24 HOURS OF BITCOIN

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September 20, 2018

ABSTRACT

This study examines the intraday patterns of the bitcoin market using BitMEX trading and quote data from April 2017 to July 2018. The largest magnitude of order imbalance measures is observed at 11:00 Korea Standard Time (KST) and at 13:00 KST, respectively. The correlations between returns and order imbalance measures are significant and positive at all times. The return and volatility of bitcoin price tend to increase from 10:00 KST to 16:00 KST while decreasing from 00:00 KST to 06:00 KST. Total number and dollar volume of transactions move similarly. Market returns show strong rising tendency during the lunch time in Korea between 11:00 and 13:00. Especially return and other trading activities surge during 11:00-13:00, the Korean lunch time. In sum, global bitcoin trading activities are largely in sync with the Korean stock market.

KEYWORDS: bitcoin, cryptocurrency, order book, order imbalance, market microstructure

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This research is supported by Entropy Trading Group Co., Ltd. We thank Hanjin Park, Juyeong Lee, and Kyungjun Shin for providing superb research assistance.

INTRODUCTION

Trading rules between bitcoin market and stock market are different. For example, bitcoin exchanges, in general, are continuously open 24 hours a day and 7 days a week while stock exchanges have designated trading hours. Then, will these distinctions render their intraday patterns different? We answer this question firstly in the literature.

First, with all variables measured at one minute interval, we quantitatively describe bitcoin market order imbalances with 3 different measures, and then compare those measures with traditional market liquidity measures, e.g., number of transactions and dollar volume. Next, we investigate the correlations between order imbalances and bitcoin returns. We track and show those relationships by 24 hours. The main contribution of this paper is to study the intraday patterns of order imbalances and bitcoin returns with high frequency data.

We organize this paper as follows. First, we explain the data and the variables. Second, we show descriptive statistics of the data including the 24 hourly subdivided samples. Third, we present changes of return and volatility of bitcoin during the day. The final section concludes.

DATA AND VARIABLES

Table 1: Variable Definitions

We measure all variables per minute with sample period from April 25th, 2017 to July 12th, 2018. We use OIBNUM, OIBBIT, and OIBDOL to measure order imbalance in bitcoin transactions. QSPR is average quoted spread. NUMTRANS and TVOL are total number of transactions and total dollar volume. Price is the closing price of bitcoin at each minute in dollar. Return is log return of bitcoin price over a one minute interval.

Concepts	Definitions
OIBNUM	Number of buyer-initiated trades less the number of seller-initiated trades
OIBBIT	Buyer-initiated bitcoins purchased less the seller-initiated bitcoins sold
OIBDOL	Buyer-initiated dollars paid less the seller-initiated dollars received
QSPR	Quoted bid-ask spread averaged across all trades
NUMTRANS	Total number of transactions
TVOL	Total dollar volume
PRICE	Close price of bitcoin at each minute
RETURN	Log return of bitcoin price over a minute

This paper uses trade and quote data of bitcoin/US Dollar perpetual swap contract[6] traded in BitMEX, a leading exchange for bitcoin futures and swaps. BitMEX is the largest exchanges in the bitcoin market, as of July 2018 according to CoinMarketCap.

Table 1 presents the definitions of the variables used in this study. We analyze the following variables measured at one minute interval. OIBNUM is the number of buyer-initiated trades less the number of seller-initiated trades. OIBBIT is the buyer-initiated bitcoins purchased less the seller-initiated bitcoins sold. OIBDOL is the buyer-initiated dollars paid less the seller-initiated dollars received. OIBNUM, OIBBIT, and OIBDOL are all related to trading intensity possibly associated with private information. Positive and negative numbers signify buying and selling pressures respectively. QSPR is the quoted bid-ask spread averaged over all trades within the same minute. NUMTRANS is the total number of transactions and TVOL is the total trade volume in dollars. QSPR, NUMTRANS, and TVOL are all related to the trading activity or liquidity. It is well known that order imbalances are negatively correlated with asset liquidity in traditional stock markets. PRICE is the closing price of bitcoin at each minute, and RETURN is the log return of bitcoin over a one minute interval. These variables are frequently analyzed in high frequency market microstructure literature for

[6] The swap contract symbol is XBTUSD. Each contract represents the dollar value of one bitcoin. This contract does not have an expiration date, and provides a way for investors to speculate or hedge on the future value of bitcoin.

traditional financial markets. This paper attempts to analyze the microstructural characteristics of the bitcoin market, using the same measures.

Our data offers information on whether a trade is buyer-initiated or seller-initiated. Hence, we do not need to rely on trade direction detecting algorithms, e.g., Lee and Ready (1991), but use the exact trade direction when determining order imbalance measures. Therefore, our measures are less susceptible to measurement errors, compared to those calculated without trade direction using standard US equity trade data. e.g., NYSE TAQ.

One of the unique features of the bitcoin market itself, is that it is always open unlike traditional stock markets. This means that all investors around the world can continue to trade bitcoin 24 hours a day and 7 days a week . These unique features of the bitcoin market can lead to different market microstructural characteristics from those of stock markets. Since time-related factors are crucial in determining the bitcoin price, we divide the data into 24 different hours and conduct an hourly analysis to examine the market behaviors in each hour of the day.

DESCRIPTIVE STATISTICS

Table 2: Descriptive Statistics

Descriptive statistics are given for each variables given in Table 1. All measures are calculated per minute using BitMEX trade and quote data of 634,563 observations in total, with 1440 minutes per day over 444 days from April 25th, 2017 to July 12th, 2018. DQSPR and DOIBNUM (Panel C) refer to changes of QSPR and OIBNUM over a minute

Panel A: Summary statistics (N = 634,563)

	Mean	St. Dev.	Min	Median	Max
OIBNUM	-0.21	164.73	-6,967.00	0.00	6,919.00
OIBBIT	-7,188	1,181,097	-56,141,095	0.0	57,299,540
OIBDOL	-59,110,749	10,403,288,754	-468,000,000,000	0.0	382,000,000,000
QSPR	2.61	5.21	-182.30	1.33	1,393.97
NUMTRANS	193.72	229.34	0.00	126.00	7,661.00
TVOL (dollars)	8,192,722,298	15,183,335,259	0.0	2,635,366,468	51,000,000,0000
Bitcoin price ($)	6,880.28	3,931.78	1,263.20	6,667.50	20,090.50
Bitcoin returns	0.00	0.00	-0.07	0.00	0.08

Panel B: Correlation

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.892						

	(1576.83)						
OIBDOL	0.839	0.966					
	(1229.57)	(2993.25)					
QSPR	-0.004	-0.014	-0.018				
	(-3.08)	(-11.41)	(-14.39)				
NUMTRANS	-0.062	-0.074	-0.071	0.153			
	(-50.93)	(-60.70)	(-57.59)	(123.69)			
TVOL	-0.063	-0.090	-0.093	0.188	0.859		
	(-51.96)	(-72.99)	(-75.83)	(152.42)	(1340.57)		
Bitcoin Price	0.001	-0.002	-0.002	-0.036	0.338	0.405	
	(0.79)	(-1.26)	(-1.54)	(-29.08)	(285.66)	(352.12)	
Bitcoin Returns	0.560	0.499	0.525	0.008	-0.017	-0.019	0.0005
	(539.08)	(458.27)	(491.24)	(6.36)	(-13.67)	(-14.85)	(0.36)

Panel C: Autocorrelation

Lag minutes	OIBNUM	OIBBIT	OIBDOL	Returns	DQSPR	DOIBNUM
1	0.218	0.260	0.255	0.029	-0.325	-0.390
2	0.047	0.061	0.056	-0.025	-0.097	-0.093
3	0.021	0.020	0.015	-0.026	-0.036	-0.010
4	0.010	0.011	0.010	-0.014	-0.013	-0.007
5	0.011	0.010	0.011	-0.009	-0.007	0.002

Table 2 presents descriptive statistics for bitcoin order imbalance and other measures regarding liquidity and trading activity. In Panel A, all three order imbalance measures are observed to have zero median values. The mean of OIBNUM is negative at -0.21, with means of OIBBIT and OIBDOL also being negative at -7188 and -59110749, respectively. The mean quoted spread is 2.61 dollars, and the mean number of transactions is 193.72. The standard deviation of bitcoin price is 3931.78 dollars.

Panel B reports correlations among the variables used in this study , e.g., order imbalance measures, quoted spread, total number of transactions, dollar volume, price of bitcoin, and minute-by-minute bitcoin return. In our sample, all three measures of order imbalance are observed to be strongly and positively correlated with bitcoin returns. However, traditional trading activity indicators (e.g., total number of transactions and dollar volume) and bitcoin returns are observed to be weakly correlated with magnitudes of correlations being much lower than those between order imbalance measures and bitcoin returns. Hence, order imbalance appears to have stronger association with bitcoin returns than traditional trading activity indicators do.

Panel C reports autocorrelations. In our sample, order imbalances exhibit statistically significant and positive autocorrelation at one-minute lag, but such autocorrelation decays rapidly with longer lags. However, the bitcoin returns have no statistically significant autocorrelation. DQSPR, defined as the change in the quoted spread, shows negative autocorrelation up to one-minute lag. Likewise, DOIBNUM, defined as the change in OIBNUM, presents negative autocorrelation up to one-minute lag.

Figure 1: Hourly averages of order imbalance measures
Next figures show the the hourly averages of order imbalance measures in KST.

