

Progress Report

Information share on Bitcoin exchanges

2017

Financial Markets and Trading Laboratory

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Top 10 Bitcoin exchanges

Exchange	Total_trade	Total_volume	VolumePerDay	VolumePerTrade	TradePerDay	First_date	Last_date
mtgoxUSD	8295809	55575353.12	42294.79	51.740	6313.401	2010-07-17 23:09	2014-02-25 1:59
bitfinexUSD	10182252	25730210.06	18975.08	2.517	7509.035	2013-03-31 22:07	2016-12-22 12:43
bitstampUSD	12448193	20305460.20	9605.23	3.647	5888.455	2011-09-13 13:53	2017-07-17 22:23
btceUSD	32601774	14911715.96	7083.95	2.901	15487.779	2011-08-14 14:14	2017-07-17 22:34
coinbaseUSD	18192817	7500931.48	8100.36	0.436	19646.671	2014-12-01 5:33	2017-07-17 23:03
itbitUSD	1345266	4333967.33	3193.79	5.107	991.353	2013-08-25 0:21	2017-08-30 22:02
lakeUSD	3581917	2110627.84	4130.39	1.041	7009.622	2014-03-01 12:01	2017-07-05 10:56
localbtcUSD	2702973	1976944.22	1210.62	1.176	1655.219	2013-03-11 23:57	2017-08-30 21:47
krakenUSD	2314129	1355886.41	1093.46	0.642	1866.233	2014-01-07 18:18	2017-07-17 22:28
thUSD	159159	1184918.03	4720.79	8.492	634.100	2011-06-08 20:12	2012-02-13 22:26

Hacking Issues on Bitcoin exchanges

Mt. Gox (2013. Aug)

- The second hack as of February 2014 caused the company to go bankrupt. With 744,408 BTC missing for an unknown reason

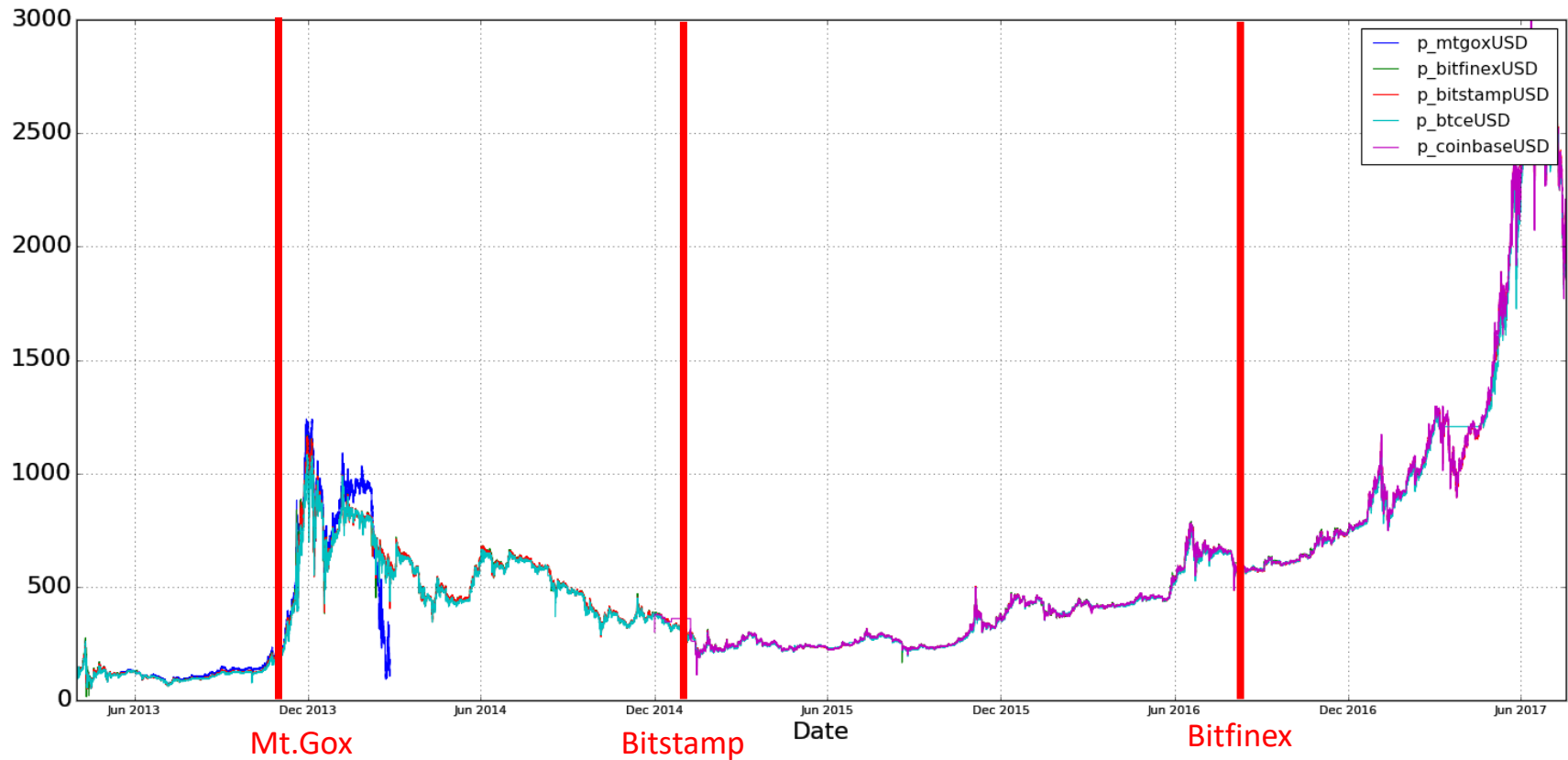
Bitstamp(2015. Jan)

- The losses amounted to 19,000 BTC or roughly \$5.2 million at the time of the breach.

