The Impact of Derivatives on Cash Markets: Evidence from the Introduction of Bitcoin Futures Contracts

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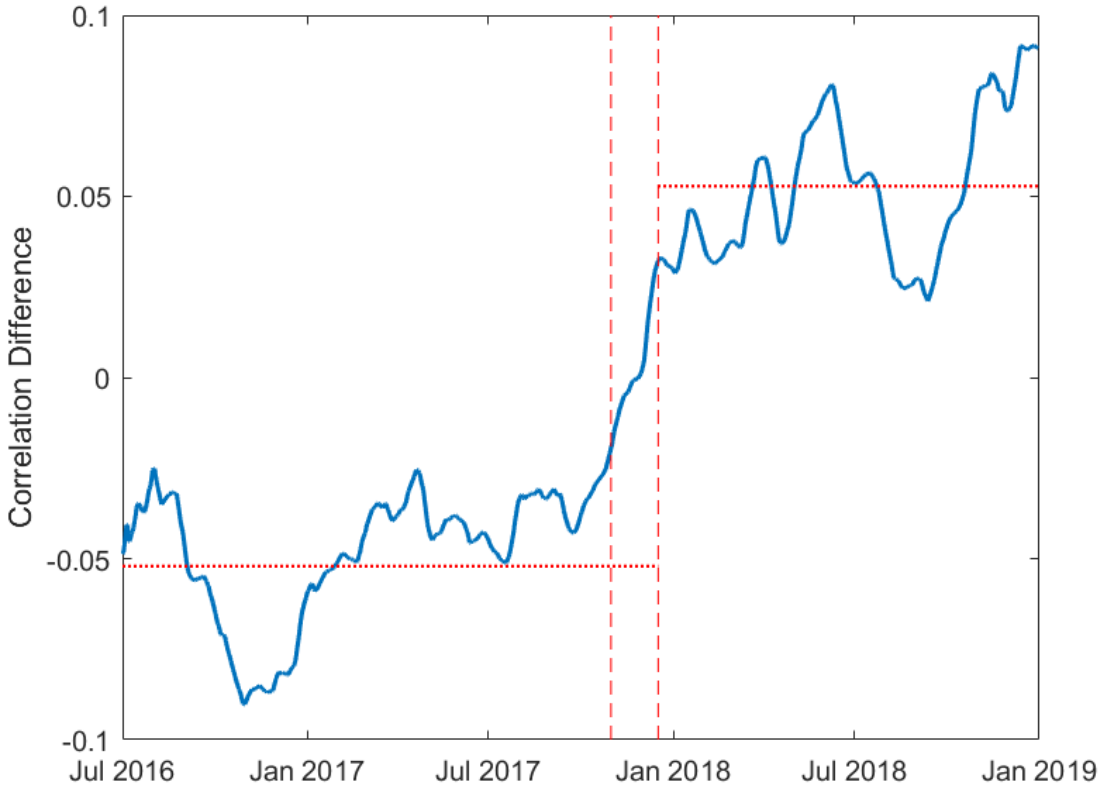
This Paper

- How does the introduction of derivatives impact spot markets?
  - Without "frictions," derivatives are redundant
  - With "frictions," depends on whether derivatives are complements or substitutes
- Extensive debate in the literature that is far from settled.
  - Conflicting evidence from various asset classes and sample periods
- Introduction of bitcoin futures by CBOE & CME in December 2017
  - Cryptocurrencies provide a unique setting to shed new light on the old question.
  - Studying the impact of regulated crypto derivatives on crypto cash markets is important in light of growing (unregulated) crypto derivatives markets.

Motivating Evidence from Bitcoin Futures Introduction



- Bitcoin is traded on multiple exchanges with multiple fiat currencies.
  - Significant price dispersion across exchanges (Makarov and Schoar, 2020)
- Correlation of returns of BTC-USD - Correlation of returns of BTC-CCY (CCY: fiat currencies excluding USD).
- Following futures introduction, BTC–USD more "efficient" than BTC-CCY.