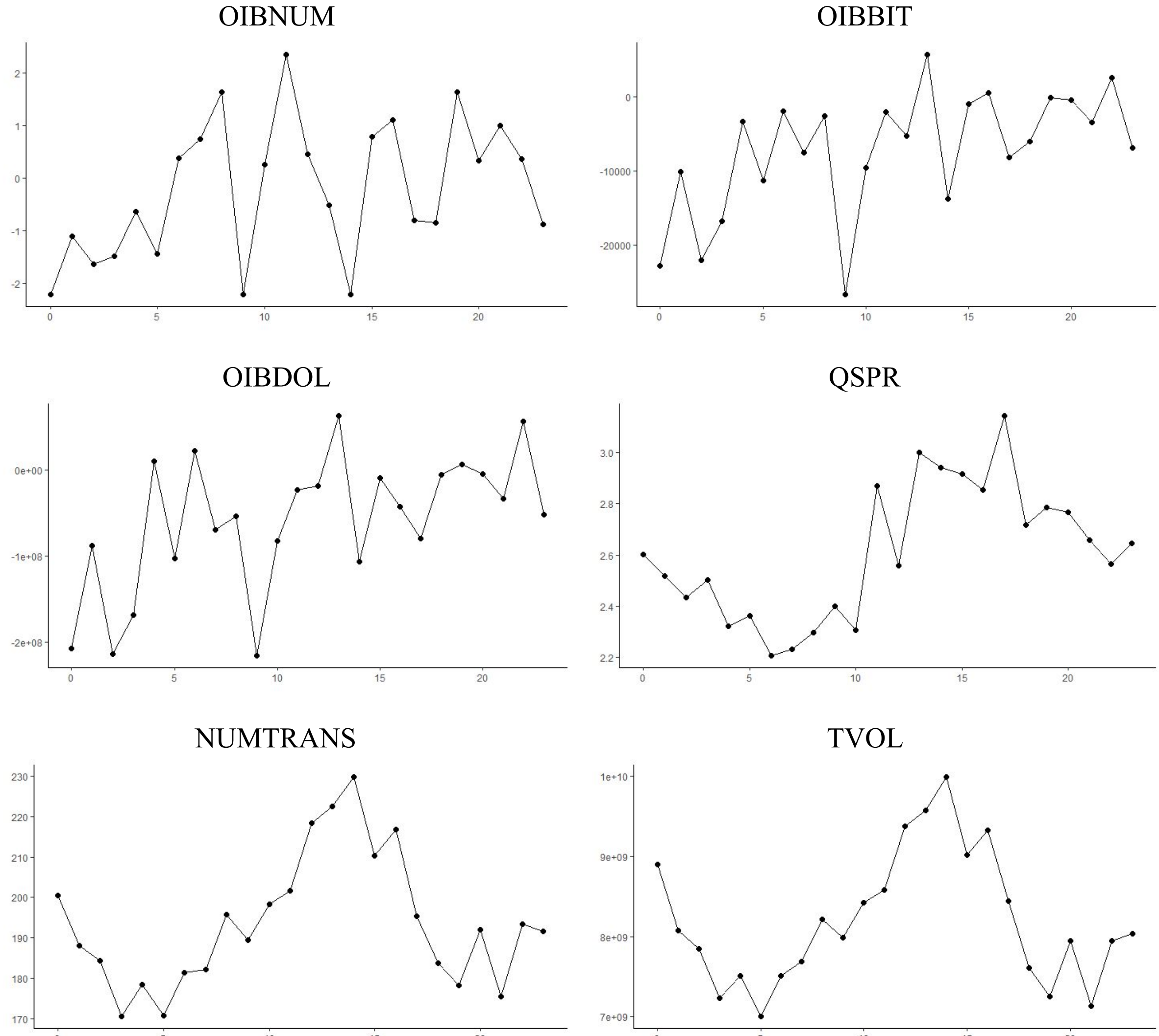

Figure 1 shows the mean value of order imbalance, liquidity, and trading activity measures, aggregated by each hour. The mean order imbalance is positive at 06:00-09:00, 10:00-13:00, 15:00-17:00 and 19:00-23:00, where the hours are based on Korea Standard Time (KST). Total number of transactions (NUMTRANS) and total dollar volume (TVOL) at 11:00-17:00 are much larger than those of any other periods.

During Korea trading hours (09:00-15:00), all measures of order imbalance, quoted spread, total number of transactions, and dollar volume are generally higher than those of trading hours of other regions. Order imbalance measures start to rapidly decrease at 9:00-10:00 and then sharply rise during 10:00-11:00. Total number of transactions and dollar volume also slightly decrease at 9:00-10:00, but afterwards, they continue to grow until around 15:00. However, QSPR slightly increases at 9:00-10:00, and continues to increase during the next time period, 10:00-11:00.

OIBNUM peaks between 11:00 and 12:00 with the mean value of 2.35, and bottoms between 14:00 and 15:00 with the mean value of -2.21. OIBBIT and OIBDOL peak between 13:00 and 14:00 with the mean values of 5712 and 62773749, respectively. OIBBIT and OIBDOL bottom during 09:00-10:00, reaching -26665 and -215903095, respectively. For traditional trading activity indicators, dollar volume peaks between 14:00 and 15:00 at 9990594213 and reaches the bottom between 05:00 and 06:00 with the mean value of 7000897290. Total number of transactions is observed to be the highest at 229.82 between 14:00 and 15:00 and the smallest at 170.47 between 03:00 and 04:00. QSPR follows a similar pattern, reaching the peak between 17:00 and 18:00 and hitting the bottom at 06:00-07:00. Detailed values are available in the appendix table 2.

Table 3: Correlations between bitcoin returns and order imbalance measures

This table shows the correlations between bitcoin minute returns and order imbalance measures (column names) for each hour in KST.

Hour: GMT+9	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
00	0.580	0.516	0.540	0.014	-0.037	-0.049	-0.006
	(115.66)	(97.83)	(104.28)	(2.23)	(-5.96)	(-8.03)	(-0.95)
01	0.589	0.527	0.559	-0.001	-0.028	-0.020	-0.004
	(118.46)	(100.6)	(109.58)	(-0.13)	(-4.53)	(-3.31)	(-0.63)
02	0.584	0.527	0.555	-0.071	-0.047	-0.061	-0.010
	(116.79)	(100.6)	(108.3)	(-11.64)	(-7.58)	(-9.99)	(-1.68)
03	0.576	0.518	0.540	0.027	-0.029	-0.028	-0.007
	(114.5)	(98.38)	(104.32)	(4.35)	(-4.65)	(-4.49)	(-1.11)
04	0.582	0.528	0.563	0.035	-0.003	0.024	0.014
	(116.4)	(101.21)	(110.68)	(5.76)	(-0.48)	(3.84)	(2.25)
05	0.549	0.496	0.523	0.006	-0.035	-0.042	-0.010
	(106.76)	(93.02)	(99.7)	(0.97)	(-5.66)	(-6.86)	(-1.7)
06	0.531	0.458	0.486	0.019	-0.009	0.010	0.014
	(101.9)	(83.73)	(90.47)	(3.02)	(-1.41)	(1.55)	(2.25)
07	0.557	0.490	0.518	0.040	-0.010	-0.007	0.000
	(109.07)	(91.49)	(98.37)	(6.49)	(-1.67)	(-1.07)	(0.01)
08	0.559	0.481	0.503	-0.023	-0.016	-0.028	-0.012
	(109.55)	(89.35)	(94.68)	(-3.78)	(-2.65)	(-4.56)	(-1.89)
09	0.560	0.496	0.528	-0.006	-0.055	-0.052	-0.009

	(110.06)	(93.06)	(101.18)	(-0.94)	(-8.96)	(-8.51)	(-1.52)
10	0.571	0.488	0.503	-0.043	-0.024	-0.021	0.001
	(113.07)	(90.95)	(94.7)	(-7.08)	(-3.97)	(-3.45)	(0.21)
11	0.567	0.507	0.532	-0.019	0.010	0.010	0.005
	(112.08)	(95.58)	(102.26)	(-3.07)	(1.55)	(1.58)	(0.74)
12	0.560	0.479	0.490	0.030	-0.007	-0.006	0.005
	(109.84)	(88.68)	(91.51)	(4.96)	(-1.06)	(-0.92)	(0.87)
13	0.559	0.497	0.521	0.006	0.018	0.026	0.004
	(109.67)	(93.22)	(99.14)	(1.05)	(2.87)	(4.27)	(0.69)
14	0.524	0.468	0.493	0.019	-0.031	-0.024	0.000
	(99.92)	(85.95)	(92.13)	(3.13)	(-5.03)	(-3.9)	(0.07)
15	0.565	0.503	0.537	0.027	-0.024	-0.024	-0.003
	(111.36)	(94.67)	(103.64)	(4.41)	(-3.88)	(-3.86)	(-0.49)
16	0.581	0.522	0.553	-0.019	0.018	-0.014	-0.001
	(116.3)	(99.57)	(108.1)	(-3.09)	(2.88)	(-2.28)	(-0.23)
17	0.548	0.493	0.523	0.062	-0.041	-0.051	-0.007
	(106.61)	(92.19)	(100.04)	(10.08)	(-6.71)	(-8.31)	(-1.13)
18	0.572	0.498	0.522	0.022	-0.017	-0.010	0.012
	(113.59)	(93.41)	(99.65)	(3.58)	(-2.81)	(-1.68)	(1.87)
19	0.546	0.511	0.527	-0.039	-0.032	-0.046	0.009
	(105.84)	(96.58)	(100.94)	(-6.36)	(-5.24)	(-7.51)	(1.38)
20	0.573	0.513	0.521	0.025	-0.010	-0.007	0.006
	(113.78)	(97.1)	(99.2)	(4.12)	(-1.67)	(-1.18)	(1.02)
21	0.591	0.529	0.544	-0.011	-0.015	-0.020	0.000
	(118.72)	(100.98)	(105.05)	(-1.82)	(-2.47)	(-3.28)	(-0.01)
22	0.564	0.517	0.541	0.015	0.005	0.017	0.007
	(110.8)	(98.15)	(104.51)	(2.39)	(0.78)	(2.68)	(1.18)
23	0.534	0.474	0.517	0.011	-0.014	-0.024	0.003
	(102.75)	(87.41)	(98.11)	(1.71)	(-2.24)	(-3.83)	(0.45)

Table 3 reports concurrent correlations between bitcoin returns and other variables, e.g., bitcoin order imbalance and other measures of liquidity, and trading activity by trading hour. In all trading hours, bitcoin returns and all three bitcoin order imbalance measures are strongly and positively correlated. From 21:00 to 22:00, the correlation between returns and OIBNUM is 0.591, and the correlation between returns and OIBBIT is 0.529. Both correlations account for the highest value in all time periods. However, the correlation between returns and OIBNUM is the lowest of the day with 0.524 between 14:00 and 15:00, and the correlation between returns and OIBBIT is the lowest of the day with 0.458 between 06:00 and 07:00. From 04:00 and 05:00, the correlation between bitcoin returns and OIBDOL is 0.563, the highest value among all periods, and the correlation between returns and OIBDOL from 06:00 and 07:00 is 0.486, the lowest value during the day. In particular, for all time periods, correlation between bitcoin returns and OIBNUM is stronger than the correlation between returns and any other order imbalance measures. Regardless of the order imbalance directions, we observe that both number of transactions (NUMTRANS) and dollar volume (TVOL) have small correlations with bitcoin returns. The absolute correlation value between bitcoin returns and NUMTRANS is the lowest between 09:00 and 10:00, with the correlation coefficient of -0.055. Likewise, the absolute correlation value between returns and

TVOL was the lowest between 02:00 and 03:00, with the correlation coefficient of -0.061. This suggests that order imbalance is much more significant than traditional trading activity indicators, e.g., total number of transactions and dollar volume, in explaining bitcoin returns.

