Distant or close cousins: Connectedness between cryptocurrencies and traditional currencies volatilities

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Paper Structure:

1. Objective
2. Econometric Framework
3. Data Analysis
4. Empirical Result
5. Determinants of detected connectedness
6. Concluding Remarks

Objectives

1. Provide insights on the extent and the nature of interdependencies and spillovers between four highly capitalized cryptocurrencies and four major exchange rates
2. Capture connectedness within both groups or blocks of currencies
3. Evaluate net directional connectedness for each currency
4. Analyze the potential drivers of the detected, dynamic volatility connectedness

Data

- Both types of currencies are considered against USD.
- Traditional currency (daily exchange rates):

  EUR, AUD, JPY and GBP (a, b, c, d)

- Cryptocurrencies (daily data):

  Bitcoin-XBT, Ripple-XRP, Litecoin-XLT and Dash-XDS

  (e, f, g, h)

- February 2014 to September 2018 (1160 observations)

Data

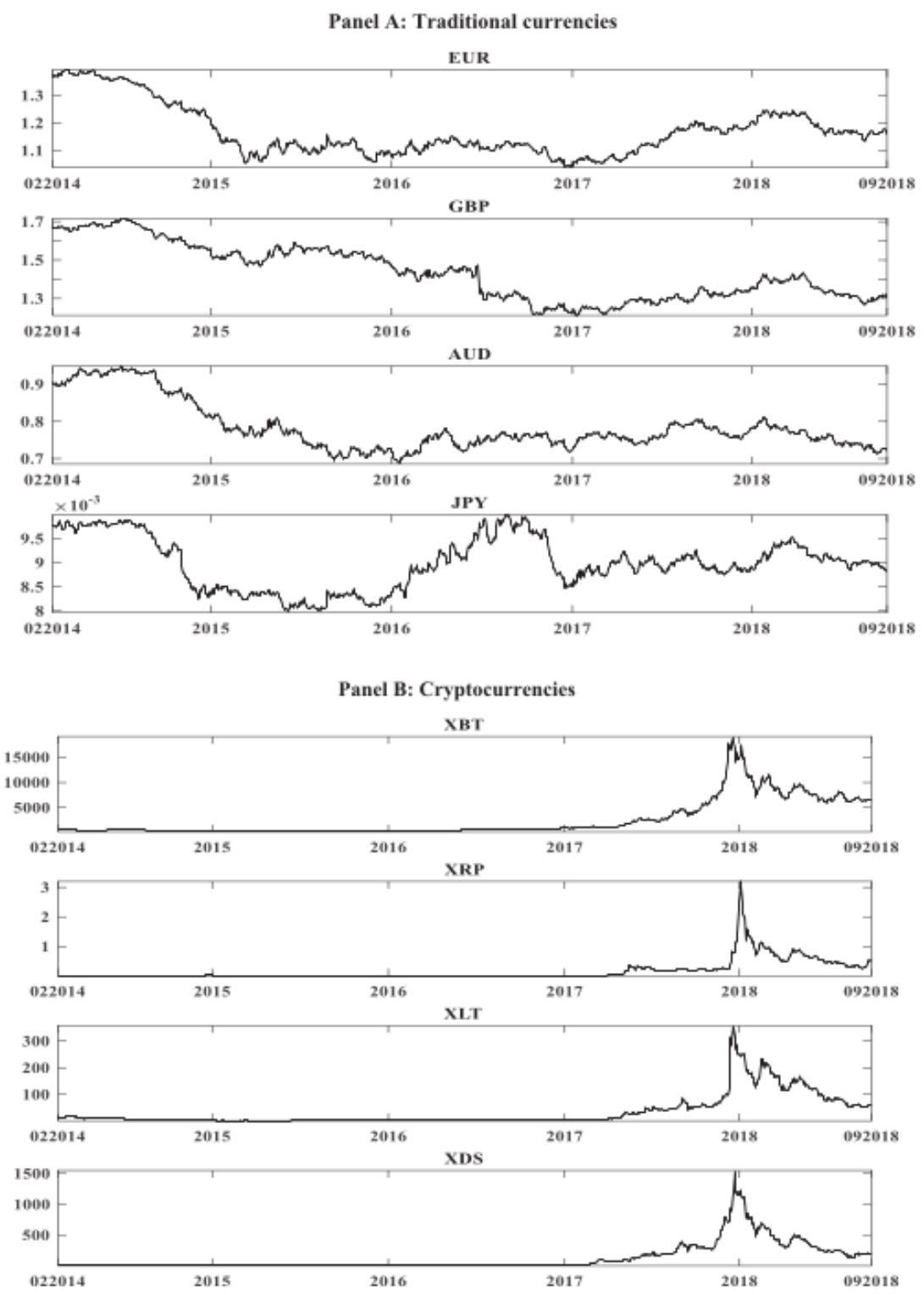

Fig. 1a Daily exchange rates.

