Structural Issues with Crypto Asset Markets

Given the unique nature of the market microstructure of Cryptocurrency exchanges, traditional market making firms would face several challenges to which they would not be subject to in traditional markets.

1. The first structural challenge would be that of a **fragmented market infrastructure**. What this means is that there is not one single market but many different centralized and decentralized exchanges, to illustrate this, it is known that:
    - CoinMarketCap tracks **258 spot exchanges**
    - CoinGecko tracks **1183 crypto exchanges**
        - **217 Crypto exchanges**
        - **966 Decentralized**
    - **Forbes Advisors claims that there are around 500 Exchanges to choose from (Both Centralized and Decentralized)**[1]
2. The second structural challenge would be **non-stop nature of cryptomarket activity**

This makes it particularly challenging for firms because, even with automated models making most/all trading decisions, human oversight is crucial to prevent or mitigate the effect of potential catastrophes.

The continuous operation would demand market makers to maintain liquidity and manage risk non-stop, which can lead to higher operational costs, personnel challenges, and technical demands.

Furthermore, this leads to **increased exposure to volatility:** With no pauses in trading, sudden market moves (such as flash crashes) can occur at any time. This can exacerbate risk management challenges, as market makers must be prepared to handle the highly volatile nature of crypto markets continuously.

3. The third structural challenge involves **liquidity variability and depth concerns**
    - **Liquidity Variability:** It is a known fact that the crypto-market is generally considered less liquid than traditional financial markets like stocks or bonds. This means that it can be more difficult in general to and potentially more expensive to buy/sell large amounts of coins without significantly impacting its price. To illustrate this it is good to compare the market capitalization of Bitcoin with the two major US Exchanges:
        - Market Cap of BTC: **1.63 Trillion**
        - Market Cap of US Stock Exchanges:
            - NYSE: **28.33 Trillion (July 2024)**
            - NASDAQ: **30.13 Trillion (November 2024)**

[1] https://www.forbes.com/advisor/investing/cryptocurrency/best-crypto-exchanges/

- **Thin or Inconsistent Liquidity:** Many crypto assets, especially altcoins, experience periods of low liquidity. This thin order book depth can lead to significant slippage and rapid price movements when large orders are executed. This means market makers in these assets must set wider bid-ask spreads or risk inventory imbalances.
- **Cross-Exchange Liquidity Issues:** Since liquidity is often dispersed, arbitrage opportunities arise—but they can also create challenges. A market maker may find that liquidity on one exchange is robust while another suffers from fragmentation or sudden drops in volume, complicating risk hedging across venues.

4. Regulatory Uncertainty

- **Unstable Regulatory Environment:** Unlike established traditional markets with comprehensive regulation, the crypto industry features a patchwork of evolving regulations across jurisdictions. This uncertainty can affect market confidence and may lead to sudden changes in market operations or liquidity flows that challenge market makers.

5. Challenges with Price Discovery & Volatility

- **High-Price Volatility:** Cryptocurrencies are well-known for dramatic price swings. Rapid changes in price can erode margins and expose market makers to inventory risk, making it difficult to maintain balanced positions while still offering competitive spreads.
    - Bitcoin's surge from under $1,000 to nearly $20,000 in 2017, followed by a crash to around $3,200 in 2018, and its subsequent recovery to over $60,000 in 2021. Altcoins, like LINK, have also shown extreme volatility, with LINK's price soaring over 48,000% in 2021 before declining
- **Inconsistent Price Discovery:** With multiple trading venues and less transparent order book data in some cases, establishing a consistent and reliable price for a given cryptocurrency can be challenging. No centralized best bid and offer system like NBBO.

6. Manipulative Practices

- The Crypto Asset market is notorious for being populated with a plethora of scams and deceptive financial activities such as pump and dump schemes. A famous example of this occurred when globally popular Youtuber KSI was accused of executing a “pump-and-dump” consecutively by exploiting his large fanbase and making trades to exploit their reactions to his advice[2].