Figure 2 : Hourly distribution of Bitcoin returns
X-axis represents the time from 00:00 to 23:59 in minutes. Y-axis represents cumulative bitcoin returns. The graph shows the cumulative average (green solid line) and median (blue dotted line) returns in each minute. Vertical dashed lines indicate the opening and closing time of the US and Korea stock markets. Korea stock market is open from 09:00 to 15:30 KST, and the USA stock market is open from 23:30 to 06:00 KST. Summertime is not considered.

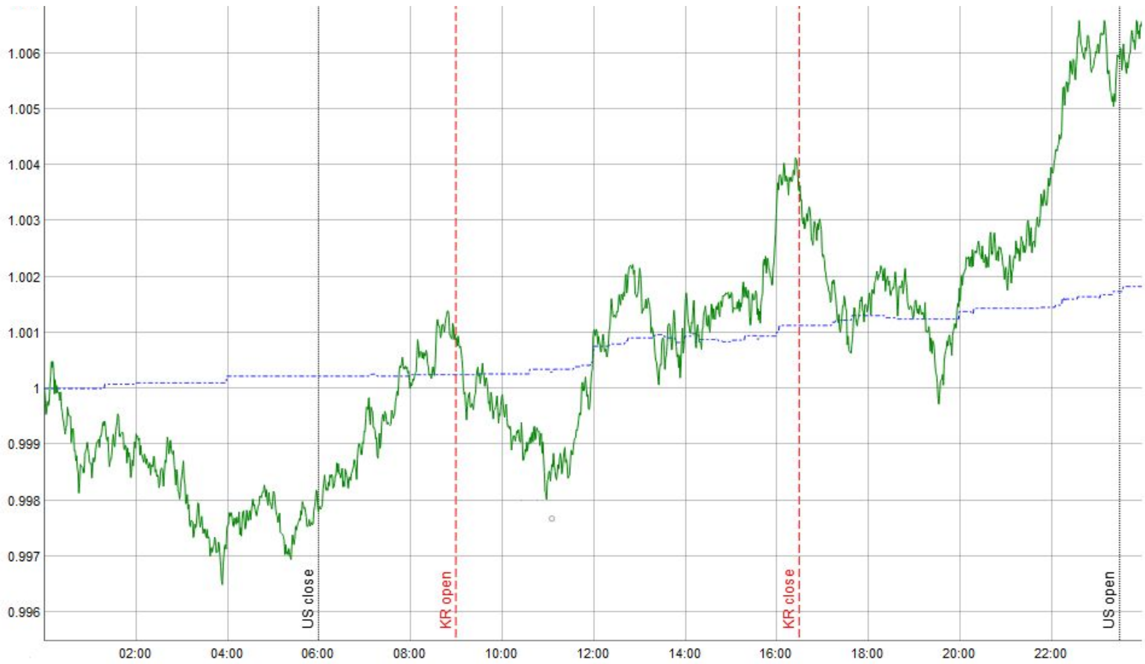

Figure 2 shows the cumulative returns by calculating the mean and median returns over the whole trading day, and aggregating the return s for each minute during the day. We observe that median returns, represented in dotted line, show little change. This indicates that medians of most one-minute returns are zero, during the entire trading period . However, we observe a large and sudden increase at approximately 12:00 in KST. This tendency is also strongly visible in mean returns, represented in solid line. We observe that the cumulative mean return also surges at around 12:00. This observation is very interesting, as both medians and means of returns increased sharply during the lunch time in Korea around 11:00-13:00. While cumulative returns of bitcoin decline when the US stock market is open, cumulative returns, in contrast, increase when the Korean stock market is open.

Figure 3 : Hourly Standard Deviation of Bitcoin

X-axis represents the time from 00:00 to 23:59 in minutes. Y-axis represents rolling standard deviations of bitcoin returns. The graph shows the average of standard deviations (green solid line) and median of standard deviations (blue dotted line) in each minute. Dashed vertical lines indicate the opening and closing time of the Korea stock market and grey vertical lines indicate the opening and closing time of the US stock market. Korea stock market is open from 09:00 to 16:00 KST, and the USA stock market is open from 23:30 to 06:00 KST. Summertime is not considered.

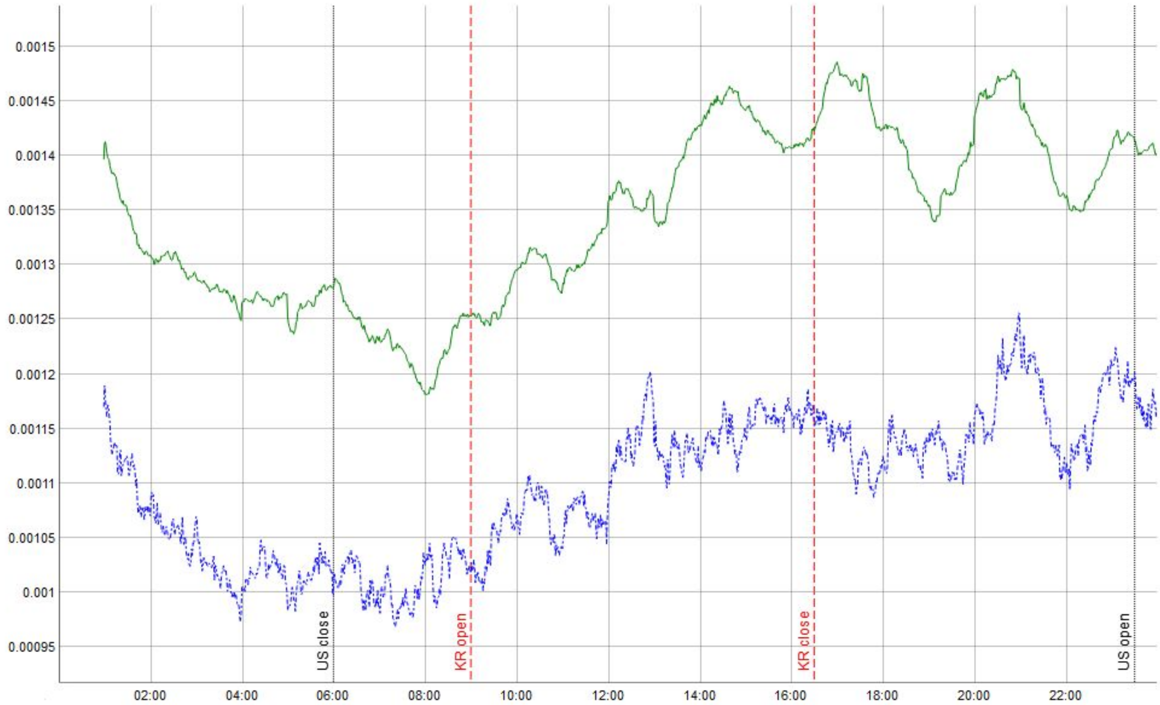

Figure 3 presents the mean and median standard deviations of bitcoin returns at each minute. Each standard deviation is computed using past 60 minutes return. The standard deviation plot shows how the price volatility of the bitcoin changes throughout the day. The median of the standard deviation, in dotted line, steadily declines from 1:00 to 4:00 in KST but gradually increases as Korean stock market opens. In particular, we observe that the standard deviation significantly increases at around 12:00. The mean standard deviation in solid line presents a similar surging pattern at around 12:00, although its magnitude is smaller compared to that of the median value. In addition, the median and the mean, or the dotted line and the solid line, tend to act differently in different time periods. At around Korea stock market opening time, the mean of standard deviation shows more fluctuating patterns than the median of standard deviation. In contrast, both the median and the mean display similar patterns when the Korea stock market is closed. We can also observe that, during the lunch time in Korea, 11:00-13:00, the returns and volatilities of bitcoin show strong rising tendencies, and this pattern can also be observed in the hourly pattern analysis in the Appendix.

CONCLUSION

The intraday patterns, trading activity and liquidity of bitcoin market have been explored. Our analysis has several findings. First, the dollar volume and number of order imbalances are largest during Korean stock market trading time. Second, order imbalance measures are always positively and strongly correlated with bitcoin returns. Third, the return and the volatility of bitcoin tend to increase during Korea stock market trading time. In particular, such patterns are shown more prominent during the lunch time in Korea, 11:00–13:00. For future research, we propose the following. What influences the market microstructure characteristics in bitcoin market.

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APPENDIX

This appendix shows the descriptive statistics for the variables listed in Table 1 by hours (00:00 - 23:00). The hours are based on KST.