Data

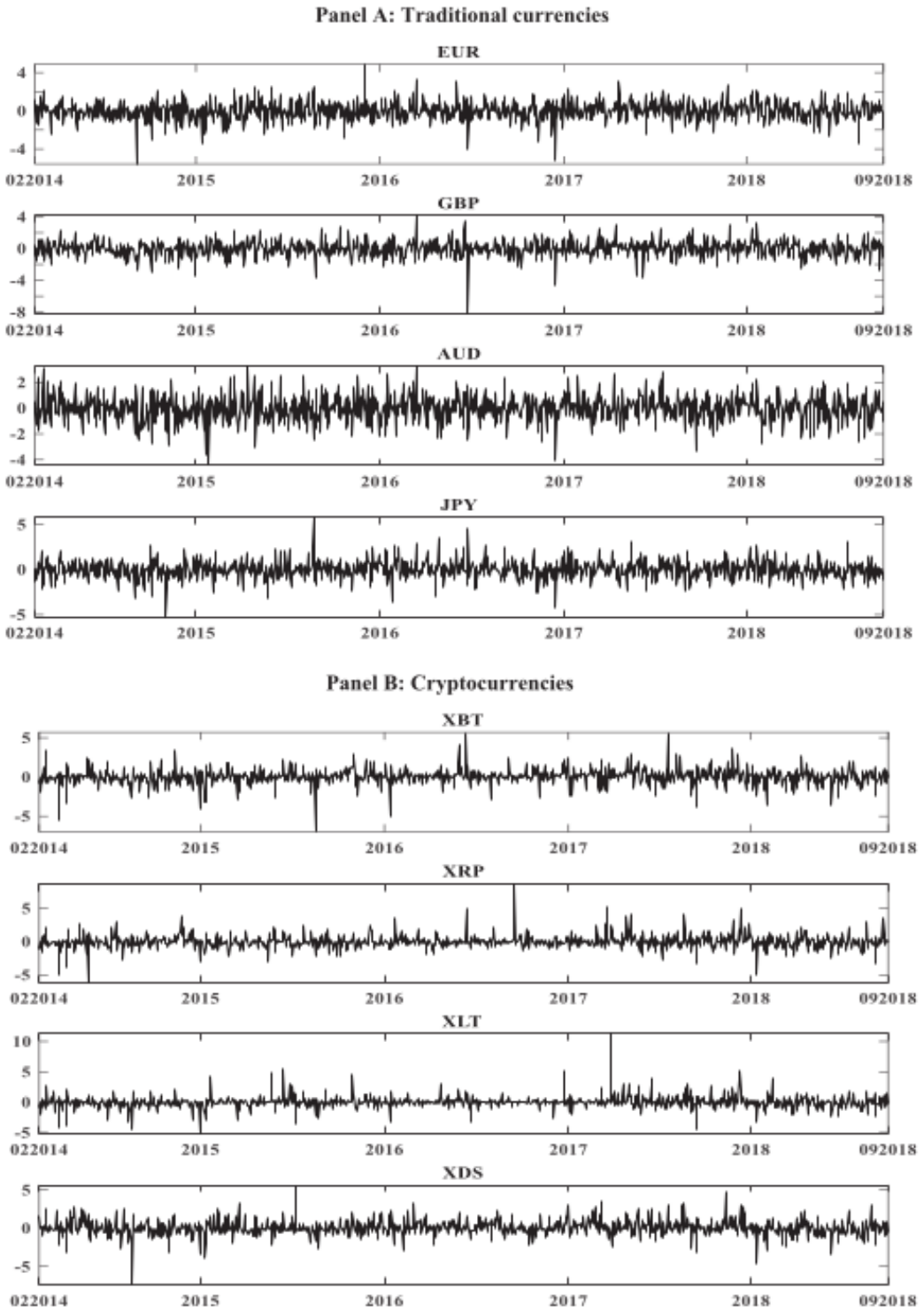

Fig. 1b. Daily normalized volatilities.

Descriptive Statistics

Table 2
Descriptive statistics and contemporaneous Pearson correlations of daily normalized volatilities.

	EUR	GBP	AUD	JPY	XBT	XRP	XLT	XDS
Panel A: Descriptive statistics								
Min	−5.5631	−8.2655	−4.4465	−5.2339	−6.9915	−6.0989	−5.1429	−7.3784
Median	−0.0493	−0.0122	0.0000	−0.0458	0.0619	−0.0708	0.0000	−0.0430
Max	4.8714	4.1487	3.2797	5.7953	5.6981	8.6982	11.2370	5.6021
Skewness	−0.2217	−0.5528	−0.1469	0.1346	−0.3995	0.8758	1.5422	−0.0396
Kurtosis	5.1481	7.8618	3.8052	5.5615	9.4466	13.1570	22.1141	8.2760
Observations	1159	1159	1159	1159	1159	1159	1159	1159
Jarque-Bera	232.326[a]	1200.503[a]	35.480[a]	320.355[a]	2037.769[a]	5130.160[a]	18102.680[a]	1344.533[a]
p-value	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Panel B: Matrix correlations								
EUR	1.0000							
GBP	0.5309[a]	1.0000						
AUD	0.4485[a]	0.3990[a]	1.0000					
JPY	0.4680[a]	0.2298[a]	0.3081[a]	1.0000				
XBT	0.0102	−0.0176	−0.0067	−0.0028	1.0000			
XRP	0.0032	0.0034	−0.0258	0.0149	0.1543[a]	1.0000		
XLT	−0.0147	−0.0320	−0.0050	−0.0053	0.5959[a]	0.1342[a]	1.0000	
XDS	0.0064	−0.0220	−0.0052	−0.0816[a]	0.4052[a]	0.0983[a]	0.3441[a]	1.0000

Notes:
Daily data from February 14, 2014 to September 28, 2018.
[a], [b], [c] indicates significance at the 1%, 5% and 10% level, respectively

Notes on Cryptocurrencies

- Intention:
  - Store of value
  - Medium of exchange
  - Unit of account
- Not issued by central banks
- Decentralized: Transferred without involvement of central authority
- Rely only on cryptographic integrity, where traditional currencies rely on political and legal mechanisms

Results

- 34.43% is the total connectedness between the eight examined currencies, indicating that 65.57% of the variation is due to idiosyncratic shocks
- Both block of currency are high intra-connected but disconnected to each other.
- Volatility connectedness varies over time; increasing in periods of increasing economic and financial instability.

