Order Book Liquidity on Crypto Exchanges

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Introduction

- In recent years, cryptocurrencies have gained in importance in various ways
- An increasing number of investors have come to acknowledge cryptocurrencies as a separate asset class
- This is supported by the rise of altcoins, several of which outperformed Bitcoin in recent years and broadened the investment opportunities within this new asset class.
- These developments have spurred new research on cryptocurrencies
- This is observed by a rapidly growing number of papers on topics in this area

Motivation

- However, most of the literature still focuses on Bitcoin and on data derived from price series, such as returns or volatilities
- Price data are widely available, order book data are harder to come by

➢ **We incorporate altcoins and to derive our results from order book data**

- Liquidity, while of high importance for cryptocurrency investors, has received less attention
- No particular concept or aspect of liquidity is broadly accepted in the literature

➢ We use liquidity measures which are applicable to all trading pairs and allows us to compare results across exchanges and currencies

➢ **Relevance for academia**: liquidity is an important indicator of (and requirement for) market efficiency

➢ **Relevance for investors**: liquidity impacts transaction costs, which in turn impact the investor's profit/loss from trading

Data (1/2) – Raw Data & Data Processing

- Order book data from the exchanges Binance, Kraken, Huobi, and OKEx provided by Cryptotick
- Time frame: Jan. 1, 2019 until Sept. 30, 2019 (273 days)
- 24/7 limit order book data

- We created 5-minute order book snapshots, 288 order book snapshots per day
- Filters to ensure data quality

- Crypto reported as quantity is labeled as **Target Currency**
- Crypto or fiat currency reported as price is labeled as **Base Currency**
- Each combination of a target currency and base currency yields a **Currency Pair** or **Trading Pair**

Data (2/2) – Descriptive Statistics

Exchange	# of Base Currencies	# of Target Currencies	# of Trading Pairs
BINANCE	11	161	514
HUOBI	4	22	57
KRAKEN	7	21	79
OKEX	5	160	436

- Modest number of base currencies
- Strong variation in target currencies and trading pairs

Exchange	Base Type	# of Target Currencies	# of Trading Pairs
BINANCE	cryptocurrency	157	377
BINANCE	stablecoin	57	137
HUOBI	cryptocurrency	20	33
HUOBI	fiat currency	4	4
HUOBI	stablecoin	20	20
KRAKEN	cryptocurrency	20	29
KRAKEN	fiat currency	19	50
OKEX	cryptocurrency	140	276
OKEX	stablecoin	143	160

- Distinguish between three base currency types: fiat currencies, stable coins and other cryptocurrencies
- ➢ The exchanges pursue different objectives in their services

(a) Target Currencies

	1	2	3	4
Frequency	182	54	10	11
Rel. Freq.	70.8%	21.0%	3.9%	4.3%

(b) Trading Pairs

	1	2	3	4
Frequency	714	117	30	12
Rel. Freq.	81.8%	13.4%	3.4%	1.4%

- 71% of the target currencies and 82% of the currency pairs are only traded on one exchanges
- ➢ Necessity to apply liquidity measures which are comparable among all currency pairs to understand the overall crypto market better

Methodology (1/3)

- We choose liquidity measures which can be applied to all trading pairs and make them comparable regardless of their target and base currency
- Many liquidity measures keep the units of either the target or base currency, e.g. trading volume
- We disregard transaction data and solely derive the liquidity measures from the order books
- We generate daily values for the liquidity measures by taking the average of our studied measures for the day
- We compare the results based on the exchanges and the base currency types

Methodology (2/3) – Order Book Slippage (Intraday)

– We measure slippage by the number of order book levels the mid price moves from one such snapshot to the next

$$l_{\text{bid}} = \arg\min_{l} \left(|P_{bid,1,t} - P_{mid,t-1}|, |P_{bid,2,t} - P_{mid,t-1}|, ..., |P_{bid,l,t} - P_{mid,t-1}|, ..., |P_{bid,L,t} - P_{mid,t-1}|\right)$$

$$l_{\text{ask}} = \arg\min_{l} \left(|P_{ask,1,t} - P_{mid,t-1}|, |P_{ask,2,t} - P_{mid,t-1}|, ..., |P_{ask,l,t} - P_{mid,t-1}|, ..., |P_{ask,L,t} - P_{mid,t-1}|\right)$$

$$l = \max(l_{\text{bid}}, l_{\text{ask}})$$

– We measure two variables, the average slippage and the maximum slippage of the day

– This slippage measure accounts for two liquidity-consuming factors, **cancelled orders** and **trades**, but trades are expected to be the main driver

– The big advantage of this measure is that it captures the liquidity dynamics of the order books without putting too much emphasis on the exact numbers

– It allows to evaluate if an order book can supply sufficient liquidity for the demand of traders

Methodology (3/3) – Order Book Spread and Imbalance

Spread Measures

– Gomber et al. (2015) interpret the relative spread as a liquidity premium which has to be paid to execute an order immediately

– Cao et al. (2009) provides evidence that levels deeper in the order book are less prone to noise and carry more relevant information about the liquidity of limit order books.

$$\text{Relative Spread} = \frac{P_{\text{best ask}} - P_{\text{best bid}}}{P_{\text{mid}}}$$

$$\text{Relative Spread}_L^{\text{VWAP}} = \frac{P_{\text{ask},L}^{\text{VWAP}} - P_{\text{bid},L}^{\text{VWAP}}}{P_{\text{mid}}}$$

$$P_L^{\text{VWAP}} = \frac{\sum_{l=1}^{L} P_l * Q_l}{\sum_{l=1}^{L} Q_l}$$

Imbalance Measures

– Biais et al. (1995) find evidence that a higher order imbalance is linked to higher trading costs.

