Universiteit van Amsterdam
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Master in International Finance

Master Thesis:

Analyzing cross-regional cryptocurrency price differences – What factors contribute to arbitrage opportunities?

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Statement of Originality

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Abstract

This thesis examines cross-regional Bitcoin price differences to assess whether they create arbitrage opportunities and how institutional frictions shape these opportunities. Using high-frequency order book data from Kraken and nine regional exchanges across different regulatory environments, the study constructs arbitrage spreads and tests their persistence through panel regressions, beta estimations, and profitability measures. Results show that liquidity and latency risks are significant drivers of spreads, while restrictive capital environments and high transaction fees amplify inefficiencies, particularly during volatile periods. Although many markets display returns to baselines similar to the global exchanges, exchanges in South Africa and South Korea exhibit systematic and profitable arbitrage opportunities, highlighting the consistent impact of capital controls and institutional frictions on cryptocurrency market integration.

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1. Introduction

Bitcoin is a decentralized digital currency. The concept was first proposed in 2008 by the anonymous developer Satoshi Nakamoto in the paper "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto, 2008). It was created to allow peer-to-peer transactions without needing trusted third-parties, such as banks. Since then, the technology has had a meteoric rise in adoption.

The cryptocurrency market operates continuously across many exchanges, but despite its decentralized and digital nature, which implies global ease of access, notable price differences exist across regions. These differences suggest barriers to entry at the market level, driven by heterogeneous actors and frictions. In this sense, price differences could be considered a feature rather than a bug, as arbitraging agents provide a service to compress spreads for those with limited market access (O'Flynn, 2025).

Cryptocurrency price differences present potential arbitrage opportunities, situations where traders can buy an asset on one exchange and simultaneously sell it on another for profit.

The focus of this thesis is to investigate the role of capital controls and institutional frictions in shaping Bitcoin arbitrage spreads across countries. Arbitrage spreads represent one of the best measures of integration, if markets are frictionless and capital is easily moveable, prices should converge quickly across exchanges, with only minimal deviations. However, evidence and prior studies suggest that significant and persistent spreads have existed in certain environments, particularly where cross-border flows are restricted. The research therefore asks whether these deviations are systematic, how long they persist, and whether they generate meaningful arbitrage opportunities after transaction costs. The central research question is whether Bitcoin behaves like a global, unified asset or whether capital controls give rise to stale, segmented markets.

This question is important for several reasons. It challenges the perception of Bitcoin as a borderless form of money immune to traditional regulation. If spreads remain wider and more persistent in countries with stronger restrictions, this suggests that even decentralised assets are effected by the regulations of national institutions. It contributes to the broader literature on financial integration. Much of this literature has focused on equities, bonds, and foreign exchange, showing that capital controls can segment markets and slow the transmission of global shocks. Extending this logic to cryptocurrencies not only tests the robustness of these findings but also provides new insight into whether controls remain effective in a world of decentralised finance. Finally, the topic has practical relevance. For traders, persistent spreads represent opportunities to earn profits by buying low in one market and selling high in another. For regulators, they raise questions about the effectiveness and unintended consequences of restrictions. For exchanges, they highlight where integration is weakest and where liquidity provision is most critical.

The contribution of this thesis lies in combining institutional measures of financial openness with high-frequency data on Bitcoin arbitrage spreads. While existing studies have documented short-lived price discrepancies across exchanges, few have systematically linked the persistence of these spreads to capital controls. By focusing on the rate of spread closure and the conditions under which spreads remain profitable, this research adds a new dimension to the literature. It shows not only whether spreads exist, but also whether they are arbitraged away quickly in open markets and whether they linger in closed ones. This perspective helps distinguish between temporary inefficiencies due to liquidity shortages and more structural inefficiencies created by institutional frictions.

To address the research question, a dataset of minute-level prices and order book data across a global reference exchange (Kraken) and a set of regional exchanges located in both open and closed financial systems. The sample includes exchanges in South Korea (Upbit, Bithumb), South Africa (Luno), Latin America (Bitso, Novadax), Japan (Bitflyer), Turkey (Btcturk), and the United States (BinanceUS). This dataset allows for the construction of arbitrage spreads and the estimation of their persistence over multiple time horizons. By linking these spreads to the Chinn-Ito index of financial openness and to alternative institutional measures, it can directly be tested whether more restricted markets are characterised by slower spread convergence.

With regards to Methodology, descriptive statistics document the distribution of spreads across exchanges and highlight differences in their magnitude and volatility. This step provides a first indication of heterogeneity across countries and suggests which markets may be more segmented. Panel regressions are used to examine spreads, interacting lagged spreads with measures of openness and volatility. This design allows testing of how spreads react in different market conditions, and gauging of the of influence of capital controls. Finally, hypothetical arbitrage profits are computed after accounting for transaction fees, withdrawal costs, and FX conversion rates. This step ensures that the results are not only statistically but also economically meaningful, by showing whether persistent spreads translate into real trading opportunities.

2. Literature Review

The literature on cryptocurrency markets has grown in recent years, in line with its growth of use and institutional adoption. Past studies draw on cryptocurrency economics, international finance, and market microstructure. This literature review captures key ideas most relevant to the study of cross-regional Bitcoin price differences and arbitrage opportunities. The review covers market efficiency and price discovery, arbitrage opportunities and persistence, the role of capital controls and market regulation, microstructure and order flow models, and approaches using econometrics.

2.1 Market Efficiency and Price Discovery

A key question in existing literature is that of the Efficient Market Hypothesis, and whether cryptocurrency markets display efficiency in line with this hypothesis. Early studies have shown significant deviations from efficiency due to the youth and fragmentation of the market. Brauneis and Mestel (2018) find evidence of persistent inefficiencies in Bitcoin trading across multiple exchanges, suggesting that price discovery is uneven, and arbitrage opportunities occur due to information asymmetries. Similarly, Baur and Dimpfl (2019) show that while large and globalized exchanges such as Coinbase and Kraken often display efficient price discovery, smaller regional exchanges often show price deviations driven by liquidity constraints, limited depth, and regulatory frictions.

The research implies that cryptocurrencies do not operate as a unified global market, but rather as a cluster of exchanges with varying levels of integration, where prices often diverge. This paints a contrast to traditional equity and FX markets, where strong infrastructure and arbitrage capital mean that the law of one price is adhered to more strictly. The persistence of these inefficiencies in the cryptocurrency market raises questions regarding the nature of the barriers that prevent complete arbitrage.

2.2 Arbitrage Opportunities and Persistence

Other closely related studies examine arbitrage in cryptocurrency markets in great depth. Makarov and Schoar (2020) provide one of the most in depth analyses, documenting large and systematic price differences across multiple exchanges worldwide. They show that arbitrage opportunities persist for extended periods of time, and do not converge nearly as quickly as expected. Their study shows that arbitrageurs face multiple significant frictions such as withdrawal limits, capital controls, and transfer delays.

Shin, Liu, and Anwar (2020) investigate triangular arbitrage strategies within cryptocurrency markets. They demonstrate that profitable trades can be executed by cycling through three currency pairs. However, once transaction costs and latency are included, profit shrinks substantially. Their findings reinforce the idea that frictions, rather than lack of arbitrage awareness, explain persistent opportunities.

Other studies highlight the decomposition of arbitrage spreads into different components. Some portion reflects true arbitrage opportunities, while other portions are representations of compensation for risk and costs. For example, spreads often include a latency risk premium, the expected cost of price movement during the time it takes to transfer assets across exchanges. Recognizing these decompositions is important, as arbitrage can be seen not only as correcting market inefficiencies, but also as a service provided by agents who bridge fragmented markets. This service compensates for barriers to entry and allows for financial integration where access is usually limited.

2.3 Capital Controls, Regulation, and Market Segmentation

A strong driver of persistent price differences across markets is the presence of capital controls and regulatory restrictions. Auer and Claessens (2018) argue that regulation plays a dual role in cryptocurrency markets. They suggest it can improve market stability but also segment markets by restricting cross-border flow of capital. Their study shows that in emerging economies, capital controls and exchange rate management often create significant price premiums in regional cryptocurrency markets.

Liu and Tsyvinski (2021) extend this view by explicitly linking cryptocurrency price differences to capital control restrictions, global risk factors, and foreign exchange constraints. They show that restrictive environments tend to have systematically higher Bitcoin prices, which is consistent with the idea that cryptocurrencies serve as an alternate way of circumventing strict financial control. Similarly, Pieters and Vivanco (2017) show that countries with strict capital restrictions and limited USD liquidity show larger and more persistent arbitrage spreads.

This literature shows that macro-level institutions, capital openness, financial freedom, and regulatory environments are key to explaining cross-regional price differences. However, existing empirical studies often stop short of how these factors interact with microstructural dynamics. This thesis contributes by bridging these two factors by modelling spreads as a function of capital control indices and market variables such as volatility.

2.4 Microstructure and Order Flow Models

In addition to macro-level frictions, the literature also shows that market microstructure, trading processes, and order flows, play a role in price formation. Kyle (1985) presents information showing that prices adjust according to the order imbalance created by informed versus uninformed traders. Hasbrouck (1991) extends this by developing tools to measure the information content of trades, demonstrating that signed trading volume, which is buy pressure versus sell pressure, can predict short-term price movements.

In the context of cryptocurrencies, order flow may drive local deviations from global reference prices. A surge of buy orders in a regional exchange with low liquidity can temporarily elevate local prices above global benchmarks, creating arbitrage spreads.

2.5 Addition to Literature

Existing research uses a mix of econometric models and predictive algorithms. On the econometric side, studies such as Makarov and Schoar (2020) use panel regressions to identify causes of spreads across various exchanges, while Liu and

Tsyvinski (2021) use capital control indices as explanatory variables. Standard time series tools like autocorrelation, unit root testing, and vector autoregression have also been applied to test spread persistence and co-movement.

