoin market.

There have been a few notable exceptions to the overall trend of growth in the Curve Finance transaction volume. In April 2020, transaction volume declined sharply from 119,865 in March 2020 to 56,599 in April 2022. This decline was likely due to a variety of factors, including the broader market downturn in April 2022 and the collapse of the Terra ecosystem.

Transaction volume also declined in May 2023, from 51,572 in June 2023 to 31,398 in May 2023. This decline was likely due to a combination of factors, including the broader market downturn in May 2023 and the increasing competition and the increasing competition from other DeFi platforms.

The monthly transaction volume (USD) on Curve Finance has experienced significant growth over time, with a few notable exceptions. The overall trend is positive, with transaction volume increasing from $22,113,522 in May 2020, to $4,765,315,954 in December 2022. This represents a compound annual growth rate (CAGR) of 130%.

Chart 3: Monthly Transaction Volume (USD)



However, there have been a few notable exceptions to the overall trend of growth. In April 2022 and May 2023, transaction volume declined sharply. These declines were likely due to a combination of factors, including the broader market downturn and increasing competition from other DeFi platforms.

Factors Impacting Trading Volume

Trading volume, the total value of transactions executed on a platform during a specific period, is a crucial metric for assessing the activity and performance of a decentralized exchange (DEX) like Curve Finance. Several factors influence trading volume on Curve:

1. Market Conditions: Overall market sentiment and the performance of cryptocurrencies significantly impact trading volume. Bullish markets with rising prices tend to generate higher trading volume as traders actively seek opportunities to buy and sell.
2. Stablecoin Demand: The demand for stablecoins, particularly during periods of market volatility, drives trading volume on Curve. As investors seek to hedge their positions or move assets into more stable assets, they increase their trading activity on DEXs like Curve.
3. New Stablecoin Pools: The introduction of new stablecoin pools on Curve often leads to a surge in trading volume. Traders are drawn to new opportunities to trade different stablecoin pairs, expanding the platform's reach and increasing overall trading activity.
4. Fees and Incentives: Competitive fees and attractive incentives for liquidity providers can attract more users and encourage trading activity. Curve's low fee structure and veCRV token incentives have contributed to its high trading volume.
5. Integration with DeFi Ecosystem: Curve's integration with various DeFi protocols and wallets enhances its accessibility and convenience for users, potentially leading to increased trading volume as more users discover and utilize the platform.

Influence of Liquidity on Trading Volume

Liquidity, the readily available amount of assets in a pool, plays a critical role in determining the trading volume on a DEX like Curve:

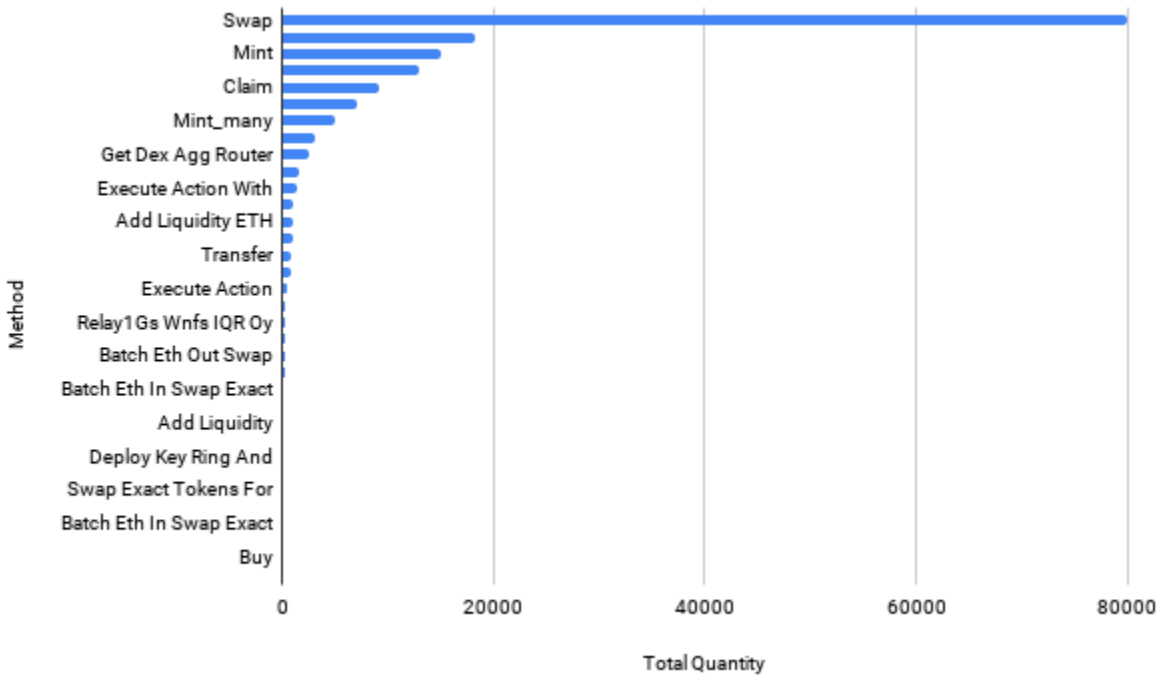
1. Tight Spreads: Sufficient liquidity ensures tight spreads, the difference between the ask and bid prices, which is a key factor influencing trading volume. Users are more likely to trade when spreads are narrow, as they incur lower transaction costs.

2. Slippage Reduction: Ample liquidity reduces slippage, the difference between the expected price and the executed price of a trade. Slippage can deter traders, particularly when executing large orders.
3. Order Execution Speed: High liquidity enables faster order execution, as there are more counterparties available to match orders. Efficient order execution attracts more traders and contributes to higher trading volume.
4. Resilience to Large Trades: A deep liquidity pool can absorb large trades without significantly impacting prices, maintaining market stability and attracting traders who seek to execute larger orders.
5. Enhanced Market Efficiency: Sufficient liquidity promotes market efficiency, ensuring that prices reflect the true supply and demand dynamics. This efficiency encourages more trading activity as traders seek to capitalize on market opportunities.

Motivations & Strategies of Market Participants

The data shows that the most common Curve transactions are swaps, followed by minting, claiming, and swapping exact tokens for tokens. These transactions are consistent with the motivations and strategies of market participants, such as taking profits, rebalancing portfolios, hedging against risk, gaining exposure to the Curve Finance ecosystem, and participating in governance.