Decentralized Market-Making: A Crypto Market Exception

Unlike in traditional financial markets, which feature large institutional market makers. Cryptocurrency markets feature automated market makers (AMMs). These are a form of decentralized cryptocurrency trading platform that uses smart contracts to enable token swaps and value exchange.

[2] https://cointelegraph.com/news/youtuber-ksi-pump-dump-allegations

Unlike centralized exchanges, this process doesn't rely on order books to determine asset prices. Instead, it uses a mathematical formula to determine prices based on the asset's supply and demand curve.

Advantages of AMM:

- They're more accessible,
- less expensive, and
- far more efficient

than traditional cryptocurrency platforms.

Major Disadvantage: Fees can be dynamic based on network traffic

Another interesting thing about an AMM is that it stabilizes the price of an asset relative to its market size. → This makes sure the underlying asset doesn't experience price swings when trading is ongoing.

What Do Institutional Investors Do?

Given the novel nature of cryptocurrency markets, combined with the previously mentioned structural challenges, which prevent traditional players from entering the market, it becomes difficult to discern possible strategies utilized by institutional players in the cryptomarket space.

However, after further research, a specific strategy kept resurging several years in a row. This strategy encompassed the concept of basis trading. The basis in this case being the spread (or difference) between the spot price of a crypto asset and the price of a futures contract for that asset. In-fact basis spreading was such a popular strategy that Bloomberg[3] commented saying that this specific type of trade was done exclusively by hedge funds, and was “roaring back.”

Presence of Large Basis Spreads in Cryptomarkets:

The reason behind the popularity of this strategy is two-fold. The first reason, unique to cryptomarkets, is that the basis can go into double digits. Contrast that with spreads on traditional commodities such as gold, where the spread almost never crosses 5 dollars. No source directly comments on why this massive spread exists for crypto-assets, however many sources indirectly hint at two main reasons:

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[3] https://www.wsj.com/personal-finance/crypto-and-its-many-fees-what-to-know-about-the-hidden-costs-of-digital-currency-11639825202

- **Bullish Sentiment:** Sellers, anticipating that the spot price will surpass the current futures price, need to set their contracts at a premium to cover the risk of missing out on these gains.
- **Risk Compensation:** The high volatility of Bitcoin means that there is a significant risk associated with holding futures positions. Sellers require compensation for the risk of adverse moves if the market doesn't perform as expected.

Delta-neutrality of Basis Trading Strategies:

The second reason this strategy is so popular is its near “risk-free” nature, thanks to its delta-neutral structure. By buying spot and selling futures, the trader effectively hedges their position, locking in the price difference as profit—regardless of whether Bitcoin’s price rises or falls. However, despite its delta-neutral nature, the strategy is not entirely risk averse.

OKX a popular cryptocurrency exchange published a report back in 2024[4] discussing three different types of basis trading strategies that were implemented by three different institutional traders who contributed to OKX’s report. They are outlined as follows:

1. Long Physically Backed ETF & Short front-month CME Futures
2. Purchase Crypto-asset directly at the spot price & sell futures-contract
3. Buy & Sell Spot and Perpetual Swap Contracts

Risks Involved:

The risks involved in trading these strategies are several and apply different to the different types. For the first trading strategy, the short futures leg is marked-to-market daily. A sudden upward move in Bitcoin’s price can trigger steep losses on the short position and force a margin call. Moreover, there is convergence uncertainty. If market dynamics or liquidity constraints cause a persistent premium (or discount) that does not normalize, your hedge could be less effective, cutting into or even erasing the intended profit margin.

Since purchasing a crypto-asset directly means that it must be fully paid for, alternative means of financing might be necessary to finance the spot leg of the strategy. If borrowed funds are used, the borrowing costs might erode or even erase the spread. Moreover, the convergence risk that was discussed earlier is still applicable in this specific scenario.

