

Financial Regulations and Price Inconsistencies across Bitcoin Markets

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What is Bitcoin?

Bitcoin is a crypto-currency

- A digital currency with no physical form or issuing country.
- Difficult to restrict access to bitcoin exchanges (online only, no global regulatory system)

Nakamoto created 21 million bitcoins.

- Can be discovered by solving algorithms in a process called mining.
- Once mined, bitcoin can be repeatedly bought and sold. Used for
 - Investment
 - Purchases (Microsoft, Dell, Overstock, Amazon, etc.)
- Purchases occur on bitcoin exchanges using a variety of currencies.

Example of an Exchange: ANXBTC

BUY/SELL

Please enter the transaction amount below

Available Funds	
USD	0
BTC	0

BUY BTC SELL BTC

Amount

QUOTE PRICE

QUICK TIPS

Buying and selling Bitcoins is easy! Once you have your account set up, you can start buying or selling Bitcoins. More instructions are available at [ANXBTC](#)

BTC ▼

- BTC
- USD
- EUR
- GBP
- HKD
- CAD
- AUD
- SGD
- JPY
- NZD

Example of an Exchange: BTC-e

BTC-E | Bitcoin Exchange | x

https://btc-e.com

BTC/USD 321.521
BTC/RUR 67.23
BTC/EUR 308.678
LTC/BTC 0.00966
LTC/USD 3.092
LTC/RUR 206.91661
LTC/EUR 2.971
NMC/BTC 0.00118
NMC/USD 0.384
NMC/BTC 0.00273

USD/RUR 67.23
EUR/USD 1.04
EUR/RUR 69.78329
PPC/BTC 0.00116
PPC/USD 0.377

Buy BTC

Your balance: 0 USD
Lowest ask Price: 321.598 USD

Amount BTC:

Price per BTC: USD

Total: 0 USD

Fee: 0 BTC

Click to sum your order.

Sell BTC

Your balance: 0 BTC
Highest Bid Price: 321.521 USD

Amount BTC:

Price per BTC: USD

Total: 0 USD

Fee: 0 USD

Click to sum your order.

Sell orders

Total: 9819 BTC

price	BTC	USD
321.598	0.011052	3.55430109
321.636	0.01097802	3.52093644

Buy orders

Total: 4312725.77 USD

price	BTC	USD
321.521	0.49161947	158.06598361
321.341	0.01100033	3.56277773

baldpope: dan
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 baldpope: yea
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 angel148: oh
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Tweets

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Network issue in
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Motivation

- Presents a data source for a global price (in multiple currencies) with minimal regulatory or reporting distortions.
- No “official” price: Bitfinex is largest exchange (11%), Bitstamp is big+long time series, BPI is an index...

Author	Bitstamp	BTC-e	BitFinex	BTC China	Quandl (BPI)	OKCoin
Badev and Chen (2014)	X	X	X	X		X
Chu, Nadarajah, and Chan (2015)	X					
Fink and Johann (2014)	X	X	X	X		
Georgoula, Pournarakis, Bilanakos, Sotiropoulos, and Giaglis (2015)	X					
Hur, Jeon, and Yoo (2015)					X	
Lo and Wang (2014)	X					

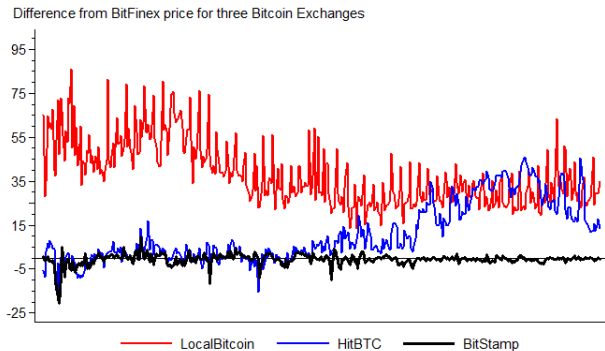
- Tempting to assume that bitcoin obeys (relative) LOP across all bitcoin markets:

$$p_t^{m1} = \beta p_c^{m2} + c$$

where $\beta = 1$

Questions and Results

- 1 Is relative LOP obeyed?
 - No.
 - Examining 12 exchanges, 26% of bitcoin trades



SOURCE: Author calculations, daily USD bitcoin price data between 1 June 2014 and 31 July 2015