Appendix Table 1: Descriptive statistics

Time zone (00 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26394	-2.21	168.48	-4237.00	0.00	4177.00
OIBBIT	26394	-22772.09	1276326.00	-42045039.00	0.00	31855099.00
OIBDOL	26394	-207185668.00	11856396942.00	-398000000000.00	0.00	284000000000.00
QSPR	26394	2.60	6.50	0.60	1.34	764.55
NUMTRANS	26394	200.44	237.72	0.00	129.00	4419.00
TVOL (dollars)	26394	8900939298.00	17427751682.00	0.00	2789322949.00	467000000000.00
Bitcoin close price	26394	6902.43	3949.03	1277.60	6716.00	19571.50
Bitcoin minute returns	26389	0.00	0.00	-0.03	0.00	0.05

Time zone (01 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26385	-1.11	156.38	-4793.00	0.00	4348.00
OIBBIT	26385	-10075.40	1109712.00	-41077962.00	0.00	21561871.00
OIBDOL	26385	-88100197.00	9913584495.00	-343000000000.00	0.00	143000000000.00
QSPR	26385	2.52	3.41	-1.65	1.33	88.48
NUMTRANS	26385	188.12	218.10	0.00	124.00	5107.00
TVOL (dollars)	26385	8072577916.00	14616050807.00	0.00	2641058594.00	389000000000.00
Bitcoin close price	26385	6893.92	3940.16	1277.80	6705.50	19493.00
Bitcoin minute returns	26385	0.00	0.00	-0.02	0.00	0.02

Time zone (02 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26384	-1.63	151.37	-4267.00	0.00	3927.00
OIBBIT	26384	-21974.21	1079207.00	-36508858.00	0.00	28661379.00
OIBDOL	26384	-213582637.00	10063174506.00	-271000000000.00	0.00	183000000000.00
QSPR	26384	2.43	4.81	0.75	1.29	517.15
NUMTRANS	26384	184.31	215.21	0.00	119.00	4707.00
TVOL (dollars)	26384	7849769971.00	14753992851.00	0.00	2496366812.00	311000000000.00
Bitcoin close price	26384	6894.56	3935.10	1276.60	6691.50	19509.50
Bitcoin minute returns	26383	0.00	0.00	-0.02	0.00	0.02

Time zone (03 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26372	-1.48	134.96	-3321.00	0.00	3391.00
OIBBIT	26372	-16802.06	950321.20	-25546460.00	0.00	26848273.00
OIBDOL	26372	-168897870.00	9229882278.00	-218000000000.00	0.00	226000000000.00
QSPR	26372	2.50	4.12	0.97	1.28	145.54
NUMTRANS	26372	170.47	189.69	0.00	112.00	3627.00
TVOL (dollars)	26372	7228991645.00	13281286135.00	0.00	2348063232.00	234000000000.00
Bitcoin close price	26372	6891.18	3916.69	1275.30	6702.50	19455.00
Bitcoin minute returns	26370	0.00	0.00	-0.02	0.00	0.03

Time zone (04 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26458	-0.64	144.33	-3477.00	0.00	4125.00
OIBBIT	26458	-3341.70	1018001.00	-35197444.00	0.00	32560293.00
OIBDOL	26458	10205425.00	9408216120.00	-327000000000.00	0.00	270000000000.00
QSPR	26458	2.32	3.06	1.00	1.25	64.95
NUMTRANS	26458	178.37	211.09	0.00	114.00	4389.00
TVOL (dollars)	26458	7512948335.00	13788374770.00	0.00	2348769784.00	348000000000.00
Bitcoin close price	26458	6878.82	3931.20	1280.90	6666.75	19362.00
Bitcoin minute returns	26457	0.00	0.00	-0.02	0.00	0.03

Time zone (05 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26460	-1.45	143.45	-4729.00	0.00	3570.00
OIBBIT	26460	-11290.30	993506.10	-38011640.00	0.00	25542645.00

OIBDOL	26460	-102479349.00	8766886284.00	-290000000000.00	0.00	154000000000.00
QSPR	26460	2.36	3.72	0.97	1.26	146.02
NUMTRANS	26460	170.63	203.17	0.00	111.00	4985.00
TVOL (dollars)	26460	7000897290.00	12823328413.00	0.00	2289621422.00	331000000000.00
Bitcoin close price	26460	6876.30	3928.27	1282.50	6690.00	19607.00
Bitcoin minute returns	26460	0.00	0.00	-0.03	0.00	0.04

Time zone (06 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26460	0.38	170.60	-6967.00	0.00	5140.00
OIBBIT	26460	-1945.44	1219711.00	-52335643.00	0.00	48212221.00
OIBDOL	26460	21863915.00	10203319721.00	-326000000000.00	0.00	369000000000.00
QSPR	26460	2.21	2.68	1.00	1.26	61.07
NUMTRANS	26460	181.38	238.78	0.00	112.00	7661.00
TVOL (dollars)	26460	7513732503.00	15138679965.00	0.00	2297346245.00	489000000000.00
Bitcoin close price	26460	6881.34	3937.79	1285.10	6658.50	19640.00
Bitcoin minute returns	26460	0.00	0.00	-0.02	0.00	0.02

Time zone (07 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26452	0.74	160.27	-5819.00	0.00	3429.00
OIBBIT	26452	-7508.53	1156179.00	-39307531.00	0.00	25558310.00
OIBDOL	26452	-69507937.00	9795071965.00	-266000000000.00	0.00	194000000000.00
QSPR	26452	2.23	2.88	0.84	1.27	70.33
NUMTRANS	26452	182.13	221.95	0.00	118.00	6473.00
TVOL (dollars)	26452	7690727968.00	14305654791.00	0.00	2413426479.00	318000000000.00
Bitcoin close price	26452	6886.21	3942.52	1287.00	6634.75	19866.50
Bitcoin minute returns	26451	0.00	0.00	-0.02	0.00	0.03

Time zone (08 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26460	1.64	157.33	-2942.00	0.00	2584.00
OIBBIT	26460	-2579.99	1120177.00	-32223046.00	0.00	18444268.00
OIBDOL	26460	-54165791.00	9688958234.00	-308000000000.00	0.00	144000000000.00
QSPR	26460	2.30	2.91	0.97	1.28	76.28
NUMTRANS	26460	195.76	225.65	0.00	128.00	4191.00
TVOL (dollars)	26460	8211550856.00	14290385631.00	0.00	2860492662.00	331000000000.00
Bitcoin close price	26460	6886.46	3937.59	1284.80	6629.00	19875.00
Bitcoin minute returns	26460	0.00	0.00	-0.02	0.00	0.02

Time zone (09 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26516	-2.22	168.15	-5260.00	0.00	3110.00
OIBBIT	26516	-26665.15	1177128.00	-38828491.00	0.00	26921172.00
OIBDOL	26516	-215903095.00	10049179047.00	-250000000000.00	0.00	227000000000.00
QSPR	26516	2.40	3.28	0.97	1.31	111.42
NUMTRANS	26516	189.47	228.75	0.00	122.00	5626.00
TVOL (dollars)	26516	7989664671.00	14358911641.00	0.00	2502088329.00	295000000000.00
Bitcoin close price	26516	6867.46	3926.71	1263.20	6633.75	19860.50
Bitcoin minute returns	26515	0.00	0.00	-0.02	0.00	0.02

Time zone (10 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26492	0.26	164.82	-2841.00	0.00	4461.00
OIBBIT	26492	-9520.98	1166309.00	-20460427.00	0.00	44175987.00
OIBDOL	26492	-82551888.00	10470102504.00	-226000000000.00	0.00	369000000000.00
QSPR	26492	2.31	2.80	0.95	1.30	75.97
NUMTRANS	26492	198.37	232.65	0.00	128.00	4811.00
TVOL (dollars)	26492	8424137099.00	15390701901.00	0.00	2664569683.00	397000000000.00
Bitcoin close price	26492	6866.67	3921.88	1264.80	6627.00	19907.50
Bitcoin minute returns	26492	0.00	0.00	-0.01	0.00	0.02

Time zone (11 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26460	2.35	173.25	-5982.00	0.00	4561.00
OIBBIT	26460	-2011.49	1265491.00	-44548214.00	36.00	28775731.00
OIBDOL	26460	-23031016.00	10863975277.00	-336000000000.00	81172.55	223000000000.00
QSPR	26460	2.87	8.59	0.92	1.36	629.08

NUMTRANS	26460	201.75	231.78	0.00	138.00	6378.00
TVOL (dollars)	26460	8583633072.00	15722438827.00	0.00	3041790676.00	411000000000.00
Bitcoin close price	26460	6871.75	3917.76	1270.20	6625.00	19971.00
Bitcoin minute returns	26460	0.00	0.00	-0.02	0.00	0.02

Time zone (12 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26460	0.46	181.61	-5021.00	0.00	4949.00
OIBBIT	26460	-5272.68	1301324.00	-43368791.00	0.00	28664000.00
OIBDOL	26460	-18465739.00	11322847191.00	-373000000000.00	0.00	214000000000.00
QSPR	26460	2.56	3.46	0.97	1.36	118.15
NUMTRANS	26460	218.42	248.98	0.00	149.00	5375.00
TVOL (dollars)	26460	9381203569.00	16168037941.00	0.00	3483005431.00	399000000000.00
Bitcoin close price	26460	6881.98	3932.06	1271.80	6625.50	20090.50
Bitcoin minute returns	26460	0.00	0.00	-0.02	0.00	0.02

Time zone (13 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26440	-0.51	184.63	-3736.00	0.00	5361.00
OIBBIT	26440	5712.35	1320402.00	-23800015.00	0.00	37144722.00
OIBDOL	26440	62773749.00	11272734829.00	-205000000000.00	0.00	293000000000.00
QSPR	26440	3.00	5.82	0.87	1.43	205.08
NUMTRANS	26440	222.64	250.31	0.00	156.00	5829.00
TVOL (dollars)	26440	9571949978.00	16498956268.00	0.00	3554865259.00	363000000000.00
Bitcoin close price	26440	6885.36	3930.26	1268.20	6664.75	19970.00
Bitcoin minute returns	26440	0.00	0.00	-0.03	0.00	0.03

Time zone (14 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26375	-2.22	186.71	-4415.00	0.00	4053.00
OIBBIT	26375	-13773.08	1362171.00	-53168639.00	0.00	36234801.00
OIBDOL	26375	-106924721.00	11984517298.00	-468000000000.00	0.00	233000000000.00
QSPR	26375	2.94	5.17	0.93	1.40	250.85
NUMTRANS	26375	229.82	259.30	0.00	156.00	5717.00
TVOL (dollars)	26375	9990594213.00	17231296204.00	0.00	3618455250.00	510000000000.00
Bitcoin close price	26375	6897.76	3924.41	1270.60	6705.00	19866.50
Bitcoin minute returns	26373	0.00	0.00	-0.03	0.00	0.08

Time zone (15 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26508	0.79	168.06	-3870.00	0.00	3501.00
OIBBIT	26508	-935.92	1206967.00	-48220809.00	277.00	33986632.00
OIBDOL	26508	-8849775.00	10733344119.00	-375000000000.00	731305.20	259000000000.00
QSPR	26508	2.92	4.25	0.94	1.44	126.86
NUMTRANS	26508	210.33	227.49	0.00	146.00	4188.00
TVOL (dollars)	26508	9014863078.00	15254552685.00	0.00	3247951365.00	388000000000.00
Bitcoin close price	26508	6881.02	3917.53	1270.90	6701.50	19630.50
Bitcoin minute returns	26504	0.00	0.00	-0.03	0.00	0.02