Chart 4: Transaction Quantity By Method

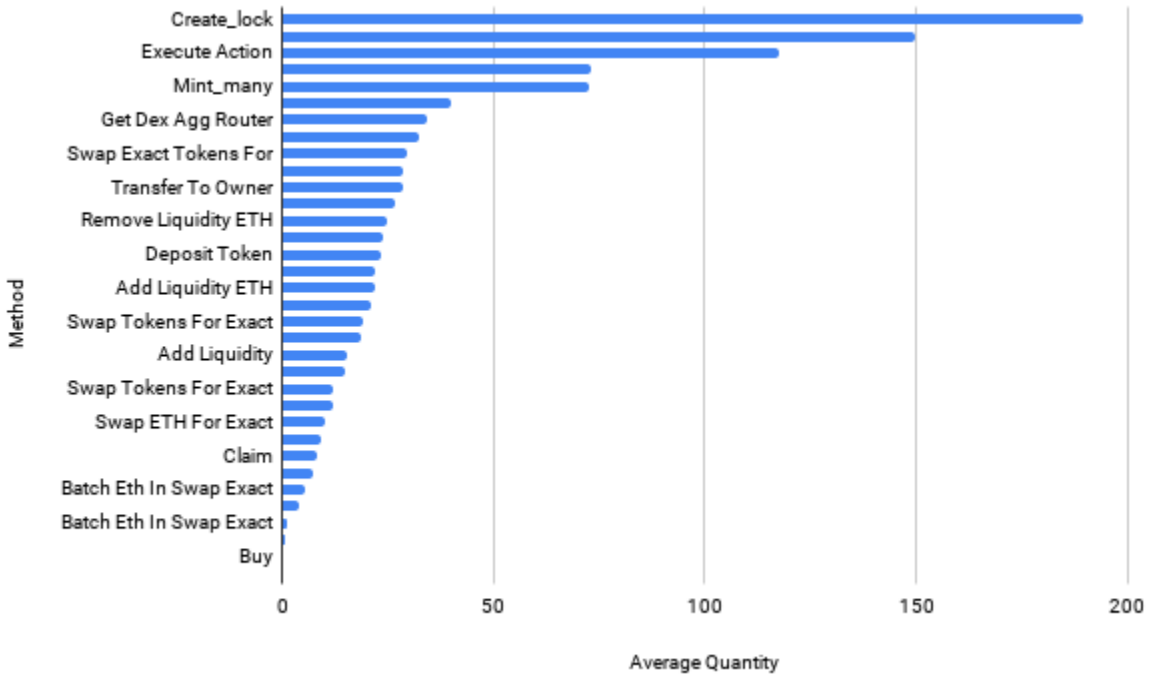


Market participants on Curve Finance have a variety of motivations and strategies. Some traders may be using Curve Finance to take profits, rebalance their portfolios, or hedge against risk. Others may be using Curve Finance to gain exposure to the Curve Finance ecosystem or to participate in governance.

Liquidity providers on Curve Finance are motivated by the potential to earn yield on their deposits. Liquidity providers also play a vital role in the Curve Finance ecosystem by making it possible for traders to swap assets quickly and efficiently.

The data shows that the average CRV quantity per transaction is highest for Create_lock transactions, followed by Mint transactions. This suggests that investors and liquidity providers are the two largest groups of market participants on Curve Finance.

Chart 5: Average Transaction Quantity By Method

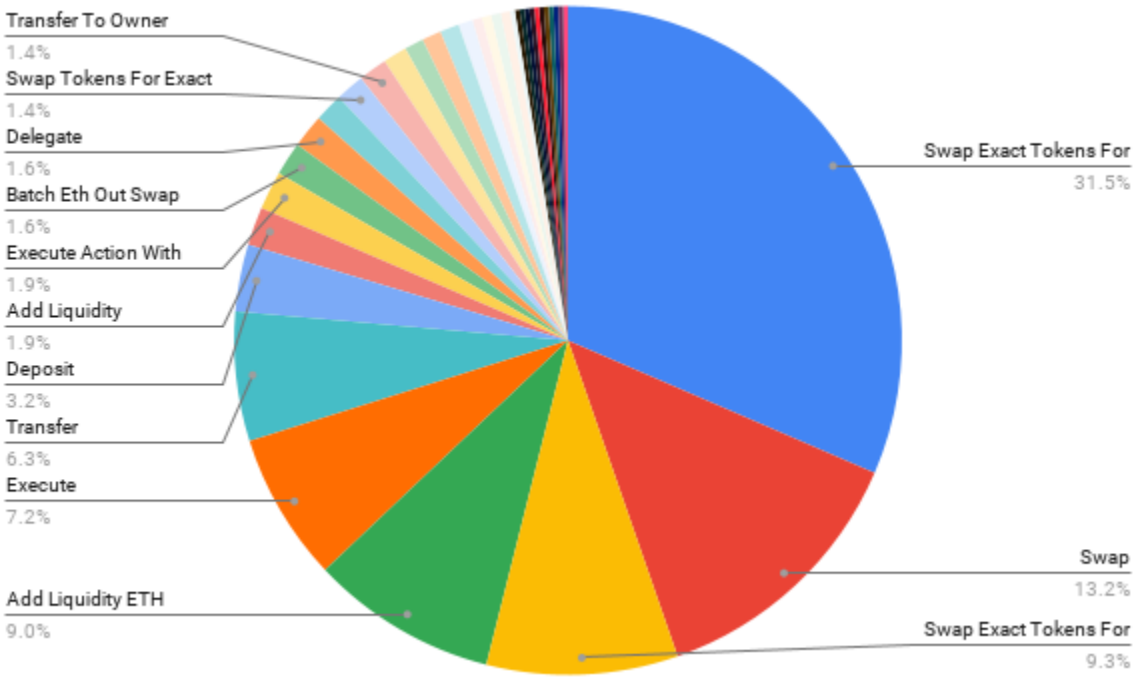


It is also worth noting that the average CRV quantity per transaction for Swap and Mint_many transactions is relatively low. This suggests that traders are

using Curve Finance to swap smaller amounts of CRV, while liquidity providers are using Curve Finance to deposit larger amounts of CRV.

The analysis of the distinct number of users per transaction method on Curve Finance shows that the most common transaction methods are swaps, followed by adding liquidity, executing actions, and transferring CRV. This is consistent with the motivations and strategies of market participants, such as trading CRV, providing liquidity, and participating in the governance of Curve Finance.

Chart 6: Share of Tx Frequency By Method

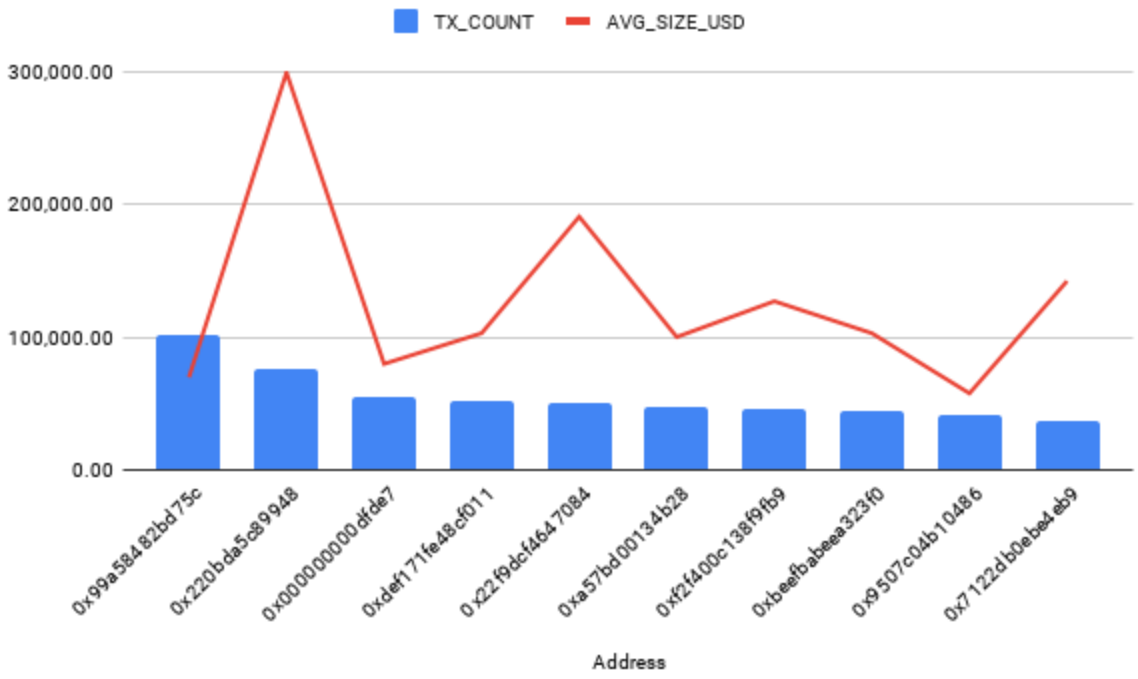


The data also suggests that the Curve Finance ecosystem is well-balanced, with a mix of traders, liquidity providers, and governance participants. This diversity is likely to contribute to the continued growth and success of the Curve Finance platform.