Roadmap

1. Why is this event (the introduction of bitcoin futures) unique and useful?

2. Broader importance of the question in current context

3. Analysis
   - 3.1 Hypothesis and Identification
   - 3.2 Measuring market characteristics
   - 3.3 Data
   - 3.4 Results
   - 3.5 Refinements
   - 3.6 Robustness

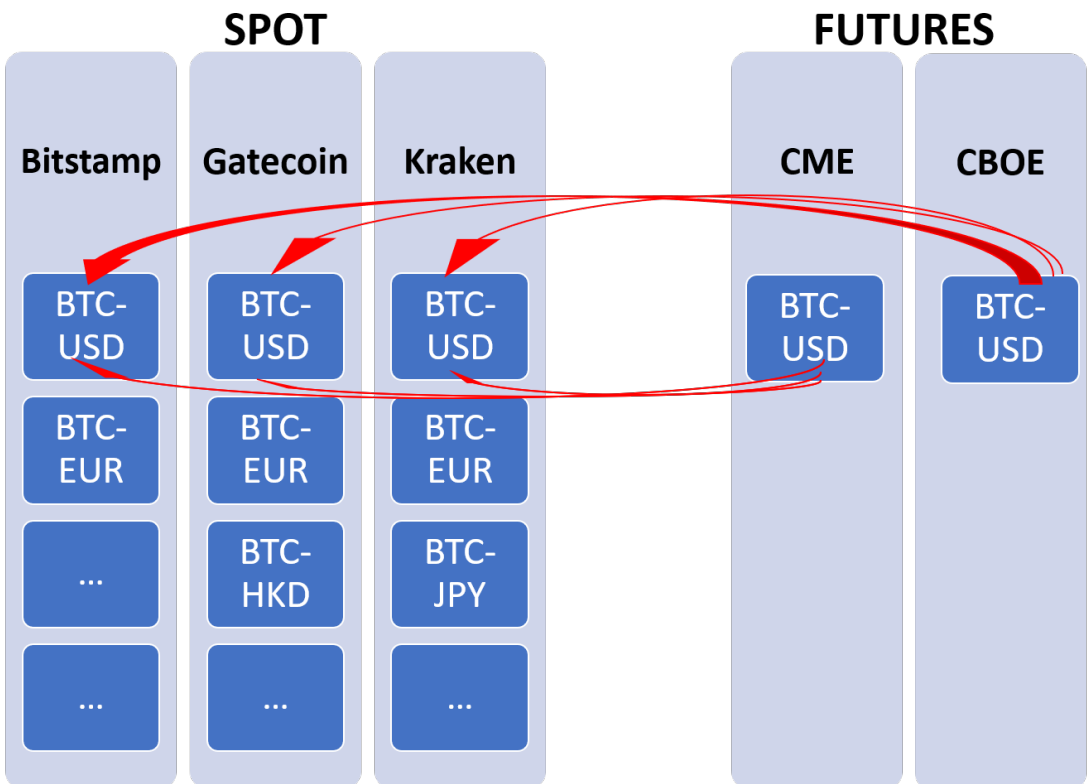
4. Conclusion

(1) Unique Cryptocurrency Trading Infrastructure

- Identical cryptocurrencies trade on multiple cryptocurrency exchanges
- Cryptocurrencies are fully fungible across trading venues
  - For example, investors who are trading bitcoins in an exchange in the U.S. can send them to an exchange in another country and sell them there.
- Rare features even in closely related markets
  - e.g. ADRs, Gagnon and Karolyi (2010)