Time zone (16 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26521	1.11	183.47	-5069.00	0.00	6158.00
OIBBIT	26521	563.45	1343873.00	-36405887.00	0.00	39994170.00
OIBDOL	26521	-42732647.00	11635249212.00	-275000000000.00	0.00	274000000000.00
QSPR	26521	2.85	5.19	0.82	1.39	162.25
NUMTRANS	26521	216.92	258.28	0.00	146.00	6600.00
TVOL (dollars)	26521	9329417764.00	17859841587.00	0.00	3105057932.00	360000000000.00
Bitcoin close price	26521	6871.59	3925.37	1272.80	6681.00	19590.00
Bitcoin minute returns	26519	0.00	0.00	-0.03	0.00	0.05

Time zone (17 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26539	-0.80	161.78	-4073.00	0.00	3759.00
OIBBIT	26539	-8189.62	1263716.00	-37154113.00	0.00	30828762.00
OIBDOL	26539	-79256046.00	11130965565.00	-264000000000.00	0.00	236000000000.00
QSPR	26539	3.14	12.43	-11.25	1.37	1393.97
NUMTRANS	26539	195.40	226.43	0.00	128.00	4315.00
TVOL (dollars)	26539	8441258578.00	16428654087.00	0.00	2586587200.00	348000000000.00

Bitcoin close price	26539	6863.46	3913.25	1282.40	6689.00	19375.00
Bitcoin minute returns	26539	0.00	0.00	-0.07	0.00	0.06

Time zone (18 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26489	-0.84	153.25	-5149.00	0.00	2471.00
OIBBIT	26489	-6014.21	1087738.00	-35450385.00	0.00	15615044.00
OIBDOL	26489	-5556087.00	9539160284.00	-240000000000.00	0.00	123000000000.00
QSPR	26489	2.72	6.50	0.47	1.32	345.54
NUMTRANS	26489	183.76	215.70	0.00	118.00	5487.00
TVOL (dollars)	26489	7607857096.00	14099198409.00	0.00	2325103103.00	275000000000.00
Bitcoin close price	26489	6864.53	3920.53	1278.10	6679.00	19292.00
Bitcoin minute returns	26489	0.00	0.00	-0.02	0.00	0.02

Time zone (19 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26445	1.63	153.80	-4308.00	0.00	3099.00
OIBBIT	26445	-97.04	1069787.00	-30637218.00	0.00	27839762.00
OIBDOL	26445	6040659.00	9482758089.00	-209000000000.00	0.00	211000000000.00
QSPR	26445	2.79	5.40	0.05	1.34	242.87
NUMTRANS	26445	178.22	206.77	0.00	117.00	4512.00
TVOL (dollars)	26445	7246449234.00	13471357507.00	0.00	2239159193.00	252000000000.00
Bitcoin close price	26445	6856.78	3916.62	1280.50	6632.00	19345.00
Bitcoin minute returns	26444	0.00	0.00	-0.06	0.00	0.03

Time zone (20 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26445	0.33	166.27	-3039.00	0.00	4101.00
OIBBIT	26445	-416.81	1151471.00	-25254447.00	0.00	27264526.00
OIBDOL	26445	-4742202.00	10375923965.00	-246000000000.00	0.00	209000000000.00
QSPR	26445	2.77	4.18	-6.76	1.36	122.98
NUMTRANS	26445	192.00	229.34	0.00	122.00	4674.00
TVOL (dollars)	26445	7946261738.00	14891372113.00	0.00	2408896214.00	290000000000.00
Bitcoin close price	26445	6872.61	3942.68	1281.10	6636.00	19595.00
Bitcoin minute returns	26445	0.00	0.00	-0.03	0.00	0.02

Time zone (21 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26262	1.00	143.42	-4738.00	0.00	3756.00
OIBBIT	26262	-3399.95	1010825.00	-35434079.00	9.50	22903938.00
OIBDOL	26262	-33054664.00	9087127324.00	-212000000000.00	25182.30	191000000000.00
QSPR	26262	2.66	3.67	0.90	1.34	116.10
NUMTRANS	26262	175.44	204.85	0.00	112.00	5736.00
TVOL (dollars)	26262	7127985462.00	13255293791.00	0.00	2089348998.00	235000000000.00
Bitcoin close price	26262	6886.39	3941.44	1277.90	6645.00	19510.00
Bitcoin minute returns	26261	0.00	0.00	-0.02	0.00	0.02

Time zone (22 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26355	0.37	182.98	-6346.00	0.00	5499.00
OIBBIT	26355	2579.15	1255001.00	-41966510.00	72.00	37075370.00
OIBDOL	26355	56863049.00	10686025884.00	-338000000000.00	189004.30	297000000000.00
QSPR	26355	2.57	3.52	1.00	1.32	62.48
NUMTRANS	26355	193.48	252.29	0.00	119.00	6784.00
TVOL (dollars)	26355	7941536193.00	15568331393.00	0.00	2340285232.00	450000000000.00
Bitcoin close price	26355	6883.99	3957.69	1277.60	6649.00	19844.50
Bitcoin minute returns	26353	0.00	0.00	-0.02	0.00	0.02

Time zone (23 time)

	N	Mean	St. Dev.	Min	Median	Max
OIBNUM	26431	-0.88	178.88	-6764.00	0.00	6919.00
OIBBIT	26431	-6819.16	1301889.00	-56141095.00	0.00	57299540.00
OIBDOL	26431	-51773462.00	11192704390.00	-423000000000.00	0.00	382000000000.00
QSPR	26431	2.65	5.33	-182.30	1.35	330.04
NUMTRANS	26431	191.55	239.84	0.00	125.00	7443.00
TVOL (dollars)	26431	8036363451.00	15829410102.00	0.00	2639187561.00	440000000000.00
Bitcoin close price	26431	6884.56	3957.30	1277.70	6636.00	19876.00
Bitcoin minute returns	26430	0.00	0.00	-0.04	0.00	0.03

Appendix Table 2: Correlation (Hourly)

Time zone (00 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.885						
OIBDOL	0.824	0.965					
QSPR	-0.016	-0.014	-0.006				
NUMTRANS	-0.088	-0.129	-0.121	0.113			
TVOL	-0.111	-0.171	-0.176	0.237	0.832		
Bitcoin Price	0.002	-0.009	-0.015	0.003	0.369	0.414	
Bitcoin Returns	0.58	0.516	0.54	0.014	-0.037	-0.049	-0.006

Time zone (01 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.895						
OIBDOL	0.838	0.963					
QSPR	-0.003	-0.023	-0.032				
NUMTRANS	-0.102	-0.124	-0.117	0.211			
TVOL	-0.105	-0.143	-0.146	0.272	0.856		
Bitcoin Price	0.003	-0.004	-0.007	-0.027	0.37	0.437	
Bitcoin Returns	0.589	0.527	0.559	-0.001	-0.028	-0.02	-0.004

Time zone (02 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.887						
OIBDOL	0.824	0.963					
QSPR	-0.048	-0.069	-0.069				
NUMTRANS	-0.107	-0.136	-0.132	0.176			
TVOL	-0.109	-0.167	-0.172	0.204	0.859		
Bitcoin Price	-0.005	-0.014	-0.018	-0.023	0.391	0.437	
Bitcoin Returns	0.584	0.527	0.555	-0.071	-0.047	-0.061	-0.01

Time zone (03 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.875						
OIBDOL	0.811	0.964					
QSPR	-0.024	-0.053	-0.059				
NUMTRANS	-0.078	-0.099	-0.102	0.246			
TVOL	-0.091	-0.138	-0.146	0.317	0.837		
Bitcoin Price	-0.006	-0.014	-0.015	0.011	0.423	0.464	
Bitcoin Returns	0.576	0.518	0.54	0.027	-0.029	-0.028	-0.007

Time zone (04 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.881						
OIBDOL	0.82	0.965					
QSPR	0.006	0.003	0.019				
NUMTRANS	-0.042	-0.038	-0.021	0.219			
TVOL	-0.018	-0.037	-0.022	0.267	0.858		
Bitcoin Price	0.01	0.009	0.012	-0.018	0.388	0.443	
Bitcoin Returns	0.582	0.528	0.563	0.035	-0.003	0.024	0.014

Time zone (05 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.886						
OIBDOL	0.827	0.965					
QSPR	-0.017	-0.031	-0.036				
NUMTRANS	-0.137	-0.136	-0.129	0.223			
TVOL	-0.13	-0.136	-0.135	0.264	0.851		
Bitcoin Price	-0.009	-0.006	-0.006	-0.018	0.348	0.409	
Bitcoin Returns	0.549	0.496	0.523	0.006	-0.035	-0.042	-0.01

Time zone (06 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.915						
OIBDOL	0.878	0.975					
QSPR	0.006	-0.001	0.005				

NUMTRANS	-0.055	-0.039	-0.017	0.163			
TVOL	-0.023	-0.015	-0.005	0.137	0.891		
Bitcoin Price	0.006	0.008	0.011	-0.129	0.298	0.341	
Bitcoin Returns	0.531	0.458	0.486	0.019	-0.009	0.01	0.014

Time zone (07 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.903						
OIBDOL	0.87	0.976					
QSPR	-0.001	-0.005	-0.004				
NUMTRANS	-0.066	-0.1	-0.088	0.204			
TVOL	-0.078	-0.114	-0.103	0.212	0.888		
Bitcoin Price	-0.005	-0.003	-0.004	-0.074	0.323	0.368	
Bitcoin Returns	0.557	0.49	0.518	0.04	-0.01	-0.007	0.00004

Time zone (08 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.894						
OIBDOL	0.855	0.971					
QSPR	-0.042	-0.058	-0.068				
NUMTRANS	-0.01	-0.043	-0.056	0.192			
TVOL	-0.056	-0.092	-0.109	0.177	0.878		
Bitcoin Price	-0.007	-0.008	-0.01	-0.096	0.341	0.394	
Bitcoin Returns	0.559	0.481	0.503	-0.023	-0.016	-0.028	-0.012

Time zone (09 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.908						
OIBDOL	0.868	0.972					
QSPR	-0.016	-0.025	-0.027				
NUMTRANS	-0.223	-0.246	-0.213	0.217			
TVOL	-0.199	-0.232	-0.208	0.226	0.888		
Bitcoin Price	-0.009	-0.007	-0.008	-0.053	0.340	0.396	
Bitcoin Returns	0.560	0.496	0.528	-0.006	-0.055	-0.052	-0.009