Bitfinex (2016. Aug)

- In April 2017, Bitfinex announced that it was no longer able to let users withdraw their funds in USD

Hacking Issues on Bitcoin exchanges



Information share

$$IS_i = \frac{(\sigma^2 + \psi_i)\pi_i}{\sigma^2} = \pi_i \left(1 + \frac{\psi_i}{\sigma^2} \right)$$

directed calculated

by Non-linear programming
with constraints and no objective function

Objective function

minimize $Z = \sum_{i=1}^n |\pi_i \psi_i| = 0,$

Constraints

$$E[y_{jt}y_{it}] = \sigma^2 + 2\omega_{ij} + \psi_j + \psi_i$$

$$E[y_{jt}y_{i,t-1}] = -\omega_{ij} - \psi_j + \gamma_j$$

$$E[y_{jt}y_{i,t-2}] = -\gamma_j$$

$$E[y_{it}y_{j,t-2}] = -\gamma_i$$

$$\omega_i^e \geq 0$$

$$\rho_{1,ii} = \frac{-(\omega_i^e + \psi_i - \gamma_i)}{\sigma^2 + 2(\omega_i^e + \psi_i)}$$

- σ^2 can be observed directly as **the variance of the aggregated return** of the four exchanges.
- γ_i, γ_j defined in (4d) and (4e) can be observed directly as **the covariance between a market and its corresponding exchange lagged two intervals**.
- Only $\omega_i^e, \omega_{ij}, \psi_i$, and ψ_j unknown

Paper replication

Step1. Create 5min-interval tick-data

```
for i, file in enumerate(files):  
    print(file)  
    try:
```

```
        data = pd.read_csv(file, date_parser=['date'])  
        data['date'] = pd.to_datetime(data['date'])
```

```
files = ['usd/mtgoxUSD.csv',  
         'usd/btceUSD.csv',  
         'usd/bitstampUSD.csv',  
         'usd/bitfinexUSD.csv',  
         ]
```

```
        data_within = data[(data['date'] >= dt.datetime(2013,4,1,0,5,0)) & (data['date'] <= dt.datetime(2014,2,25))]
```

```
        data_within.set_index('date', inplace=True, drop=True)
```

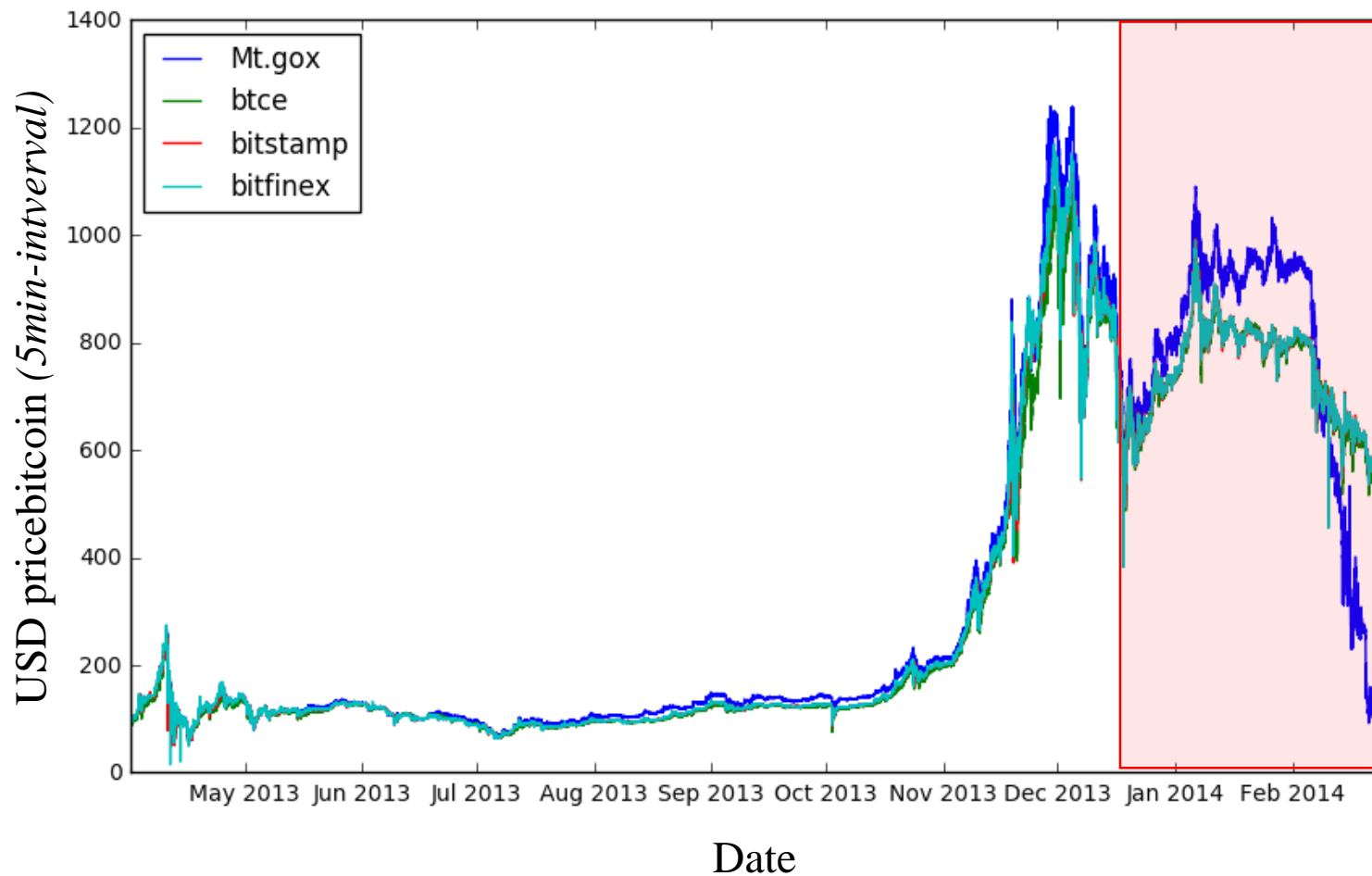
```
        data_within = data_within.groupby(pd.TimeGrouper('5Min')).last()
```

```
        data_within.to_csv('dated/' + file.split('/')[1], header='column_names', encoding='utf-8')
```

