# 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 orderbooks, 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.

## 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 = _____.

## Contributions

- **Multi-exchange CEX price index** (volume-weighted reference price)
- **Real-time DEX swap capture** (Uniswap V2/V3 on Ethereum/BSC)
- **Deviation & lead–lag analysis** between CEX index and DEX execution
- **Slippage characterization** (theoretical AMM impact + empirical distributions)

## 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.

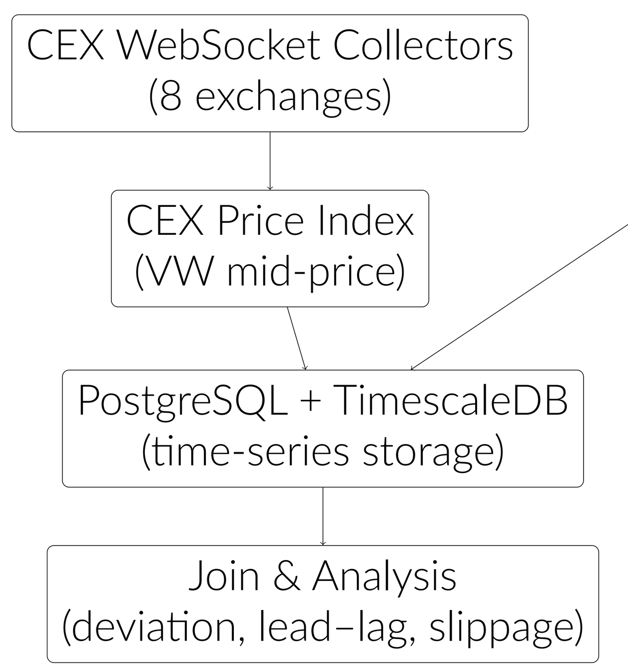


Figure 1. High-level architecture (schematic).

## Methodology (Core Metrics)

**CEX reference price (index):**

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

**Deviation per DEX trade:**

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

**Lead–lag:** cross-correlation of log returns over lags $\tau \in [-60s, +60s]$.

**Slippage (V2 theoretical):**

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

## Implementation

- **Collectors:** Go (`price-index/`, `dex-prices/`)
- **Storage:** PostgreSQL 16 + TimescaleDB (`database/`)
- **Analysis:** Python (`analysis/`)
- **Dashboard:** Streamlit (`price-index/dashboard.py`)
- **Analysis runner:** `analysis/run_analysis.py` (deviation, lead–lag, slippage, volume)

## Results (Placeholders)

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

Figure 2. Deviation over time (placeholder).

Placeholder: Lead–lag CCF plot
(peak lag and correlation per pair)

Figure 3. Lead–lag cross-correlation (placeholder).

Placeholder: Slippage vs trade size
(P50/P90/P99)

Figure 4. Slippage curves (placeholder).

## Key Findings (Fill with final numbers)

- **Deviation distribution:** median = ___ bps, P95 = ___ bps
- **Lead–lag:** CEX leads DEX by ___ seconds (typical), varies by volatility
- **Slippage:** grows nonlinearly with size; tails dominated by large trades / adverse ordering

## 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.

## References

[1] Hayden Adams, Noah Zinsmeister, Moody Salem, River Keefer, and Dan Robinson. Uniswap v3 core. 2021. Available at https://uniswap.org/whitepaper-v3.pdf.

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

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

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

[5] Claude E. Shannon. A mathematical theory of communication. *Bell System Technical Journal*, 27(3):379–423, 1948.