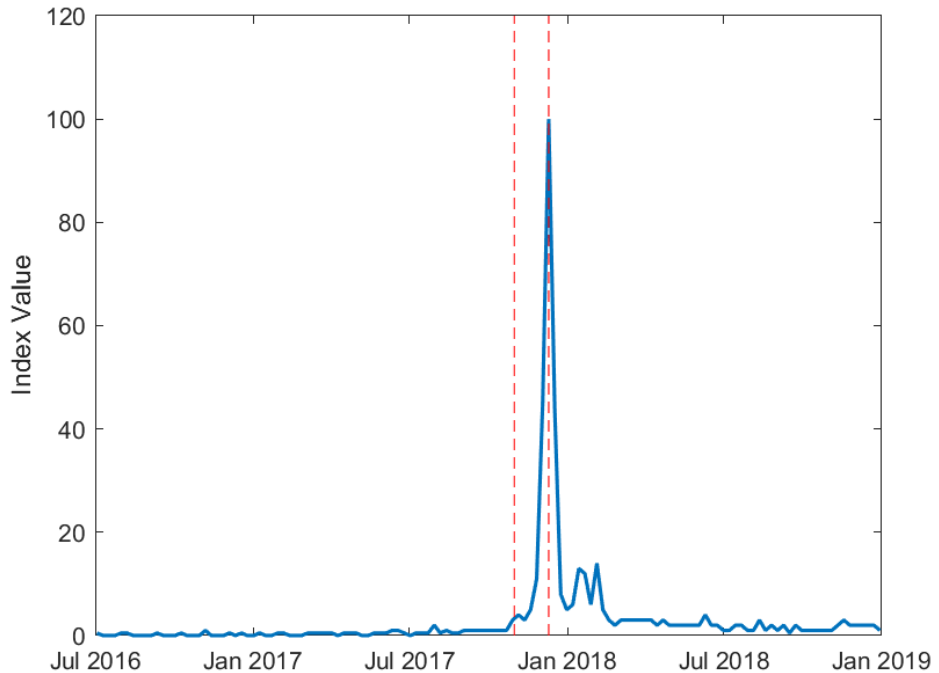
(2) Selective Futures Introduction on BTC–USD

- CBOE and CME introduced futures only on BTC–USD
- No futures on other BTC-CCY exchange rate pairs (e.g., BTC–EUR)
- Exploit both across-/within-exchange variation of BTC attributes while keeping exchange/currency characteristics constant.



(3) Largely Unanticipated

- CME announced BTC–USD futures on 31 Oct. 2017 (introduction on 17 Dec.)
- CBOE launched BTC–USD futures on 10 Dec. 2017
- Google search volume index for a keyword, "bitcoin futures."



- Overall, this unique setting allows us to identify the impact of the introduction of futures in a DiD setup.

Why does it matter?

- Regulatory debates about the benefits and detrimental effects of crypto derivatives and crypto products
  - Opposing views by regulators
    - Former CFTC chairman C. Giancarlo: "Regulators allowed the launch of BTC futures because it would pop the bitcoin bubble and make prices better reflect fundamental values."
  - Yellen calls bitcoin 'inefficient' (NYT Dealbook, 21 Feb 2021)
  - Canada's financial regulator approved its first Bitcoin ETF in Feb 2021.
  - CBOE officially filed with SEC to list shares of VanEck's bitcoin ETF (Mar 2021)
  - SEC consistently denies proposals for bitcoin ETFs until Oct 2021.

Why does it matter?

October 19, 2021
6:02 PM EDT
Last Updated 23 days ago

Future of Money

U.S. futures-based bitcoin ETF rises in first day of trading, bitcoin nears record