date	p_mtgoxUSD	v_mtgoxUSD	p_btceUSD	v_btceUSD	p_bitstampUSD	v_bitstampUSD	p_bitfinexUSD	v_bitfinexUSD
2014-02-24 23:55	173.84344	0.01077366	555.759	1.73876	535.49	0.068	517.87	1.3904
2014-02-24 23:50	174.94099	3	557.775	0.328894	542.34	0.01	509.5	2
2014-02-24 23:45	176.46678	0.01077659	555.668	0.14981	547.88	1.77675033	508.5	1.2
2014-02-24 23:40	171	5	557.53	0.000332	546.15	1.5	512.2	10
2014-02-24 23:35	176.63995	3.73253728	558.982	0.01	547.09	0.07695894	524.9999	1.5
2014-02-24 23:30	171.30013	3.57477567	558.999	0.214161	550.01	0.005027	516	1
2014-02-24 23:25	175.52	0.02799801	559.5	1.96724	550	0.5	517	0.05775061
2014-02-24 23:20	174	0.01	558	0.23146	542	5	520.11	4
2014-02-24 23:15	171.528	0.64101656	555.003	0.05	543	0.0312	523.5	5
2014-02-24 23:10	168.213	0.01	556.48	0.02	542.9	0.017	523.5	0.35
2014-02-24 23:05	168.214	0.05	556.308	0.0504	541.53	1.83025	527.7444	1
2014-02-24 23:00	166.75635	0.46338413	557.45	0.453188	542.94	0.119	523	2
2014-02-24 22:55	171.99997	1.46190054	555.98	0.0504	540	0.32488293	535.9999	0.2122052
2014-02-24 22:50	169.99998	0.00999994	555.3	1.45934	543.9	0.101716	543.749	0.01686008

Paper replication

Step1. Create 5min-interval tick-data



Paper replication

Step3. Calculate Non-linear programming with constraints

```
def objective(x):
    sum_value = 0
    for i in range(0,4):
        sum_value += abs(x[4*i]*df['pi'][i])
    return sum_value
```

$$\begin{aligned}
 E[y_{jt}y_{it}] &= \sigma^2 + 2\omega_{ij} + \psi_j + \psi_i \\
 E[y_{jt}y_{i,t-1}] &= -\omega_{ij} - \psi_j + \gamma_j \\
 E[y_{jt}y_{i,t-2}] &= -\gamma_j \\
 E[y_{it}y_{j,t-2}] &= -\gamma_i
 \end{aligned}
 \quad
 \rho_{1,ii} = \frac{-(\omega_i^e + \psi_i - \gamma_i)}{\sigma^2 + 2(\omega_i^e + \psi_i)}$$

Iteration limit exceeded (Exit mode 9)

	$x_0 = \psi_i$	$x_1 = \psi_j$	$x_2 = \omega_{ij}$	$x_3 = \omega_i^e$
mtgox	[-2.11252300e-05	4.51218139e-04	-4.89468103e-04	5.77526499e-09]
btce	[-3.06263578e-05	1.48496716e-04	-8.95843027e-05	4.38873023e-06]
bitstamp	[-2.93215903e-05	-2.61040012e-03	2.38997702e-03	4.35854438e-08]
bitfinex	[1.93514624e-04	2.20975657e-03	-2.20827883e-03	2.04790226e-05]
objective	2.778706e-09			

Paper replication

Step3. Calculate Non-linear programming with constraints

```
def constraint0(x):
    sum_value = 0
    for i in range(0,4):
        sum_value += x[4*i]*df['pi'][i]
    return sum_value

def constraint1(x):
    sum_up1 = 0
    for i in range(0,4):
        sum_up1 += abs(2*x[4*i+2] + x[4*i+1] + x[4*i] + df['sigma'][i] - df['E[yj_t,i_t]'][i])
    return sum_up1

def constraint2(x):
    sum_up2 = 0
    for i in range(0,4):
        sum_up2 += abs(x[4*i+1] + x[4*i+2] + df['E[yj_t,i_t-1]'][i])
    return sum_up2

def constraint3(x):
    sum_up3 = 0
    for i in range(0,4):
        sum_up3 += abs(((x[4*i+3] + x[4*i+0] - df['gamma_i'][i]) / (df['sigma'][i] + 2*(x[4*i+3]+x[4*i+0]))) + df['rho_ii'][i])
    return sum_up3

def constraint4(x):
    return x[3]

def constraint5(x):
    return x[7]

def constraint6(x):
    return x[11]

def constraint7(x):
    return x[15]
```

Paper replication

Step3. Calculate

$$\begin{aligned}
 E[y_{jt}y_{it}] &= \sigma^2 + 2\omega_{ij} + \psi_j + \psi_i \\
 E[y_{jt}y_{i,t-1}] &= -\omega_{ij} - \psi_j + \gamma_j \\
 E[y_{jt}y_{i,t-2}] &= -\gamma_j \\
 E[y_{it}y_{j,t-2}] &= -\gamma_i
 \end{aligned}
 \quad \rho_{1,ii} = \frac{-(\omega_i^e + \psi_i - \gamma_i)}{\sigma^2 + 2(\omega_i^e + \psi_i)}$$

	rho_ii	sigma	gamma_i	gamma_j	pi	psi_i	psi_j	omega_i_j	omega^e_j	IS	IS/AS
mtgox	-0.154301	0.000114	-0.000032	1.520455e-06	0.384279	-0.000021	0.000451	-0.000489	5.775265e-09	0.312975	0.814446
btce	-0.105662	0.000114	-0.000033	-2.952613e-07	0.262009	-0.000031	0.000148	-0.000090	4.388730e-06	0.191527	0.730993
bitstamp	-0.062312	0.000114	-0.000033	2.348097e-06	0.234716	-0.000029	-0.002610	0.002390	4.358544e-08	0.174266	0.742454
bitfinex	-0.399637	0.000114	-0.000036	8.766151e-07	0.118996	0.000194	0.002210	-0.002208	2.047902e-05	0.321257	2.699736

Mt.Gox has got an information share of 0.313, meaning that 31.3% of all the information in the market comes from this exchange.

$$IS_i = \frac{(\sigma^2 + \psi_i)\pi_i}{\sigma^2} = \pi_i \left(1 + \frac{\psi_i}{\sigma^2} \right)$$

Paper replication

Comparison of original results

Table 4
Model parameters.