While the existing literature has made important analysis in documenting price deviations, efficiency dynamics, and the role of regulation in shaping cryptocurrency markets, there are still gaps. Most prior work either focuses on short lived inefficiencies that vanish quickly, or focuses on broad measures of return predictability and volatility effects across assets. Fewer studies directly test whether institutional restrictions, such as capital controls, systematically influence the persistence of arbitrage spreads across exchanges. The majority of empirical evidence relies on daily or lower frequency data, which limits the ability to observe how spreads open and close within intraday periods.

This thesis contributes by filling these gaps. It uses high frequency data on multiple global and regional exchanges, it provides a direct test of whether capital controls translate into slower spread convergence and persistent arbitrage opportunities, linking the literatures on financial openness and cryptocurrency efficiency. Additionally, the analysis focuses explicitly on the interaction between institutional measures and spread dynamics, offering evidence on whether restrictions designed for fiat capital flows effect digital asset markets. In doing so, the thesis bridges theories of international financial with the unique microstructure of cryptocurrency markets.

3. Methodology

The dataset that is examined in this thesis consists of:

- Exchange-level order book data (prices, volumes, bid/ask spreads) across 22,570 observations and 140 features from various exchanges.
- Arbitrage spreads between Kraken (reference) and regional exchanges, with multiple lag structures.
- Macroeconomic indicators merged from external sources.
- Derived features such as rolling volatility and global buying pressure

This section outlines the methodological framework adopted to analyze cross-regional Bitcoin price differences. The approach uses descriptive statistics and econometric models

3.1 The Law of One Price

In frictionless markets, the same asset should trade for the same price across locations. In the context of Bitcoin, the asset should trade at the same price when converted into the same currency:

$$P_{i,t}^{USD} = P_{j,t}^{USD}$$

Where:

- $P_{i,t}^{USD}$ = Price of Bitcoin on exchange *i* at time *t*
- $P_{j,t}^{USD}$ = Price of Bitcoin on exchange *j* at time *t*

This often does not hold, creating arbitrage opportunities. The causes of these price discrepancies shall be investigated.

3.2 Arbitrage Spreads

The first step is to measure arbitrage spreads consistently across exchanges. The spread is defined as:

$$Spread_{i,j,t-k} = \frac{P_{i,t-k}^{exchange} \cdot FX_{i,t} - P_{j,t}^{USD}}{P_{j,t}^{USD}}$$

Where:

- $FX_{i,t}$ = Exchange rate from local currency to USD
- $P_{i,t-k}^{exchange}$= The price of Bitcoin on a local exchange lagged by a time of k
- $P_{j,t}^{USD}$= The price of Bitcoin on the reference exchange (Kraken)

To ensure spreads represent true arbitrage opportunities, spreads will be computed with lag structures corresponding to blockchain transfer times and exchange settlement delays. This adjustment avoids showing opportunities that cannot be realized immediately without inventory on both exchanges.

3.3 Panel Regressions

To analyze the causes of cross-exchange arbitrage spreads in cryptocurrency markets, a panel regression framework with exchange fixed effects and time fixed effects is used. This allows for the separation of idiosyncratic frictions at the exchange level from global shocks common to all exchanges.

Baseline Model:

The baseline regression focuses on two fundamental frictions, latency risk, and liquidity risk.

$$Spread_{i,j,t} = \alpha_i + \gamma_t + \beta_1 Latency_t + \beta_2 Liquidity_{i,t} + \epsilon_{i,t}$$

Where:

- Latency risk captures the expected cost of settlement delay, calculated using rolling Bitcoin volatility and expected settlement time.
- Liquidity risk measures the bid-ask spread on each exchange.

Augmented Model:

$$\begin{aligned} Spread_{i,j,t} = {} & \alpha_i + \gamma_t + \beta_1 Latency_t + \beta_2 Liquidity_{i,t} + \beta_3 (KAOPEN_i \times Vol_t) \\ & + \beta_4 (Fees_{i,j} \times Vol_t) + \epsilon_{i,t} \end{aligned}$$

Where:

- Capital openness $(KAOPEN_i)$ is derived from the Chinn-Ito Index (Chinn & Ito, 2006)
- Capital openness x BTC Volatility interaction $(KAOPEN_i \times Vol_t)$ captures whether restrictive capital regulation deepens arbitrage spreads during volatile periods.
- Fees interaction $(Fees_{i,j} \times Vol_t)$ tests whether high exchange fees amplify arbitrage frictions when volatility is high.

By interacting structural characteristics with volatility, the model identifies how institutional frictions condition market dynamics.

3.4 Bitcoin Beta Estimation

In order to test whether global demand shocks transmit into regional spreads, a measure of buying pressure is created. To extract short-term demand shocks from the U.S. Bitcoin price series, the Hodrick-Prescott filter is used. This technique decomposes the log price into a smooth long-term trend and a cyclical component. The cyclical deviations are interpreted as buying pressure, reflecting temporary shifts from equilibrium prices driven by shifts in global demand.

$$BuyingPressure_t = \log{(P_{US,t})} - Trend_{US,t}$$

Estimate country specific beta using regression:

$$Spread_{c,t} = \alpha_c + \beta_c BuyingPressure_{t-k} + \epsilon_t$$

Where:

- β_c= Bitcoin beta, sensitivity of country *c* spread to global demand shocks

Note the inclusion of k lags. Without lags, the same U.S. price could be influencing both the spread and the explanatory variable at time. Lags also capture delays in asset transfer, regulatory barriers, and information diffusion. Testing multiple lags will show whether some markets are systematically slower to incorporate global shocks, particularly those with tighter capital controls.

3.5 Correlation of Arbitrage Spreads and Capital Controls

The co-movement of spreads across countries is studied using correlations. The baseline specification is:

$$\rho_{i,j} = Corr(Spread_{i,t}, Spread_{j,t})$$

Use capital control index:

$$Capital\ Openness_{i,j} = CCI_i \cdot CCI_j$$

Where:

- CCI_i= capital control index for country *i*

Regress correlation of arbitrage spreads on capital openness:

$$\rho_{i,j} = \alpha + \beta\left(CCI_i \cdot CCI_j\right) + \epsilon$$

3.6 Measuring Arbitrage Profits

Determine whether arbitrage still exists after accounting for costs.

$$Net\ Profit_{i,j,t} = P_{sell} - P_{buy} - C_t$$

Where C_t includes:

- Trading, withdrawal, network fees
- Blockchain confirmation delays
- FX conversion slippage or cost of hedging

4. Data and Descriptive Statistics

4.1 Data Sources

The dataset combines real-time order book and price data from Kraken and a range of regional exchanges as shown in Table 1 below.

Table 1: Exchange and Country

Exchange	Country
Kraken	United States
Binance	United States
Luno	South Africa
Upbit	South Korea
Novadax	Brazil
Bitflyer	Japan
BtcTurk	Turkey
Bitso	Mexico
Coins.ph	Phillipines
Bithumb	South Korea

Data was collected at minute frequency over the sample period (approx. 22,570 rows, spanning July 2025). This high-frequency structure allows for the computation of arbitrage spreads between Kraken (as a global reference) and local exchanges.

Alongside spreads, Indicators of capital openness and other institutional characteristics were collected, which serve as independent variables in later regressions. The data file contains 155 variables, including raw exchange prices (open, high, low, close), bid-ask quotes, traded volumes, and multiple lagged spread measures. A full breakdown of the dataset statistics can be found in the Appendix.

4.2 Summary Statistics

The table located in the Appendix shows key descriptive statistics for the main variables.

The average Kraken close price is 118,210 USD with a tight distribution (standard deviation of 890). Prices range between 114,758 and 120,994 USD, consistent with relatively stable BTC/USD trading over the short sample. Spread distributions vary strongly by exchange, but most exchanges cluster around 0 to ±1%.