2 minute read

By John Mccrank

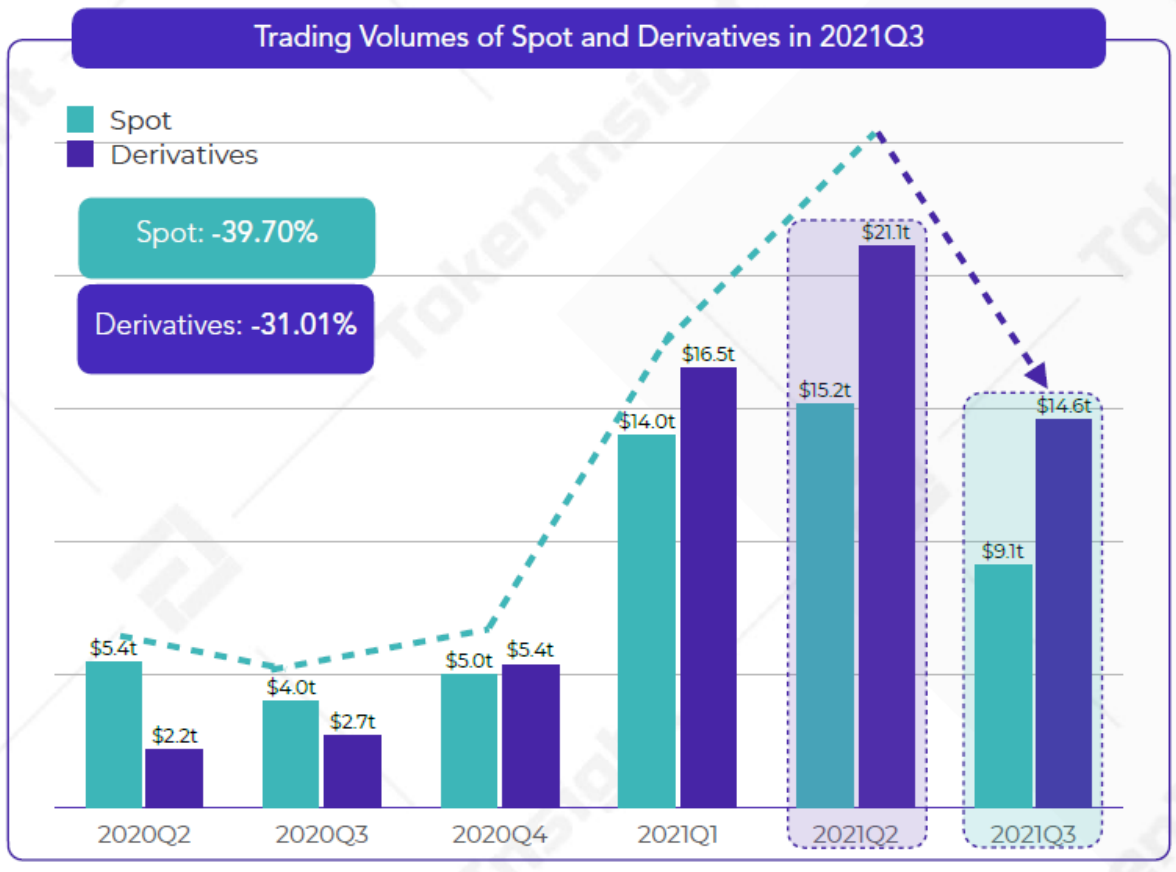
- SEC finally approved Bitcoin futures-based ETF of ProShares (BITO) in Oct 2021.
  - SEC Chair Gary Gensler signaling in early August he's open to approving Bitcoin futures ETFs (rather than physical Bitcoin-based ETFs) because of a potential spot market manipulation.
  - The recent approval of Bitcoin futures-based ETF calls for a better understanding of the impact of Bitcoin futures market on spot market.

Rapid Growth of Crypto Derivatives

- Growth of regulated crypto-derivatives
  - Many institutions not allowed to hold Bitcoin physically: Open Interest for Bitcoin futures on the CME exchange, increased by 116.1% from Feb 2020 to Feb 2021.
  - Options on bitcoin futures (CME, Jan 2020), Ethereum futures (CME, Feb 2021), Micro bitcoin futures (CME, May 2021)
  - Recent approval of Bitcoin futures-based ETF (Oct 2021)

Rapid Growth of Crypto Derivatives

- Growth of unregulated crypto-derivatives
  - Many cryptocurrency exchanges started to offer various types of derivatives contracts in their own exchanges.
  - The size of the unregulated crypto-derivatives market has increased dramatically.
  - $21.1 trillion crypto derivatives trading volume in 2021Q2 surpassing spot trading volume ($15.2 trillion).



Development of Hypotheses and Analysis

- Measure market characteristics of bitcoin spot markets (e.g., BTC–USD, BTC–EUR) using the past three month data at the end of each month.

$$Characteristic_{i,j,t} \in \{Synchronicity,\ Volatility,\ Efficiency,\ Quality,\ Liquidity\}$$

Follow literature for measuring market characteristics.