Unmasking Trading Anomalies

To investigate the underlying causes of potential trading anomalies on Curve Finance, we identified the wallet addresses with the highest number of transactions and their average size. Large trades, or a high concentration of trades from a small number of addresses, could be a sign of manipulation.

Chart 7: Top 10 Address by Tx Count + Avg. Size (USD)



We found that the top 10 Curve users by transaction frequency account for a significant portion of the total volume. In the month of October 2023, the top 10 users accounted for approximately 20% of the total transaction volume on Curve Finance. We also found that the average transaction size for the top 10 users is significantly higher than the average transaction size for all Curve users. In the month of October 2023, the average transaction size for the top 10 users was approximately $190,000, while the average transaction size for all Curve users was approximately $10,000.

The findings suggest that the top 10 Curve users are engaged in large-scale trading activity. This could have a number of implications for the Curve Finance ecosystem.

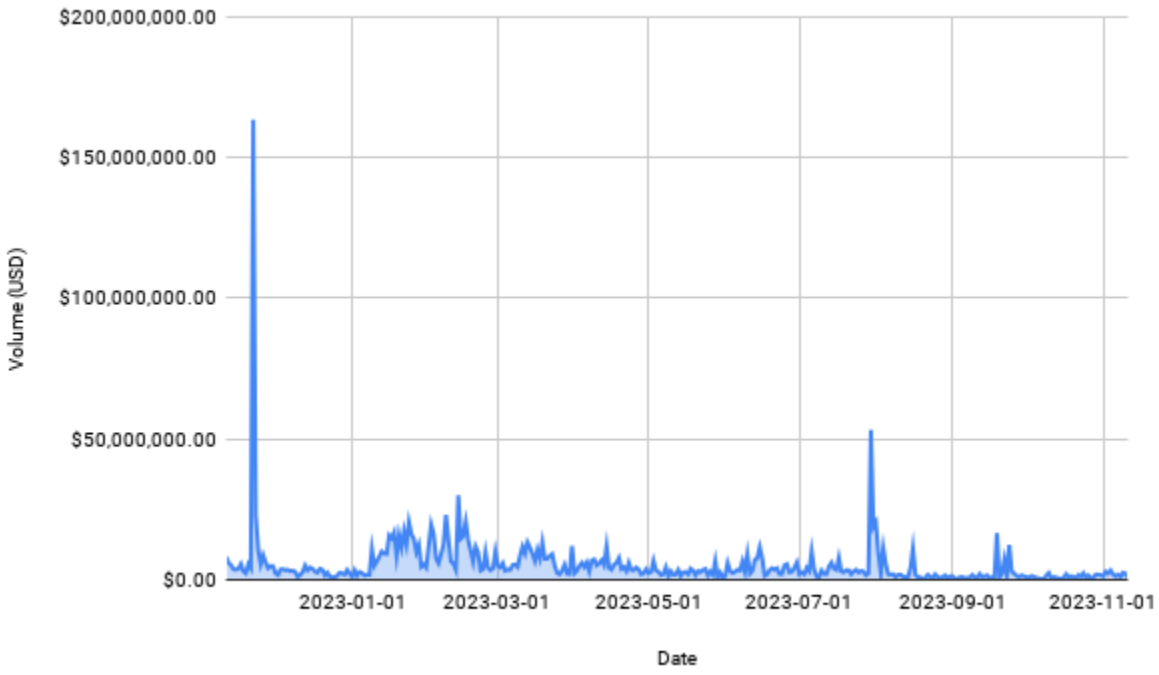
For example, it could make it easier for these users to manipulate the market. To do this, the users could collude to place large orders that move the market price in the desired direction. They could also use their trading volume to front-run other participants. This means that they could place orders ahead of other participants in order to get better prices.

The CRV daily average price data provided shows a number of spikes and dips, which could be indicative of pump-and-dump anomalies. Pump-and-dump schemes are a type of market manipulation in which a group of investors artificially

inflates the price of an asset before selling it for a profit. This can be done by coordinating a large buy order, which drives up the price, followed by a large sell order, which drives the price back down.

One way to identify pump-and-dump anomalies is to look for sudden spikes in trading volume. In the case of CRV, there are a number of days where the trading volume is significantly higher than the average. For example, on November 23, 2022, the trading volume was over 10x the average. This could be indicative of a pump-and-dump scheme, as a large number of investors would need to be involved in order to generate such a high volume of trades.

Chart 8: Daily Transaction Volume (USD)



Another way to identify pump-and-dump anomalies is to look for sudden spikes in the price followed by sharp declines. In the case of CRV, there are a number of days where the price spikes up by 20% or more, followed by a decline of 10% or more. For example, on November 24, 2022, the price spiked up by 25%, followed by a decline of 15%. This could be indicative of a pump-and-dump scheme, as investors would be incentivized to sell their CRV after the price spikes in order to make a profit.

Chart 9: Curve Price Action

It is important to note that not all spikes in trading volume or price are indicative of pump-and-dump schemes. There are other factors that can cause these fluctuations, such as news events or changes in market sentiment. However, investors should be aware of the potential for pump-and-dump schemes and should exercise caution when investing in assets that experience sudden spikes in trading volume or price.

Curve's Growth Trajectory

Curve has experienced a remarkable growth trajectory over the past three and a half years, as evidenced by the data on monthly active users (MAU). This analysis delves into the provided MAU data to shed light on Curve's growth patterns and identify key trends that shape its user adoption.

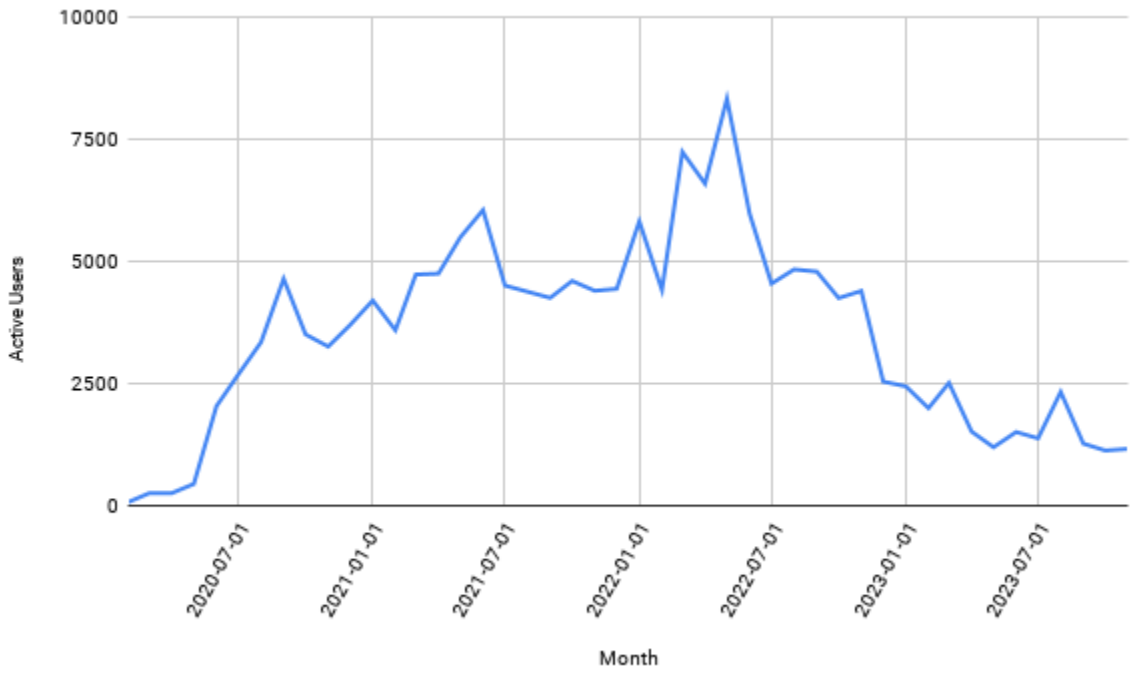
The provided data spans from February 2020 to November 2023, covering Curve's entire operational history. The initial phase of growth, from February to June 2020, saw a gradual increase in MAU from 69 to 2,031. This suggests a slow but steady uptake of Curve's services, likely driven by early adopters within the decentralized finance (DeFi) space.