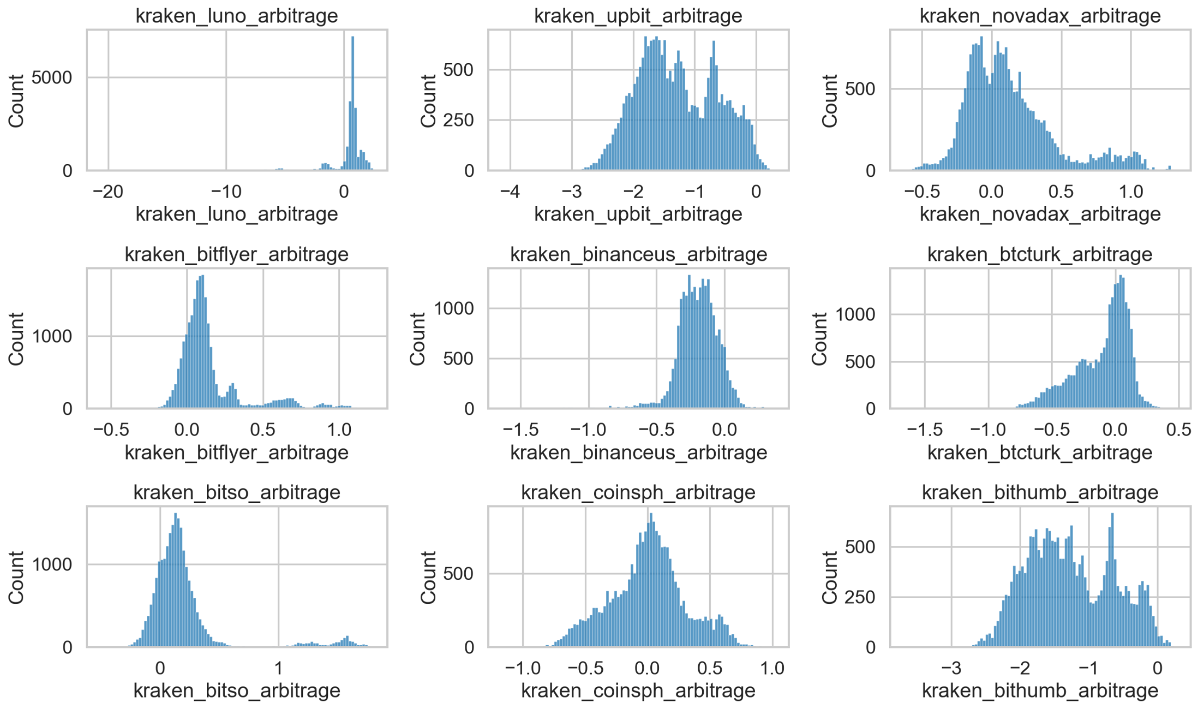
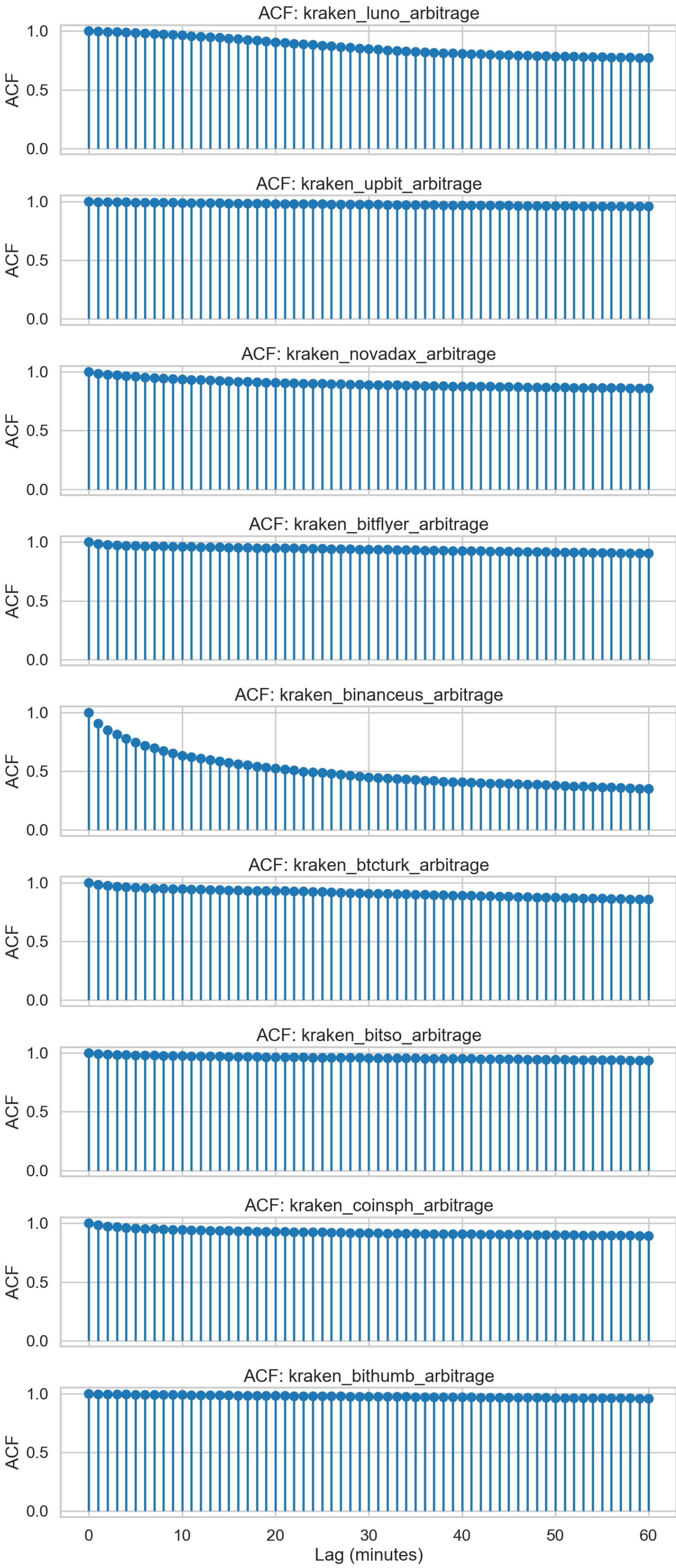


Figure 1: Spread Histograms for Exchanges

The spread histograms in Figure 1 above illustrate spread differences. Some markets (Bitflyer, Bitso, BinanceUS) show narrow, near normal distributions around zero, reflecting small and short lived arbitrage deviations. Others (Luno, Upbit, Bithumb) display wide or skewed distributions, suggesting more persistent or asymmetric frictions.

The autocorrelation functions in Figure 2 below highlight persistence. Most exchanges, with the exception of the other U.S. exchange Binance, show autocorrelations close to 1 even at long lags, indicating spreads decay very slowly.

Figure 2: ACF for Different Exchanges



The correlation heatmap in Figure 3 presents co-movements across exchanges.

High correlations (0.5-0.6): Novadax (Brazil), Bitflyer (Japan), and Bitso (Mexico) are strongly linked, showing they are more integrated with global flow.

Moderate correlations (0.3-0.5): Upbit and Bithumb (Korea) correlate strongly with eachother and moderately with other markets, suggesting partial segmentation.

Weak correlations (<0.2): Luno (South Africa) and BtcTurk (Turkey) exhibit weak co-movements, consistent with their more restrictive environments.

This heterogeneity indicates the presence of institutional frictions.

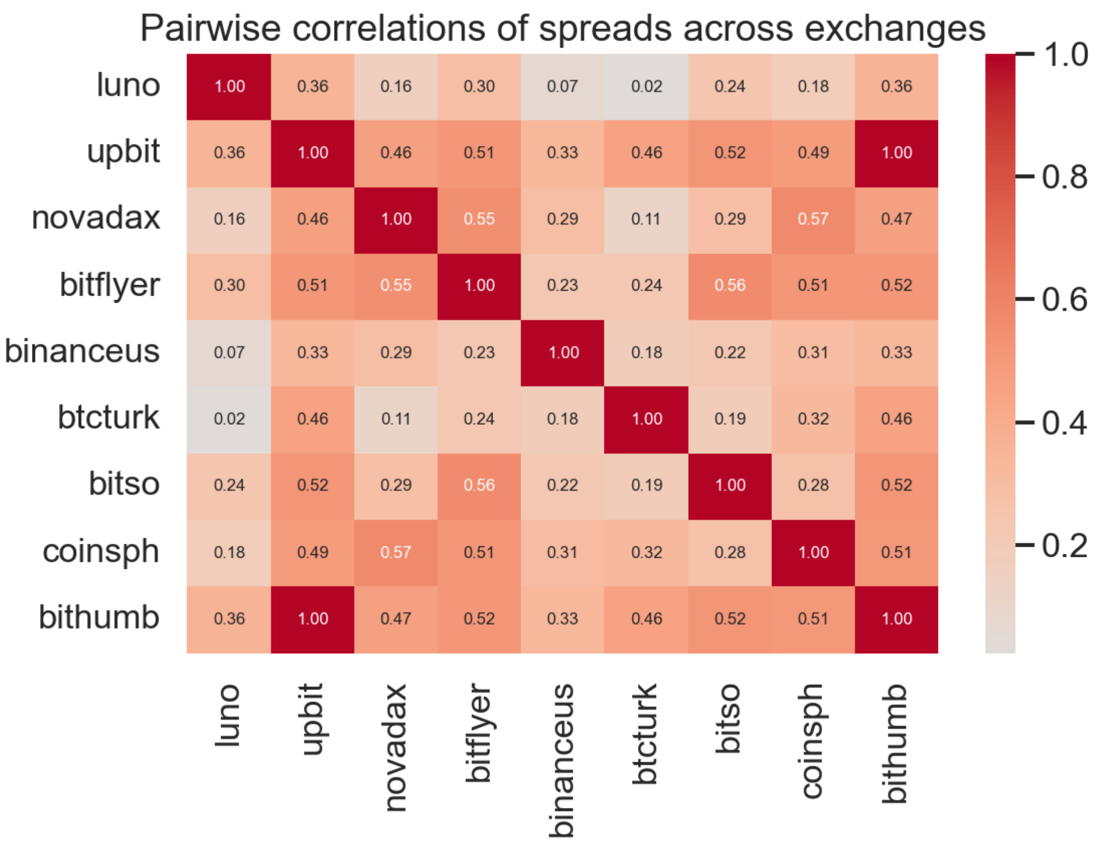


Figure 3: Correlations between Exchanges

Figure 4 shows the evolution spreads over time. Most markets fluctuate around zero. Luno exhibits extreme, short-lived negative spreads (up to -20%), this is a result of a period of low trading volume and a liquidity shortage. Upbit consistently trades below

Kraken by 1-2%, suggesting structural price discounting. BtcTurk and Bitso track Kraken more closely, with deviations typically <1%. These time series patterns reinforce the view that certain exchanges are structurally segmented, while others remain closely integrated with global prices.