Questions and Results

- 1 Why do prices deviate from bitcoin price trends?
 - Liquidity/Market Depth of the bitcoin exchange?
 - No
 - Fees?
 - No
 - Regulations?
 - **Yes**

Consequences: Results Depend on Source of data

Simple example: Measuring bitcoin volatility (30 day standard deviation/median)

	First	Last	Weighted	Low	High
S&P 500	—————1.3—————				
USD-EUR	—————1.4—————				
Gold	—————1.8—————				
BitFinex	6.37	6.37	6.32	6.60	6.29
BitStamp	6.33	6.34	6.27	6.61	6.18
BPI	6.40	6.40	—	6.60	6.27
itBit	6.27	6.29	6.24	6.45	6.16
BTC-e	6.22	6.28	6.13	6.38	6.14
The Rock Trading	6.22	6.38	5.99	6.27	6.51
HitBTC	6.08	6.09	5.87	6.20	6.09
LocalBitcoins	20.37	19.08	5.97	10.32	39.32

Consequences: Results Depend on Source of data

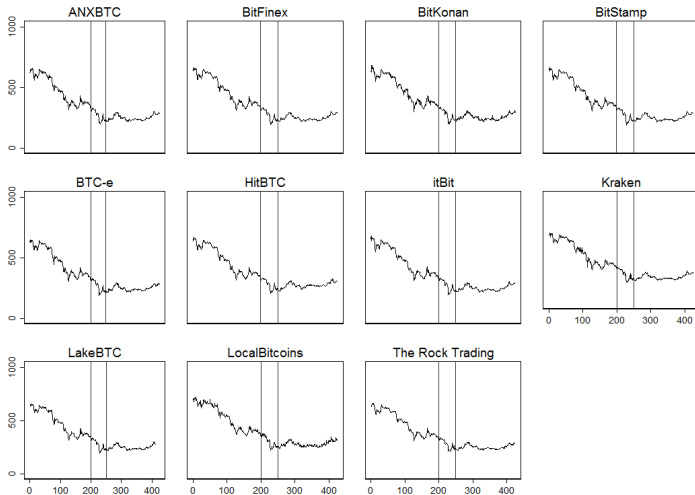
Simple example: Measuring bitcoin volatility

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BitFinex	6.37	6.37	6.32	6.60	6.29
BitStamp	6.33	6.34	6.27	6.61	6.18
BPI	6.40	6.40	—	6.60	6.27
itBit	6.27	6.29	6.24	6.45	6.16
Kraken	6.40	6.45	6.32	6.61	6.27
LakeBTC	6.27	6.28	6.17	6.42	6.18
BitKonan	6.32	6.93	6.49	7.08	6.98
BTC-e	6.22	6.28	6.13	6.38	6.14
The Rock Trading	6.22	6.38	5.99	6.27	6.51

Bitcoin Price Data

- Daily bitcoin price in USD from bitcoincharts.com
- June 1, 2014 - July 31, 2015 (426 observations)
- 12 exchanges
 - 26% of all bitcoin trade volume
- High, Low, Transaction-Weighted, Open, and Close prices
 - Bitcoin exchanges never close." Midnight-Midnight" measure.

Median Price...no obvious outliers



Methods

- Test for shared trend between m and Bitfinex using Johansen Cointegration Test
- If shared trend, estimate VECM, $\mathbf{P}_t = [p_t^m, r_t]$:

$$\Delta \mathbf{P}_t = \alpha \Pi' \mathbf{P}_{t-1} + \sum_{i=1}^{\ell-1} \Gamma_i \Delta \mathbf{P}_{t-i} + \gamma + \epsilon_t \quad (1)$$

where $\Delta \mathbf{P}_t = \mathbf{P}_t - \mathbf{P}_{t-1}$

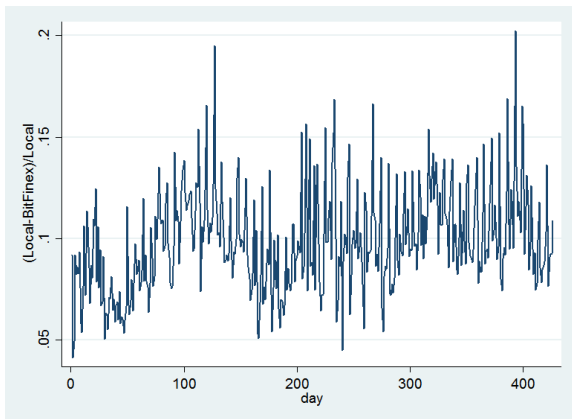
- Long-run relationship between the two price series is captured in the coefficient $\Pi = [1, -\beta]$
 - Relative Law of One Price (LOOP): $\beta = 1$