- Impact of futures introduction on BTC–USD relative to BTC–CCY?

$$Characteristic_{i,j,t} = \alpha_0 + \alpha_1 Treatment_{BTC-USD} \times Post_{futures} + \delta_i + \eta_j + \gamma_t + \varepsilon_{i,j,t}$$

  - fiat i
  - exchange (or Pair) j
  - month t

- In most saturated specifications, exploit within-exchange variation using $\eta_j \times \gamma_t$

Data

- Merge Kaiko and CryptoCompare
- July 1, 2016 and December 31, 2018
- 22 exchanges
  - Bitfinex, bitFlyer, Bitstamp, Bittrex, BTCbox, BTCC, BTC–e, Cex.io, Coinbase, Exmo, Gatecoin, Gemini, HitBTC, itBit, Kraken, LakeBTC, Liquid, OKCoin, Poloniex, QuadrigaCX, Quoine, and Zaif
- 10 bitcoin-fiat currency exchange rate pairs
  - BTC–USD vs. BTC–EUR, BTC–GBP, BTC–HKD, BTC–SGD, BTC–JPY, BTC–AUD, BTC–IDR, BTC–CAD, BTC–RUB
- 46 bitcoin-fiat currency-exchange pairs.

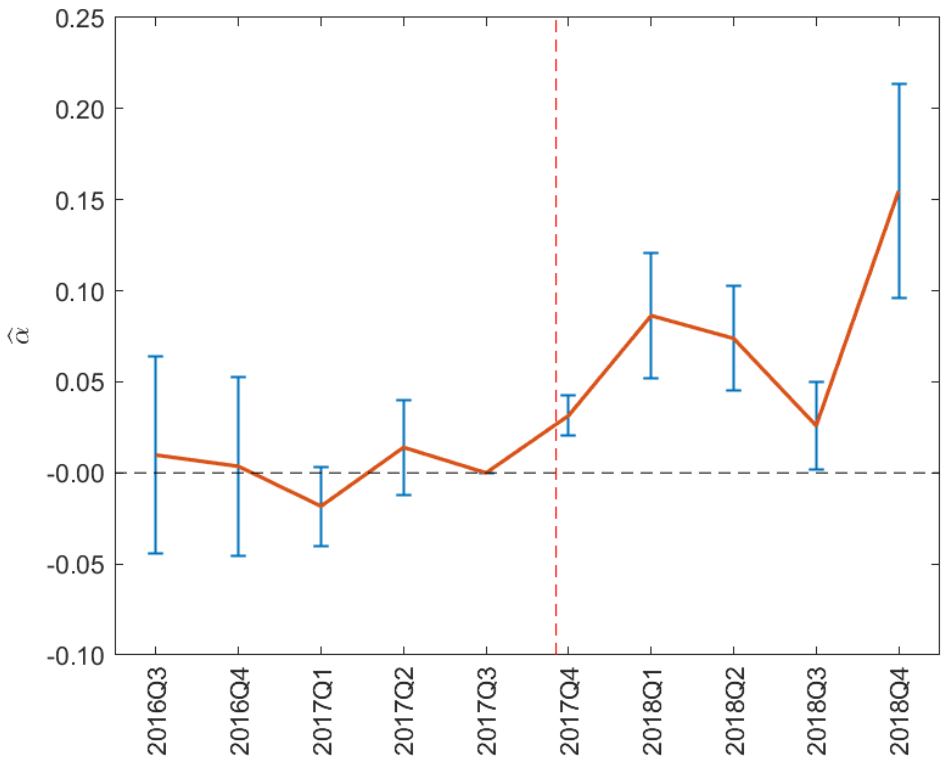
Differences-in-Differences Results - Price Synchronicity/Correlations

Panel A: Synchronicity ρ	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment	-0.053***	-0.001	-0.054***						
	(0.012)	(0.011)	(0.012)						
Post	-0.073***	-0.054***		-0.070***					
	(0.020)	(0.019)		(0.019)					
Treatment×Post	0.121***	0.110***	0.121***	0.119***	0.109***	0.050***	0.144***	0.050***	0.073***
	(0.019)	(0.017)	(0.019)	(0.018)	(0.017)	(0.010)	(0.022)	(0.017)	(0.018)
N	4310	4310	4310	4310	4310	1586	3906	3606	1056
adj. R^2	0.030	0.370	0.081	0.054	0.437	0.812	0.440	0.456	0.510
Control	ALL	ALL	ALL	ALL	ALL	ALL	EUR	CCY*	X-M
Xchange-Pair FE		✓			✓		✓	✓	✓
Month FE			✓		✓		✓	✓	✓
Ccy FE				✓	✓	✓	✓	✓	✓
Xchange-Pair×Month FE						✓			

- Std. dev of ρ of BTC-USD is 0.18.