Results

- Financial market variables are the main drivers of connectedness between traditional currencies
- Cryptocurrency-specific variables are the main drivers of connectedness between cryptocurrencies
- A combination business cycle and cryptocurrency-specific variables explains the directional connectedness between both blocks

Econometric Methodology

1) Forecast variance decomposition

2) Connectedness measures

3) Generalized connectedness measures

4) Dynamic connectedness

Forecast error variance decomposition

1. Fit a reduced-form vector autoregressive (VAR) model to the series [VAR(1)] $Y_t = \beta Y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma)$
2. Establish H-period-ahead forecast
3. Decompose variance of the forecast for each component w.r.t. shocks from the same or other components at time t
4. → This decomposition is the key to the connectedness measures defined later

Connectedness measures

Let us denote by d_{ij}^H the ij-th H-step variance decomposition component

$$D^H = \begin{bmatrix} d_{11}^H d_{12}^H \ldots d_{1N}^H \\ d_{21}^H d_{22}^H \ldots d_{2N}^H \\ d_{N1}^H d_{N2}^H \ldots d_{NN}^H \end{bmatrix}$$

$$D^H = \begin{bmatrix} d_{aa}^H & d_{ab}^H & d_{ac}^H & d_{ad}^H & d_{ae}^H & d_{af}^H & d_{ag}^H & d_{ah}^H \\ d_{ba}^H & d_{bb}^H & d_{bc}^H & d_{bd}^H & d_{be}^H & d_{bf}^H & d_{bg}^H & d_{bh}^H \\ d_{ca}^H & d_{cb}^H & d_{cc}^H & d_{cd}^H & d_{ce}^H & d_{cf}^H & d_{cg}^H & d_{ch}^H \\ d_{da}^H & d_{db}^H & d_{dc}^H & d_{dd}^H & d_{de}^H & d_{df}^H & d_{dg}^H & d_{dh}^H \\ d_{ea}^H & d_{eb}^H & d_{ec}^H & d_{ed}^H & d_{ee}^H & d_{ef}^H & d_{eg}^H & d_{eh}^H \\ d_{fa}^H & d_{fb}^H & d_{fc}^H & d_{fd}^H & d_{fe}^H & d_{ff}^H & d_{fg}^H & d_{fh}^H \\ d_{ga}^H & d_{gb}^H & d_{gc}^H & d_{gd}^H & d_{ge}^H & d_{gf}^H & d_{gg}^H & d_{gh}^H \\ d_{ha}^H & d_{hb}^H & d_{hc}^H & d_{hd}^H & d_{he}^H & d_{hf}^H & d_{hg}^H & d_{hh}^H \end{bmatrix}$$

Table 1
Schematic connectedness table.

	x_1	x_2	...	x_N	Connectedness from others
x_1	d_{11}^H	d_{12}^H	...	d_{1N}^H	$\sum_{j=1}^N d_{1j}^H, j \neq 1$
x_2	d_{21}^H	d_{22}^H	...	d_{2N}^H	$\sum_{j=1}^N d_{2j}^H, j \neq 2$
.	.	.	.		
..	..	..	..		
x_N	d_{N1}^H	d_{N2}^H	...	d_{NN}^H	$\sum_{j=1}^N d_{Nj}^H, j \neq N$
Connectedness to others	$\sum_{i=1}^N d_{i1}^H i \neq 1$	$\sum_{i=1}^N d_{i2}^H i \neq 2$	...	$\sum_{i=1}^N d_{iN}^H i \neq N$	**Total connectedness** $= \frac{1}{N} \sum_{\substack{i,j=1 \\ i \neq j}}^N d_{ij}^H$

Connectedness measures (Cont.)

Gross pairwise directional connectedness: $C^H_{i \leftarrow j} = d^H_{ij}$

Net pairwise directional connectedness

(from j to i): $C^H_{ij} = C^H_{j \leftarrow i} - C^H_{i \leftarrow j}$

Total directional connectedness:

→ From others to i: $C^H_{i \leftarrow \cdot} = \sum_{\substack{j=1 \\ j \neq i}}^{N} d^H_{ij},$

→To others from j: $C^H_{\cdot \leftarrow j} = \sum_{\substack{i=1 \\ j \neq i}}^{N} d^H_{ij}$

Net total directional connectedness: $C^H_i = C^H_{\cdot \leftarrow i} - C^H_{i \leftarrow \cdot}$

Total connectedness: $C^H = \frac{1}{N} \sum_{\substack{i,j=1 \\ j \neq i}}^{N} d^H_{ij}$

Generalized connectedness measures

Measure spillovers among blocks (here: traditional currencies vs. cryptocurrencies)

Block aggregation of the connectedness matrix

Example below (left) is for m = 3 variables in each market, for a total of N markets

$$D^H = \begin{bmatrix} B^H_{11} B^H_{12} \dots B^H_{1N} \\ B^H_{21} B^H_{22} \dots B^H_{2N} \\ \dots \\ B^H_{N1} B^H_{N2} \dots B^H_{NN} \end{bmatrix},$$

where

$$D^H = \begin{bmatrix} B^H_{11} & B^H_{12} \\ B^H_{21} & B^H_{22}, \end{bmatrix}$$

$$\text{Where } B^H_{ij} = \begin{bmatrix} d^H_{x_i x_j} d^H_{x_i y_j} d^H_{x_i z_j} \\ d^H_{y_i x_j} d^H_{y_i y_j} d^H_{y_i z_j} \\ d^H_{z_i x_j} d^H_{z_i y_j} d^H_{z_i z_j} \end{bmatrix} \text{ for } i, j = 1, \dots, N,$$

$$B^H_{11} = \begin{bmatrix} d^H_{aa} & d^H_{ab} & d^H_{ac} & d^H_{ad} \\ d^H_{ba} & d^H_{bb} & d^H_{bc} & d^H_{bd} \\ d^H_{ca} & d^H_{cb} & d^H_{cc} & d^H_{cd} \\ d^H_{da} & d^H_{db} & d^H_{dc} & d^H_{dd} \end{bmatrix}$$

Generalized connectedness measures (Cont.)

- Total within market forecast error variance:

$$W_{ii}^{H} = \frac{1}{m} e_m' B_{ii}^{H} e_m$$

- Total pairwise directional spillover: $P_{ij}^{H} = \frac{1}{m} e_m' B_{ij}^{H} e_m$

- Aggregated connectedness matrix:

$$D^{H} = \begin{bmatrix} W_{11}^{H} P_{12}^{H} \cdots P_{1N}^{H} \\ P_{21}^{H} W_{22}^{H} \cdots P_{2N}^{H} \\ P_{N1}^{H} P_{N2}^{H} \cdots W_{NN}^{H} \end{bmatrix} \qquad D^{H} = \begin{bmatrix} W_{11}^{H} & P_{12}^{H} \\ P_{21}^{H} & W_{22}^{H} \end{bmatrix}$$

Generalized connectedness measures (Cont.)