Failure of Cointegration=Failure of LOOP

	ANX	BitK	BitS	BTC-e	Coin	HitBit	itBit	Kraken	Lake	Local	Rock
<i>Cointegrated with BitFinex?</i>											
Open	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
Close	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
Weighted	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
Low	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
High	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y

Abbreviations: ANX, ANXBTC; BitK, BitKonan; BitS, BitStamp;
Local, LocalBitcoin; LOP, relative law of one price; Rock, The Rock Trading.

Percent change: not stationary



Relevant Technical Details (Very broadly described)

"Bitcoin transactions are more private but less anonymous than cash transactions."

- 1 Private: Can trade with anyone, anywhere, with no regulations
- 2 Anonymous:
 - A bitcoin has a publically visible "blockchain"—a digital ledger.
 - "User xyz sold this bitcoin to User abc who sold this bitcoin to User mpq", etc
 - Anonymity only results if "User xyz" cannot be linked to an individual's identity. Once the link is made, every transaction containing "User xyz" in the blockchain can be linked to the individual.
 - Anonymity requires that the exchange not collect documentation.
- 3 If an exchange enforces AML (Anti-Money Laundering) or KYC (Know your customer) it requires proof of identity (passport photo, etc.) ⇒ no longer anonymous.

Anonymity versus Proof of Ownership

- 1 Criminal use of bitcoin (anonymity and privacy)
 - Wilson and Yelowitz (2015): Google trend data show significant criminal interest in bitcoin
 - Marketplaces such as Silk Road accept payments only in bitcoin
 - 2016: Hollywood hospital computer system taken ransom. Hackers required \$17,000 ransom paid in bitcoin.
- 2 Bitcoin transactions cannot be reversed or canceled. Lack of records makes it difficult to prove that bitcoin was NOT acquired in a transaction
 - Early solution: “Holding pens” for transactions
- 3 Exchanges can disappear
 - Early solution: “Legitimate” users trade on large exchanges
- 4 Early solutions do not reduce user anonymity

Characteristics of Selected Bitcoin Exchanges

Name	Fees			Exchange Transparency			Regulations	
	Trading	Deposit [†]	Withdrawal [†]	Incorp.	Physical	Server	AML/KYC	ID required at
ANXBTC	Free	Free	\$30	Hong Kong	Hong Kong	Hong Kong	Yes	Funding
	<i>Offers a debit card. A fully centralized service: upon indicating a quantity to buy/sell, users receive a 30-second "take-it-or-leave-it" price offer. Also accepts EUR, GBP, CHF, CAD, AUD, YEN, HKD, NZD, and SGD.</i>							
BitFinex	0.00%-0.20%	\$20	\$20	British Virgin Islands	UK	Italy	Yes	W-USD
	<i>Advertising a job opening at London office. Claims offices in New York, Hong Kong and Taiwan. Included in BPI. Free Bitcoin deposit</i>							
BitKonan	0.29%	\$15	\$15	Croatia	Croatia	Netherlands	Yes	None
	<i>Accepts deposits in multiple currencies, but automatically converts into USD.</i>							
BitStamp	0.10%-0.25%	\$7.50	\$15	UK	UK, USA, Luxembourg	(?)	Yes	Funding
	<i>Offers a debit card. Included in the CoinDesk BPI. Hacked during sample period. Also accepts EUR, GBP.</i>							
BTC-e	0.20%	\$0-\$60	\$0-\$60	Cyprus	(?)	(?)	Yes	None
	<i>Included in the CoinDesk BPI. Known for an active message board displayed alongside the buy/sell window. Fees may vary by user. Also accepts EUR, RUR.</i>							
HitBTC	0.10%	\$9	\$9	(?)	(?)	(?)	Yes (Tiered)	W-USD
	<i>No countries are referenced in the Terms of Service Agreement. Also accepts EUR.</i>							
itBit	0.10%-0.50%	\$10	\$20	USA	USA	USA	Yes	Funding
	<i>Board of directors includes former FDIC chairman, Sheila Bair. Also accepts EUR, SGD.</i>							
Kraken	0.10%-0.35%	\$20	\$20	USA	USA	(?)	Yes	Funding
	<i>Also accepts EUR, GBP, JPY. May not allow off-chain transactions.</i>							
LakeBTC	0.00%-0.20%	Free	\$6-\$8	(?)	China	(?)	Yes	None
	<i>Terms of Service Agreement refers to USA, Sweden and the UK. Also accepts CNY, SEK.</i>							
LocalBitcoins	0.00%-1.00%	N/A	N/A	Finland	Finland	(?)	No	None
	<i>Acts as a message board and bitcoin wallet to facilitate peer-to-peer trades. Allows prices to be posted in any currency or commodity (gold, etc.), but only accepts bitcoin deposits into wallets. Has a fee to deposit bitcoin. Database hacked during sample period.</i>							
The Rock Trading	0.075%-0.50%	Free	€11	Malta	Malta	(?)	Yes (Tiered)	W-USD
	<i>Also accepts EUR, GBP</i>							