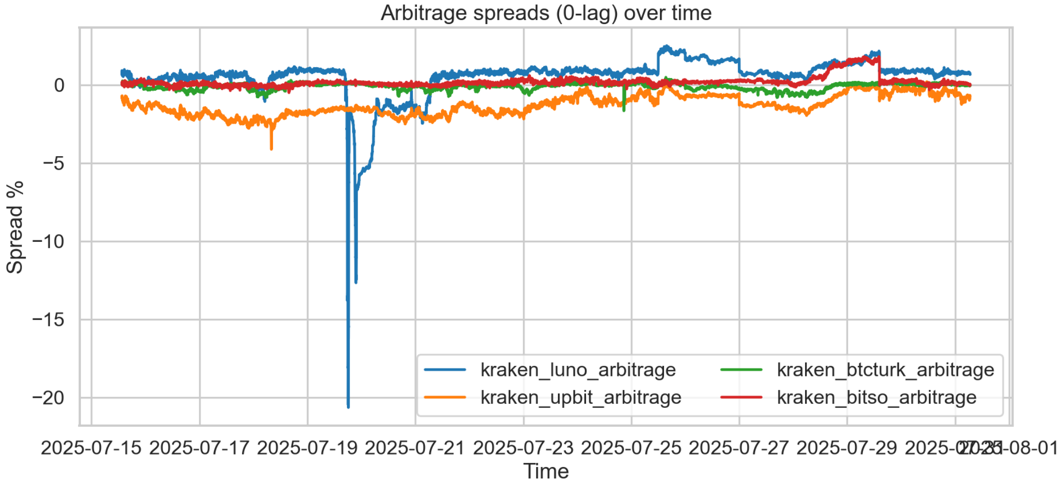


Figure 4: Arbitrage Spreads Over Time

5. Results

5.1 Panel Regressions

The regressions were estimated on 203040 observations covering 9 exchanges.

Table 2: Baseline Model and Augmented Model Regression Results

Robust t-statistics are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Variable	Baseline Model	Augmented Model
Latency premium	2.9201**	29.0832***
	(1.2517)	(1.7048)
Liquidity premium	-136.7081***	-136.9844***
	(1.1913)	(1.1894)
KAOPENxVol	N/A	-115.6871***
	N/A	(4.4695)
Fees×Vol	N/A	-991.0288***
	N/A	(51.8873)
Exchange Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
N	203040	203040
Adj. R-sq	0.659	0.660

Baseline Model:

The baseline regression included both exchange fixed effects and time fixed effects, alongside two explanatory variables, a latency premium, representing transfer and settlement risk and a liquidity premium, capturing depth and tightness of order books.

The model achieved an R-squared of 0.6595, suggesting that approximately 66% of the variation in arbitrage spreads is explained by the included regressors and fixed effects. The adjusted R-squared, 0.6589, is nearly identical, implying a robust fit without overfitting.

The latency premium has a positive and statistically significant coefficient of 2.92 ($p = 0.0197$). This indicates that spreads widen as latency increases, consistent with theory. Arbitrageurs facing longer transfer or confirmation times require additional compensation for risk exposure during volatile periods. Even a slight increase in expected latency translates into higher spreads.

The liquidity premium is negative and highly significant (-136.71, $p < 0.0001$). This strong effect confirms that higher liquidity reduces arbitrage frictions. Exchanges with greater market depth exhibit lower arbitrage spreads relative to those with thinner liquidity.

The baseline regression shows that latency and liquidity are two key influencers of cross-exchange arbitrage spreads, with liquidity having a particularly strong influence.

Augmented Model:

To capture the role of structural, time invariant frictions, those being capital openness and fee structures, the regression was augmented with interaction terms between volatility and these exchange specific characteristics. Because fees and capital openness are constant within exchanges, they are absorbed by exchange fixed effects in their raw form. However, by interacting them with time varying volatility, we test whether these characteristics condition how spreads respond under stressed market conditions.

The augmented regression gives an R-squared of 0.6606, slightly higher than the baseline.

Latency premium = 29.08 ($p < 0.0001$)
The effect of latency increases strongly relative to the baseline. This shows that once volatility interactions are accounted for, latency risk becomes a strong driver of spreads. Arbitrageurs thus seem to penalize latency heavily in volatile periods, where the risk of unfavourable price movement during transactions is greatest.

Liquidity premium = -136.99 ($p < 0.0001$)
The liquidity effect remains the same and strongly negative. This confirms that liquidity consistently narrows spreads.

KAOPEN x Volatility = -115.69 ($p < 0.0001$)
Negative and highly significant. Therefor higher KAOPEN values (more capital openness) reduces spread widening during volatility spikes. Restrictive capital environments create greater spread persistence in volatile periods. This shows evidence that capital controls act as a constraint on arbitrage efficiency when it matters most.

Fees x Volatility = -991.03 ($p < 0.0001$)
Also negative and highly significant. High-fee exchanges suffer more during volatile periods, as arbitrageurs cannot absorb costs quickly enough. Spreads widen more strongly on exchanges with high transaction costs when volatility rises.

Table 3: Augmented and Baseline Model Fixed Effects

Exchange	Fixed Effects (Baseline)	Fixed Effects (Augmented)
Bitflyer	0.036	0.081
Bithumb	-1.40	-1.37
Bitso	0.13	0.11
Btcturk	-0.21	-0.31
Coinsph	0.05	0.007
Luno	0.43	0.39
Novadax	0.42	0.45
Upbit	-1.41	-1.35

Exchange Fixed Effects:

The exchange fixed effects capture time invariant, structural differences in arbitrage spreads across exchanges. Fixed effects for South Korea (Bithumb and Upbit) are strongly negative across both models. This suggests that Korean exchanges systematically trade at discounts relative to Kraken. This is surprising considering that Korea is well known for trading at prices significantly higher than global exchanges, hence the term “Kimchi Premium”. The discount shows the segmentation in the Korean market, and is contributed to due to weak investor sentiment in South Korea, as well as a growth in demand for assets on foreign platforms. South Africa (Luno) and Brazil’s (Novadax) fixed effects are significantly positive. These markets show systematically higher spreads. Mexico (Bitso) and Phillipines (Coins.ph) have small but positive fixed effects. These exchanges experience slightly higher spreads, but not as extreme as South Africa or Brazil. Turkey (BtcTurk) is slightly negative. This suggests that Turkish markets trade at slightly narrower spreads. Japan (Bitflyer) is close to zero in both models. Japanese markets appear tightly integrated, with spreads close to the global baseline.

5.2 Bitcoin Beta

Table 4: Regression Results for Bitcoin Beta

Robust t-statistics are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Variable	BR	JP	KR	MX	PH	TR	US	ZA
Constant	0.1293***	0.1517***	-1.2674***	0.2023***	0.0061***	-0.1022***	-0.2009***	0.5031***
	(0.0021)	(0.0015)	(0.0030)	(0.0023)	(0.0020)	(0.0014)	(0.0011)	(0.0095)
Beta	-30.537***	-10.118***	-34.545***	-17.891***	-24.801***	-12.631***	-38.594***	-26.004***
	(2.1659)	(1.5216)	(3.0322)	(2.3362)	(2.0393)	(1.4539)	(1.0782)	(9.6576)
N	22570	22570	45140	22570	22570	22570	22570	22570

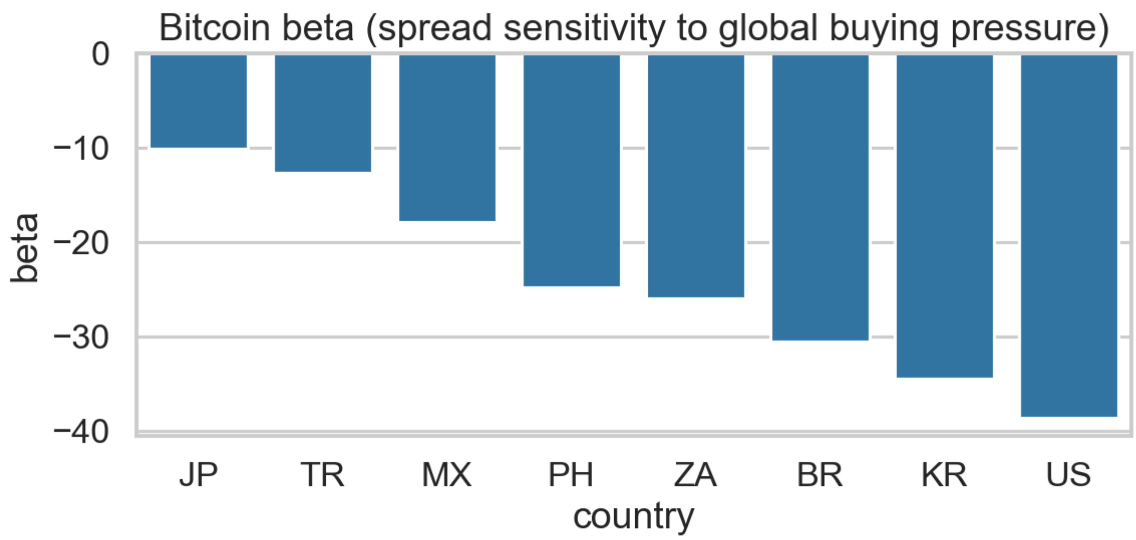


Figure 5: Bitcoin Beta per Country

Across all countries, the estimated betas are negative. This indicates that when U.S. prices rise above trend, foreign spreads compress relative to the U.S. benchmark exchange (Kraken). In other words, U.S. demand shocks push U.S. prices upward first, and foreign markets subsequently adjust, narrowing the measured spread. The negative sign is thus consistent with arbitrage dynamics. U.S. shocks flow through outward, and local markets catch up with some delay.

The magnitudes of the betas, which range from roughly -10 (Japan) to -38 (U.S.), are largely negative. This partly reflects the construction of the buying pressure measure, it also reflects the strong co-movement of Bitcoin markets, where even small U.S. deviations are mirrored abroad. The relative sizes of the betas are meaningful. Countries with smaller betas (Japan, Turkey) are more tightly integrated with U.S. markets, while those with larger betas (South Africa, Brazil, Korea) display heightened sensitivity.