Differences-in-Differences Results - Price Synchronicity/Correlations

$$\rho_{i,j,t} = \alpha_0 + \sum_{t \neq -1} \alpha_t \, Treatment_{BTC-USD} \times Post_t + \delta_i + \eta_j + \gamma_t + \varepsilon_t$$



Differences-in-Differences Results

	Volatility (σ)		Market quality (q)		Price Efficiency (D1)		Liquidity (λ)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treatment_Post	-0.039**	-0.026*	0.036***	0.030**	-0.072**	-0.035**	-0.347**	-0.170**
	(0.017)	(0.015)	(0.012)	(0.012)	(0.031)	(0.013)	(0.153)	(0.080)
N	920	683	920	683	573	374	920	683
adj. R^2	0.827	0.839	0.539	0.589	0.663	0.792	0.749	0.847
std. dev.	0.22		0.076		0.22		0.641	
Control	ALL	ALL	ALL	ALL	EUR	EUR	ALL	ALL
Xchange FE	✓		✓		✓			
Month FE	✓		✓		✓		✓	
Ccy FE	✓	✓	✓	✓	✓	✓		
Xchange ×Month FE		✓		✓		✓		✓
Xchange ×Ccy FE							✓	✓

- Volatility decreases, market quality, price efficiency, and liquidity increase more for BTC-USD relative to BTC-CCY after the introduction of BTC futures.
- Magnitude is economically significant: 10-50% of std. dev.

Refinement - 4:00 p.m. Settlement Prices

- CME bitcoin futures cash settled using CME CF bitcoin reference rate (BRR) determined at 4:00 p.m. London time (itBit, Kraken, BitStamp, and GDAX)
- CBOE bitcoin futures cash settled using USD auction price for bitcoin determined at 4:00 p.m. Eastern time (Gemini).

Refinement - 4:00 p.m. Settlement Prices

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Market quality q, BTC−USD vs. BTC−CCY						
	End-of-day prices			*Settlement prices*		
Treatment×Post	-0.001	-0.003	-0.003	0.028*	0.023*	0.012
	(0.016)	(0.007)	(0.007)	(0.016)	(0.012)	(0.011)
N	232	232	210	232	232	210
adj. R^2	0.037	0.788	0.739	0.045	0.423	0.440
Control	ALL	ALL	ALL	ALL	ALL	ALL
Xchange FE		✓			✓	
Month FE		✓			✓	
Ccy FE		✓	✓		✓	✓
Xchange×Month FE			✓			✓
Panel B: Liquidity λ, BTC−USD vs. BTC−CCY						
	End-of-day prices			*Settlement prices*		
Treatment×Post	-0.288**	-0.275***	-0.216***	-0.556***	-0.519***	-0.369***
	(0.139)	(0.063)	(0.064)	(0.181)	(0.108)	(0.103)
N	232	232	210	232	232	210
adj. R^2	0.363	0.857	0.844	0.296	0.723	0.691
Control	ALL	ALL	ALL	ALL	ALL	ALL
Month FE		✓			✓	
Xchange×Ccy FE		✓	✓		✓	✓
Xchange×Month FE			✓			✓

- The effect is stronger with returns measured at the settlement time.
- Bitcoin price is likely more informative at the settlement time.

