Programmable Vested Automated Market Makers

Abstract

Decentralized Finance (DeFi) continues to disrupt the traditional financial sector, and Automated Market Makers (AMMs) are at the core of this movement. While traditional AMMs offer immediate liquidity and trading, they suffer from capital flight risks and liquidity instability. **Programmable Vested AMMs** introduce time-locked mechanisms across liquidity, trading, rewards, loans, and fees, promoting long-term liquidity commitments and aligning user behavior with protocol stability. This article presents a detailed exploration of the mechanics, game-theoretical models, and strategic innovations within vested AMMs, including the role of Dollar-Cost Averaging (DCA) and how it enhances liquidity provisioning. The paper also highlights the importance of vested AMMs in a multichain DeFi environment and outlines future research directions.

1 Introduction

In the decentralized finance (DeFi) landscape, Automated Market Makers (AMMs) have established themselves as the backbone of token exchanges, enabling decentralized, permissionless liquidity provisioning. However, while traditional AMMs such as Uniswap provide instant trades and liquidity, they come with significant challenges, primarily **capital flight risks** and market instability due to LPs' ability to withdraw liquidity at will.

Programmable Vested AMMs address these issues by embedding time-lock mechanisms within every layer of liquidity provision and trading. Unlike traditional AMMs, where rewards, fees, and liquidity are immediately accessible, vested AMMs incorporate vesting schedules, ensuring that liquidity remains locked and rewards are distributed over time. This time-locking feature helps to mitigate liquidity shocks, reducing capital flight risks and improving long-term liquidity stability.

This article explores the design principles and strategic implications of vested AMMs, focusing on how **time-locked mechanisms** apply not only to liquidity but also to emissions, fees, and even trades. Special attention is given to **Dollar-Cost Averaging (DCA)** within vested AMMs, which is critical for managing market volatility and enhancing long-term returns. We also investigate the impact of programmable vested AMMs on multichain ecosystems and outline the future of DeFi liquidity management.

2 Understanding Traditional AMMs and Capital Flight Risks

Traditional Automated Market Makers (AMMs), such as Uniswap V2, fundamentally operate by allowing liquidity providers (LPs) to deposit assets into liquidity pools, which are then used to facilitate token swaps based on an algorithm that determines prices from the ratio of the two assets in the pool. While this system democratizes liquidity provisioning, offering **instant liquidity** and ease of use, it presents notable risks. **Capital flight risk**—the sudden withdrawal of liquidity from a pool—is one of the most critical challenges. LPs can withdraw their assets at any time, leaving the pool exposed to a sharp reduction in available liquidity. This sudden exodus can destabilize markets, disrupt price discovery, and cause increased **slippage**, thereby adversely impacting traders.

Capital flight occurs primarily because LPs in traditional AMMs are only incentivized to keep their liquidity in the pool when they expect immediate rewards. If market conditions change or other opportunities arise, LPs may exit rapidly, leaving the pool vulnerable. The volatility and unpredictability of this liquidity provision model force protocols to offer inflated rewards or yield incentives to attract liquidity. This reliance on short-term incentives further exacerbates the instability of liquidity, since these rewards are often tied to short-term market behavior and do little to promote long-term engagement.

Another critical issue in traditional AMMs is the absence of a mechanism to **concentrate liquidity** in specific price ranges, which can lead to inefficient liquidity distribution. Uniswap V2's model is inefficient in this regard because it requires LPs to spread liquidity across the entire price curve, even when assets spend most of their time trading in specific ranges. This leads to suboptimal capital utilization.

Uniswap V3 introduced **concentrated liquidity**, where LPs can provide liquidity within custom price ranges, improving capital efficiency. However, despite these innovations, the challenge of liquidity flight remains unresolved because liquidity is still immediately accessible, and LPs are free to move in and out at will. This underscores the need for a new model where **long-term liquidity commitment** is built into the system to stabilize and secure liquidity provisioning over time.