A third, more flexible variant seeks to capture the same basis by substituting dated futures with perpetual swap contracts—derivatives that never expire but are kept in line with the spot market via recurring funding payments. This approach introduces several distinct risks. Funding rates are path-dependent and can flip signs within a single interval. This can effectively transform anticipated carry into a liability. Moreover, since perpetuals are often traded with high leverage, even modest intraday volatility can trigger margin calls or forced liquidations long before the funding differential accrues.

[4] https://www.okx.com/en-us/learn/basis-trading-report

Implementing the Strategy (Step-by-Step):

If a trader wanted to trade the spread between a well-known cryptocurrency exchange (Coinbase for example) and the CME, exploiting the spread between the two, they would have to follow this process:

1. **Account Opening:**
    a. Open institutional-grade accounts on both venues: a Coinbase Exchange/Prime account for spot, plus a CME futures account cleared through an FCM (Broker).
    b. Becoming an institutional trader on Coinbase involves showing proof of maintaining a reserve of $500,000.
2. **Deposit Collateral and Funds:**
    a. Deposit USD (or USDC) at Coinbase for spot purchases or BTC if the trader anticipates selling his spot.
    b. Wire USD margin to the FCM for CME futures. The trader must make sure excess capital is available to absorb intraday swings and variation margin calls.
3. **Monitor Market Data on Both CME and Coinbase Markets:**
    a. Subscribe to Coinbase WebSocket order-book feeds and CME Globex market-data feeds.
    b. Stream both into a common clock domain so the basis calculation uses synchronized timestamps.
4. **Define the Basis Model and Entry Thresholds:**
    a. Compute the real-time difference between the CME front-month price and Coinbase's spot mid-price, adjusting for contract size (5 BTC for the main contract, 0.1 BTC for the micro).
    b. Decide the minimum spread—after fees, borrowing costs, and slippage—at which the trade is worth opening.
5. **Execute the Hedge Simultaneously:**
    a. When the spread widens beyond your trigger, buy BTC spot on Coinbase and short the equivalent notional of CME futures (or reverse the legs if the futures trade at a discount).
    b. Use IOC/limit-peg or TWAP child orders to minimize market impact on each venue.
6. **Confirm Fills and Lock the Hedge:**
    a. Verify both legs are fully executed; if one leg is only filled partially, immediately adjust the other side or flatten the trade to avoid unhedged exposure.
7. **Maintain or Roll the Position:**
    a. For dated futures, either close both legs as the basis converges or roll the short into the next contract month before expiry.
8. **Close the Spread Trade:**
    a. When the basis compresses to your profit-take level—or if risks deteriorate—buy back the short futures and sell (or withdraw) the spot BTC.

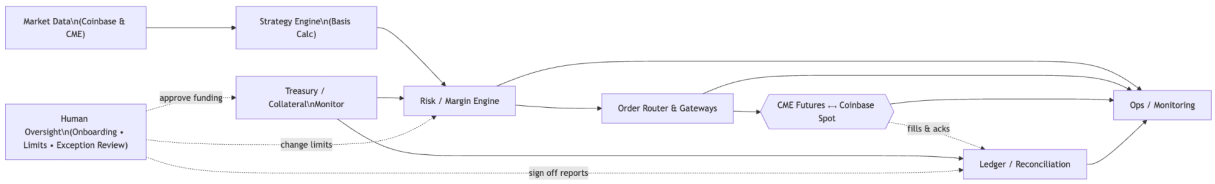
    b. Reconcile all cash flows, fees, and funding to confirm realized P&L.

How Would an Automated Cryptocurrency Trading System Differ from a Traditional Trading System Utilized by HFT Firms?

Given the structural challenges mentioned previously, a non-traditional trading system implemented within the context of cryptocurrency markets would feature several differences from its traditional counterparts.