1) Total directional spillover

Aggregate from connectedness: $P^H_{i\leftarrow\cdot} = \sum_{j=1, j\neq i}^{N} P^H_{ij}$

Aggregate to connectedness: $P^H_{\cdot\leftarrow i} = \sum_{j=1, j\neq i}^{N} P^H_{ji}$

2) Net total directional spillover: $P^H = P^H_{\cdot\leftarrow i} - P^H_{i\leftarrow\cdot}$

3) Aggregate between-market spillover: $S^H = \frac{1}{N}\sum_{i=1}^{N} P^H_{i\leftarrow\cdot}$

4) Aggregate within-market effect: $H^H = 100 - S^H$

Dynamic Connectedness

Recall VAR(1): $Y_t = \beta Y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma)$

Now: Time-Varying Parameter Vector

Autoregressive (TVP-VAR) model

TVP-VAR(1): $Y_t = \beta_t Y_{t-1} + \varepsilon_t, \quad \varepsilon_t | F_{t-1} \sim N(0, \Sigma_t)$

$$\beta_t = \beta_{t-1} + v_t, \quad v_t | F_{t-1} \sim N(0, R_t)$$

Empirical results

Static (full-sample, unconditional) analysis for all currencies

Table 3
Full-sample connectedness.

	EUR	GBP	AUD	JPY	XBT	XRP	XLT	XDS	Directional *FROM* Others
EUR	57.7058	16.7002	12.2844	12.3470	0.0490	0.1745	0.0535	0.6858	42.2942
GBP	19.0523	65.9000	10.5386	3.2539	0.4227	0.1700	0.3210	0.3413	34.1000
AUD	14.3228	11.1161	67.7276	6.4921	0.0297	0.0410	0.0152	0.2556	32.2724
JPY	15.2860	3.6545	7.2166	72.9712	0.0365	0.0635	0.0117	0.7601	27.0288
XBT	0.0061	0.0433	0.1508	0.0169	58.7197	7.5710	22.1151	11.3771	41.2803
XRP	0.2530	0.1983	0.0803	0.4650	9.1989	72.6631	10.6362	6.5051	27.3369
XLT	0.0876	0.1206	0.1807	0.0648	22.5928	8.4122	59.6596	8.8817	40.3404
XDS	0.0310	0.1262	0.0512	0.5043	13.5031	6.3939	10.1682	69.2223	30.7777
Directional *TO* Others	49.0388	31.9592	30.5026	23.1440	45.8327	22.8260	43.3208	28.8066	**34.4288**
NetContribution(To – From) Others	6.7446	−2.1408	−1.7698	−3.8848	4.5524	−4.5108	2.9804	−1.9711	–

65.57 % due to idiosyncratic shock

Empirical results

Static (full-sample, unconditional) analysis for all currencies

Greenwood-Nimmo

Table 4
Full-sample connectedness by blocks of currencies.

	Traditional currencies	Cryptocurrencies
Traditional currencies	99.1423	0.8577
Total connectedness within Trad. currencies	*33.0661*	–
Cryptocurrencies	0.5950	99.4050
Total connectedness within Cryptocurrencies	–	*34.3388*
Net Contribution (To – From) Others	−0.2627	0.2627
Total connectedness across blocks		0.7264