Time zone (10 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.898						
OIBDOL	0.847	0.972					
QSPR	-0.003	-0.008	-0.010				
NUMTRANS	-0.006	-0.028	-0.034	0.201			
TVOL	-0.025	-0.066	-0.085	0.177	0.865		
Bitcoin Price	0.001	-0.003	-0.004	-0.079	0.346	0.402	
Bitcoin Returns	0.571	0.488	0.503	-0.043	-0.024	-0.021	0.001

Time zone (11 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.896						
OIBDOL	0.851	0.971					
QSPR	0.003	-0.040	-0.038				
NUMTRANS	-0.028	-0.048	-0.046	0.135			
TVOL	-0.035	-0.071	-0.078	0.171	0.865		
Bitcoin Price	0.000	-0.001	-0.004	-0.025	0.324	0.383	
Bitcoin Returns	0.567	0.507	0.532	-0.019	0.010	0.010	0.005

Time zone (12 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.896						
OIBDOL	0.847	0.973					
QSPR	-0.006	-0.027	-0.022				
NUMTRANS	-0.042	-0.056	-0.050	0.190			
TVOL	-0.049	-0.098	-0.093	0.167	0.860		
Bitcoin Price	0.003	0.004	0.006	-0.084	0.328	0.403	
Bitcoin Returns	0.560	0.479	0.490	0.030	-0.007	-0.006	0.005

Time zone (13 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price

OIBBIT	0.902						
OIBDOL	0.846	0.966					
QSPR	0.013	0.017	0.015				
NUMTRANS	0.023	0.037	0.023	0.153			
TVOL	0.038	0.059	0.053	0.161	0.857		
Bitcoin Price	0.002	0.005	0.009	-0.024	0.324	0.400	
Bitcoin Returns	0.559	0.497	0.521	0.006	0.018	0.026	0.004

Time zone (14 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.894						
OIBDOL	0.842	0.968					
QSPR	-0.019	-0.023	-0.023				
NUMTRANS	-0.158	-0.169	-0.159	0.188			
TVOL	-0.155	-0.202	-0.196	0.203	0.858		
Bitcoin Price	-0.004	-0.002	-0.001	-0.037	0.335	0.424	
Bitcoin Returns	0.524	0.468	0.493	0.019	-0.031	-0.024	0.000

Time zone (15 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.894						
OIBDOL	0.834	0.963					
QSPR	-0.007	-0.008	-0.008				
NUMTRANS	-0.045	-0.056	-0.048	0.209			
TVOL	-0.042	-0.063	-0.056	0.259	0.852		
Bitcoin Price	0.002	0.000	0.001	-0.018	0.357	0.452	
Bitcoin Returns	0.565	0.503	0.537	0.027	-0.024	-0.024	-0.003

Time zone (16 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.897						
OIBDOL	0.841	0.960					
QSPR	0.020	-0.008	-0.046				
NUMTRANS	0.032	0.009	-0.014	0.209			
TVOL	-0.008	-0.054	-0.090	0.294	0.856		
Bitcoin Price	-0.003	-0.008	-0.012	-0.016	0.324	0.394	
Bitcoin Returns	0.581	0.522	0.553	-0.019	0.018	-0.014	-0.001

Time zone (17 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.862						
OIBDOL	0.819	0.970					
QSPR	-0.007	-0.010	-0.016				
NUMTRANS	-0.076	-0.078	-0.076	0.103			
TVOL	-0.076	-0.082	-0.088	0.142	0.853		
Bitcoin Price	-0.004	-0.004	-0.007	-0.011	0.333	0.377	
Bitcoin Returns	0.548	0.493	0.523	0.062	-0.041	-0.051	-0.007

Time zone (18 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.884						
OIBDOL	0.841	0.967					
QSPR	-0.006	-0.020	-0.018				
NUMTRANS	-0.117	-0.124	-0.103	0.121			
TVOL	-0.095	-0.111	-0.092	0.166	0.868		
Bitcoin Price	0.013	0.009	0.014	-0.041	0.340	0.416	
Bitcoin Returns	0.572	0.498	0.522	0.022	-0.017	-0.010	0.012

Time zone (19 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.883						
OIBDOL	0.829	0.964					
QSPR	-0.021	-0.039	-0.042				
NUMTRANS	-0.068	-0.097	-0.088	0.170			
TVOL	-0.074	-0.116	-0.114	0.203	0.846		
Bitcoin Price	0.009	0.002	0.004	-0.058	0.321	0.412	
Bitcoin Returns	0.546	0.511	0.527	-0.039	-0.032	-0.046	0.009

Time zone (20 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.887						
OIBDOL	0.829	0.966					
QSPR	-0.003	-0.011	-0.015				
NUMTRANS	-0.025	-0.040	-0.038	0.176			
TVOL	-0.034	-0.055	-0.063	0.168	0.855		
Bitcoin Price	0.002	0.000	-0.001	-0.110	0.322	0.412	
Bitcoin Returns	0.573	0.513	0.521	0.025	-0.010	-0.007	0.006

Time zone (21 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.872						
OIBDOL	0.807	0.957					
QSPR	-0.016	-0.033	-0.053				
NUMTRANS	-0.067	-0.068	-0.063	0.225			
TVOL	-0.056	-0.064	-0.082	0.258	0.846		
Bitcoin Price	0.004	-0.002	-0.004	-0.098	0.328	0.421	
Bitcoin Returns	0.591	0.529	0.544	-0.011	-0.015	-0.020	0.000

Time zone (22 time)

	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.904						
OIBDOL	0.848	0.964					
QSPR	0.015	0.021	0.019				
NUMTRANS	-0.016	-0.005	-0.002	0.168			
TVOL	-0.001	0.017	0.016	0.185	0.870		
Bitcoin Price	0.011	0.009	0.015	-0.119	0.293	0.383	
Bitcoin Returns	0.564	0.517	0.541	0.015	0.005	0.017	0.007

Time zone (23 time)

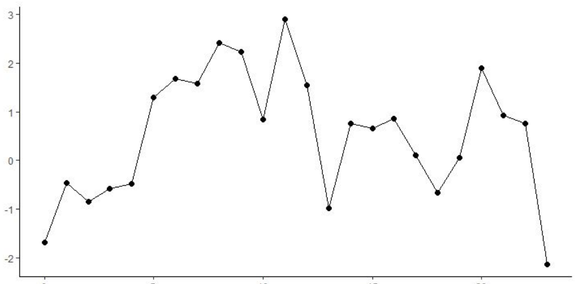
	OIBNUM	OIBBIT	OIBDOL	QSPR	NUMTRANS	TVOL	Bitcoin Price
OIBBIT	0.886						
OIBDOL	0.827	0.965					
QSPR	-0.017	-0.031	-0.036				
NUMTRANS	-0.137	-0.136	-0.129	0.223			
TVOL	-0.13	-0.136	-0.135	0.264	0.851		
Bitcoin Price	-0.009	-0.006	-0.006	-0.018	0.348	0.409	
Bitcoin Returns	0.549	0.496	0.523	0.006	-0.035	-0.042	-0.01