Abbreviations: AML, anti-money laundering; Incorp., country of incorporation; KYC, know-your-client/customer; Tiered: Has tiered KYC compliance

[†]: The fee for a transfer of US\$1,000 via bank wire either into (deposit) or out of (withdrawal) the exchange.

Cointegration and Exchange Properties

	Exchanges with LOOP				Weak LOOP Fail		Strong LOOP Fail		Consistent LOOP Fail	
	ANX	BitS	itBit	Kraken	BitK	Lake	BTC-e	Rock	HitBTC	Local
<i>Exchange Transparency</i>										
Known incorporation?	1	1	1	1	1	0	1	1	0	1
Known physical address?	1	1	1	1	1	1	0	1	0	1
Known server location?	1	1	1	0	1	0	0	0	0	0
USA location?	0	1	1	1	0	0	0	0	0	0
<i>Regulation Compliance</i>										
Stated AML/KYC?	1	1	1	1	1	1	1	1	1	0
ID for Funding	1	1	1	1	0	0	0	0	0	0
ID for W-Currency	1	1	1	1	0	0	0	1	1	–
<i>Fees</i>										
Free Fiat Deposit	1	0	0	0	0	1	0	1	0	–
Free Bitcoin Deposit	1	1	1	1	1	1	1	1	1	0
Fixed Trading Fee	1	0	0	0	1	0	1	0	1	0
Free Trades Feasible	1	0	0	0	0	1	0	0	0	1
<i>Share of Global Transactions</i>										
High (> 4%)	0	1	0	0	0	0	1	0	0	0
Low (\approx 0%) (etc.)	0	0	0	1	1	0	0	1	0	0

Fees, liquidity effect level of prices, even for LOOP exchanges

	First		Last		Weighted		High		Low	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
ID to Fund	-1.38***	-1.92***	-1.34***	-1.79***	-1.22***	-1.53***	-1.64***	-2.27***	-1.16***	-1.53***
ID to Fund x Low Share		1.50***		1.50***		0.98***		1.25***		1.18***
Low Global Share		-0.40***		-0.23**		-0.32***		-0.57***		-0.32***
Fixed Cost to Trade		-0.12*		0.05		0.01		-0.83***		0.09
Free Trade Feasible		0.83***		0.82***		0.78***		1.86***		0.99***
Trade Volume		-0.33***		-0.39***		-0.58***		-0.74***		-0.33**
Volume x Low Share		-167.55***		-248.08***		-159.61***		-160.24***		-227.45***
Volume x Fixed Cost		-1.02***		-1.07***		-0.73***		-0.74***		-1.07***
Volume x Free Trade		-3.06***		-2.56***		-2.47***		-5.07***		-2.72***
Constant	-4.15***	-3.87***	-4.13***	-3.99***	-4.17***	-3.99***	-3.55***	-3.03***	-4.10***	-4.01***
Date fixed effect?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R^2	0.15	0.25	0.15	0.25	0.15	0.24	0.09	0.30	0.13	0.24
N	4243	4243	4243	4243	4238	4238	4241	4241	4233	4233

Significance: ***1%, **5%, *10% .

Conclusion

- Prices on bitcoin exchanges are not necessarily cointegrated with each other
 - Must use caution when selecting and/or combining data from multiple sources
- Deviations can be explained by the extent of regulations on exchange