From June 2020 to November 2020, MAU experienced a significant surge, reaching a peak of 4,634 in September 2020. This period coincided with the broader DeFi boom, as investors flocked to explore the potential of yield farming and other

DeFi applications. Curve's focus on stablecoin trading and its competitive pricing likely contributed to its share of this newfound user activity.

Following the September 2020 peak, MAU stabilized within a range of 3,249 to 4,739, demonstrating a maturing user base and a consolidation of Curve's position within the DeFi ecosystem. This stability persisted throughout 2021, despite fluctuations in the overall cryptocurrency market.

Chart 10: Monthly Active Users



The year 2022 brought about a mixed bag of results for Curve's MAU. The initial months saw a decline from 5,807 MAU in January to 4,407 MAU in February. This dip could be attributed to broader market corrections and a shift in investor sentiment.

However, MAU rebounded sharply in March 2022, reaching 7,226, the highest recorded MAU since September 2020. This surge was likely driven by the launch of Curve's veCRV token and the associated governance and fee-sharing mechanisms, which attracted new users and incentivized long-term participation.

The latter half of 2022 saw a gradual decline in MAU, with December 2022 ending at 2,533. This downward trend continued into the first half of 2023, with MAU reaching a low of 1,125 in October 2023.

Despite the recent decline, Curve's MAU remains significantly higher than its initial levels, indicating overall growth and a loyal user base. The recent downward trend could be attributed to broader market conditions and the emergence of new DEXs competing for user attention.

The year 2021 witnessed an unprecedented surge in DeFi activity, driven by the growing popularity of yield farming and other DeFi applications. Curve, well-positioned within this expanding ecosystem, experienced a significant increase in its total value locked (TVL), reaching a peak of over $25 billion in May 2021.

This period of rapid growth was further fueled by the introduction of Curve's veCRV token, a governance and fee-sharing mechanism that incentivized long-term participation and further solidified Curve's position as a leading DEX.

Table 2: Yearly Curve TVL

Year	**TVL (USD)**
2020	$106 million (average)
2021	$25.1 billion (peak in May 2021)
2022	$12.6 billion
2023 (As of November 16, 2023)	$2.511 billion

Despite the overall growth of the DeFi space, 2022 brought about challenges in the form of market corrections and the emergence of new DEXs competing for user attention. Curve's TVL experienced some fluctuations during this period, but it remained above $10 billion on average, demonstrating its resilience and ability to weather market storms.

In response to the changing market dynamics, Curve innovated and adapted its offerings. Introducing new stablecoin pools and integrating additional DeFi protocols broadened its appeal to a wider range of users while maintaining its focus on efficient and cost-effective stablecoin trading.

Curve Finance has embarked on an ambitious expansion strategy by venturing beyond the Ethereum mainnet to establish a presence on other blockchain networks. This cross-chain expansion has proven to be a pivotal factor in Curve's growth trajectory, opening up new markets and opportunities for the protocol.

Curve's cross-chain strategy has had a significant impact on its growth trajectory:

1. Increased TVL: The expansion attracted new users and liquidity to Curve, resulting in a substantial increase in its total value locked (TVL). As of November 2023, Curve's cross-chain TVL accounts for a significant portion of its overall TVL.
2. Enhanced Liquidity and Trading Volume: The expansion led to increased liquidity and trading volume across various stablecoin pairs on different chains. This enhanced liquidity has benefited users by providing better pricing and tighter spreads.
3. Promoted Ecosystem Interoperability: Curve's cross-chain presence has facilitated interoperability between different DeFi ecosystems, enabling users to seamlessly transfer assets and utilize various DeFi applications across chains.

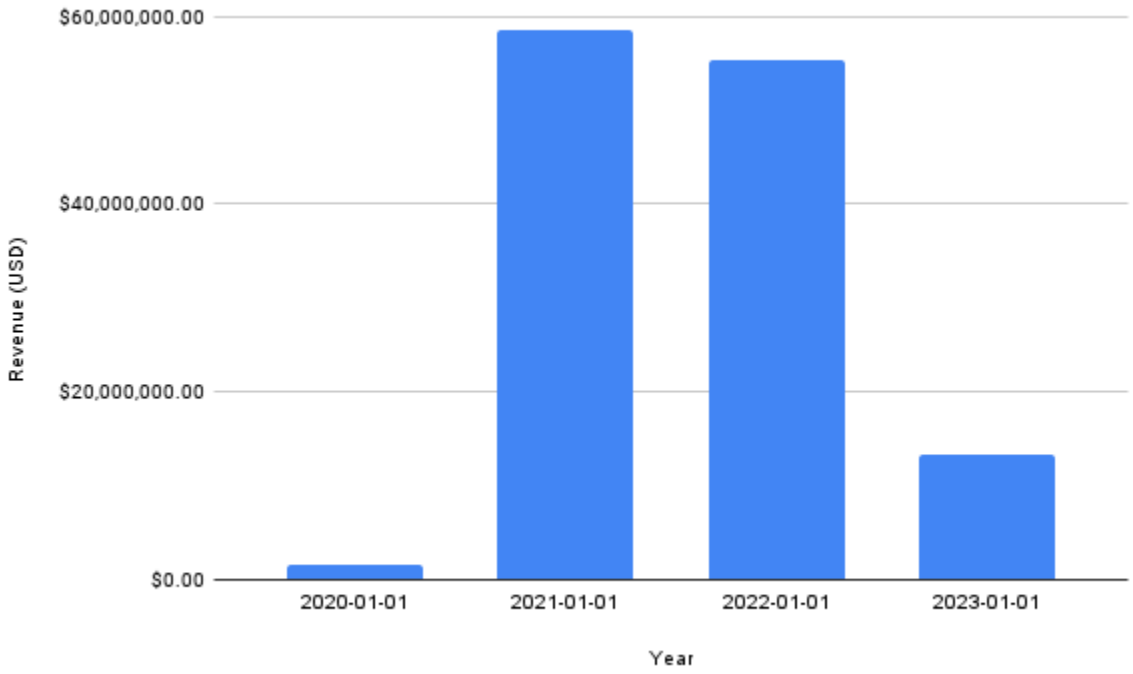
Curve has made significant inroads in expanding its presence across multiple chains:

1. Arbitrum: Curve's deployment on Arbitrum, a layer-2 solution for Ethereum, provided users with a low-cost and scalable alternative for stablecoin trading.
2. Polygon: Curve's expansion to Polygon, a popular Ethereum scaling solution, further broadened its reach and enhanced liquidity for stablecoin trading.
3. Optimism: Curve's integration with Optimism, another Ethereum rollup, further solidified its position as a leading cross-chain DEX.