σ^2	$7.55E-05$						
	π	ψ_i	Market ψ_j	ω_i^e	ω_{ij}	IS	IS/AS ratio
Bitcurex	0.009	$-2.2E-05$	$2.78E-05$	$3.42E-05$	$-2.95E-05$	0.006	0.71
Bitfinex	0.073	$-4.3E-05$	$3.55E-05$	$6.95E-05$	$-3.35E-05$	0.031	0.42
Bitstamp	0.146	$-1.5E-05$	$3.17E-05$	$1.97E-05$	$-3.48E-05$	0.118	0.81
Btce	0.287	$9.34E-06$	$4.48E-05$	$3.21E-05$	$-5.18E-05$	0.322	1.12
Btcn	0.177	$-1.1E-05$	$4.25E-05$	$9.67E-06$	$-4.55E-05$	0.152	0.86
Mtgox	0.302	$1.61E-05$	$5.73E-05$	$3.29E-06$	$-6.35E-05$	0.366	1.21
Virtex	0.006	$-2.4E-05$	$2.87E-05$	$2.59E-05$	$-2.59E-05$	0.004	0.68

	rho_ii	sigma	gamma_i	gamma_j	pi	psi_i	psi_j	omega_i_j	omega^e_j	IS	IS/AS
mtgox	-0.154301	0.000114	-0.000032	1.520455e-06	0.384279	-0.000021	0.000451	-0.000489	5.775265e-09	0.312975	0.814446
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bitfinex	-0.399637	0.000114	-0.000036	8.766151e-07	0.118996	0.000194	0.002210	-0.002208	2.047902e-05	0.321257	2.699736

Paper replication

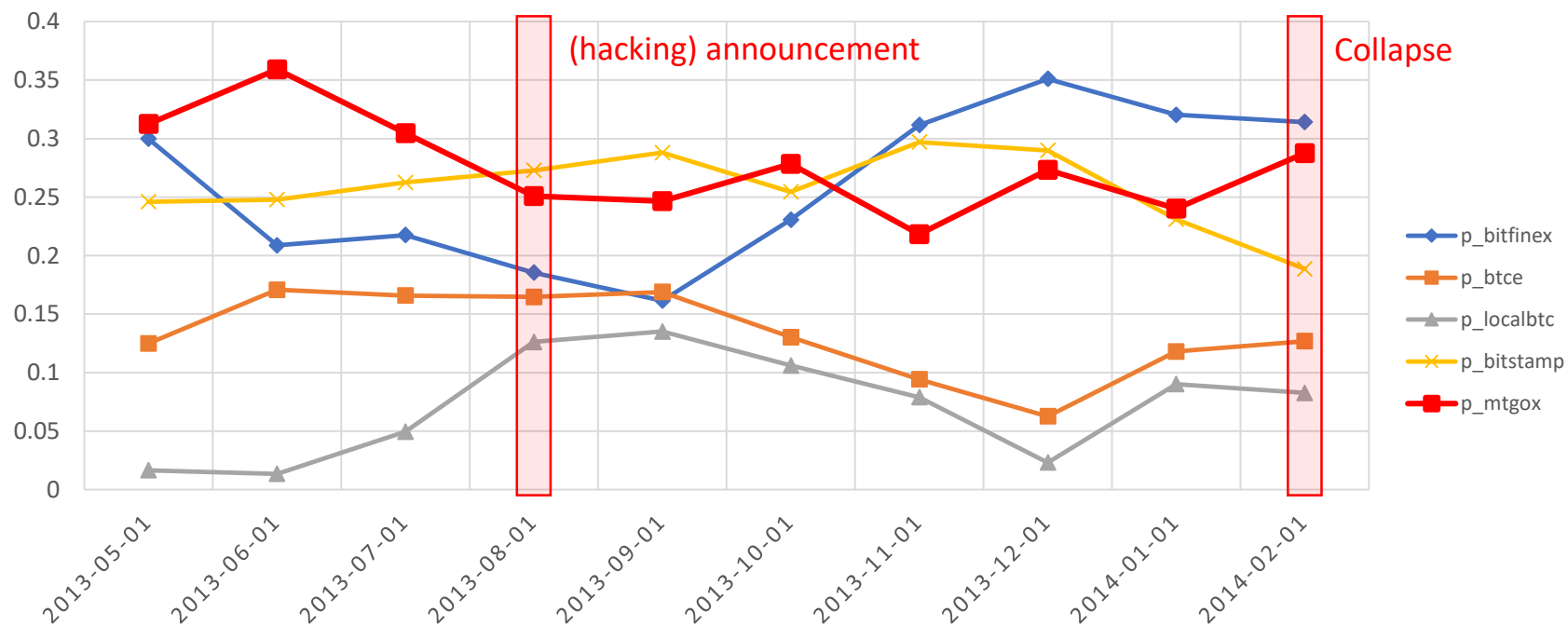
Result

- Took a look at the covariance between the fundamental price change and the idiosyncratic shocks, ψ_i , which forms the basis for the information share
- Mt.Gox and Bitfinex have the by far biggest information share, indicating that most information is generated/incorporated at these two exchanges.
- Bitfinex has relatively lower π_i , which represents the activity share(proportion of trading volume) of each exchange.

	rho_ii	sigma	gamma_i	gamma_j	pi	psi_i	psi_j	omega_i_j	omega^e_j	IS	IS/AS
mtgox	-0.154301	0.000114	-0.000032	1.520455e-06	0.384279	-0.000021	0.000451	-0.000489	5.775265e-09	0.312975	0.814446
btce	-0.105662	0.000114	-0.000033	-2.952613e-07	0.262009	-0.000031	0.000148	-0.000090	4.388730e-06	0.191527	0.730993
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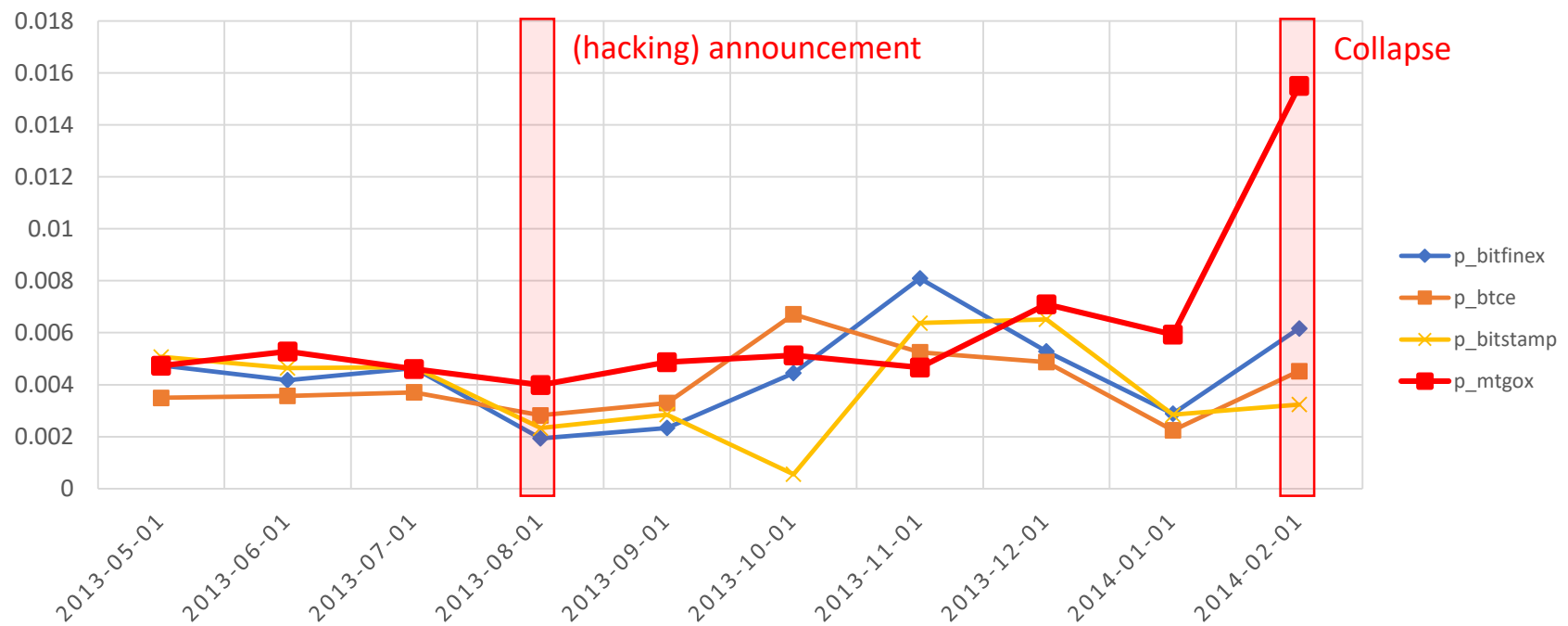
Mt. Gox (August, 2013)