Appendix Figure 1: Mean of Variables

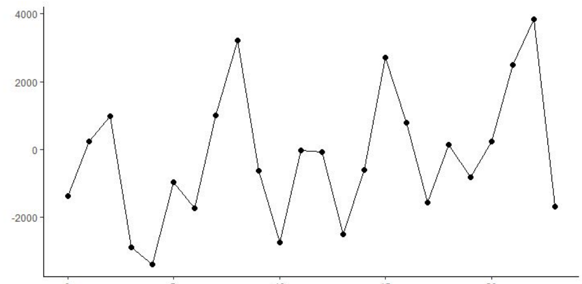
Period 1

All X axis are 00-23 hour time zone

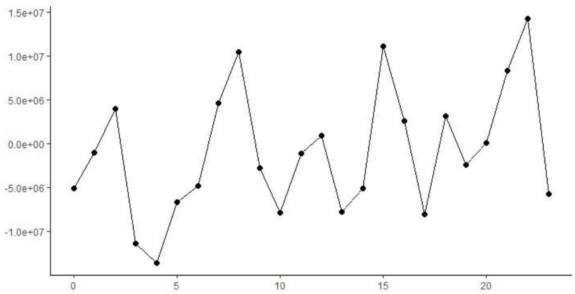
OIBNUM



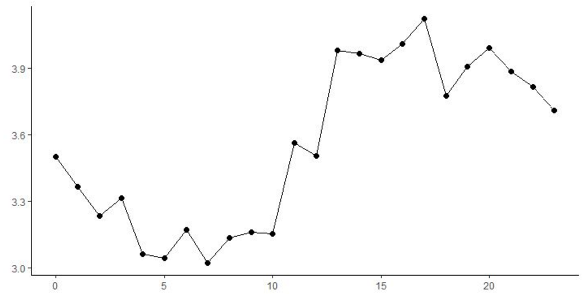
OIBBIT



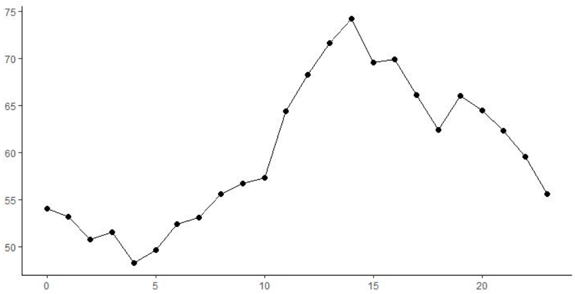
OIBDOL



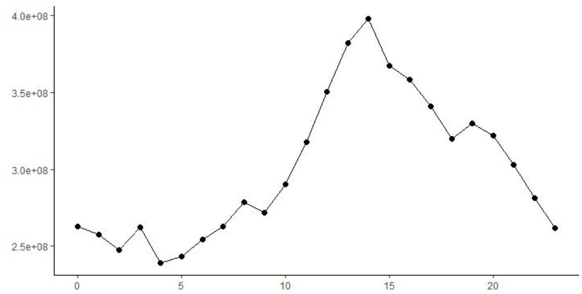
QSPR



NUMTRANS



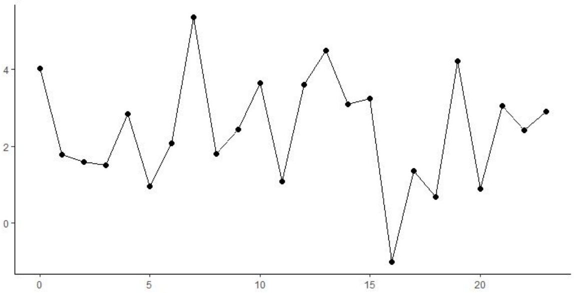
TVOL



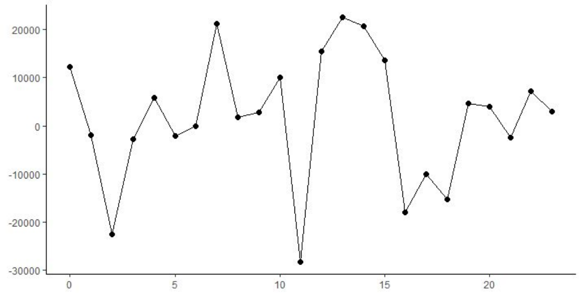
Period 2

All X axis are 00-23 hour time zone

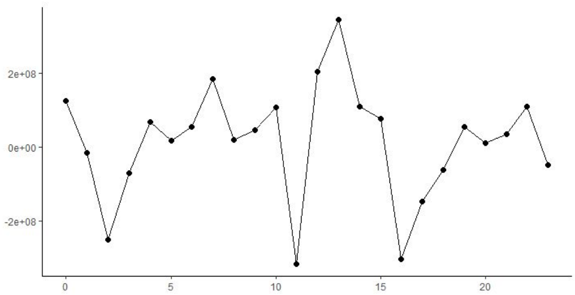
OIBNUM



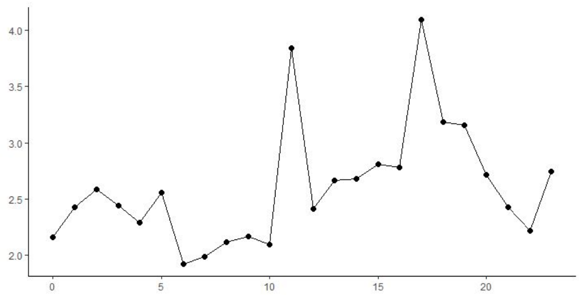
OIBBIT



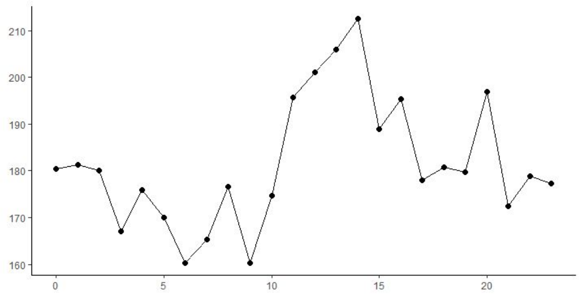
OIBDOL



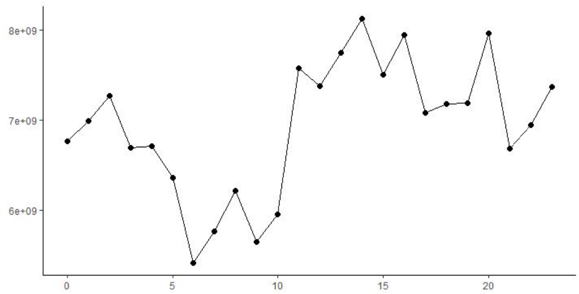
QSPR



NUMTRANS



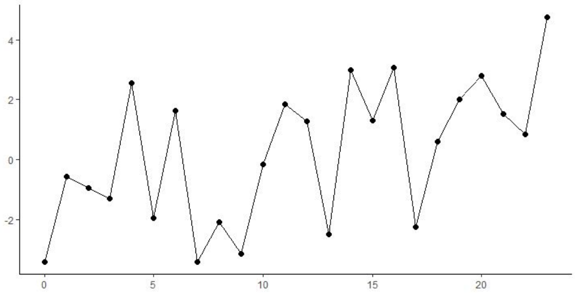
TVOL



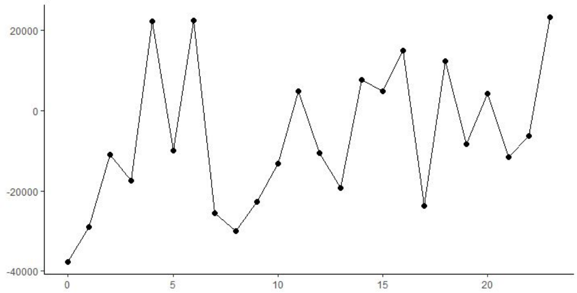
Period 3

All X axis are 00-23 hour time zone

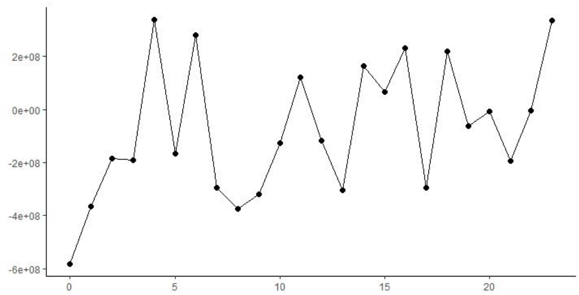
OIBNUM



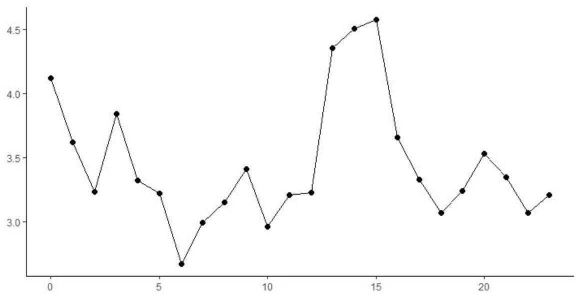
OIBBIT



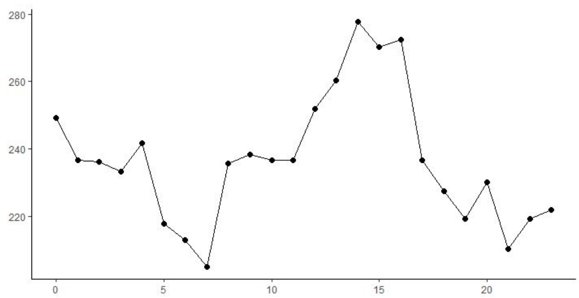
OIBDOL



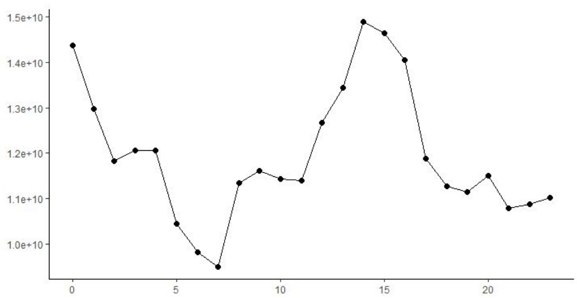
QSPR



NUMTRANS



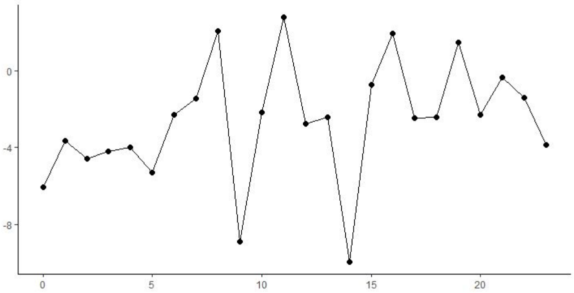
TVOL



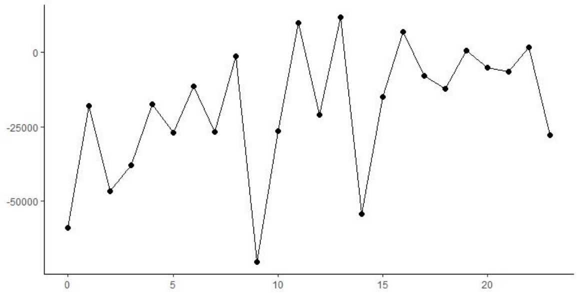
Period 4

All X axis are 00-23 hour time zone

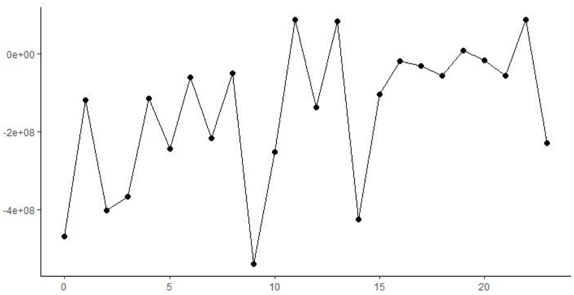
OIBNUM



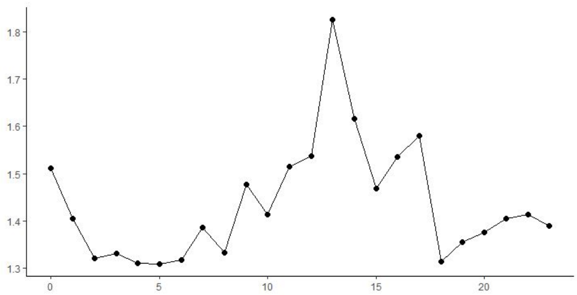
OIBBIT



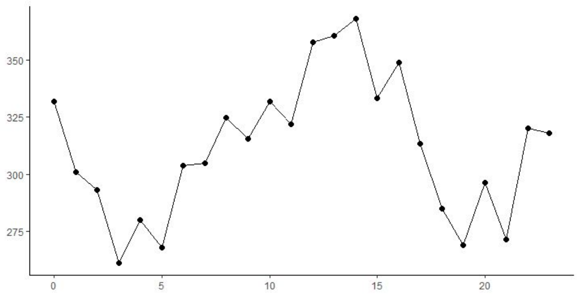
OIBDOL



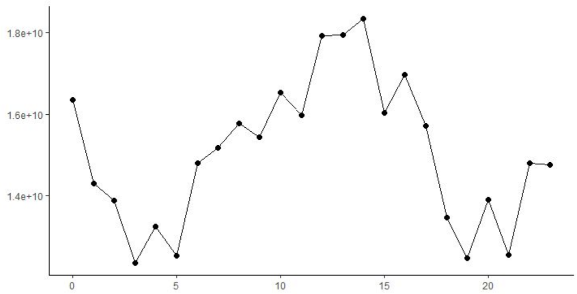
QSPR



NUMTRANS



TVOL



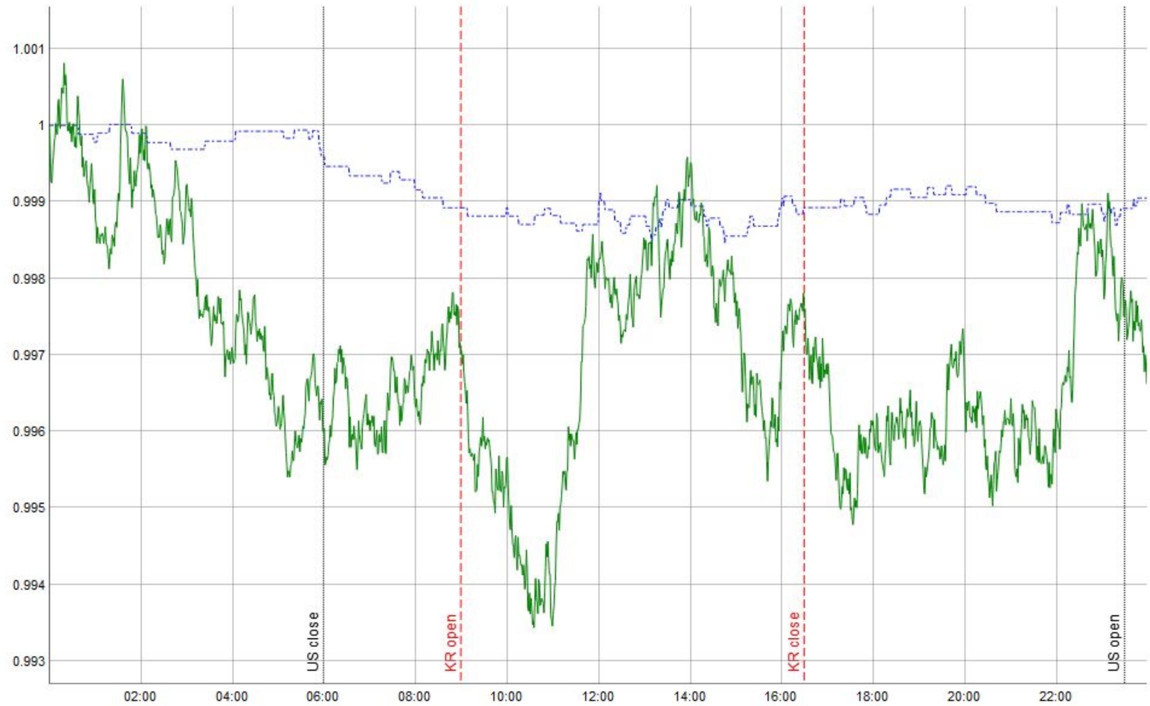
Appendix Figure 2: Movement of bitcoin returns in four subperiod

Period 1

Period 2

Period 3

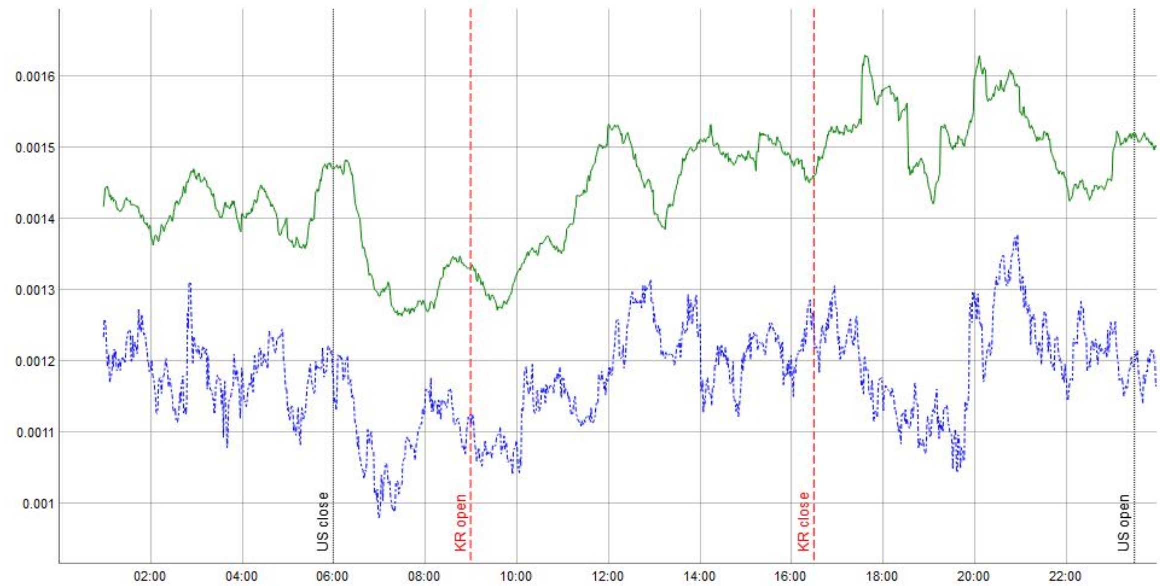
Period 4



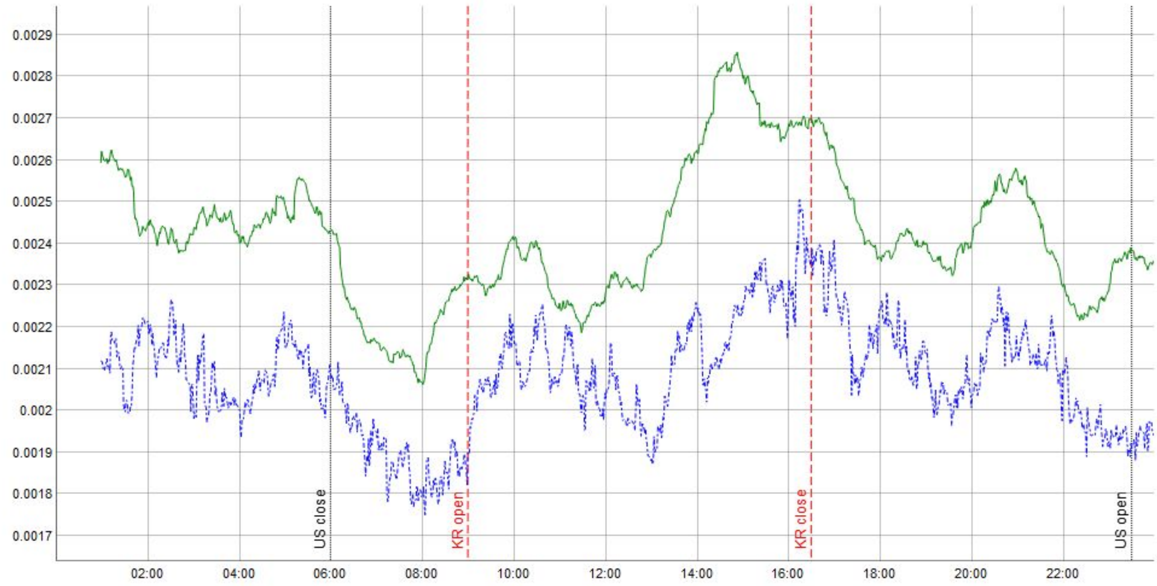
Appendix Figure 3: Movement of bitcoin volatility in four subperiod

Period 1

Period 2



Period 3



Period 4

SUPPLEMENT

Table 1: Marketwide order imbalance - summary statistics and correlation

This table shows order imbalances and trading activity measures of the traditional stock market. This table is described in Chordia et al (2002).