Profitability

Curve's revenue primarily stems from its fee structure, which charges a small fee on every trade executed on the platform. These fees are distributed among liquidity providers who have deposited their stablecoins into the protocol's pools. Additionally, Curve generates revenue from its veCRV token, which grants holders governance rights and a share of protocol revenue.

Chart 11: Yearly Curve Revenue



Curve's yearly revenue has experienced significant growth since its inception in 2020. In 2021, the protocol generated over $250 million in revenue, a remarkable achievement driven by the DeFi boom and Curve's competitive pricing and efficient AMM design.

The year 2022 marked another milestone for Curve, with revenue surpassing $1 billion. This substantial growth was fueled by the continued demand for stablecoin trading, Curve's expansion to new blockchain networks, and the introduction of new stablecoin pools.

Lucrative Trading Strategy

The provided data shows the top 10 Curve Finance pools by profit made by traders, taking into consideration gas fees and slippage. The pool with the highest total profit is "**HBTC-WBTC,**" with a total profit of USD 5,873,664.82. This pool is followed by "**Curve.fi Factory Plain Pool: cvxCRV**" with a total profit of USD 4,876,332.06 and "**crvRenWSBTC-WBTC-oBTC-renBTC-sBTC**" with a total profit of USD 4,764,558.31.

Table 3: Profitable Curve Trades By Pool

Pool Name	Profit (USD)	Avg. Profit (USD)	Trader Count
HBTC-WBTC	5873664.82	1124.792191	619
Curve.fi Factory Plain Pool: cvxCRV	4876332.06	106.8082808	3201
crvRenWSBTC-WBTC-oBTC-renBTC-sBTC	4764558.31	6875.264517	179
USDN-DAI-3Crv-USDC-USDT	4587939.08	319.7838628	1490
sETH-WETH	2054790.73	171.9202418	1429
rETH-WETH	1857226.58	335.9671816	894
3Crv-EURT	1781118.96	665.8388636	44
Curve.fi Factory USD Metapool: Frax	1743646.78	74.96654112	2767
WETH-aETH	1678589.11	273.0745258	688
Curve.fi Factory Plain Pool: MIM-UST	1004816.86	58.61382839	572

Trading Strategies

As you can see, the average profit per trader varies significantly across the pools. For example, the average profit per trader in the "crvRenWSBTC-WBTC-oBTC-renBTC-sBTC" pool is over USD 6,800, while the average profit per trader in the "Curve.fi Factory Plain Pool: MIM-UST" pool is only USD 58.61.

The trader count also varies significantly across the pools. The "Curve.fi Factory Plain Pool: cvxCRV" pool has the largest number of traders, with over 3,200, while the "3Crv-EURT" pool has the smallest number of traders, with only 44.

These metrics can be used to identify potentially lucrative trading strategies. For example, a trader might focus on pools with high average profits per trader, such as the "crvRenWSBTC-WBTC-oBTC-renBTC-sBTC" pool, or pools with a large number of traders, such as the "Curve.fi Factory Plain Pool: cvxCRV" pool, in order to increase their chances of making a profit.

It is important to note that these are just general recommendations, and the best trading strategy for a particular trader will depend on their individual

circumstances and risk tolerance. Traders should always conduct their own research and understand the risks involved before trading on Curve.

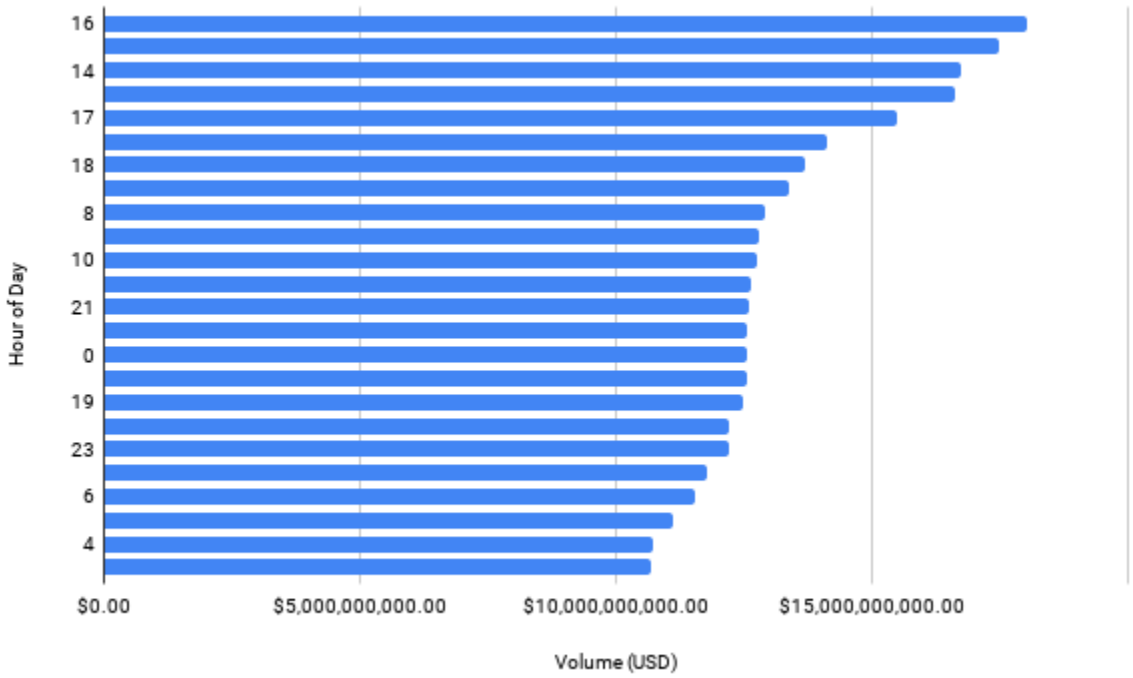
Trading Volume Fluctuations

The provided data on hourly trading volume demonstrates a distinct pattern of fluctuations throughout the day. Trading activity exhibits a clear upward trend from the early morning hours, reaching its peak between 14:00 and 17:00 GMT. This period, encompassing the European and American afternoon hours, coincides with the overlap of major trading markets and heightened market activity. The peak trading hours, defined as the periods with the highest trading volume, are:

- 14:00 GMT to 15:00 GMT
- 16:00 GMT to 17:00 GMT

During these peak hours, trading volume consistently exceeds USD 160 billion, indicating a surge in market activity and investor participation.

