Analysis of Market Dynamics of Crypto Exchanges: A Comparative Study of CEX and DEX Markets

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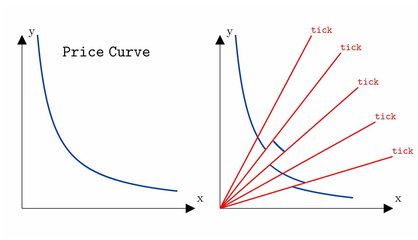
Motivation & Problem

Centralized exchanges (CEXs) provide deep liquidity and low-latency order books, while decentralized exchanges (DEXs) execute on-chain via AMMs with self-custody and transparency. These structural differences create measurable gaps in **price discovery**, **execution quality**, and **transaction costs**.

Goal: Build an end-to-end system that monitors CEX and DEX venues in real time and quantifies: deviation dynamics, lead-lag behavior, and slippage characteristics.

AMM vs Order Book

Uniswap v2 follows a constant-product curve over the full price range, while Uniswap v3 introduces **ticks** and **concentrated liquidity**.



AMM curve
Uniswap v2/v3

Price (USDT)	Size (USDT)	Sum (USDT)
90,621.5	114.81K	2.12M
90,621.4	6.16K	2.01M
90,621.3	130.22K	2.00M
90,621.2	181.3	1.87M
90,621.1	10.33K	1.87M
90,621.0	10.78K	1.86M
90,620.9	1.85M	1.85M
90,620.8 ↓ 90,620.9		
90,620.8	387.58K	387.58K
90,620.7	906.3	388.49K
90,620.4	271.9	388.76K
90,620.3	3.35K	392.11K
90,620.2	543.8	392.66K
90,620.1	181.3	392.84K
90,620.0	453.1	393.29K

CEX order book
Binance BTC/USDT

Data Sources & Scope

CEX feeds (WebSocket): Coinbase, MEXC, Binance, Gate.io, OKX, Bybit, HTX, KuCoin.

DEX feeds (on-chain events): Uniswap V2 and Uniswap V3 Swap events.

- **Chains used in analysis:** Ethereum + BSC
- **Pairs:** BTC/USDT, ETH/USDT, BNB/USDT
- **DEX listener capability:** multi-chain configurable (additional networks supported via configuration)

Dataset size (placeholder): #CEX updates = _____, #DEX swaps = _____, period = _____.

References

[1] Agostino Capponi, Ruizhe Jia, et al. Transaction costs on decentralized exchanges: The case of uniswap v3. *Management Science*, 2024. Forthcoming.

[2] Kaiko Research. Dex market structure report 2024. Technical report, Kaiko, 2024. Available at https://www.kaiko.com.

[3] Alfred Lehar and Christine A. Parlour. Decentralized exchange markets: Design choices and market performance. *Journal of Financial Economics*, 141(3):951–977, 2021.

System Overview

Pipeline: Two real-time streams run in parallel: (i) CEX tickers → price index, and (ii) DEX swaps from on-chain events. Both are stored, then joined to compute deviations and run analytics.

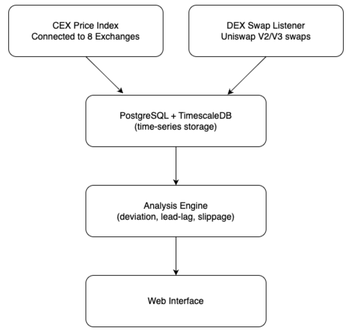


Figure 1. High-level architecture (schematic).

Price Index (CEX Reference Price)

We compute a robust CEX reference price by aggregating best bid/ask quotes from 8 exchanges. Each exchange contributes with a weight $w_i(t)$ that is **adapted via EMA** based on observed top-of-book liquidity share (using bid/ask quantities).

$$\text{price\_index}(t) = \frac{\sum_i \text{mid}_i(t) \cdot w_i(t)}{\sum_i w_i(t)}, \qquad \text{mid}_i(t) = \frac{\text{bid}_i(t) + \text{ask}_i(t)}{2}$$

In addition to the composite mid-price, we record **side VWAPs** and aggregated bid/ask quantities (`bid_vwap`, `ask_vwap`, `bid_qty_total`, `ask_qty_total`) for diagnostics.

Analysis Metrics (Deviation, Lead-lag, Slippage)

1) Price Deviation (per DEX swap)

$$\text{deviation} = \frac{\text{DEX\_price} - \text{CEX\_index}}{\text{CEX\_index}} \times 100\%$$

2) Lead-lag (price discovery)

Using log returns $r(t) = \log p(t) - \log p(t-1)$, we compute cross-correlation over lags τ:

$$\text{CCF}(\tau) = \text{Corr}\big(r_{\text{CEX}}(t),\ r_{\text{DEX}}(t+\tau)\big)$$

3) Slippage (Uniswap V2 theoretical)

For reserves (x, y) and input Δx:

$$\Delta y = y - \frac{xy}{x + \Delta x}, \qquad \text{slippage} = \left|1 - \frac{\Delta y / \Delta x}{y / x}\right|$$

Results

Placeholder: CEX vs DEX deviation time-series
(BTC/USDT, ETH/USDT, BNB/USDT)

Figure 2. Deviation over time (placeholder).

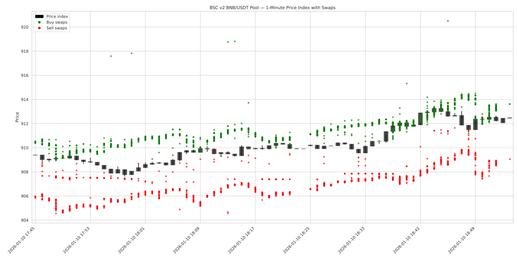


Figure 3. Price index vs DEX swaps for BNB/USDT.

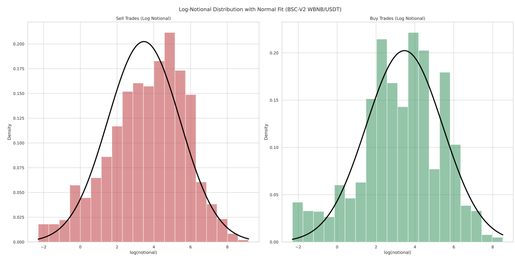


Figure 4. BSC v2 WBNB/USDT trade sizes (log-notional): split by side (after dust filtering) reveals unimodal but fat-tailed distributions.

Takeaways

- CEXs provide a fast reference price; DEX execution quality depends strongly on pool liquidity.
- Cross-venue deviation and lead–lag measurements quantify price discovery and convergence.
- A unified pipeline enables reproducible monitoring and retrospective analysis.