Descriptive statistics are given for average daily order imbalance measures from NYSE stocks belonging to the S&P500 over 1988–1998 inclusive (2779 observations). Trades are signed using the Lee and Ready (1991) algorithm. OIBNUM, OIBSH, and OIBDOL measure the value-weighted order imbalance in number of transactions, shares, and dollars, respectively. $VOL, NUMTRANS, and QSPR are the value-weighted averages of dollar volume (in millions of dollars), number of transactions, and the average daily quoted spread, respectively. The value weights are proportional to market capitalization at the end of the previous calendar year. The variables DQSPR and DOIBNUM denote the daily percentages and the daily first differences in QSPR and OIBNUM, respectively. S&P500 is the daily return on the Standard & Poor's 500 Index. Values in bold face (Panel C) are significantly nonzero with an asymptotic p-value less than 0.00001.

Panel A: Summary statistics

	Mean	Median	Standard deviation
OIBNUM	34.89	27.22	57.48
OIBSH/1×10^3	59.71	45.40	97.12
OIBDOL/1×10^6	4.167	2.830	6.498
|OIBNUM|	90.33	78.61	52.71
|OIBSH|/1×10^3	168.0	147.0	86.04
|OIBDOL|/1×10^9	9.628	7.560	6.165
QSPR	0.182	0.187	0.030
NUMTRANS	658.0	534	399.0
$VOL	58.37	40.17	42.17
|DQSPR(%)|	2.66	1.98	2.63

Panel B: Correlations

	OIBNUM	OIBSH	OIBDOL	NUMTRANS	$VOL
OIBSH	0.522				
OIBDOL	0.531	0.966			
NUMTRANS	0.533	0.468	0.562		
$VOL	0.476	0.509	0.608	0.971	
S&P500	0.408	0.599	0.528	0.012	0.024

Panel C. Autocorrelations

Lag (days)	OIBNUM	OIBSH	OIBDOL	S&P500	DQSPR	DOIBNUM
1	**0.539**	**0.376**	**0.465**	0.005	**−0.321**	**−0.420**
2	**0.470**	**0.322**	**0.421**	−0.023	**−0.096**	**−0.074**
3	**0.469**	**0.297**	**0.400**	−0.032	−0.022	**−0.037**
4	**0.434**	**0.290**	**0.399**	−0.018	−0.022	−0.016
5	**0.414**	**0.271**	**0.384**	−0.023	−0.018	**0.034**

Source: Chordia et al(2002)