Channels - Liquidity and Attention

Panel A: Synchronicity ρ	(1)	(2)	(3)	(4)	(5)	(6)
Treatment×Post×High Attention	0.059	0.069*	0.055	0.060	0.066	0.012
	(0.044)	(0.042)	(0.044)	(0.043)	(0.041)	(0.017)
N	4310	4310	4310	4310	4310	1586
adj. R^2	0.039	0.376	0.089	0.061	0.444	0.813
Panel B: Synchronicity ρ	(1)	(2)	(3)	(4)	(5)	(6)
Treatment×Post×High Liquidity	-0.130***	-0.118***	-0.127***	-0.129***	-0.120***	-0.053***
	(0.022)	(0.021)	(0.022)	(0.022)	(0.021)	(0.010)
N	4310	4310	4310	4310	4310	1586
adj. R^2	0.086	0.373	0.136	0.099	0.441	0.813
Control	ALL	ALL	ALL	ALL	ALL	ALL
Xchange-Pair FE		✓			✓	
Month FE			✓		✓	
Ccy FE				✓	✓	✓
Xchange-Pair×Month FE						✓

- No attention channel.
- Exchanges where liquidity was already high in the pre period had higher price synchronicity before the futures introduction.
- Qualitatively similar results for price efficiency, market quality, and liquidity.

Triangular Arbitrage

- Triangular arbitrage with fiat FX challenging (BTC–USD, BTC–EUR, USD–EUR)
  - "customers from different countries can only trade cryptocurrencies on their local exchange and in their local currency" (Makarov and Schoar 2020; Dyhrberg 2021)
  - USD–EUR not tradable on crypto exchanges
- Triangular arbitrage without fiat FX easier (e.g., BTC–USD, BTC–ETH, ETH–USD)

	(1)	(2)	(3)	(4)
	BTC–USD vs ETH–USD		ETH–USD vs ETH–CCY	
	Synchronicity ρ			
Treatment×Post	0.068***	-0.006	-0.088	0.003
	(0.016)	(0.007)	(0.113)	(0.035)
N	3778	1376	777	60
adj. R^2	0.471	0.867	0.399	0.838
Xchange-Pair FE	✓		✓	
Month FE	✓		✓	
Ccy FE	✓	✓	✓	✓
Xchange-Pair×Month FE		✓		✓

- Bitcoin vs. USD effect: ETH–USD vs. ETH–CCY

Introduction of Ethereum Futures (Preliminary Results)

- CME announced the launch of Ethereum futures on December 16, 2020. (introduction on Feburary 8, 2021)
- Data: CryptoCompare
- Pre: September 16, 2020 - December 15, 2020
- Post: Feburary 8, 2021 - May 8, 2021

Panel A: Synchronicity (ρ)	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	-0.044***	-0.004	-0.044***			
	(0.009)	(0.005)	(0.009)			
Post	0.004	0.003		0.003		
	(0.002)	(0.002)		(0.002)		
Treatment×Post	0.055***	0.019***	0.055***	0.055***	0.019***	0.016**
	(0.008)	(0.004)	(0.008)	(0.008)	(0.004)	(0.006)
N	3172	3172	3172	3172	3172	1491
adj. R^2	0.059	0.678	0.073	0.065	0.700	0.233
Control	ALL	ALL	ALL	ALL	ALL	ALL
Xchange-Pair FE		✓			✓	
Month FE			✓		✓	
Ccy FE				✓	✓	✓
Xchange-Pair×Month FE						✓

Robustness

- Change data window for construction of market characteristics: 1m vs. 3m
- Change frequency of data for construction of market characteristics: daily vs. monthly, different window lengths (30 and 90 days)
- Different sample windows (e.g., excluding vs. including anticipation period)
- Alternative standard error corrections
- Results for individual liquidity metrics rather than aggregate liquidity factor
- Examine differences for manipulated and non-manipulated exchanges
- Placebo test using hypothetical dates of introduction of BTC futures

Conclusion

- Cryptocurrencies provide unique opportunity to shed new light on a long standing question.

- Do derivatives increase the "efficiency" of spot markets?
  - Yes, they do!, based on the impact on price synchronicity, volatility, price efficiency, market quality, and liquidity.

- Future work
  - External validity
  - Channels
  - Introduction of unregulated crypto derivatives.

Measuring Market Characteristics

- Price synchronicity and integration (Kapadia and Pu 2012)

$$\rho_{i,j/j',t} = cov\left(r_{i,j,t}, r_{i,j',t}\right) / \left(\sigma_{i,j,t}\sigma_{i,j',t}\right)$$

$$\kappa_{i,j/j',t} = \sum_{k=1}^{M-\tau} \mathcal{I}\left(r^{\tau}_{i,j,k} r^{\tau}_{i,j',k} > 0\right)$$

  Kapadia and Pu measure is normalized between -1 and 1.