Information share (2013.04 ~ 2014.02)



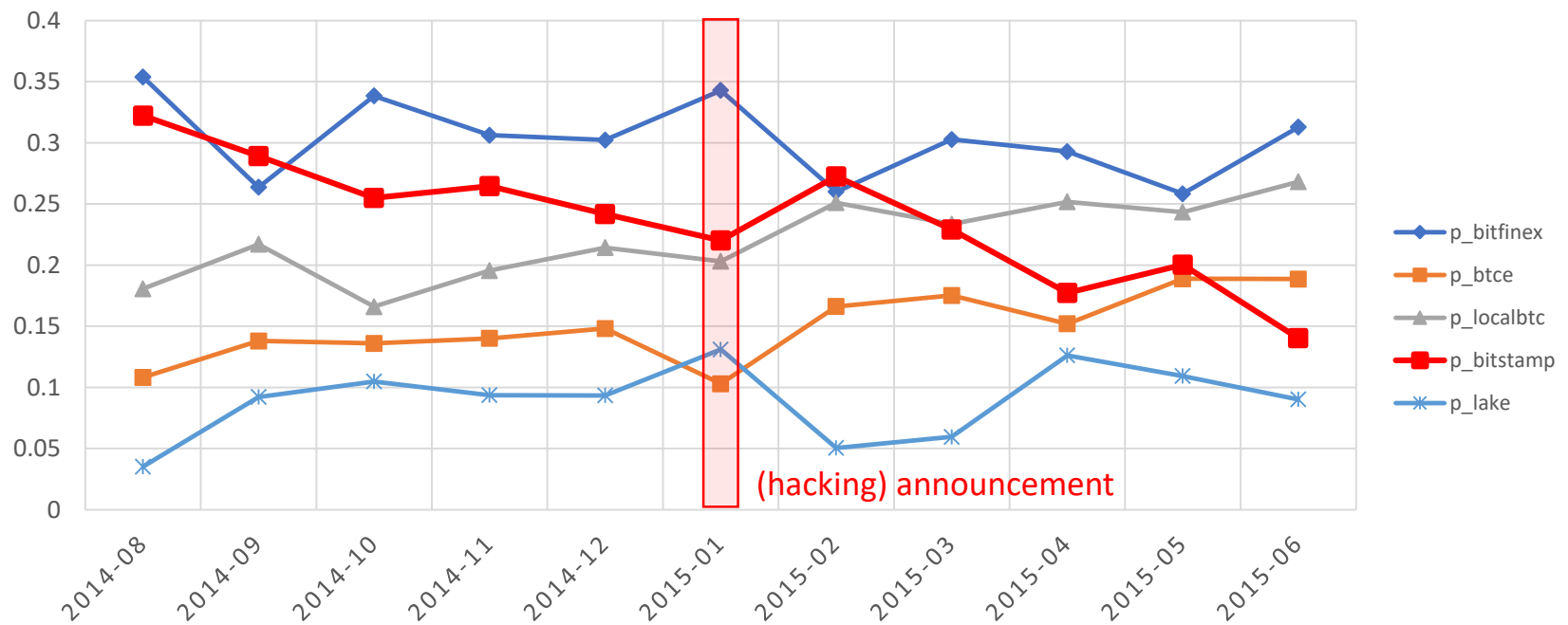
Mt. Gox (August, 2013)

Roll's measure (2013.04 ~2014.02)



