Redirecting Arbitrage Profits to LPs in Stable AMMs via Directional Dynamic Fees

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June 25, 2025

Abstract

This document proposes a novel Uniswap V4 hook specifically designed to redirect arbitrage profits to liquidity providers (LPs). It implements a *directional dynamic fee* mechanism that adjusts transaction fees based on the deviation between the pool price and a trusted oracle price. Unlike traditional AMMs, where arbitrage profits are fully extracted by external actors, this design redirects a larger share of that value back to LPs. It addresses a core inefficiency in existing AMMs — impermanent losses that predominantly benefit arbitrageurs — by aligning fee incentives with LPs interests.

1 Problem Statement and Motivation

In traditional AMMs, the primary extractors of value are arbitrageurs and MEV bots. These actors profit by correcting price discrepancies between the pool and external markets, yet they typically pay only a small fraction of their profits back to the protocol via swap fees (often under 10%). The rest is captured privately or spent on gas fees, which do not benefit LPs.

This model, while supporting price discovery, does little to reward the liquidity providers who enable trading. The result is a misalignment of incentives: LPs shoulder impermanent loss and receive modest fees, while arbitrageurs capture most of the surplus.

Redirecting some of this arbitrage profit to LPs can significantly increase their returns. Higher LP yields attract more Total Value Locked (TVL), and in AMMs, *liquidity is paramount*: more liquidity leads to better prices, deeper markets, and improved peg resilience over time.

2 Concept Overview

DynamicFeeHook: Key Idea

The `DynamicFeeHook` introduces a fee mechanism that adapts dynamically based on whether a swap improves or worsens the deviation from an oracle reference price:

- Swaps that move the pool price **closer** to the oracle incur a **higher fee**.
- Swaps that push the price **further away** pay only the **minimum fee**.

This functions as a *selective arbitrage tax*, capturing value from actors who realign prices — typically MEV bots and arbitrageurs — and redirecting it to LPs instead of letting it leak from the system.

Benefits

- LPs capture a larger share of arbitrage profits → improved yields.
- Inherently mitigates MEV extraction and sandwich attacks.

3 Comparison With Existing Work

Some protocols, such as Renzo, have implemented hooks like `PegStability`, which reduce fees for arbitrageurs who help restore the peg. While this mechanism improves short-term price stability, it does **not** benefit LPs — arbitrage profits continue to be fully captured by bots.

Our approach inverts this design philosophy. By **increasing fees** on swaps that restore the peg (and reducing them otherwise), we redirect surplus value toward LPs. This may slightly reduce peg resilience in the short term, but:

- Higher LPs rewards attract greater liquidity,
- Increased liquidity enhances long-term price stability,

Ultimately, this creates a more sustainable AMM ecosystem in which LPs are fairly compensated for the risks they bear.

4 Implementation Summary

Contracts

- **DynamicFeeHook.sol**: Contains the core logic for dynamic fee computation based on price deviation.
- **MockOracle.sol**: A simple test oracle that returns a static or manually updated price for testing purposes.

Mechanism Summary

- **Direction and oracle price**: Both are fetched in the `beforeSwap()` function.
- **Deviation detection**: The pool's `sqrtPriceX96` is compared to the oracle's `oracleSqrtPriceX96` to determine the magnitude and direction of deviation.
- **Directional logic**: If the swap moves the price *towards* the oracle peg, the fee is increased to slow it down; if it moves *away* from the peg, the fee remains unchanged.
- **Fee calculation**: The dynamic fee is computed using a convex (quadratic) function of the deviation:

```
uint256 scale = 1e18;
uint256 power = 2; // quadratic growth
uint256 factor = (absDeviation ** power) / scale;
uint24 fee = MIN_FEE + (factor * (MAX_FEE - MIN_FEE)) / scale;
```

5 Potential Extensions

- Expanding the dynamic fee mechanism to volatile asset pools is a promising direction. These pools typically offer more arbitrage opportunities. By redirecting arbitrage profits to LPs, this extension could significantly increase fee revenue and help mitigate impermanent loss, improving long-term sustainability. It would also enhance price discovery while disincentivizing pure arbitrage extraction. This approach would require an oracle that updates its price at every block.

Liquidity is the lifeblood of any AMM. By dynamically rewarding liquidity providers, we aim to attract more LPs and increase the Total Value Locked (TVL), thereby strengthening the overall health of the protocol.

- Additionally, incorporating a TWAP-based delay mechanism could help detect persistent price discrepancies. If a deviation persists over time, the directional fee could be reduced to allow for an easier return to price parity and avoid penalizing legitimate trading activity.

6 Conclusion

This hook provides a principled way to share arbitrage revenue with LPs while preserving the core function of AMMs. By rewarding LPs directly, the `DynamicFeeHook` aligns incentives, attracts liquidity, and strengthens the ecosystem. Deep liquidity are achieved not through arbitrage giveaways, but through sustainable LP yield.