Empirical results
Dynamic connectedness analysis

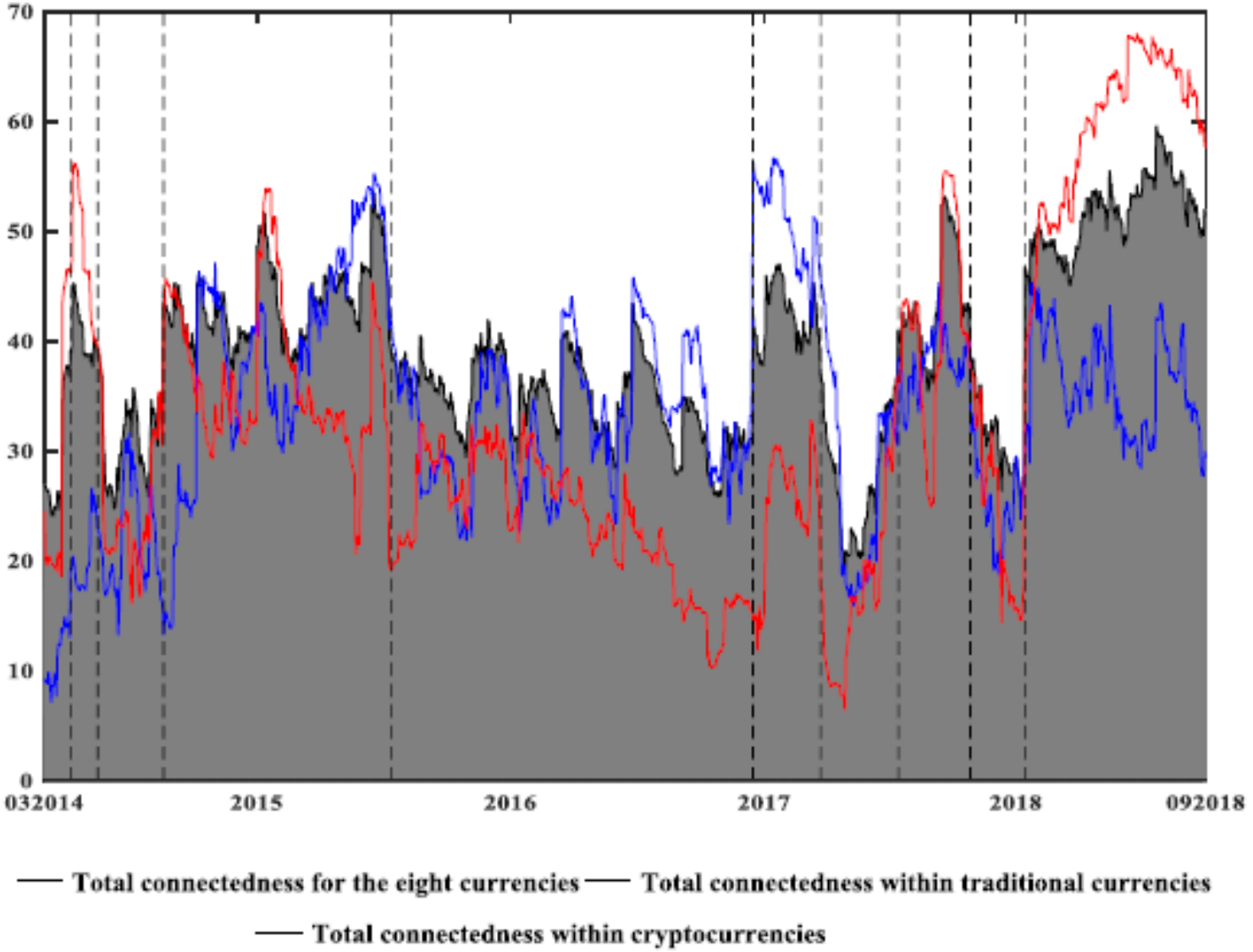

Fig. 2. Dynamic total connectedness for the eight currencies and by blocks of currencies. Note: The vertical lines delimit the following episodes: I: March 2014-April 2014; II: April 2014-May 2014, III: May 2014-August 2014, IV: August 2014-July 2015, V: July 2015-November 2016, VI: November 2016-March 2017, VII: March 2017-July 2017, VIII: July 2017-October 2017, IX: October 2017-January 2018, X: January 2018-Sep 2018.

Empirical results

Net and dynamic net pair-wise directional volatility connectedness plots

77.4% of positive values

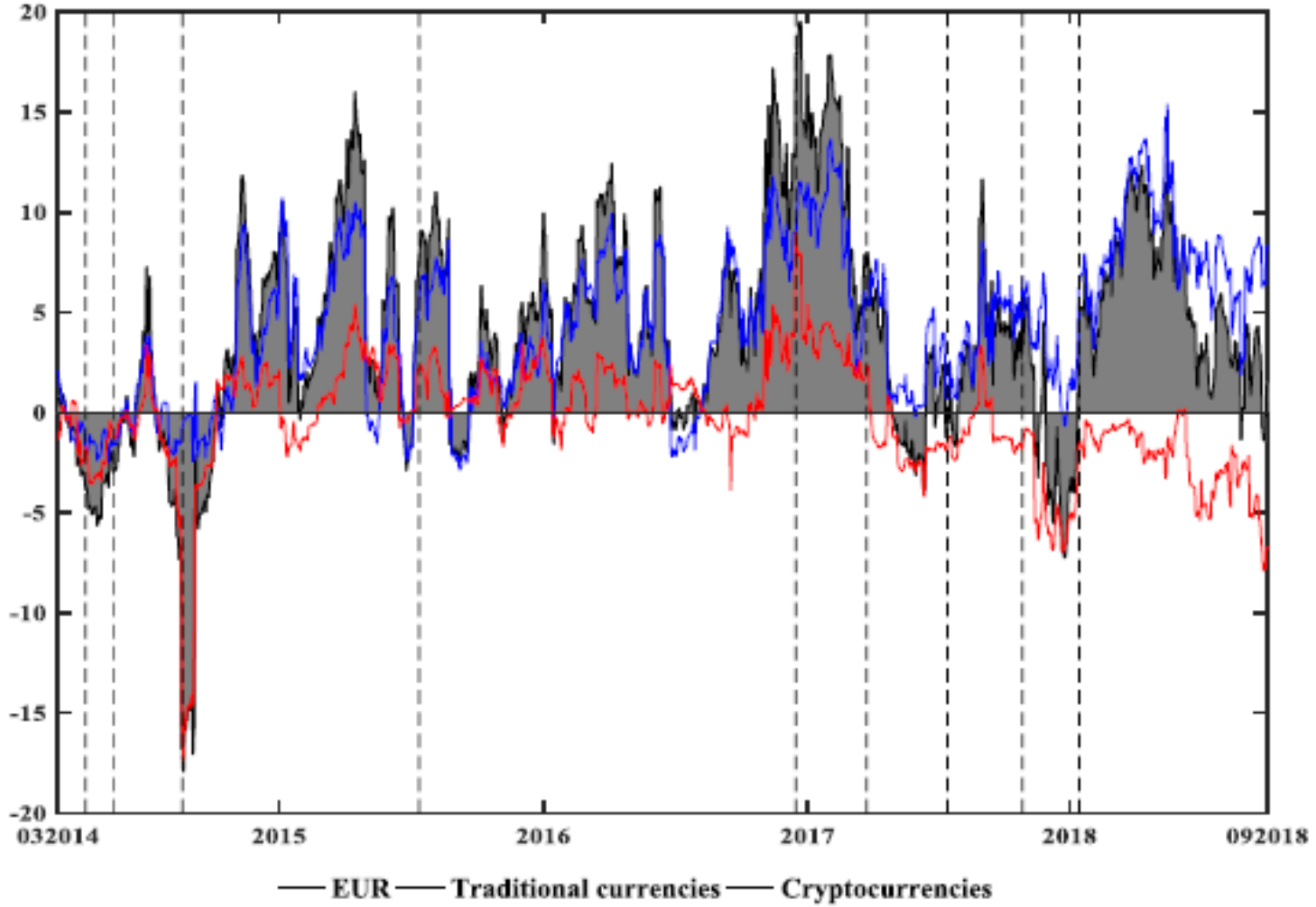

Fig. 3a. Net directional connectedness and net pair-wise directional connectedness by blocks of currencies for EUR. Note: The vertical lines delimit the following episodes: I: March 2014-April 2014; II: April 2014-May 2014, III: May 2014-August 2014, IV: August 2014-July 2015, V: July 2015-November 2016, VI: November 2016-March 2017, VII: March 2017-July 2017, VIII: July 2017-October 2017, IX: October 2017-January 2018, X: January 2018-Sep 2018.