– Bonart and Gould (2017) argue that order book imbalance is a strong predictor of order flow

$$\text{NOBI}_L = \frac{\sum_{l=1}^{L} (P_{\text{ask},l} * Q_{\text{ask},l} - P_{\text{bid},l} * Q_{\text{bid},l})}{\sum_{l=1}^{L} (P_{\text{ask},l} * Q_{\text{ask},l} + P_{\text{bid},l} * Q_{\text{bid},l})}$$

$$\text{ANOBI}_L = |NOBI_L|$$

Results (1/3): Slippage, Spreads & Imbalance

Exchange	Base Type	Mean Slippage	Max Slippage	L5 Rel. Spread	L10 ANOBI
BINANCE	cryptocurrency	1.97	12.5	1.53	0.249
		(0.011)	(0.079)	(0.012)	(0.0014)
BINANCE	stablecoin	3.24	15.5	1.14	0.143
		(0.034)	(0.203)	(0.031)	(0.0019)
HUOBI	cryptocurrency	2.95	19.3	1.17	0.185
		(0.055)	(0.358)	(0.019)	(0.0030)
HUOBI	fiat currency	2.71	15.7	0.283	0.142
		(0.055)	(0.409)	(0.010)	(0.0067)
HUOBI	stablecoin	6.86	39.4	0.459	0.0882
		(0.148)	(0.724)	(0.010)	(0.0019)
KRAKEN	cryptocurrency	1.63	10.5	1.19	0.171
		(0.016)	(0.136)	(0.024)	(0.0030)
KRAKEN	fiat currency	2.32	14.3	2.05	0.175
		(0.023)	(0.180)	(0.057)	(0.0024)
OKEX	cryptocurrency	1.48	8.04	4.76	0.346
		(0.023)	(0.185)	(0.094)	(0.0036)
OKEX	stablecoin	2.02	13.0	3.12	0.241
		(0.065)	(0.451)	(0.105)	(0.0041)

- Contradicting results for liquidity measures (slippage vs spread & imbalance)
- Indication that slippage is endogenous

Results (2/3): Regressions for Slippage I

	Dependent variable:			
	log(Max Slippage)			
	Pooled OLS	*Fixed Effects*		
		Pair	*Time*	*Pair & Time*
	(1)	(2)	(3)	(4)
log(L5 VWAP Spread)	-0.566***	-0.452***	-0.592***	-0.535***
	(0.005)	(0.007)	(0.004)	(0.007)
log(L10 ANOBI)	-0.035***	-0.069***	-0.050***	-0.061***
	(0.009)	(0.010)	(0.008)	(0.009)
log(L5 VWAP Spread):log(L10 ANOBI)	0.002	-0.009***	-0.003**	-0.009***
	(0.002)	(0.002)	(0.002)	(0.002)
Constant	-0.422***			
	(0.020)			
Individual and/or Time Effects		YES***	YES***	YES***
Note:				*p<0.1; **p<0.05; ***p<0.01

- Pooled OLS and 3 Fixed Effect models
- Also include interaction term to account for collinearity of spread and imbalance
- Significant trading pair individual and time fixed effects
- Economically, stronger effect of spread than of imbalance

➢ Strong evidence that slippage can be explained by spread and imbalance

➢ Large trades are timed for high liquidity phases

- Similar results for other combinations of spread and imbalance levels

Results (3/3): Regressions for Slippage II

	Dependent variable:	
	log(Max Slippage)	
	(1)	(2)
log(L5 VWAP Spread)	-0.537***	-0.487***
	(0.010)	(0.013)
log(L10 ANOBI)	-0.060***	-0.048***
	(0.012)	(0.014)
log(L5 VWAP Spread):log(L10 ANOBI)	-0.009***	-0.006**
	(0.003)	(0.003)
Note:	*p<0.1; **p<0.05; ***p<0.01	

- Panel (1): negative imbalance
- Panel (2): positive imbalance

- Stronger effects of spreads and imbalances for negative imbalanced order books
- higher depth on the bid side contributes more strongly to lower slippage than the other way around

- This could explain price drawdowns and panic selling behavior of traders if they observe a decline in selling opportunities (lower bid volume) or an increase in offers to sell (higher ask volume)

➢ Traders are accepting higher spreads to sell their currencies than they are to buy new ones

Concluding Remarks

- Using **standardized liquidity measures** is necessary to capture the special features of crypto markets.
- **Contradicting results for liquidity** (slippage vs spread & imbalance) indicates that slippage is endogenous
- Slippage can be explained by spread and imbalance, **large orders causing slippage are timed** in phases with high liquidity in terms of small spreads and balanced order books
- Traders are **accepting higher spreads to sell their currencies** than they are to buy new ones

Thank you for your attention.

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