3 The Vested AMM Model: Time-Locking Liquidity and Incentives

Programmable Vested AMMs (veAMMs) represent a critical evolution of the AMM model, introducing **time-locked liquidity** and incentives that fundamentally alter the dynamics of liquidity provision. Unlike traditional AMMs, where liquidity and rewards are instantly accessible, veAMMs enforce vesting schedules on liquidity, rewards, trades, and even loans. This time-lock mechanism addresses the core problem of capital flight by ensuring that liquidity remains locked in the system for a defined period.

3.1 Time-Locked Liquidity and Concentrated Liquidity

In veAMMs, LPs commit liquidity for a predetermined vesting period, during which they cannot withdraw their assets prematurely. This ensures that liquidity remains stable over time, which mitigates the risks of sudden liquidity exits. Moreover, veAMMs can also incorporate **concentrated liquidity** mechanisms from Uniswap V3, allowing LPs to provide liquidity only within certain price ranges. This enhances capital efficiency because liquidity is deployed more effectively where it is most needed. By combining **concentrated liquidity** with **vesting schedules**, veAMMs can achieve both stability and efficiency, addressing the liquidity wastage found in traditional AMMs.

Mathematically, the reward structure can be represented as a function of the **duration** of liquidity commitment and the **concentration** of liquidity. For example, a function such as:

$$R(v, c) = k \times v^n \times c^m$$

Where:

- $R(v, c)$ is the total reward. - v represents the vesting period. - c is the concentration factor (the percentage of liquidity concentrated within a particular price range). - n and m are exponents that reflect the importance of long-term commitment and concentrated liquidity.

By tuning the parameters n and m, protocols can dynamically adjust rewards to incentivize both long-term liquidity provision and efficient liquidity concentration.

3.2 Vested Rewards, Fees, and Delayed Execution

In veAMMs, rewards—whether in the form of trading fees or governance tokens—are distributed incrementally over the vesting period, preventing LPs from withdrawing rewards immediately. This feature discourages speculative liquidity provision, where LPs may add liquidity for a short time to collect quick rewards before exiting the pool. Additionally, **fees** generated from trades are also time-locked, further aligning incentives with long-term liquidity provision.

Moreover, veAMMs may apply **time-locks** to the execution of certain trades or loans. For instance, flash loans or large trades may be delayed or subject to gradual settlement over time, reducing the market shocks that could result from large, immediate transactions. This temporal aspect ensures that trades and liquidity shifts are more gradual, allowing the market to adjust and reducing volatility.

The vesting schedule for rewards and fees can be expressed as a **continuous distribution function** over time, such as:

$$R_t = \frac{R_{\text{total}}}{T} \times t$$

Where:

- R_t is the reward at time t. - R_{total} is the total reward to be distributed. - T is the total vesting period.

In veAMMs, this type of structure is crucial to ensuring that both liquidity providers and traders act in ways that promote market stability rather than short-term profits.

4 Importance of Dollar-Cost Averaging (DCA) in Vested AMMs

In traditional AMMs, trades occur instantly, which can lead to **price slippage** and other inefficiencies, especially during periods of high volatility. By contrast, in veAMMs, the **time-locked** nature of liquidity provision, fees, and rewards introduces a significant advantage: the ability to integrate **Dollar-Cost Averaging (DCA)** directly into the AMM framework.

DCA is a well-known investment strategy in which a fixed amount of capital is invested at regular intervals, regardless of the asset's price. This strategy mitigates the impact of market volatility and reduces the risk associated with trying to time the market. In veAMMs, DCA can be leveraged at both the LP and trader levels.

4.1 DCA for Liquidity Provision

In veAMMs, LPs can structure their liquidity provisioning over time to align with vesting schedules. Instead of providing liquidity in a single large deposit, LPs can use DCA to inject liquidity into the pool in smaller increments over time. This gradual approach reduces the impact of short-term price fluctuations, making the market more stable overall. Additionally, each DCA-based liquidity deposit initiates a new **vesting schedule**, leading to compounded rewards as multiple vesting periods overlap.