Empirical results

Net and dynamic net pair-wise directional volatility connectedness plots

79.3% of negative values

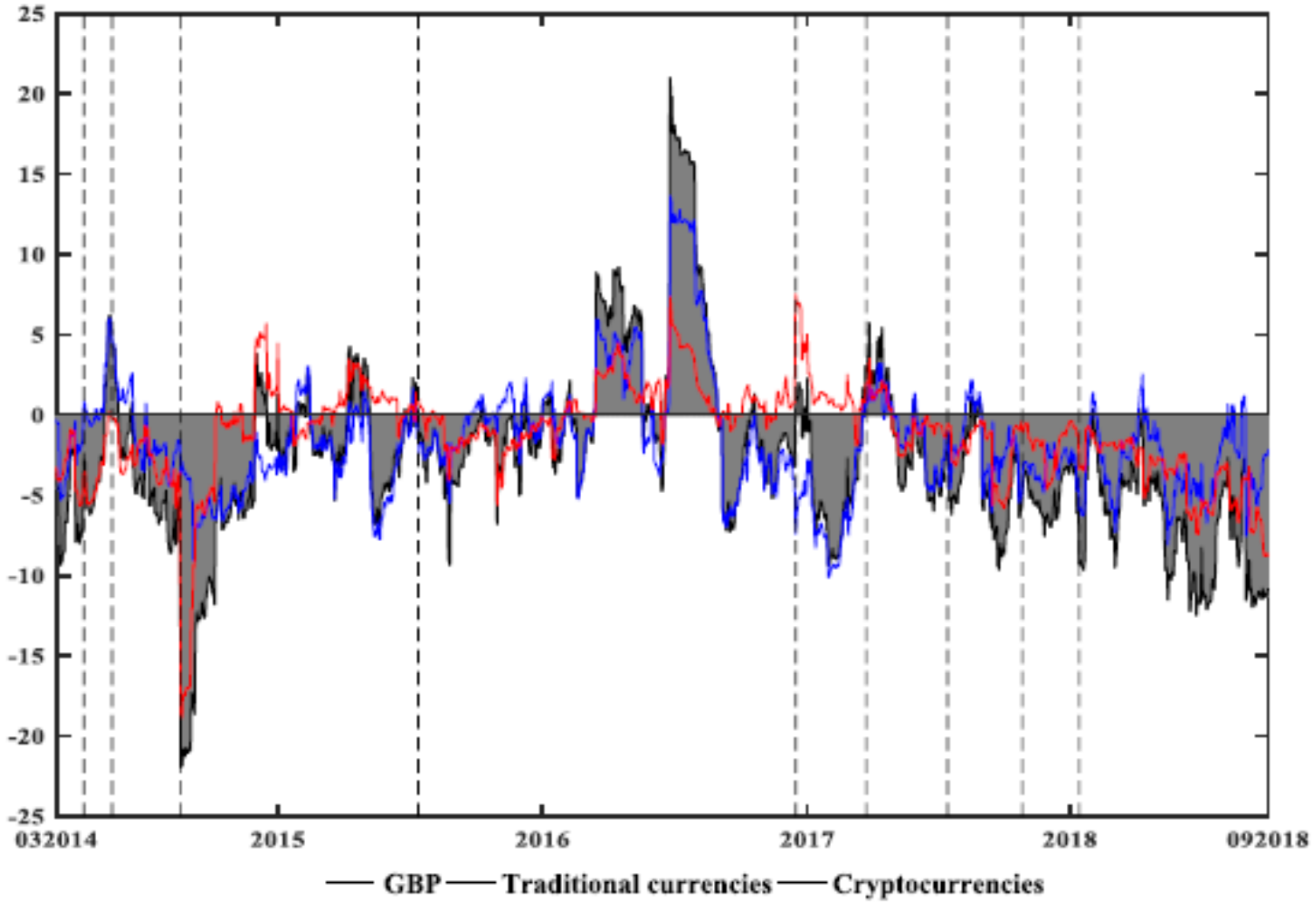

Fig. 3b. Net directional connectedness and net pair-wise directional connectedness by blocks of currencies for GBP. Note: The vertical lines delimit the following episodes: I: March 2014-April 2014; II: April 2014-May 2014, III: May 2014-August 2014, IV: August 2014-July 2015, V: July 2015-November 2016, VI: November 2016-March 2017, VII: March 2017-July 2017, VIII: July 2017-October 2017, IX: October 2017-January 2018, X: January 2018-Sep 2018.