In this paper we will discuss the implementation of a semi-automated system for implementing a basis trading strategy as described in the previous section. The reason this system is semi-autonomous is due to the fact that many of the steps discussed must be conducted in person. Below is an outline of a theoretical system that would be trading the basis between Coinbase and the CME.

Outline of System:



Basic Overview of Cryptocurrency Basis Trading System

The components of the system are described as follows:

- **Market Data:** Gathers live prices from Coinbase and CME, lines them up, and feeds them to the rest of the system.
- **Strategy Engine (Basis Calc):** Watches the price gap between spot and futures, decides when to trade and how much.
- **Risk / Margin Engine:** Checks that each trade stays within limits and that there's enough cash to cover it.
- **Order Router & Gateways:** Sends approved orders to the right exchange and tracks their status.
- **CME Futures ⇆ Coinbase Spot:** The two exchanges where the buy and sell orders actually take place.
- **Ledger / Reconciliation:** Records every trade, fee, and balance so the books are always correct.
- **Treasury / Collateral Monitor:** Watches cash and crypto balances and moves funds when any account gets low.
- **Ops / Monitoring:** Keeps an eye on system health and alerts people if something goes wrong.

- **Human Oversight:** Handles paperwork, big decisions, and unusual events that can't be automated.

How is the System Different from a Traditional System?

There are several distinctions between this system and the system discussed in our class:

1. **Singular Strategy:** The entire system works only on calculating the conditions for a profitable basis trade. No other strategies are considered or executed.
2. **24/7 Operation**: The spot leg of the basis trading strategy operates 24/7 unlike the CME which has defined trading hours and is offline during the weekends. This means the risk system would have to monitor the spot price perpetually.
3. **Custody and wallet operations move to the front office:** The trading program itself—not a back-office clerk—has to keep an eye on how much cash and Bitcoin are on each exchange, move funds when a balance runs low, and react right away if a withdrawal is delayed or a network fee jumps. In short, keeping the wallets topped up and safe becomes a live part of the trading job, just as important as watching prices. This is especially true when accounting for convergence risk. When the gap between the two markets stops shrinking—and starts eating into the profit the trade was meant to lock in—the risk engine confirms there is enough free collateral to close safely; if not, it requests an emergency top-up from the Treasury module.
4. **Alert to Human Oversight:** A real-time alert is fired so a trader can review market conditions and decide whether to adjust thresholds, keep the block in place, or exit manually.

How Would a Market-Making System on Binance Differ from Traditional HFT Trading Systems?

Designing a trading system for a cryptocurrency exchange such as Binance differs significantly from the systems traditionally used in high-frequency trading. While both systems aim to capitalize on small price discrepancies through speed and automation, the unique structure and limitations of crypto markets create several differences.

- Traditional HFT systems operate in regulated markets with a consolidated tape, best bid and offer (NBBO), and centralized clearing. In contrast, Binance is one of hundreds of exchanges, and no unified view of price or order flow exists. As a result, a Binance-specific system must operate independently, without visibility into global liquidity or pricing unless the trader builds cross-exchange infrastructure.
- Whereas traditional systems can rely on standardized FIX protocols, Binance uses proprietary REST and WebSocket APIs. This requires specialized adapters and careful rate-limit management, which can affect data freshness and execution reliability. Latency management is further complicated by frequent API upgrades or unannounced downtime.

- In traditional finance, central clearing houses manage settlement risk. On Binance, custody of crypto assets rests with the trader on-exchange, and there is no clearing guarantee. A market-making system must incorporate real-time wallet monitoring, risk controls for withdrawal delays, and dynamic position limits to prevent overexposure during volatility spikes.
- Crypto markets are more retail-driven, with less predictable order flow. Large institutional orders may cause rapid price moves, and liquidity can evaporate quickly. This means a crypto market maker must design more adaptive spread-setting algorithms, incorporating volatility detection and circuit breakers to widen spreads or cancel orders during market shocks.
- Unlike traditional markets with defined trading hours, Binance operates continuously. This means: No maintenance windows, constant monitoring of positions and system health, and greater demands on failover infrastructure, alerting systems, and human oversight