- Volatility σ: annualized standard deviation of log returns

- Price efficiency (Hou and Moskowitz 2005)

$$r_{i,j,t} = \alpha_{i,j} + \beta_{i,j} r_{m,t} + \sum_{n=1}^{4} \delta^{-n}_{i,j} r_{m,t-n} + \sum_{n=1}^{4} \phi^{-n}_{i,j} r_{i,j,t-n} + \varepsilon_{i,j,t}$$

$$D1 = 1 - \left(\frac{Constrained\ R^2}{Unconstrained\ R^2}\right).$$

  Lower D1 means higher price efficiency.

Measuring Market Characteristics

- Market quality estimated from MA(1) model (Hasbrouck 1993)

$$r_t = \Delta m_t + \Delta s_t \qquad q = 1 - \sigma_s^2/\sigma_r^2$$

where m_t is efficient price and s_t is pricing error.

  - Estimate $\{a, \sigma_e^2\}$ of the MA(1) model $r_t = e_t - ae_{t-1}$

$$q = \frac{\sigma_e^2 - 2a \cdot cov(e_t, e_{t-1})}{\sigma_e^2 + a\sigma_e^2 - 2a \cdot cov(e_t, e_{t-1})} \in (0, 1)$$

Higher q means better market quality.

- Liquidity: Price impact (Roll, Amihud), bid-ask spreads (CHL, Abdi and Ronaldo 2017), Volume
  - Aggregate liquidity factor (Dick-Nielsen, Feldhutter, and Lando 2012; Schwert 2017)

$$\lambda_{i,j,t} = \frac{1}{4}\sum_{k=1}^{4} \frac{L_{i,j,t}^k - \mu^k}{\sigma^k}$$

We sign all variables so that a lower λ is associated with greater liquidity.

Differences-in-Differences - Price Integration

Panel A: Integration κ	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment	-0.065***	0.001	-0.065***						
	(0.020)	(0.016)	(0.020)						
Post	0.020	0.045**		0.023					
	(0.020)	(0.018)		(0.019)					
Treatment×Post	0.135***	0.121***	0.133***	0.132***	0.118***	0.047***	0.139***	0.080***	0.114***
	(0.019)	(0.017)	(0.019)	(0.018)	(0.016)	(0.009)	(0.020)	(0.024)	(0.026)
N	4310	4310	4310	4310	4310	1586	3906	3606	1056
adj. R^2	0.104	0.549	0.173	0.135	0.662	0.863	0.657	0.683	0.709
Control	ALL	ALL	ALL	ALL	ALL	ALL	EUR	CCY*	X-M
Xchange-Pair FE		✓			✓		✓	✓	✓
Month FE			✓		✓		✓	✓	✓
Ccy FE				✓	✓	✓	✓	✓	✓
Xchange-Pair×Month FE						✓			

- Std. dev of κ of BTC-USD is 0.22.

Channels - Liquidity and Attention/Price Integration

Panel A: Integration κ	(1)	(2)	(3)	(4)	(5)	(6)
Treatment×Post×High Attention	0.038	0.052	0.037	0.040	0.051	0.001
	(0.048)	(0.045)	(0.047)	(0.046)	(0.044)	(0.017)
N	4310	4310	4310	4310	4310	1586
adj. R^2	0.115	0.549	0.184	0.145	0.662	0.866
Panel B: Integration κ	(1)	(2)	(3)	(4)	(5)	(6)
Treatment×Post×High Liquidity	-0.137***	-0.119***	-0.132***	-0.135***	-0.118***	-0.041***
	(0.045)	(0.044)	(0.044)	(0.044)	(0.043)	(0.009)
N	4310	4310	4310	4310	4310	1586
adj. R^2	0.188	0.551	0.260	0.205	0.664	0.864
Control	ALL	ALL	ALL	ALL	ALL	ALL
Xchange-Pair FE		✓			✓	
Month FE			✓		✓	
Ccy FE				✓	✓	✓
Xchange-Pair×Month FE						✓