Comparing these estimates to the Chinn-Ito index of capital account openness is useful. Countries with low openness (South Africa, Brazil, Philippines) exhibit large betas, while Japan and Mexico, with more open capital accounts, show smaller betas. Korea is an outlier, despite being classified as highly open, it shows one of the largest betas, reflecting the possibility of other restrictions and cryptocurrency specific frictions perhaps not accounted for in the index. The U.S. beta, estimated using Binance vs. Kraken, is the most negative by construction, since the buying pressure measure itself is U.S. defined.

The Bitcoin beta measure reflects the effective segmentation in crypto markets. Larger betas in restricted markets suggest that institutional frictions amplify the impact of global shocks.

5.3 Correlation of Arbitrage Spreads and Capital Controls

Table 5: Regression Results of Capital Controls and Arbitrage Spreads

Robust t-statistics are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Variable	Coefficient
Constant	0.3614***
	(11.807)
Capital Openness (CCI_i × CCI_j)	0.0148
	(1.388)
N	36
R-squared	0.0536
Adj. R-squared	0.0258
F-statistic	1.9263
Prob(F-statistic)	0.1742

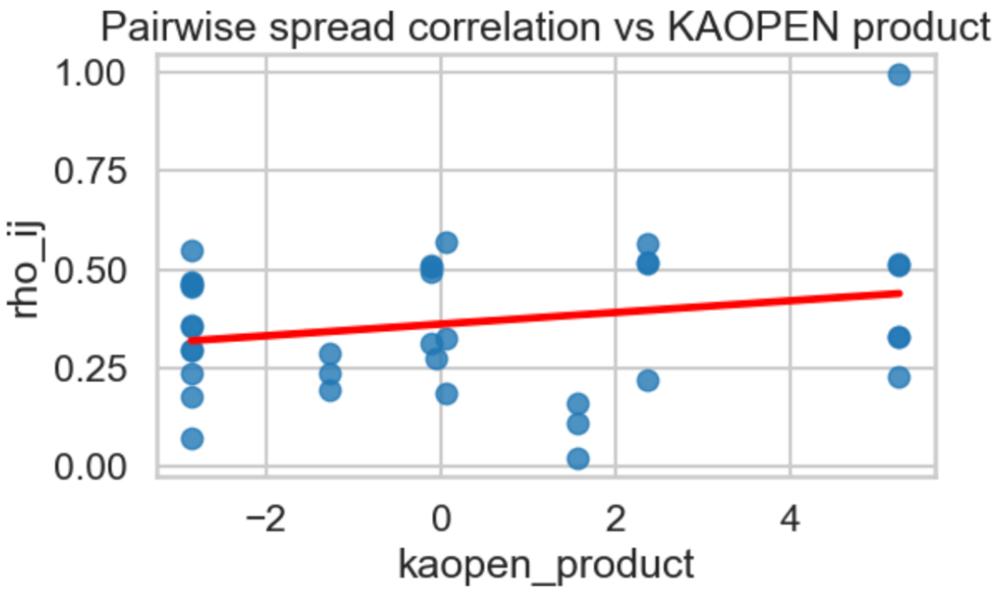


Figure 6: Spread Correlation and Capital Controls

With regards to the regression show in Table 4, the constant is highly significant and implies a baseline pairwise correlation of approximately 0.36, even when both markets are highly closed. This indicates that Bitcoin markets display a degree of co-movement across borders irrespective of institutional restrictions.

The coefficient on the KAOPEN product is positive (0.0148) but statistically insignificant ($p = 0.174$). The direction of the effect is consistent with theoretical predictions, greater openness is associated with somewhat higher spread correlations. However, the lack of statistical significance suggests that this relationship is weak and not robust across the sample. The model explains only 5.3% of the variation in spread correlations highlighting that capital openness alone is not sufficient to capture the drivers of international co-movement in arbitrage spreads.

The relationship is visualised in Figure 6. The regression line slopes upward, consistent with the positive coefficient, but the scatter of points reveals substantial dispersion. Some highly open market pairs still exhibit weak correlations, while some relatively closed market pairs display moderate or high correlations. A small number of outliers with very high correlations appear to drive the slope

5.4 Measuring Arbitrage Profits

Table 6: Profitable Arbitrage Scenarios

Exchange	Mean Profit	Standard Profit	Profit Rate	P95 Profit	Max Profit	Average Cost	Average Spread
Bitflyer	-0.21	0.23	15.6	0.33	0.82	0.41	0.2
Bithumb	-0.29	0.06	0.0	-0.17	-0.12	0.36	0.07
Bithumb (Reverse)	0.99	0.65	91.76	1.98	3.81	0.36	1.35
Bitso	-0.09	0.37	13.49	0.97	1.44	0.36	0.26
Btcturk	-0.3	0.06	0.05	-0.17	0.1	0.38	0.08
Coinsph	-0.18	0.19	22.36	0.19	0.53	0.41	0.23
Luno	0.26	0.46	72.49	1.23	1.95	0.56	0.82
Novadax	-0.46	0.29	13.78	0.18	0.47	0.76	0.3
Upbit	-0.39	0.06	0.0	-0.26	-0.15	0.46	0.07
Upbit (Reverse)	0.91	0.66	89.33	1.93	4.18	0.46	1.37

Table 6 summarises estimated arbitrage profitability across exchanges. The table reports mean profit per trade, profit variability, profit rates (the proportion of trades yielding positive returns), the 95th percentile of profits (P95), the maximum observed profit, as well as average trading costs and average spreads. These indicators provide an overview of whether arbitrage opportunities exist, whether they are systematic or merely occasional, and whether they survive once transaction costs are taken into account. Note that for the South Korean exchanges, Upbit and

Bithumb, reverse direction trades where taken into account (from local exchange to Kraken) due to the systemic discounting shown in the data of the Korean markets.

For several exchanges, the results suggest that arbitrage is largely unprofitable. This is the case for Bithumb, Btcturk, Novadax, Coins.ph, and Upbit, all of which record negative mean profits ranging from -0.18% to -0.46%. Profit rates in these markets are negligible. Btcturk's profit rate is only 0.05%, while both Bithumb and Upbit (in the forward direction) register virtually zero profitable trades. This implies that, once transaction costs are incorporated, these markets do not support sustainable arbitrage.

A second group of exchanges shows slightly better performance but still falls short of consistent profitability. Bitflyer records a mean profit of -0.21%, but with a profit rate of 15.6% and occasional large trades yielding up to 0.82%. Bitso follows a similar pattern, with a mean profit of -0.09%, a profit rate of 13.5%, and a 95th percentile profit of 0.97%. In both cases, profitable opportunities exist but are infrequent and generally small in magnitude. These findings are consistent with more integrated markets where spreads are rapidly arbitraged away.

The most striking evidence of profitable arbitrage appears in the reverse direction for Bithumb and Upbit, both located in South Korea. In these cases, mean profits are high (0.99% for Bithumb and 0.91% for Upbit), and profit rates exceed 89%. Maximum profits are substantial, reaching 3.81% and 4.18% respectively, with 95th percentile profits close to 2%. These results indicate that arbitrage opportunities are not only frequent but also systematic.

Another exchange where arbitrage appears consistently profitable is Luno (South Africa). Here, mean profits are positive (0.26%) and the profit rate is very high at 72.5%. Maximum profits reach 1.95%, and even the 95th percentile of profits is comfortably above 1%. At the same time, Luno faces high costs (0.56%) and spreads (0.82%), suggesting that local frictions are severe. The persistence of profits despite these costs reinforces the interpretation that institutional and liquidity constraints prevent arbitrageurs from fully exploiting these opportunities.

6. Robustness Checks

6.1 Lag Implementation

As a robustness check, both the baseline and augmented regression models were run, lagging the arbitrage values by 15, 30, 45, 60, 90, and 120 minute intervals.

Table 7: Baseline Model and Augmented Model Lagged Regression Results

Robust t-statistics are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Model	Latency Premium	Liquidity Premium	R-squared	N
Baseline (15min)	2.0315**	-136.6920***	0.660	203040
	(2.307)	(-114.754)		
Augmented (15min)	18.9746***	-136.9779***	0.661	203040
	(15.119)	(-115.155)		
Baseline (30min)	2.9201**	-136.7081***	0.660	203040
	(2.333)	(-114.752)		
Augmented (30min)	29.0832***	-136.9844***	0.661	203040
	(17.060)	(-115.171)		
Baseline (45min)	1.9390	-136.6648***	0.660	203040
	(1.196)	(-114.725)		

Augmented (45min)	25.8915***	-136.7769***	0.661	203040
	(13.048)	(-114.988)		
Baseline (60min)	1.7566	-136.6499***	0.660	203040
	(0.899)	(-114.727)		
Augmented (60min)	24.4558***	-136.7045***	0.660	203040
	(10.841)	(-114.933)		
Baseline (90min)	5.9412**	-136.6805***	0.660	203040
	(2.215)	(-114.752)		
Augmented (90min)	29.0628***	-136.7348***	0.660	203040
	(9.953)	(-114.954)		
Baseline (120min)	4.4303	-136.6559***	0.660	203040
	(1.355)	(-114.737)		
Augmented (120min)	27.5953***	-136.6216***	0.660	203040
	(7.939)	(-114.852)		

In the baseline model, the latency premium is small in magnitude and is only sometimes significant. This suggests that when latency is modelled alone, its estimated effect is weak and unstable across lag choices.

Once the regression is augmented with the additional factors, the premium jumps substantially (19-29) and is highly significant (t-stats > 15 for all). This indicates that when institutional frictions are included, the role of latency becomes stronger and more robust.