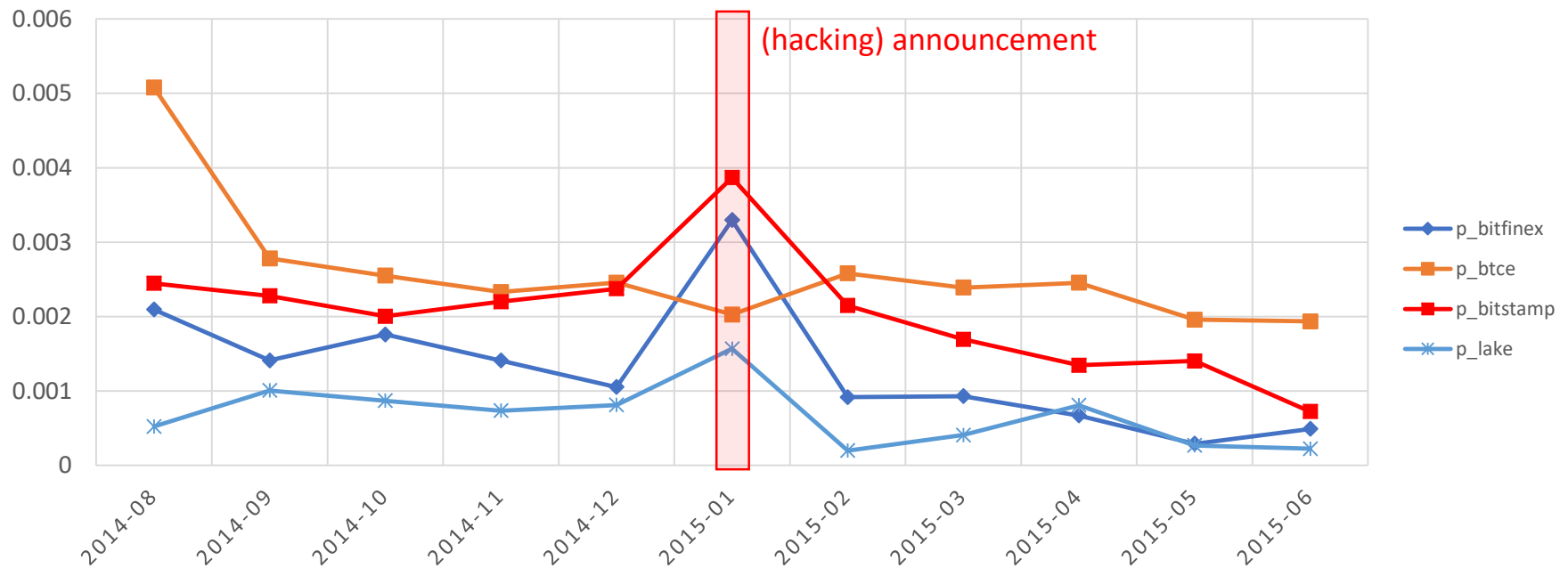
Bitstamp (Jan., 2015)

Information share (2014.08 ~ 2015.06)



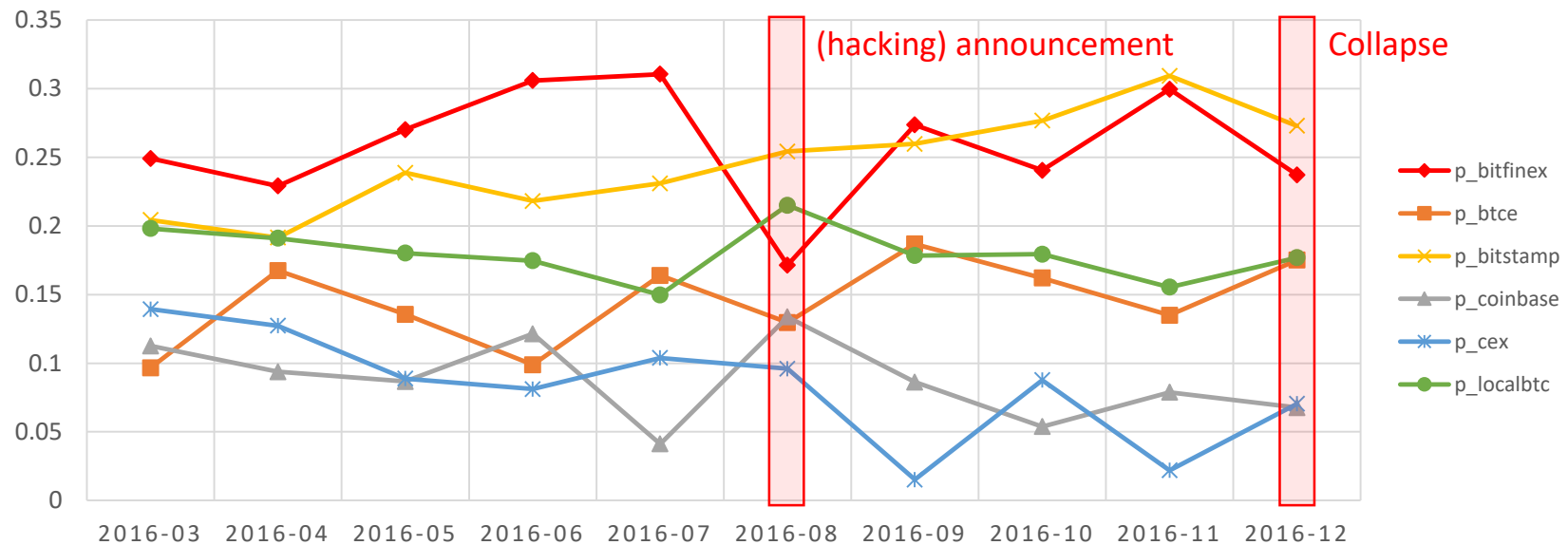
Bitstamp (Jan., 2015)

Roll's measure (2014.08 ~2015.06)