Empirical results

Net and dynamic net pair-wise directional volatility connectedness plots

73.13% of positive values

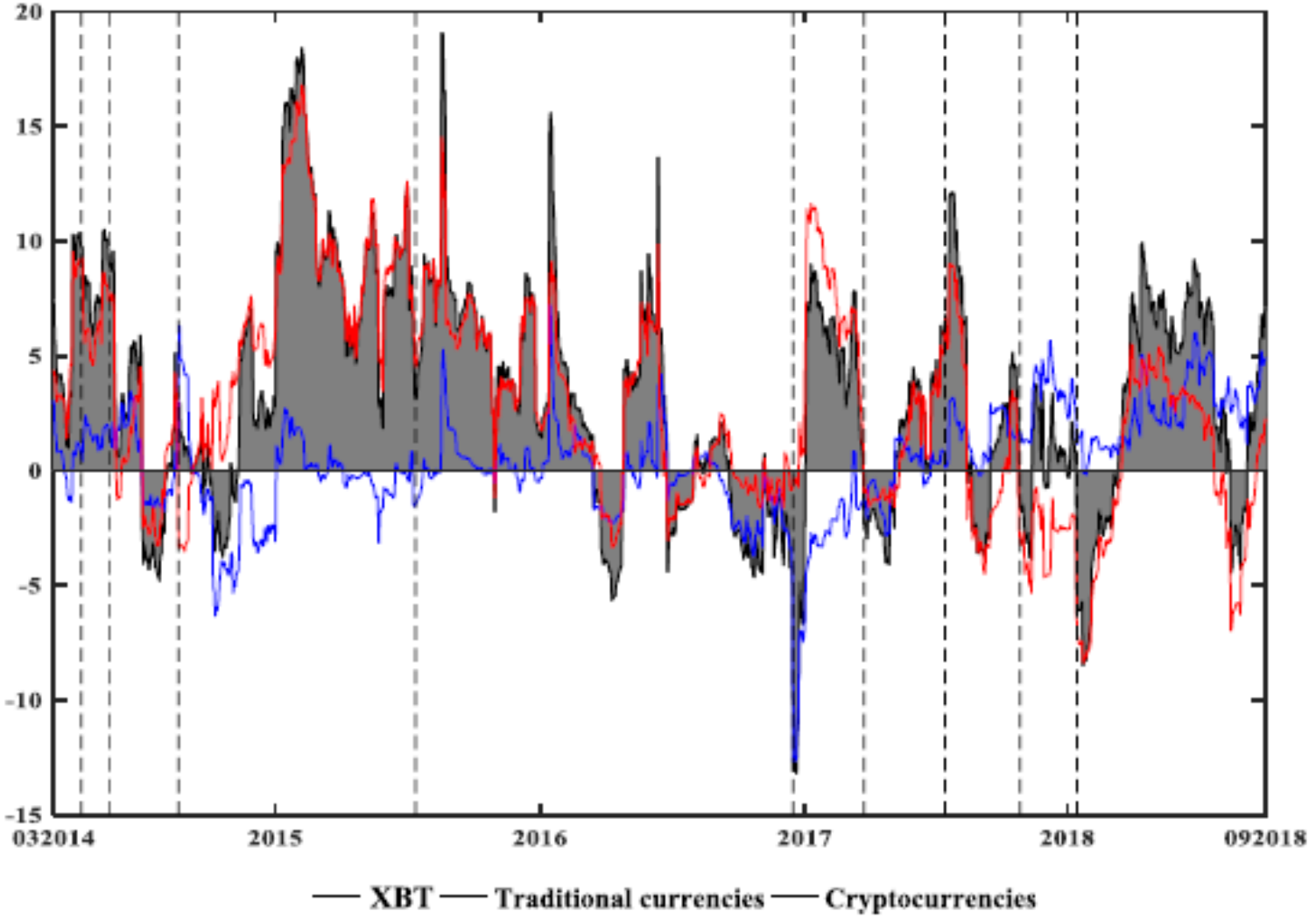

Fig. 3e. Net directional connectedness and net pair-wise directional connectedness by blocks of currencies for XBT. Note: The vertical lines delimit the following episodes: I: March 2014-April 2014; II: April 2014-May 2014, III: May 2014-August 2014, IV: August 2014-July 2015, V: July 2015-November 2016, VI: November 2016-March 2017, VII: March 2017-July 2017, VIII: July 2017-October 2017, IX: October 2017-January 2018, X: January 2018-Sep 2018.