For the liquidity premium, both baseline and augmented models show a large, negative coefficient that is highly significant. The stability of this coefficient across lag structures and model specifications suggests that liquidity consistently drives spreads lower and deeper markets converge more quickly, regardless of lags or controls.

R-squared is stable around 0.660-0.661 across all lag structures and specifications.This indicates that adding lags or augmenting the model with controls does not change explanatory power much overall, but it redistributes the power of the variables.

6.2 Leave-one-out

As a robustness check, both the baseline and augmented regression models were run multiple times, with each iteration excluding a specific exchange to analyze the effects of its removal.

Table 8: Baseline and Augmented Leave-one-out

Robust t-statistics are reported in parentheses. *, **, and *** indicate significance at 10%, 5%, and 1%, respectively.

Excluded Exchange	Model	Latency Premium	Latency t-stat	R-squared	N
luno	Baseline	1.6021***	(182.348)	0.688	60160
luno	Augmented	1.6021***	(182.348)	0.688	60160
upbit	Baseline	0.0825***	(7.155)	0.442	60160

upbit	Augmented	0.0825***	(7.155)	0.442	60160
novadax	Baseline	-1.8800***	(-186.635)	0.528	60160
novadax	Augmented	-1.8800***	(-186.635)	0.528	60160
bitflyer	Baseline	-1.8581***	(-182.539)	0.517	60160
bitflyer	Augmented	-1.8581***	(-182.539)	0.517	60160
binanceus	Baseline	-1.8651***	(-182.025)	0.525	60160
binanceus	Augmented	-1.8651***	(-182.025)	0.525	60160
btcturk	Baseline	-1.8504***	(-181.177)	0.524	60160
btcturk	Augmented	-1.8504***	(-181.177)	0.524	60160
bitso	Baseline	-1.8512***	(-183.380)	0.516	60160
bitso	Augmented	-1.8512***	(-183.380)	0.516	60160
coinsph	Baseline	-1.8547***	(-182.900)	0.525	60160
coinsph	Augmented	-1.8547***	(-182.900)	0.525	60160
bithumb	Baseline	-1.8510***	(-192.333)	0.441	60160

bithumb	Augmented	-1.8510***	(-192.333)	0.441	60160

When exchanges are excluded one by one, the latency premium remains consistently significant, though its size and sign vary depending on the market removed. For example, when Luno is excluded, the coefficient is positive and very large (1.60 with a t-stat above 180), while excluding Novadax yields a strongly negative coefficient (-1.88, t-stat 186). Excluding Upbit produces a much smaller positive coefficient (0.08), but still statistically significant. These patterns suggest that the magnitude of the latency premium is heavily influenced by which market is in the sample, but the fact that it never becomes insignificant indicates that latency is a systematic determinant of spreads across all markets.

R-squared ranges between 0.44 (when Upbit is excluded) and 0.69 (when Luno is excluded), showing that explanatory power depends on which exchange is dropped. However, the fit remains solid across all scenarios, confirming robustness.

These results demonstrate that the main findings are robust to leave-one-out analysis. The variation across exclusions also highlights that certain markets, such as Korea (Upbit) or South Africa (Luno), carry strong weight in determining the size of the effect.

7. Conclusion

This thesis set out to investigate whether Bitcoin behaves as a unified global asset or whether institutional frictions and capital controls create persistent arbitrage opportunities across regions. Using high-frequency order book data from Kraken and nine regional exchanges, arbitrage spreads were constructed, their persistence modeled through panel regressions, and their profitability assessed after costs. The main findings can be summarized as follows.

Liquidity and latency risks emerged as consistent drivers of spreads, with thin order books and settlement delays widening gaps across exchanges. Capital controls and fee structures significantly amplify inefficiencies, particularly during periods of volatility, confirming the importance of institutional frictions in market segmentation. While most exchanges displayed rapid convergence to global benchmarks, systematic and profitable arbitrage opportunities were found in South Korea and South Africa, highlighting the role of restrictive financial environments in sustaining segmentation.

These findings extend the existing literature. Prior studies such as Makarov and Schoar (2020) documented persistent arbitrage spreads, attributing them largely to withdrawal frictions and latency. This thesis supports their conclusions by finding that latency premiums are significant, but it goes further by showing that the effect is conditional on institutional characteristics. Similarly, the observation that higher liquidity narrows spreads is consistent with Baur and Dimpfl (2019), who emphasized the role of depth in reducing inefficiencies.

Most importantly, this work links spread persistence directly to measures of capital account openness, extending the insights of Pieters and Vivanco (2017) and Liu and Tsyvinski (2021). While previous studies have suggested that restrictive regimes inflate regional Bitcoin prices, the present analysis shows that such restrictions not only raise levels but also slow the speed of convergence, particularly under volatility.

Several limitations must be acknowledged. The dataset, though high-frequency, covers only a one month sample period. Market conditions in July 2025 may not reflect broader cycles of liquidity, sentiment, or regulatory shocks. A longer horizon could capture structural changes and changing patterns over time. Additionally, the analysis is limited to a set of nine exchanges. While diverse, they do not exhaust the global universe of crypto markets. Additional exchanges, particularly in regions with informal markets or stronger enforcement, might alter the findings. Furthermore, the Chinn-Ito index, while widely used, may not fully capture cryptocurrency specific restrictions such as domestic banking prohibitions or outright bans. Finally, the profitability analysis is based on simulated trades net of transaction costs, but does not account for balance sheet constraints of arbitrageurs, limits to ability to move capital, or risks associated with sudden regulatory changes.

The results have several implications. For traders, the persistence of profitable opportunities in South Africa and South Korea indicates that arbitrage can be profitable, but only in environments where institutional constraints limit competition. However, such opportunities may be difficult to exploit due to capital restrictions, suggesting that profits are more theoretical than practical for many global traders.

For regulators, the findings are interesting. Capital controls and exchange restrictions are often justified as stabilizing measures, but in cryptocurrency markets they appear to create segmentation and inefficiencies, which may encourage different channels of moving capital. This highlights the need for regulators to consider unintended consequences when designing restrictions in a world where digital assets provide alternative channels for cross-border capital flow.

For exchanges, the evidence suggests that liquidity provision remains a critical factor for integration. Exchanges with deep order books are more tightly linked to global benchmarks, while those with shallow markets display persistent deviations. This emphasizes the importance of developing robust market-making infrastructure in emerging regions.

Finally, for the broader financial system, the results caution against assuming that cryptocurrencies automatically constitute a “borderless” form of money. Institutional realities remain central. Even decentralized technologies are not entirely insulated from national regulations, and their integration with traditional financial infrastructure subjects them to similar frictions observed in equity, bond, and FX markets.

Future research could extend this study in several ways. Expanding the dataset across multiple years would allow for testing the stability of results during bull and bear cycles, as well as in response to regulatory shocks. Incorporating additional institutional measures could provide a richer account of why spreads persist. An important extension would be to consider other cryptocurrency assets.

In conclusion, this thesis demonstrates that while Bitcoin is globally traded, its market is not frictionless. Liquidity, latency, and particularly capital controls continue to generate segmentation and arbitrage opportunities, limiting its integration as a unified global asset. These findings not only deepen the understanding of cryptocurrency market structure but also touch on broader themes in international finance, institutions still matter, even in decentralized systems.

8. References

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9. Appendix

Table 9: Summary Statistics for Dataset

	count	mean	median	std	var	min	25%	50%	75%	max
id	22570	11285,5	11285,5	6515,54	4,2E+07	1	5643,25	11285,5	16927,8	22570
kraken_open	22570	118210	118200	889,918	791953	114758	117788	118200	118750	120995
kraken_high	22570	118215	118202	889,448	791118	114758	117791	118202	118756	120995
kraken_low	22570	118205	118200	890,407	792824	114733	117784	118200	118750	120995
kraken_close	22570	118210	118200	889,815	791770	114758	117788	118200	118750	120995
kraken_volume	22570	0,27223	0	1,65517	2,73958	0	0	0	0,04606	61,7347
kraken_ask	22570	118210	118200	889,778	791705	114759	117788	118200	118750	120995
kraken_bid	22570	118210	118200	889,815	791771	114758	117788	118200	118750	120995
kraken_ask_volume	22570	23,0093	22,7235	11,2325	126,169	0,046	15,8028	22,7235	30,5035	77,03
kraken_bid_volume	22570	21,525	21,84	10,9171	119,183	0,057	14,4773	21,84	28,3878	77,462
kraken_volume_24h	22570	997,447	1023,73	411,741	169531	260,616	705,922	1023,73	1210,19	2340,79
kraken_spread_pct	22570	0,00012	8,5E-05	0,00081	6,5E-07	8,3E-05	8,4E-05	8,5E-05	8,5E-05	0,03792
luno_open	22570	2107116	2113576	34458	1,2E+09	1659999	2097664	2113576	2127086	2166002
luno_high	22570	2107439	2113637	33810,6	1,1E+09	1730000	2098141	2113637	2127325	2166003
luno_low	22570	2106696	2113369	35318,7	1,2E+09	1656328	2097310	2113369	2126959	2166002
luno_close	22570	2107103	2113579	34426,7	1,2E+09	1660000	2097847	2113579	2127103	2166003
luno_volume	22570	0,0353	0,00304	0,10962	0,01202	0	0,00023	0,00304	0,02416	3,6652
luno_ask	22570	2107675	2113812	34115,9	1,2E+09	1660000	2098716	2113812	2127425	2166002
luno_bid	22570	2106326	2113277	35118,9	1,2E+09	1658469	2097021	2113277	2126704	2165541
luno_ask_volume	22570	1,33125	1,25919	0,49059	0,24068	0,14926	1,01516	1,25919	1,54772	9,71984
luno_bid_volume	22570	1,00005	0,87646	0,55801	0,31138	0,09765	0,69173	0,87646	1,13877	7,32796
luno_volume_24h	22570	52,593	46,2816	22,7401	517,114	11,126	39,6228	46,2816	64,4206	108,71
luno_spread_pct	22570	0,06488	0,02344	0,152	0,0231	4,6E-05	4,7E-05	0,02344	0,09088	8,18946
upbit_open	22570	1,6E+08	1,6E+08	1132032	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
upbit_high	22570	1,6E+08	1,6E+08	1131689	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
upbit_low	22570	1,6E+08	1,6E+08	1131975	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
upbit_close	22570	1,6E+08	1,6E+08	1131825	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
upbit_volume	22570	0,1727	0,05197	0,42761	0,18285	3,1E-05	0,01456	0,05197	0,16192	13,5171
upbit_ask	22570	1,6E+08	1,6E+08	1132000	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
upbit_bid	22570	1,6E+08	1,6E+08	1131167	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08