The gradual release of liquidity through DCA can be modeled as a **piecewise function**:

$$L_t = \sum_{i=1}^{n} \frac{L_{\text{total}}}{n} \times f(v_i)$$

Where:

- L_t is the cumulative liquidity at time t. - L_{total} is the total liquidity to be provided. - n is the number of intervals over which liquidity is deployed. - $f(v_i)$ is the reward function for each vesting period v_i.

This approach provides a more stable and controlled inflow of liquidity, smoothing market dynamics and improving capital efficiency.

4.2 DCA for Traders

In addition to liquidity providers, traders can also benefit from DCA within veAMMs. Because trades in veAMMs can be time-locked, traders can execute DCA strategies to spread their trades over time, reducing the impact of large, single-point trades on market prices. This is particularly important in veAMMs, where sudden, large trades could introduce volatility due to the locked nature of liquidity. By using DCA, traders can minimize their exposure to short-term price movements while still achieving long-term positions.

5 Strategic Liquidity Mining in Vested AMMs

Liquidity mining is a key mechanism in DeFi for attracting liquidity. However, in veAMMs, liquidity mining must be redesigned to account for the time-locked nature of liquidity and rewards.

5.1 Long-Term Liquidity Mining Strategies

In veAMMs, liquidity mining strategies can be customized to reward long-term commitment. LPs can choose different tiers of liquidity pools based on the vesting period and reward structure. **Tiered liquidity pools** offer varying levels of rewards depending on how long LPs are willing to lock their liquidity.

For instance:

- **Short-term pools** (3-6 months) may offer lower rewards but provide LPs with quicker access to their liquidity. - **Long-term pools** (12-24 months) offer significantly higher rewards, compensating LPs for the opportunity cost of locking their capital for extended periods.

This structure ensures that liquidity mining is aligned with the protocol's long-term goals, promoting sustained liquidity rather than speculative, short-term participation.

5.2 Game-Theoretical Models in veAMM Incentives

Game theory plays a critical role in ensuring that veAMM systems are sustainable. The design of incentives must achieve a **Nash Equilibrium**, where LPs are incentivized to act in the protocol's long-term interest.

A basic game-theoretical model might consider two strategies for LPs: **cooperate** (lock liquidity for the full vesting period) or **defect** (withdraw early or provide short-term liquidity). The payoffs can be structured to ensure that cooperation yields significantly higher rewards, ensuring that long-term liquidity provision becomes the dominant strategy.

Penalties for early withdrawal, represented by functions such as:

$$P(e) = p \times e^m$$

where $P(e)$ is the penalty for early exit at time e, encourage LPs to maintain liquidity positions for the full vesting period. These penalty functions dissuade short-term speculation and ensure liquidity stability over the long term.

6 Advanced Programmable Features in Vested AMMs

Vested AMMs (veAMMs) are not just a step forward in addressing liquidity instability; they offer a more flexible, programmable architecture that allows for **customized liquidity management**, more efficient **cross-chain integration**, and **adaptive reward mechanisms**. These programmable features make veAMMs dynamic and capable of evolving alongside market conditions, user behaviors, and asset volatility, making them an advanced and adaptable tool for DeFi.

6.1 Customizable Vesting Schedules

In veAMMs, vesting schedules are a key differentiator from traditional AMMs, providing a programmable structure that can be customized based on the needs of the liquidity pool, the volatility of the assets, and user participation. Different pools might demand varying vesting periods depending on the nature of the assets involved:

- **Volatile Assets:** Volatile asset pools can benefit from **longer vesting periods**, reducing the likelihood of liquidity shocks. Longer vesting helps buffer against sudden market movements, ensuring liquidity providers (LPs) stay locked in during volatile phases, thereby stabilizing the pool. - **Stablecoin Pools:** Stablecoins, which exhibit much lower price volatility, may require **shorter vesting periods**, making these pools more accessible and encouraging liquidity flow without exposing the protocol to extreme capital flight risks.