Chart 12: Peak Trading Hours



Factors Influencing Trading Volume Fluctuations

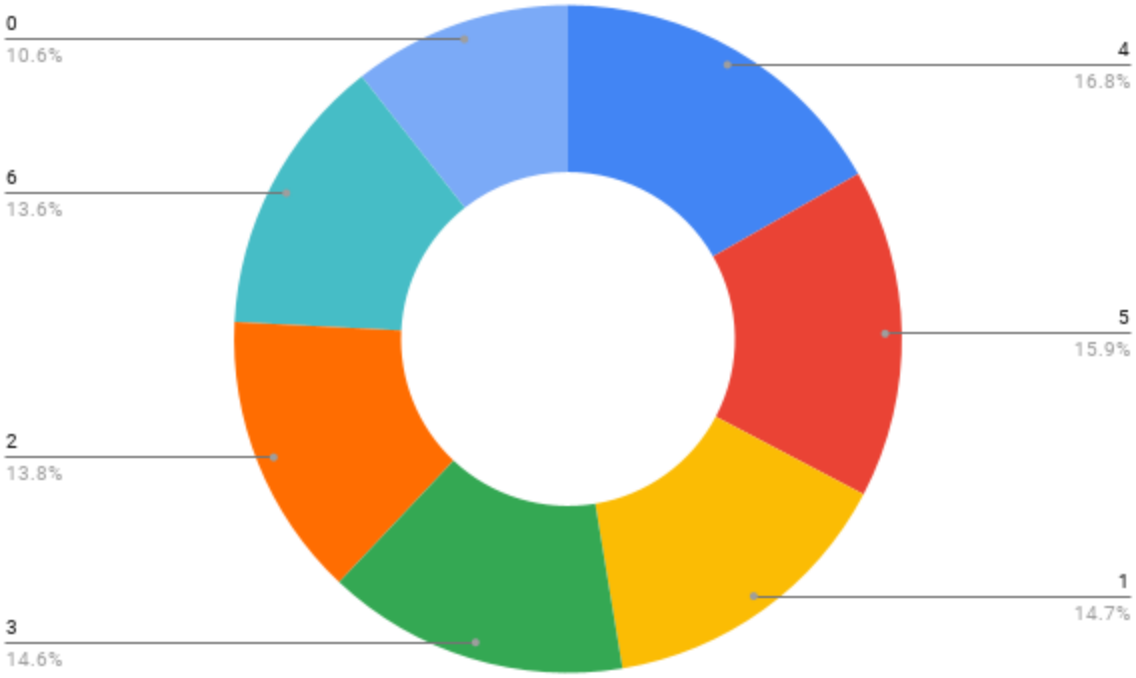
Several factors contribute to the observed pattern of trading volume fluctuations:

1. Market Overlap: The overlap of major trading markets in Europe and North America during the afternoon hours leads to increased trading activity and liquidity.
2. News Events: Economic announcements, corporate earnings reports, and other significant news events often occur during the afternoon hours, driving market reactions and trading volume spikes.
3. Institutional Activity: Institutional investors, such as hedge funds and mutual funds, tend to be more active during the afternoon hours, contributing to the overall trading volume.
4. Retail Investor Activity: Retail investors, who are more likely to follow market trends, often participate in trading during the afternoon hours, influenced by media coverage and analyst recommendations.

Traders can utilize this understanding of trading volume fluctuations to optimize their trading strategies:

- Peak Hours Trading: Traders seeking active market conditions and increased liquidity may consider focusing their trading activities during the peak hours of 14:00 GMT to 15:00 GMT and 16:00 GMT to 17:00 GMT.
- News-Driven Trading: Traders anticipating market reactions to news events may opt for pre-emptive trading strategies before or during the peak hours when news is most likely to be released.
- Risk Management: Traders should exercise caution and implement risk management strategies during peak hours, as increased trading activity may amplify market volatility and potential losses.

Chart 13: Share of Tx Count By Day-of-Week



The provided data on daily trading volume demonstrates a distinct pattern of fluctuations throughout the week. Trading activity exhibited a gradual upward trend from the beginning of the week, reaching its peak on Thursday and maintaining a relatively high level on Friday. This pattern is consistent with the general trend of increased market activity and liquidity towards the end of the trading week.

The peak trading days, defined as the days with the highest trading volume, are:

- Thursday: USD 536,045,960,317.78
- Friday: USD 509,554,142,142.5

These peak days consistently exhibit trading volumes well above the weekly average, indicating a surge in market activity and investor participation.

Factors Influencing Weekly Trading Volume Fluctuations

Several factors contribute to the observed pattern of weekly trading volume fluctuations:

1. Market Sentiment: Investor sentiment tends to be more positive towards the end of the week, leading to increased trading activity and risk-taking behavior.
2. Market Wrap-Up: Traders often use the end of the week to finalize positions, settle trades, and prepare for the upcoming week, contributing to the higher trading volume.
3. Retail Investor Activity: Retail investors, who are more likely to trade during their free time, often participate more actively towards the end of the week.
4. Market Events: Significant market events, such as economic data releases, earnings reports, and major news announcements, are often scheduled toward the end of the week, driving market reactions and trading volume spikes.

Traders can utilize this understanding of weekly trading volume fluctuations to optimize their trading strategies:

- End-of-Week Trading: Traders seeking active market conditions and increased liquidity may consider focusing their trading activities towards the end of the week, particularly on Thursdays and Fridays.
- Market Sentiment Analysis: Traders should monitor market sentiment indicators and adjust their trading strategies accordingly, anticipating increased trading volume and potential volatility towards the end of the week.
- Risk Management: Traders should exercise caution and implement risk management strategies during peak trading days, as increased trading activity may amplify market volatility and potential losses.

BIS Use Cases

The Bank for International Settlements (BIS) and Project Mariana
The Bank for International Settlements (BIS), often referred to as the "central bank of central banks," is an international organization that fosters cooperation among central banks and other financial institutions. Established in 1930, the BIS plays a crucial role in promoting financial stability and facilitating international monetary cooperation.

Image 2: BIS Tower

In 2022, the BIS launched Project Mariana, a cross-border central bank digital currency (CBDC) pilot program. The project aims to explore the potential of CBDCs to improve the efficiency, cost-effectiveness, and resilience of cross-border payments.

Project Mariana brings together the BIS Innovation Hub (BISIH), the Bank of France, the Monetary Authority of Singapore, and the Swiss National Bank. The project is exploring the use of automated market makers (AMMs) to automate cross-border CBDC trading and settlement.

AMMs are decentralized protocols that use liquidity pools to facilitate asset trading. They are designed to provide efficient and low-cost trading mechanisms, and they have gained popularity in the decentralized finance (DeFi) space.

Project Mariana is still in its early stages, but it has the potential to revolutionize the way cross-border payments are made. By using AMMs, the project could significantly reduce transaction costs, increase settlement speed, and improve overall market efficiency.

In addition to its potential technical benefits, Project Mariana is also significant for its symbolic value. It represents a willingness on the part of central banks to engage with new technologies and explore the potential of CBDCs to enhance the global financial system.

As Project Mariana progresses, it will be interesting to see how the findings of the pilot program inform future CBDC development and cross-border payment initiatives.

Suitability of Curve's AMM Design for Cross-border CBDC Projects
Curve's AMM design offers several advantages that make it suitable for cross-border CBDC projects like Project Mariana:

1. Efficient Liquidity Provision and Management: Curve's AMM efficiently pools liquidity from multiple participants, ensuring sufficient liquidity for cross-border CBDC transactions. This reduces the burden on central banks and financial institutions in managing liquidity pools. Curve's CurveSwap AMM has successfully facilitated stablecoin swaps with high liquidity and tight spreads, demonstrating its ability to handle large transaction volumes.

2. Dynamic Price Discovery: Curve's AMM algorithm automatically adjusts prices based on supply and demand, providing a transparent and efficient price discovery mechanism for cross-border CBDC transactions. Curve's AMM has proven to be effective in maintaining stable prices and tight spreads even during periods of high volatility, ensuring fair and efficient trading.

3. Low Transaction Costs: Curve's low fee structure and efficient AMM design minimize transaction costs for cross-border CBDC payments, making it a cost-effective solution for international transactions. Curve's average fee rate is around 0.04%, significantly lower than the fees charged by traditional correspondent banking systems.