Strategy Implementation

We originally intended to build and test our trading system on Binance, one of the most active global cryptocurrency exchanges. However, due to regulatory restrictions preventing U.S. users from accessing Binance's main platform, we pivoted to using Kraken instead. Kraken is a U.S. compliant exchange that offers a robust API, sufficient liquidity in major trading pairs, and the tools necessary for implementing and evaluating an automated trading strategy. While it does not perfectly mirror Binance's market structure or volume, Kraken still enabled us to explore core concepts of crypto market-making in a live environment.

The system we developed for Kraken simulates a market-making strategy that incorporates both trend following and mean reversion elements. It analyzes market conditions by calculating real-time volatility and determining whether the market is trending or ranging. Based on this assessment, the system adjusts its entry and exit thresholds using indicators such as simple moving averages (SMA), standard deviation bands, and short-term momentum. For example, in trending markets, it opens long or short positions when prices deviate significantly from the 20-period SMA, while in ranging markets, it seeks to exploit mean reversion opportunities. Risk is managed through clearly defined stop-loss and take-profit levels, alongside additional controls like cooldown periods after consecutive losses and drawdown-based trading halts. Trades are executed on Kraken's demo exchange using authenticated REST API requests, and all activity, including prices, positions, and performance metrics, is logged for ongoing analysis.

Differences from traditional trading strategies:

- Unlike traditional markets, which benefit from a centralized exchange structure, crypto trading is fragmented across many independent exchanges. As a result, our system operated in isolation using only Kraken's data, with no visibility into broader market liquidity or cross-exchange arbitrage opportunities.

- Institutional trading in traditional finance typically relies on standardized, low-latency connections like FIX protocols, while crypto platforms such as Kraken are accessed through REST and WebSocket APIs, which are subject to rate limits, inconsistent latency, and occasional downtime.
- The 24/7 nature of crypto trading further increases complexity, requiring continuous system monitoring, automated safeguards like cooldown periods, and robust error handling.
- Custody of funds remains with the exchange itself, unlike traditional systems that use central clearinghouses to mitigate settlement risk. This introduced an added layer of operational risk that our system had to account for through dynamic position management and real-time exposure tracking.
- Crypto trading is often characterized as highly volatile, with thinner liquidity, and a retail-dominated order flow. This required the use of adaptive algorithms for spread setting, volatility-based thresholds, and flexible trading logic tailored to varying market regimes.

Is There an Advantage to Co-Locating with Crypto Exchanges?

In traditional finance, co-location with exchange servers (e.g., at NYSE's Mahwah or CME's Aurora data centers) is a cornerstone of HFT strategy. However, most crypto exchanges do not offer formal colocation. Their trading infrastructure is typically cloud-based, often with undisclosed physical locations spread across multiple regions (e.g., AWS in Singapore, Tokyo, Frankfurt, etc.). Even when IP geolocation tools are used to estimate server locations, traffic may be routed through global content delivery networks (CDNs), masking true latency paths.

Since co-location is not feasible in most cases, crypto traders optimize latency in other ways: Deploying virtual private servers (VPS) near suspected data centers Using low-latency proxies and regional DNS resolution. These strategies can reduce ping times and improve market data freshness, especially for latency-sensitive strategies like market making or arbitrage. Minimizing latency to the exchange is still valuable. Even if true co-location is unavailable, proximity can reduce order transmission delays, leading to:

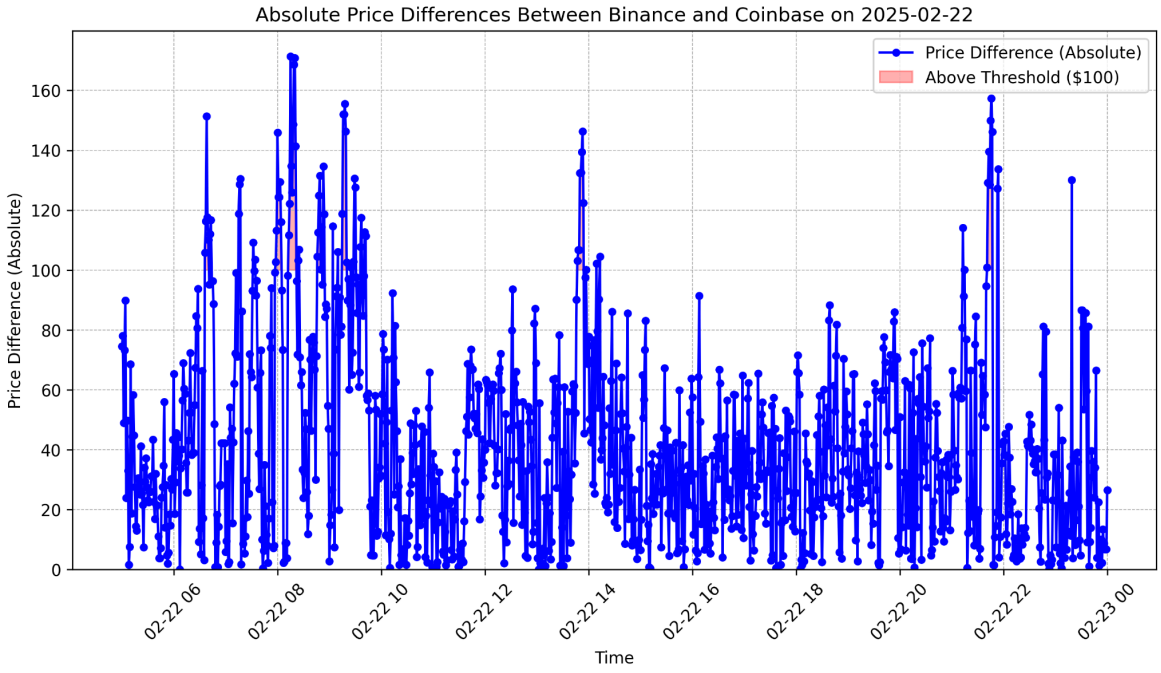
- Better queue placement
- Faster quote updates
- Reduced adverse selection risk

That said, because access is not exclusive, the edge is limited compared to traditional HFT colocation, and diminishing returns may occur beyond a certain optimization point.

Searching for Arbitrage Opportunities

Binance and Coinbase are two of the largest cryptocurrency exchanges, so we decided to explore potential arbitrage opportunities between them. In our first attempt, we used each exchange's API to retrieve historical Bitcoin price data. The most detailed data available through the APIs was at one-minute intervals. We compared the absolute values of the open prices from

each exchange to identify any price discrepancies. Even with just one day of data, we observed consistent price differences, which confirmed the potential for arbitrage. However, the one-minute resolution was not sufficient for accurate trading decisions.



For our second attempt, we connected to each exchange's websocket to access real-time data. This allowed us to detect more precise price differences and identify numerous profit opportunities, even after accounting for fees. Although our strategy is now profitable with fees included, the next challenge is transferring assets between exchanges quickly enough to capitalize on these opportunities.

Cash & Carry Arbitration Experiment

As a part of the cash and carry arbitrage experiment, we executed a strategy that involved buying the Bitcoin at the spot price of Binance while at the same time selling corresponding futures contracts on Coinbase using BIT perpetual futures. The goal of the program was to lock in risk-free profit from the price discrepancy between the spot and futures market. In the experiment we monitored real-time data using websocket and advanced API connection to check for the arbitrage opportunities. The results of the experiment suggest that while some arbitrage opportunities do exist, the potential profits from using BIT contracts are relatively small—typically in the single-digit percentage range.