upbit_ask_volume	22570	2,72116	2,29929	2,09872	4,40461	0,01245	1,31368	2,29929	3,62479	44,1655
upbit_bid_volume	22570	1,58985	1,16746	1,8084	3,2703	0,01453	0,66573	1,16746	2,02428	46,8443
upbit_volume_24h	22570	1844,17	1845,96	714,403	510371	656,85	1211,56	1845,96	2473,85	3365,62
upbit_spread_pct	22570	0,01805	0,00743	0,02295	0,00053	0,00061	0,00124	0,00743	0,02791	0,15457
novadax_open	22570	659466	660407	5232,24	2,7E+07	638000	656965	660407	662701	670136
novadax_high	22570	659667	660548	5184,78	2,7E+07	638100	657206	660548	662926	670137
novadax_low	22570	659234	660200	5287,76	2,8E+07	637113	656714	660200	662444	670136
novadax_close	22570	659466	660418	5232,32	2,7E+07	638000	656976	660418	662702	670136
novadax_volume	22570	0,65403	0,02413	6,9064	47,6983	3,8E-05	0,0105	0,02413	0,03781	95,0549
novadax_ask	22570	660281	660998	5171,99	2,7E+07	638561	658039	660998	663736	670137
novadax_bid	22570	658072	659000	5164,46	2,7E+07	637113	655479	659000	661242	669605
novadax_ask_volume	22570	0,13131	0,0884	0,11454	0,01312	0,01896	0,03821	0,0884	0,18761	1,16006
novadax_bid_volume	22570	0,10085	0,07339	0,09378	0,0088	0,02503	0,03676	0,07339	0,13503	0,90925
novadax_volume_24h	22570	74,2638	76,2012	12,3906	153,527	47,6896	64,2298	76,2012	84,5562	104,672
novadax_spread_pct	22570	0,33519	0,37421	0,15154	0,02297	1,5E-06	0,21423	0,37421	0,47173	0,92668
bitflyer_open	22570	1,8E+07	1,8E+07	151403	2,3E+10	1,7E+07	1,7E+07	1,8E+07	1,8E+07	1,8E+07
bitflyer_high	22570	1,8E+07	1,8E+07	151233	2,3E+10	1,7E+07	1,7E+07	1,8E+07	1,8E+07	1,8E+07
bitflyer_low	22570	1,8E+07	1,8E+07	151580	2,3E+10	1,7E+07	1,7E+07	1,8E+07	1,8E+07	1,8E+07
bitflyer_close	22570	1,8E+07	1,8E+07	151378	2,3E+10	1,7E+07	1,7E+07	1,8E+07	1,8E+07	1,8E+07
bitflyer_volume	22570	31,2651	0,17181	131,994	17422,4	0,0008	0,061	0,17181	0,57484	942,47
bitflyer_ask	22570	1,8E+07	1,8E+07	151776	2,3E+10	1,6E+07	1,7E+07	1,8E+07	1,8E+07	1,8E+07
bitflyer_bid	22570	1,8E+07	1,8E+07	151450	2,3E+10	1,7E+07	1,7E+07	1,8E+07	1,8E+07	1,8E+07
bitflyer_ask_volume	22570	2,66076	2,46265	1,48409	2,20253	0,11415	1,81172	2,46265	3,1287	20,2016
bitflyer_bid_volume	22570	2,1542	2,00359	1,11471	1,24258	0,11731	1,39103	2,00359	2,69951	24,1205
bitflyer_volume_24h	22570	596,97	632,658	202,42	40973,9	163,423	509,232	632,658	739,276	1074,6
bitflyer_spread_pct	22570	0,03465	0,03289	0,05452	0,00297	-7,7019	0,02262	0,03289	0,0442	0,14276
binanceus_open	22570	118156	118135	854,277	729788	115130	117702	118135	118706	120000
binanceus_high	22570	118156	118135	854,243	729731	115130	117702	118135	118706	120000
binanceus_low	22570	118155	118135	854,111	729506	115130	117702	118135	118706	120000
binanceus_close	22570	118155	118135	854,162	729592	115130	117702	118135	118706	120000
binanceus_volume	22570	0,00044	0	0,00928	8,6E-05	0	0	0	0	0,79526
binanceus_ask	22570	118287	118307	848,883	720603	115130	117864	118307	118837	120000
binanceus_bid	22570	117972	117995	832,116	692418	115130	117549	117995	118500	120000

binanceus_ask_volume	225 70	0,761 37	0,514 51	0,635 4	0,403 73	0,029 41	0,222 62	0,514 51	1,200 39	3,087 39
binanceus_bid_volume	225 70	0,320 44	0,280 02	0,265 22	0,070 34	0,018 41	0,160 72	0,280 02	0,407 1	3,241 92
binanceus_volume_24h	225 70	2,758 83	2,343 5	1,326 1	1,758 54	0,488 72	1,706 8	2,343 5	3,548 76	6,362 41
binanceus_spread_pct	225 70	0,266 46	0,276 89	0,148 56	0,022 07	8,3E- 06	0,160 44	0,276 89	0,359 5	1,117 08
btcturk_open	225 70	4776 617	4779 401	3250 7,5	1,1E +09	4654 818	4760 499	4779 401	4797 847	4870 179
btcturk_high	225 70	4776 713	4779 495	3251 6,3	1,1E +09	4654 818	4760 610	4779 495	4797 937	4871 676
btcturk_low	225 70	4776 464	4779 228	3257 0	1,1E +09	4650 000	4760 330	4779 228	4797 739	4870 179
btcturk_close	225 70	4776 568	4779 355	3257 4,1	1,1E +09	4650 000	4760 422	4779 355	4797 860	4871 676
btcturk_volume	225 70	21,38 21	22,09 47	19,36 93	375,1 7	 0	0,008 75	22,09 47	40,63 81	64,61 37
btcturk_ask	225 70	4777 644	4780 402	3256 5	1,1E +09	4654 817	4761 506	4780 402	4798 841	4874 899
btcturk_bid	225 70	4775 602	4778 417	3254 2,9	1,1E +09	4654 001	4759 575	4778 417	4796 871	4867 668
btcturk_ask_volume	225 70	2,633 45	2,324 94	1,616 99	2,614 66	0,104 44	1,538 98	2,324 94	3,414 23	9,009 98
btcturk_bid_volume	225 70	1,107 89	0,896 55	0,741 28	0,549 5	0,000 44	0,561 23	0,896 55	1,510 05	5,994 77
btcturk_volume_24h	225 70	34,85 04	37,82 58	13,55 17	183,6 49	 10,31	23,98 28	37,82 58	44,85 55	64,61 37
btcturk_spread_pct	225 70	0,042 76	0,040 39	0,027 07	0,000 73	2,1E- 05	 0,023	0,040 39	0,057 56	0,305 77
bitso_open	225 70	2211 625	2214 050	2008 1,1	4E+0 8	2135 000	2200 950	2214 050	2222 130	2269 990
bitso_high	225 70	2211 900	2214 260	2009 2,7	4E+0 8	2135 000	2201 330	2214 260	2222 245	2269 990
bitso_low	225 70	2211 347	2213 860	2009 1,9	4E+0 8	2134 000	2200 500	2213 860	2221 948	2268 000
bitso_close	225 70	2211 631	2214 055	2010 1	4E+0 8	2134 170	2200 933	2214 055	2222 120	2269 980
bitso_volume	225 70	 2,931	0,004 2	5,209 62	27,14 01	 6E-07	0,000 4	0,004 2	5,103 69	28,75 61
bitso_ask	225 70	2212 234	2214 790	2009 1,5	4E+0 8	2135 010	2201 800	2214 790	2222 765	2269 990
bitso_bid	225 70	2210 678	2213 100	2006 5,4	4E+0 8	2134 010	2200 010	2213 100	2221 210	2268 770
bitso_ask_volume	225 70	3,140 09	3,077 65	0,818 41	0,669 8	0,059 69	2,680 07	3,077 65	3,623 92	6,953 68
bitso_bid_volume	225 70	1,745 99	1,704 54	0,768 9	0,591 2	0,011 07	1,209 95	1,704 54	2,213 25	7,083 74
bitso_volume_24h	225 70	10,69 78	9,300 56	5,403 33	29,19 6	2,643 71	6,503 02	9,300 56	14,37 62	28,77 61
bitso_spread_pct	225 70	0,070 35	0,078 94	0,037 72	0,001 42	0,000 44	0,054 36	0,078 94	0,088 96	0,578 98
coinsph_open	225 70	6751 615	6754 485	5386 3,8	2,9E +09	6550 051	6729 123	6754 485	6783 827	6896 892
coinsph_high	225 70	6753 903	6756 133	5386 5,8	2,9E +09	6550 051	6731 172	6756 133	6786 657	6897 422
coinsph_low	225 70	6749 402	6752 746	5383 2	2,9E +09	6550 051	6726 746	6752 746	6781 603	6896 201
coinsph_close	225 70	6751 638	6754 506	5381 7,7	2,9E +09	6550 051	6729 001	6754 506	6784 230	6897 422
coinsph_volume	225 70	0,374 12	0,000 32	1,172 62	1,375 05	7,4E- 06	0,000 16	0,000 32	 0,003	7,710 89
coinsph_ask	225 70	6756 745	6759 252	5401 4,3	2,9E +09	6551 384	6734 279	6759 252	6789 527	6897 421
coinsph_bid	225 70	6746 417	6750 001	5386 7,1	2,9E +09	6550 051	6723 167	6750 001	6779 071	6892 889