Customization goes beyond just asset class. Protocols can offer **individualized vesting schedules** that account for a participant's engagement with the platform. For instance, **governance participation** could be incentivized by shortening the vesting period for LPs who actively participate in the protocol's governance decisions. This not only increases governance involvement but also aligns user incentives with the long-term sustainability of the protocol.

The customization of vesting schedules can be modeled as a function of both asset volatility and user participation:

$$V(a, g) = V_{\min} + \frac{\sigma_a}{1 + g}$$

Where:

- $V(a, g)$ is the vesting period. - $V_{\min}$ is the minimum required vesting time. - σ_a represents asset volatility (e.g., a high σ_a increases the vesting period for volatile assets). - g is the governance participation score (where higher values reduce the vesting period).

By implementing such models, protocols can dynamically adjust vesting schedules, ensuring that long-term participation is both rewarded and risk-mitigated.

6.2 Cross-Chain Liquidity Management

As DeFi grows into a **multichain ecosystem**, the ability to move assets and liquidity across different blockchains is increasingly important. However, cross-chain liquidity poses unique challenges, especially when vesting schedules are involved. veAMMs must be designed with **cross-chain interoperability** in mind to facilitate seamless liquidity movement while preserving vesting constraints.

To address this, veAMMs can leverage **cross-chain bridges** that allow for liquidity transfers between different blockchains. However, it's critical that these bridges respect the time-locking mechanisms of veAMMs. For instance, if liquidity is moved from one blockchain to another, the vesting schedule should carry over without disruption. Failure to do so could result in arbitrage or exploit opportunities, where users could potentially bypass vesting restrictions.

Protocols can also use **cross-chain governance models** to manage liquidity across various platforms. By synchronizing governance and liquidity decisions across chains, veAMMs ensure that liquidity remains aligned with the broader objectives of the protocol, even as it moves between ecosystems.

A mathematical model for managing cross-chain vesting could involve using **hash time-locked contracts (HTLCs)** to ensure that liquidity locked on one chain remains synchronized with the vesting conditions of another chain:

$$HTLC(v,t) = \begin{cases} \text{Release}, & \text{if } t \geq V_{\text{total}} \\ \text{Lock}, & \text{if } t < V_{\text{total}} \end{cases}$$

Where:

- $HTLC(v,t)$ represents the state of the liquidity (locked or released) on a cross-chain bridge. - t is the time elapsed since the liquidity was locked. - V_{total} is the total vesting period across the chains.

This ensures that cross-chain liquidity adheres to the same vesting schedules as the originating blockchain, preserving the integrity of the veAMM across multichain systems.

6.3 Dynamic Reward Systems

Traditional AMMs often fail to dynamically adjust rewards based on real-time market conditions, leading to suboptimal capital deployment. In veAMMs, **dynamic reward systems** solve this issue by allowing the protocol to adjust incentives for LPs based on performance metrics such as liquidity utilization, trading volume, or asset volatility.

During periods of **high volatility** or **low liquidity**, veAMMs can offer increased rewards to incentivize LPs to commit liquidity when it is most needed. Conversely, during times of low volatility or when liquidity is plentiful, rewards could be reduced to optimize the protocol's capital efficiency.

Smart contracts in veAMMs use **real-time data feeds** to adjust these rewards dynamically. This process can be modeled by linking rewards to liquidity demand through a **liquidity utilization function**:

$$R_u = R_{\text{base}} \times \frac{L_{\text{needed}}}{L_{\text{available}}}$$

Where:

- R_u is the dynamically adjusted reward. - R_{base} is the base reward. - L_{needed} is the amount of liquidity required for optimal pool functioning. - $L_{\text{available}}$ is the current available liquidity.

This dynamic reward model ensures that liquidity is not only sufficient but also efficiently deployed, optimizing the protocol's operation and maximizing returns for long-term LPs.