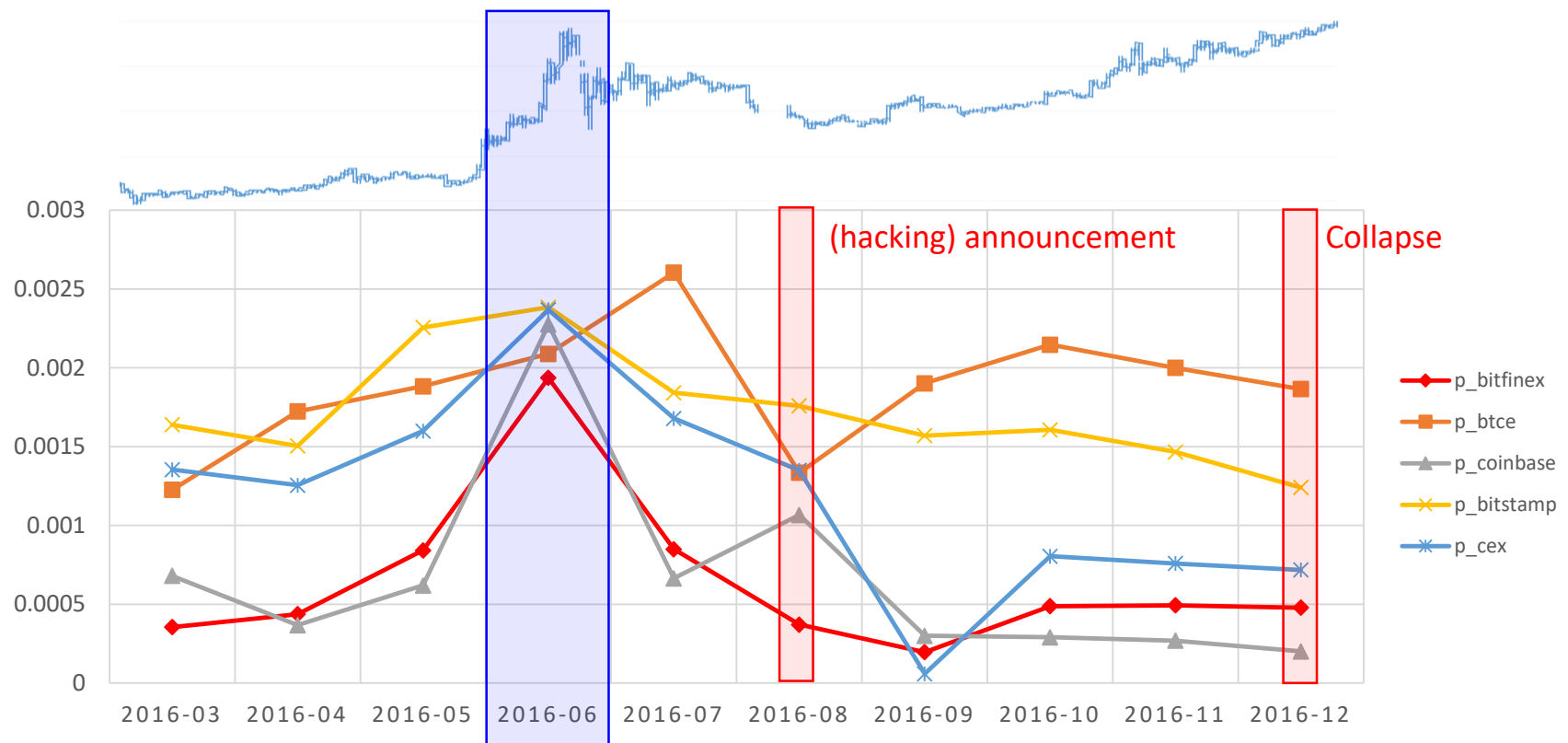
Bitfinex (August, 2016)

Information share (2016.02 ~ 2016.12)



Bitfinex (August, 2016)

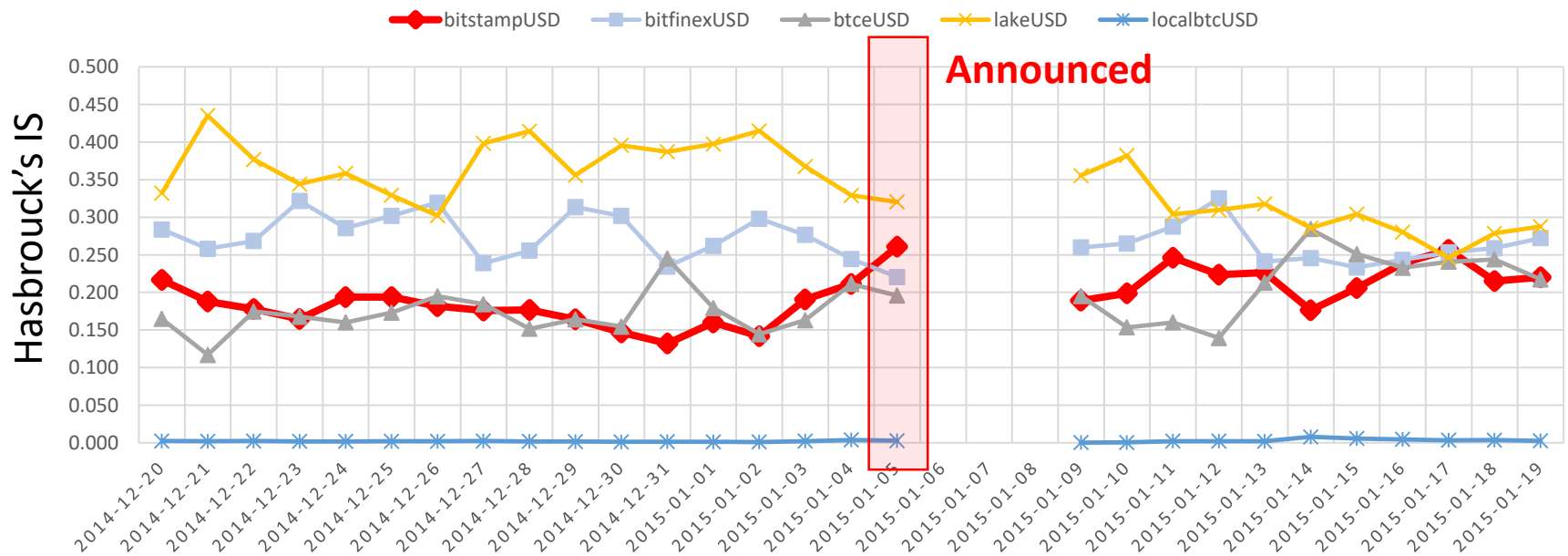
Roll's measure (2016.02 ~2016.12)



Bitstamp (Jan. 5. 2015)