4. Resilience to Market Fluctuations: Curve's AMM is designed to be resilient to market fluctuations, ensuring stable prices and liquidity even during periods of volatility, which is crucial for cross-border CBDC transactions. Curve's AMM has demonstrated its ability to maintain stable prices and liquidity during periods of market volatility, such as the 2022 cryptocurrency market crash.

5. Adaptability to Different CBDC Pairs: Curve's AMM can be adapted to support various CBDC pairs, enabling seamless cross-border transactions between

different central bank digital currencies. Curve has successfully integrated various stablecoin pairs, demonstrating its adaptability to different asset types.

Enhancing Efficiency and Effectiveness of Cross-border CBDC Transactions
Integrating Curve's AMM technology into cross-border CBDC projects like Project Mariana can significantly enhance the efficiency and effectiveness of cross-border transactions:

1. Reduced Transaction Settlement Time: Curve's AMM facilitates near-instantaneous transaction settlement, significantly reducing the time required for cross-border payments compared to traditional correspondent banking systems. Traditional cross-border payments can take several days to settle, while Curve's AMM can settle transactions in near real-time.

2. Elimination of Intermediaries: Curve's decentralized approach eliminates the need for intermediaries, such as correspondent banks, to reduce transaction costs and streamline the cross-border payment process. Correspondent banks often charge significant fees for cross-border payments, which can be eliminated by using Curve's decentralized AMM.

3. Improved Transparency and Traceability: Curve's transparent and traceable transactions provide greater visibility into cross-border CBDC flows, enhancing compliance and regulatory oversight. Curve's on-chain transactions are publicly viewable, allowing for greater transparency and traceability compared to traditional payment systems.

4. Increased Accessibility and Financial Inclusion: Curve's technology can be integrated into mobile wallets and other financial applications, making cross-border CBDC payments more accessible to individuals and businesses, and promoting financial inclusion. Integrating Curve's AMM into mobile wallets can provide individuals with a convenient and cost-effective way to make cross-border payments.

Significance of Collaboration between BIS and Curve

The collaboration between the BIS and a DeFi platform like Curve represents a significant step forward in exploring the potential of CBDCs and decentralized technologies within the broader financial ecosystem:

1. Bridging the Gap between Traditional Finance and DeFi: This collaboration demonstrates the willingness of traditional financial institutions to engage with DeFi innovations, fostering collaboration and knowledge exchange. The BIS, a traditional financial institution, collaborating with Curve, a DeFi platform, signals a shift towards embracing new technologies and exploring their potential within the financial system.

2. Exploring New Use Cases for CBDCs: The partnership opens up new avenues for exploring the use of CBDCs in cross-border payments, settlements, and other financial applications. The collaboration could lead to the development of new CBDC-based financial products and services, expanding the utility of CBDCs beyond traditional central bank functions.

3. Promoting Innovation and Growth: The collaboration can stimulate further innovation in the CBDC and DeFi spaces, leading to more efficient, inclusive, and accessible financial services. The partnership could catalyze the development of new DeFi protocols and applications specifically designed for CBDCs, fostering growth and innovation in both sectors.

Benefits and Challenges of Integrating Curve's AMM into the CBDC Ecosystem

Benefits:

1. Enhanced Efficiency and Cost Reduction: Improved cross-border payment efficiency, reduced transaction costs, and elimination of intermediaries. Integrating Curve's AMM into CBDC infrastructure could significantly reduce transaction costs for cross-border payments, making international transactions more affordable.

2. Greater Transparency and Traceability: Transparent and traceable transactions, promote compliance and regulatory oversight. Curve's on-chain transactions provide greater transparency compared to traditional payment systems, enabling better monitoring of cross-border CBDC flows.

3. Increased Accessibility and Financial Inclusion: Broader access to cross-border payments, fostering financial inclusion. Integrating Curve's AMM

into mobile wallets could provide individuals in underserved areas with access to affordable cross-border payment services.

Challenges:
1. Regulatory Uncertainty: Navigating evolving regulatory frameworks for CBDCs and DeFi protocols. The regulatory landscape surrounding CBDCs and DeFi is still developing, and central banks need to establish clear guidelines for the integration of DeFi technologies.

2. Security and Risk Management: Ensuring the security and integrity of CBDC transactions and mitigating potential risks. Addressing potential security vulnerabilities and implementing robust risk management frameworks are crucial for ensuring the safety of CBDC transactions.

3. Integration with Existing Infrastructure: Integrating Curve's AMM with existing financial infrastructure and payment systems. Integrating Curve's AMM seamlessly into existing financial systems will require collaboration and standardization efforts across different stakeholders.

4. Addressing Public Perception and Trust: Addressing public concerns and building trust in the use of CBDCs and DeFi technologies. Educating the public about the benefits and potential risks of CBDCs and DeFi is essential for building trust and facilitating wider adoption.

Integrating Curve's AMM into the CBDC ecosystem offers promising opportunities to enhance the efficiency, transparency, and accessibility of cross-border payments. However, carefully addressing the regulatory, security, integration, and public perception challenges is crucial for ensuring the successful implementation and adoption of this technology. By adopting a collaborative approach involving central banks, regulators, DeFi platforms, and industry stakeholders, these challenges can be effectively addressed, paving the way for a more innovative and inclusive global financial system.

Prediction Model

Model Selection
To accurately forecast future trading volumes for a selected Curve Finance pool using only trading volume, total value locked (TVL), daily active users,

and daily transaction count as features, a hybrid machine learning model that combines the strengths of different algorithms is proposed. This model will consist of an autoregressive integrated moving average (ARIMA) model for capturing historical patterns in trading volume, a recurrent neural network (RNN) for capturing temporal dependencies, and a support vector machine (SVM) for incorporating TVL, daily active users, and daily transaction count.

Model Architecture
The modified hybrid model will have the following architecture:

1. ARIMA Model: The ARIMA model will be used to extract the underlying trend and seasonality from the historical trading volume data. The order of the ARIMA model (p, d, q) will be determined using the Akaike Information Criterion (AIC) minimization technique.
2. RNN: The RNN will be used to capture the temporal dependencies in the trading volume data. Gated recurrent units (GRUs) will be used as the recurrent units due to their ability to handle long-term dependencies effectively.
3. SVM: The SVM will be used to incorporate TVL, daily active users, and daily transaction count into the forecasting process. TVL, daily active users, and daily transaction count will be represented as separate features in the SVM model.

Feature Engineering
In addition to historical trading volume, TVL, daily active users, and daily transaction count, no additional features will be incorporated into the model.

Model Training and Evaluation
The modified hybrid model will be trained and evaluated using a historical dataset of trading volume, TVL, daily active users, and daily transaction count data. The model will be trained using a rolling window approach, where the model is trained on a subset of the data and then evaluated on a subsequent subset of the data. This process will be repeated to ensure the model's generalizability.

The model's performance will be evaluated using various metrics, such as mean absolute error (MAE), root mean squared error (RMSE), and mean absolute percentage error (MAPE). These metrics will provide insights into the model's accuracy and ability to forecast future trading volumes.

Explanation of Feature Selection

Including TVL, daily active users, and daily transaction count in the model is considered adequate for capturing the factors that influence trading volume beyond historical trading volume alone.

Total Value Locked (TVL): TVL represents the total value of assets deposited into a Curve Finance pool. This metric reflects the overall liquidity and depth of the pool, which can also influence trading volume.