7 Impact on Liquidity Stability and Capital Efficiency

One of the most profound benefits of veAMMs is the improvement in **liquidity stability** and **capital efficiency**. Traditional AMMs suffer from capital flight and liquidity instability due to the absence of time-lock mechanisms and incentives for long-term liquidity provision. veAMMs solve these problems by locking liquidity for a set period and creating incentives that align LPs' behavior with the protocol's long-term goals.

7.1 Reduced Volatility and Enhanced Market Stability

In traditional AMMs, sudden liquidity withdrawals—often due to market panics or shifts—lead to **price swings** and **increased slippage**, which harm both LPs and traders. In contrast, veAMMs enforce **time-locked liquidity**, ensuring that liquidity remains in place even during periods of high market volatility. By preventing sudden exits, veAMMs maintain **market depth**, leading to **lower volatility** and more stable prices.

The impact of locked liquidity on market stability can be quantified by modeling the change in available liquidity over time. In a traditional AMM, the available liquidity $L(t)$ decreases sharply when LPs withdraw funds, but in a veAMM, liquidity remains stable over time:

$$L_{\text{veAMM}}(t) = L_0 - \frac{t}{V_{\text{period}}}$$

Where:

- $L_{\text{veAMM}}(t)$ is the liquidity over time in a veAMM. - L_0 is the initial liquidity. - V_{period} is the vesting period.

This gradual release of liquidity ensures that the pool is less prone to sharp declines in liquidity, reducing price volatility and making it more attractive for traders and investors to participate in the market.

7.2 Improved Capital Efficiency

In traditional AMMs, LPs often have to spread their liquidity thinly across the entire price curve, leading to inefficient capital deployment. veAMMs, particularly when combined with **concentrated liquidity** mechanisms from Uniswap V3, enable LPs to deploy their liquidity more efficiently within specific price ranges. This **concentration** increases capital efficiency because liquidity is only provided where it is needed most—within the narrow price bands where most trading occurs.

Additionally, the **time-locking mechanisms** in veAMMs ensure that LPs are committed to providing liquidity over longer periods. This reduces the **opportunity cost** of capital, as LPs are incentivized to leave liquidity in the pool rather than continually moving their assets to chase short-term returns. The result is a more efficient use of capital that benefits both LPs and the protocol.

Capital efficiency can be modeled as a function of both the vesting period and the concentration of liquidity:

$$E_c = \frac{P_{\text{traded}}}{L_{\text{total}}} \times \left(\frac{1}{1+V}\right)$$

Where:

- E_c is capital efficiency. - P_{traded} is the total value of trades. - L_{total} is the total liquidity. - V is the vesting period, where longer vesting periods reduce the opportunity for liquidity flight, improving efficiency.

This equation highlights that capital efficiency in veAMMs increases as liquidity becomes more concentrated and vesting periods grow longer, ensuring the protocol benefits from more stable, productive liquidity.

8 Conclusion: Programmable Vested AMMs as the Future of DeFi

Programmable Vested AMMs (veAMMs) represent a transformative leap forward in the evolution of decentralized liquidity management. By introducing **time-lock mechanisms** that enforce long-term liquidity provision, veAMMs solve some of the core problems that have plagued traditional AMMs, such as capital flight and liquidity instability. More importantly, veAMMs enable the integration of **advanced programmable features**, such as **customizable**

vesting schedules, **cross-chain liquidity management**, and **dynamic reward systems**, which make liquidity provisioning more adaptable to both market conditions and protocol needs.

As DeFi expands across multiple chains, veAMMs are likely to become a foundational infrastructure for liquidity provisioning. By addressing the key challenges of volatility, capital efficiency, and long-term engagement, veAMMs provide a stable and efficient solution for managing liquidity in decentralized ecosystems. The integration of **concentrated liquidity** and **dynamic rewards** further optimizes capital deployment, aligning LP incentives with the protocol's overall health.

The future of DeFi lies in protocols that can balance flexibility, security, and efficiency. veAMMs are uniquely positioned to do so, creating a more resilient and sustainable ecosystem for liquidity providers, traders, and protocol developers alike.