2014.12.21 ~ 2015.01.19

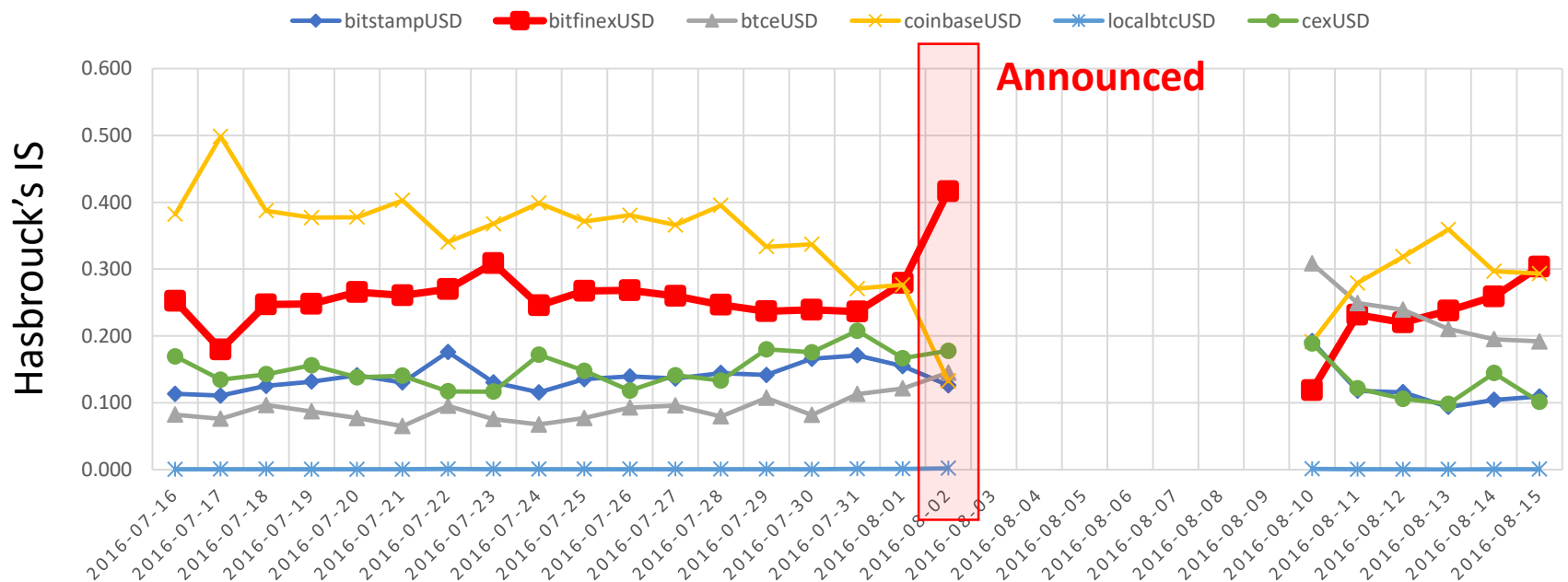
Exchange	Mean_Before	Mean_After	T-statistic	P-value
bitstampUSD	0.181	0.218	-3.347	0.003
bitfinex	0.276	0.262	1.172	0.252
btce	0.173	0.212	-2.773	0.010
lakebtc	0.368	0.305	4.309	0.0002
localbtc	0.002	0.003	-2.045	0.051



Bitfinex (August. 2. 2016)

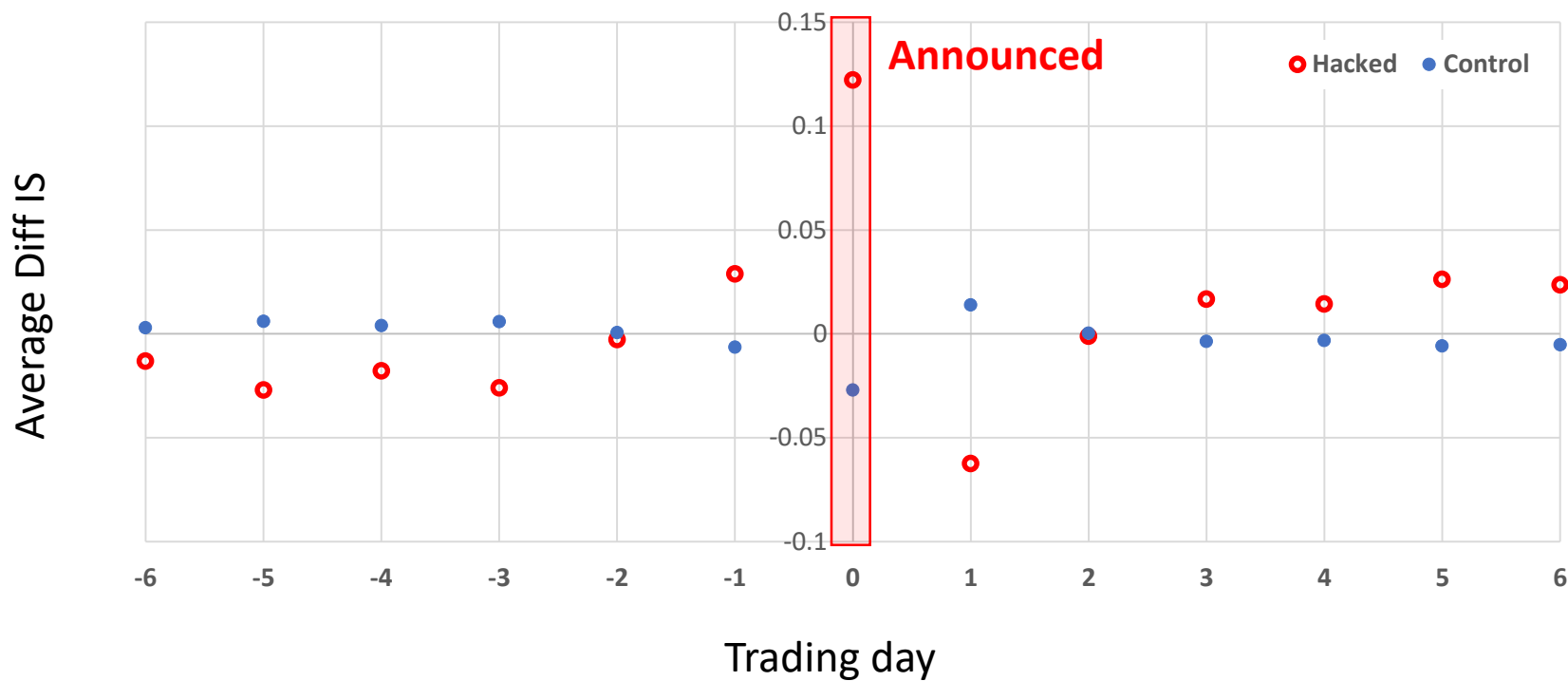
2016.07.16 ~ 2016.08.16

Exchange	Mean_Before	Mean_After	T-statistic	P-value
bitstamp	0.138	0.122	1.449	0.161
bitfinex	0.263	0.228	1.454	0.160
btce	0.091	0.232	-10.880	0.000
coinbase	0.355	0.290	1.970	0.062
localbtc	0.0007	0.0006	1.260	0.221
cex	0.152	0.127	1.930	0.067



Analysis

- Hacked : Bitfinex and Bitstamp + mtgox + coincheck+ yobit
- Baseline = -7 day
- Interval = -6 ~ +6 day
- Diff IS = IS – event day IS by exchanges



Causality

- Does the hacking issue affect the information share ?
- Other effects

Impact on information share and liquidity when exchange shut down and collapse

Lead-lag analysis

- which exchange is leader (follower)?