coinsph_ask_volume	22570	0,79021	0,83187	0,37462	0,14034	0,00022	0,51115	0,83187	1,03116	1,79988
coinsph_bid_volume	22570	0,30933	0,27523	0,17947	0,03221	0,00022	0,18383	0,27523	0,39301	1,32806
coinsph_volume_24h	22570	3,86449	3,57714	1,48177	2,19564	1,6021	2,78724	3,57714	4,62431	7,9232
coinsph_spread_pct	22570	0,15297	0,14778	0,08576	0,00736	1,5E-06	0,08464	0,14778	0,21576	0,52629
bithumb_open	22570	1,6E+08	1,6E+08	1135406	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
bithumb_high	22570	1,6E+08	1,6E+08	1131984	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
bithumb_low	22570	1,6E+08	1,6E+08	1138196	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
bithumb_close	22570	1,6E+08	1,6E+08	1135763	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
bithumb_volume	22570	0,67816	0,24807	12,7506	162,578	3,1E-05	0,10165	0,24807	0,53479	907,365
bithumb_ask	22570	1,6E+08	1,6E+08	1134008	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
bithumb_bid	22570	1,6E+08	1,6E+08	1136096	1,3E+12	1,6E+08	1,6E+08	1,6E+08	1,6E+08	1,6E+08
bithumb_ask_volume	22570	1,39939	0,8966	1,46184	2,13697	0,0039	0,43843	0,8966	2,03948	19,3302
bithumb_bid_volume	22570	0,9314	0,63365	1,13753	1,29398	0,0003	0,3726	0,63365	1,13938	30,6418
bithumb_volume_24h	22570	725,005	750,015	285,512	81516,9	239,151	455,235	750,015	996,21	1273,5
bithumb_spread_pct	22570	0,01496	0,00811	0,01692	0,00029	0,00061	0,00126	0,00811	0,02338	0,12244
usd_krw_rate	22570	1384,01	1383,96	7,14209	51,0095	1364,54	1378,86	1383,96	1391,2	1398,53
usd_zar_rate	22570	17,7295	17,7113	0,12213	0,01492	17,5048	17,6242	17,7113	17,8221	18,0214
usd_brl_rate	22570	5,55982	5,56481	0,02287	0,00052	5,51514	5,54916	5,56481	5,57628	5,62895
usd_jpy_rate	22570	147,866	147,781	0,84966	0,72192	145,862	147,217	147,781	148,719	149,525
usd_try_rate	22570	40,4409	40,4508	0,10955	0,012	40,1693	40,3755	40,4508	40,5547	41,2143
usd_mxn_rate	22570	18,6636	18,6807	0,104	0,01082	18,5226	18,5445	18,6807	18,737	18,8817
usd_php_rate	22570	57,0685	57,0637	0,27883	0,07775	56,6008	56,8781	57,0637	57,1457	58,4603
kraken_luno_arbitrage	22570	0,50313	0,76286	1,43203	2,05071	-20,64	0,52796	0,76286	0,94054	2,50649
kraken_upbit_arbitrage	22570	-1,2779	-1,3473	0,64441	0,41526	-4,1302	-1,7749	-1,3473	-0,7262	0,30878
kraken_novadax_arbitrage	22570	0,12934	0,06642	0,32251	0,10401	-0,6317	-0,097	0,06642	0,26525	1,33102
kraken_bitflyer_arbitrage	22570	0,15172	0,09142	0,22581	0,05099	-0,5674	0,02832	0,09142	0,16144	1,22639
kraken_binanceus_arbitrage	22570	-0,2009	-0,1923	0,16433	0,027	-1,6331	-0,287	-0,1923	-0,0999	0,37133
kraken_btcturk_arbitrage	22570	-0,1022	-0,0358	0,21591	0,04662	-1,6635	-0,2417	-0,0358	0,05711	0,48367
kraken_bitso_arbitrage	22570	0,20232	0,13128	0,34681	0,12028	-0,5053	0,03472	0,13128	0,22749	1,80861
kraken_coinsph_arbitrage	22570	0,00611	0,01513	0,30332	0,092	-1,1657	-0,179	0,01513	0,17779	1,02297

kraken_bithumb_arbitrage	22570	-1,2569	-1,3207	0,62869	0,39525	-3,6868	-1,7575	-1,3207	-0,7118	0,27966
kraken_luno_arbitrage_lag_-30	22540	0,50454	0,76165	1,44872	2,09878	-20,56	0,44494	0,76165	1,04098	2,97648
kraken_luno_arbitrage_lag_-45	22525	0,50504	0,75932	1,45878	2,12805	-20,578	0,417	0,75932	1,07793	2,90737
kraken_luno_arbitrage_lag_-60	22510	0,50578	0,76069	1,4689	2,15765	-20,645	0,38361	0,76069	1,11451	3,03531
kraken_upbit_arbitrage_lag_-30	22540	-1,2772	-1,3438	0,67662	0,45781	-4,3262	-1,7658	-1,3438	-0,7341	0,44377
kraken_upbit_arbitrage_lag_-45	22525	-1,2769	-1,3394	0,68986	0,4759	-4,6357	-1,764	-1,3394	-0,7343	0,69049
kraken_upbit_arbitrage_lag_-60	22510	-1,2764	-1,3545	0,7017	0,49239	-4,8076	-1,7558	-1,3545	-0,734	0,71409
kraken_novadax_arbitrage_lag_-30	22540	0,13072	0,0931	0,40032	0,16026	-1,7472	-0,1142	0,0931	0,32713	1,35276
kraken_novadax_arbitrage_lag_-45	22525	0,13131	0,09489	0,43658	0,1906	-2,3713	-0,1226	0,09489	0,34711	1,42766
kraken_novadax_arbitrage_lag_-60	22510	0,132	0,10226	0,46699	0,21808	-2,1271	-0,1374	0,10226	0,36883	1,543
kraken_bitflyer_arbitrage_lag_-30	22540	0,15266	0,12651	0,33143	0,10985	-1,8136	-0,04	0,12651	0,31822	1,65273
kraken_bitflyer_arbitrage_lag_-45	22525	0,15289	0,13499	0,36763	0,13515	-2,0084	-0,0623	0,13499	0,34439	1,71861
kraken_bitflyer_arbitrage_lag_-60	22510	0,15335	0,14616	0,39732	0,15787	-1,7289	-0,0786	0,14616	0,37007	1,76967
kraken_btcturk_arbitrage_lag_-30	22540	-0,1006	-0,0743	0,32064	0,10281	-1,8218	-0,2992	-0,0743	0,10903	1,40295
kraken_btcturk_arbitrage_lag_-45	22525	-0,0999	-0,0751	0,35587	0,12664	-2,0622	-0,3213	-0,0751	0,1327	1,34116
kraken_btcturk_arbitrage_lag_-60	22510	-0,099	-0,0827	0,3855	0,14861	-1,8871	-0,3385	-0,0827	0,15324	1,61002
kraken_bitso_arbitrage_lag_-30	22540	0,20381	0,15436	0,41641	0,1734	-1,3504	-0,0149	0,15436	0,3158	2,05704
kraken_bitso_arbitrage_lag_-45	22525	0,20439	0,16196	0,44642	0,19929	-1,8971	-0,0341	0,16196	0,34738	2,21492
kraken_bitso_arbitrage_lag_-60	22510	0,20521	0,16848	0,47298	0,22371	-1,758	-0,0538	0,16848	0,37641	2,30786
kraken_coinsph_arbitrage_lag_-30	22540	0,01055	0,01375	0,3687	0,13594	-1,7814	-0,2016	0,01375	0,23856	1,32107
kraken_coinsph_arbitrage_lag_-45	22525	0,0128	0,01562	0,3986	0,15888	-2,288	-0,2131	0,01562	0,26655	1,40155
kraken_coinsph_arbitrage_lag_-60	22510	0,01533	0,0167	0,42454	0,18023	-2,1412	-0,2234	0,0167	0,29427	1,44015

kraken_bithumb_arbitrage_lag_-30	22540	-1,2561	-1,3188	0,66136	0,4374	-3,8444	-1,7415	-1,3188	-0,7142	0,46526
kraken_bithumb_arbitrage_lag_-45	22525	-1,2558	-1,3177	0,67531	0,45605	-4,1716	-1,7363	-1,3177	-0,7117	0,66574
kraken_bithumb_arbitrage_lag_-60	22510	-1,2552	-1,3254	0,68785	0,47314	-4,3551	-1,7286	-1,3254	-0,716	0,73937
kraken_binanceus_arbitrage_lag_-30	22540	-0,2001	-0,1879	0,25004	0,06252	-1,8317	-0,3191	-0,1879	-0,06	0,99295
kraken_binanceus_arbitrage_lag_-45	22525	-0,1999	-0,1916	0,29093	0,08464	-2,373	-0,3389	-0,1916	-0,0378	1,08904
kraken_binanceus_arbitrage_lag_-60	22510	-0,1996	-0,1852	0,32516	0,10573	-2,373	-0,3599	-0,1852	-0,0201	1,04703