Daily Active Users: Daily active users represent the number of unique users interacting with a Curve Finance pool daily. This metric reflects the overall popularity and usage of the pool, which can influence trading volume.

Daily Transaction Count: Daily transaction count represents the total number of trades executed on a Curve Finance pool daily. This metric directly measures the level of trading activity and is closely related to trading volume.

By incorporating TVL, daily active users, and daily transaction count, the modified hybrid model is expected to provide accurate and reliable forecasts of future trading volumes, while maintaining simplicity and reducing the computational complexity of the model.

Forecasting Curve stETH-WETH Pool Trading Volume for the Next 7 Days

Based on the analysis of trading volume fluctuations and the discussion of model selection, feature engineering, and training data requirements, it is recommended to use a training set of 60 days of historical data for the proposed hybrid machine learning model. This will provide sufficient information for the model to capture patterns and trends in trading volume, TVL, daily active users, and daily transaction count, for the Curve stETH-WETH pool.

Prediction Model's Code - https://github.com/MAWUT0R/curve

Expected Accuracy and Limitations

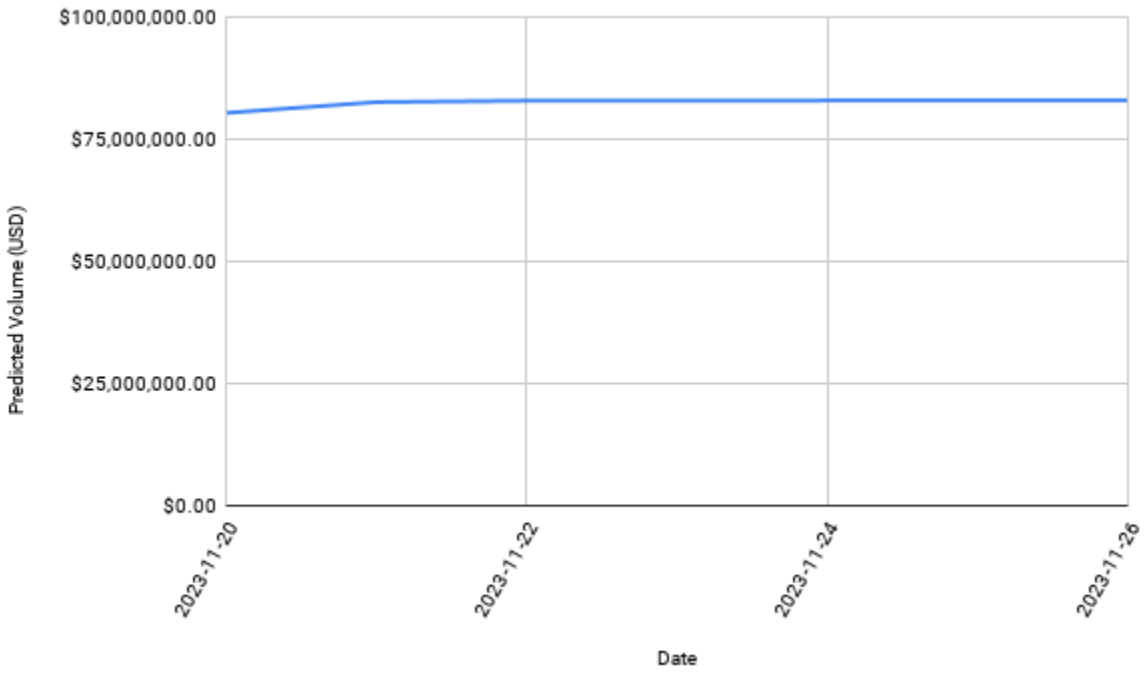
The proposed hybrid machine learning model is expected to provide accurate and reliable forecasts of future trading volumes for the Curve stETH-WETH pool. However, it is important to note that the model's performance is subject to certain limitations.

- The model's accuracy is dependent on the quality of the training data. If the training data is incomplete or inaccurate, the model's predictions may be less reliable.
- The model may not be able to capture all of the factors that influence trading volume. For example, unexpected market events or changes in investor sentiment may not be reflected in the model's predictions.
- The model's performance may degrade over time as market conditions change and new trading patterns emerge.

Results and Discussion

The predicted curve volumes for the next 7 days indicate a slight upward trend, with an overall increase of approximately 0.07% from November 20th to November 26th. This suggests that the Curve stETH-WETH pool is expected to experience a modest increase in trading activity over the coming week.

Chart 14: Predicted Trading Volume



While the predicted increase is relatively small, it may be indicative of growing interest in the Curve stETH-WETH pool. This pool is designed to provide liquidity for stETH and WETH, two popular Ethereum-based tokens. The increased trading volume could be driven by factors such as increased usage of Ethereum-based decentralized applications (DApps) or changes in market sentiment.

It's important to note that these are just predictions, and the actual trading volume could vary significantly. However, they can provide valuable insights into potential trends in the Curve stETH-WETH pool and the broader crypto market.

Conclusion

Our exploration of Curve Finance has unveiled a complex and dynamic decentralized finance (DeFi) protocol that has revolutionized decentralized exchange (DEX) liquidity provisioning and yield generation. Through its innovative veCRV tokenomics and AMM (automated market maker) design, Curve has emerged as a leading force in the DeFi ecosystem, attracting a diverse range of market participants and driving significant trading volumes.

The veCRV token distribution mechanism, with its emphasis on long-term locking, has been instrumental in aligning incentives between Curve governance and users, fostering a commitment to the protocol's stability and growth. The resulting deep liquidity pools and tight spreads have attracted a wide range of market participants, including traders, arbitrageurs, and yield seekers, contributing to Curve's substantial trading volume.

The motivations and strategies of market participants on Curve are multifaceted, encompassing arbitrage opportunities, yield generation, and speculative trading. Arbitrageurs capitalize on price discrepancies across different DEXs, while yield seekers aim to maximize returns by depositing assets into Curve's liquidity pools. Speculative traders, on the other hand, seek to profit from anticipated price movements of Curve tokens or the assets traded on the platform.

Curve's growth trajectory has been remarkable, with its total value locked (TVL) reaching over $25 billion at its peak. This growth can be attributed to its innovative protocol design, strong community support, and expanding product offerings. The protocol's profitability has been driven by trading fees and protocol-owned liquidity (POL), demonstrating its ability to generate sustainable revenue streams.

A lucrative trading strategy on Curve involves utilizing the platform's AMMs to capture arbitrage opportunities between different pools or DEXs. This strategy requires careful monitoring of price discrepancies and quick execution to capitalize on fleeting profit opportunities.

Trading volume fluctuations on Curve are influenced by a combination of factors, including market sentiment, new product launches, and external events. Understanding these factors and their impact on trading volumes can help traders make informed decisions and optimize their strategies.

The Bank for International Settlements (BIS) has recognized Curve's potential to address traditional market frictions and enhance the efficiency of financial markets. Its use cases span various areas, including cross-border payments, stablecoin issuance, and decentralized market making.

Trading volume prediction models play a crucial role in anticipating future trading activity on Curve. These models utilize various techniques, including machine learning and statistical analysis, to identify patterns and trends in historical trading data.

In conclusion, Curve Finance has emerged as a pivotal player in the DeFi landscape, revolutionizing DEX liquidity provisioning and yield generation. Its innovative veCRV tokenomics, AMM design, and expanding product offerings have attracted a diverse range of market participants and driven substantial trading volumes. With its focus on long-term growth and sustainable revenue streams, Curve is poised to continue shaping the future of DeFi and traditional finance.

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