Empirical results

Net and dynamic net pair-wise directional volatility connectedness plots

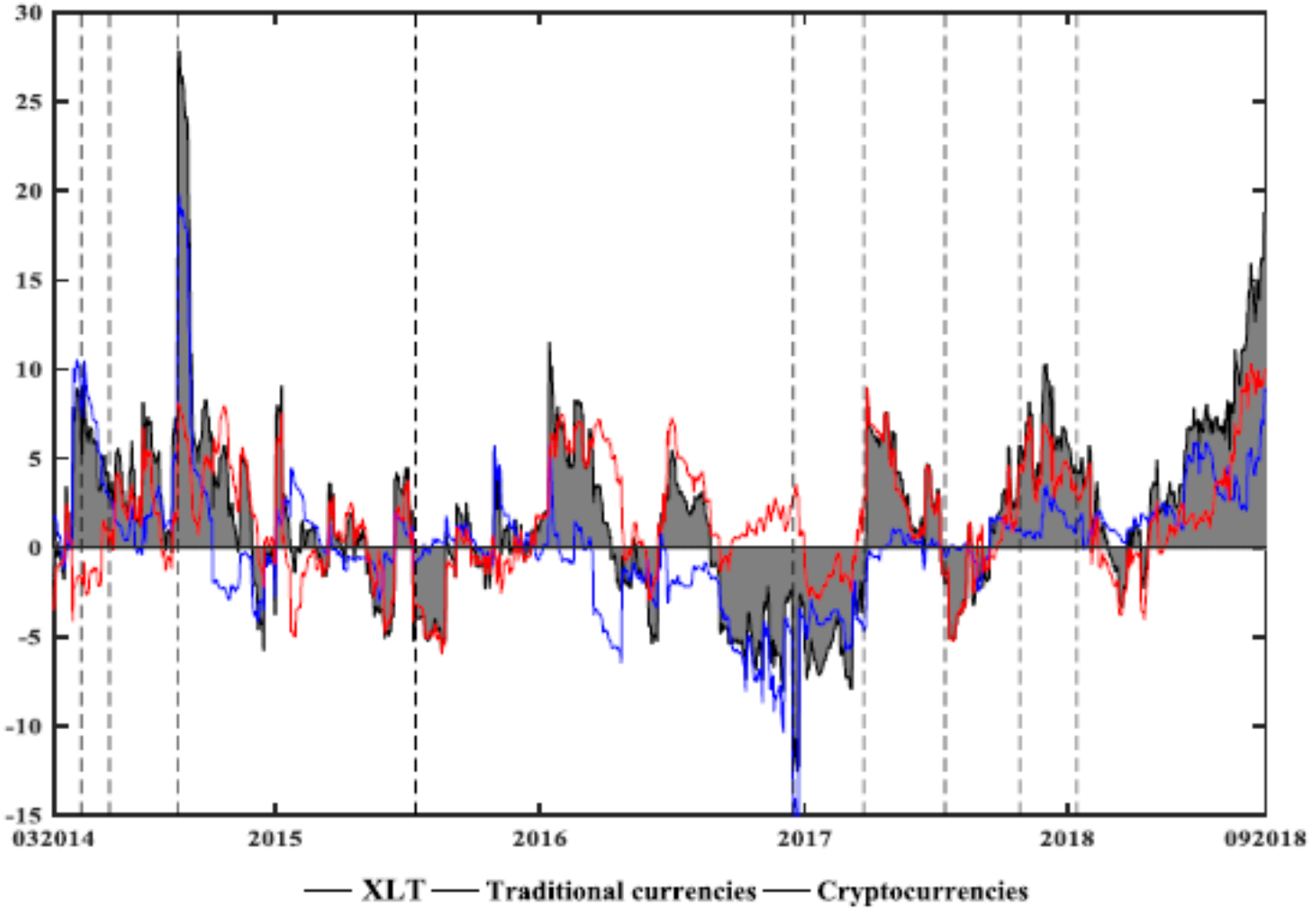

Fig. 3g. Net directional connectedness and net pair-wise directional connectedness by blocks of currencies for XLT. Note: The vertical lines delimit the following episodes: I: March 2014-April 2014; II: April 2014-May 2014, III: May 2014-August 2014, IV: August 2014-July 2015, V: July 2015-November 2016, VI: November 2016-March 2017, VII: March 2017-July 2017, VIII: July 2017-October 2017, IX: October 2017-January 2018, X: January 2018-Sep 2018.

Empirical results

Net and dynamic net pair-wise directional volatility connectedness plots

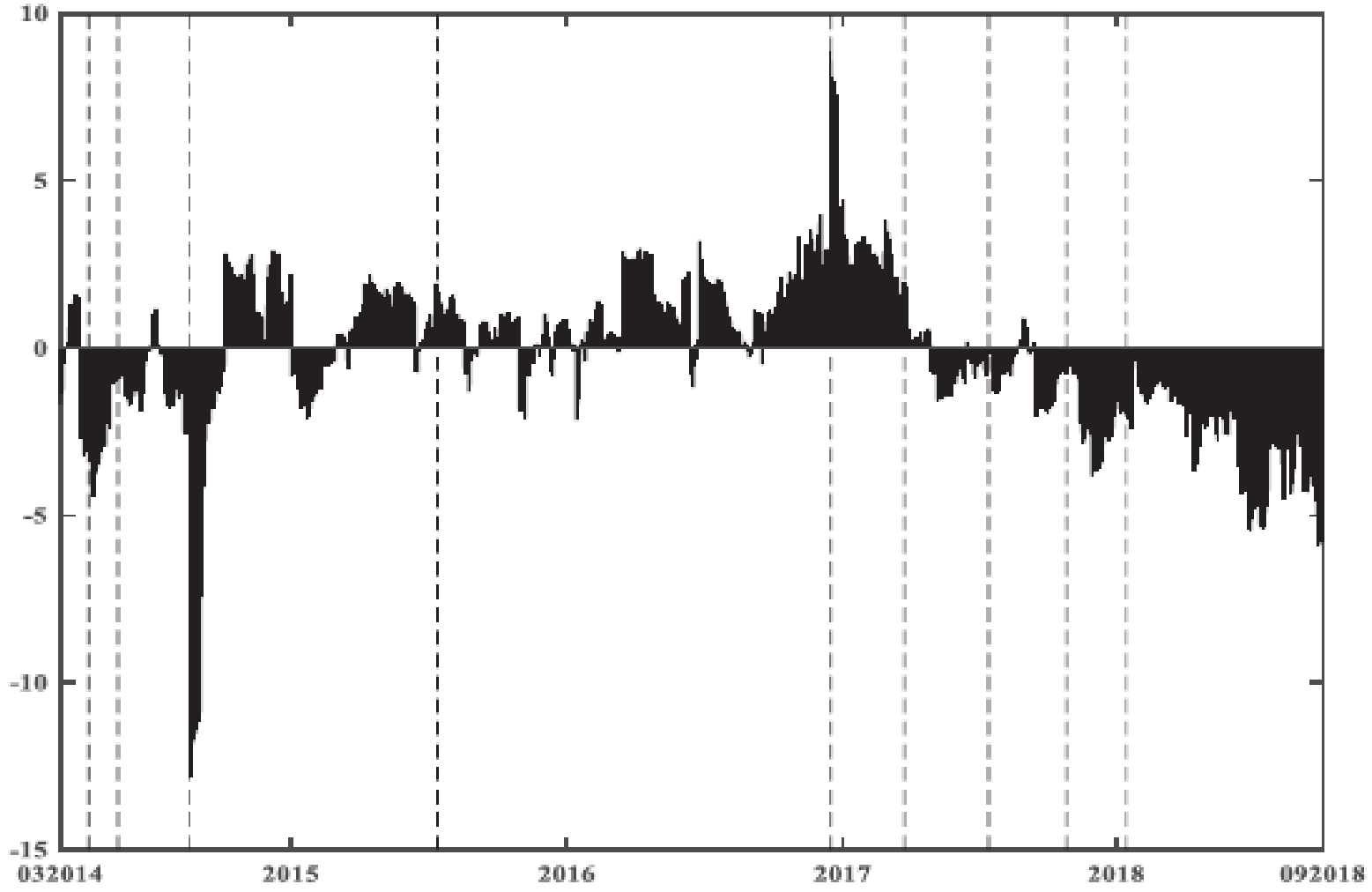

Fig. 4. Dynamic net connectedness from the block of traditional currencies to the block of cryptocurrencies. Note: The vertical lines delimit the following episodes: I: March 2014-April 2014; II: April 2014-May 2014, III: May 2014-August 2014, IV: August 2014-July 2015, V: July 2015-November 2016, VI: November 2016-March 2017, VII: March 2017-July 2017, VIII: July 2017-October 2017, IX: October 2017-January 2018, X: January 2018-Sep 2018.

Empirical results

Net and dynamic net pair-wise directional volatility connectedness plots

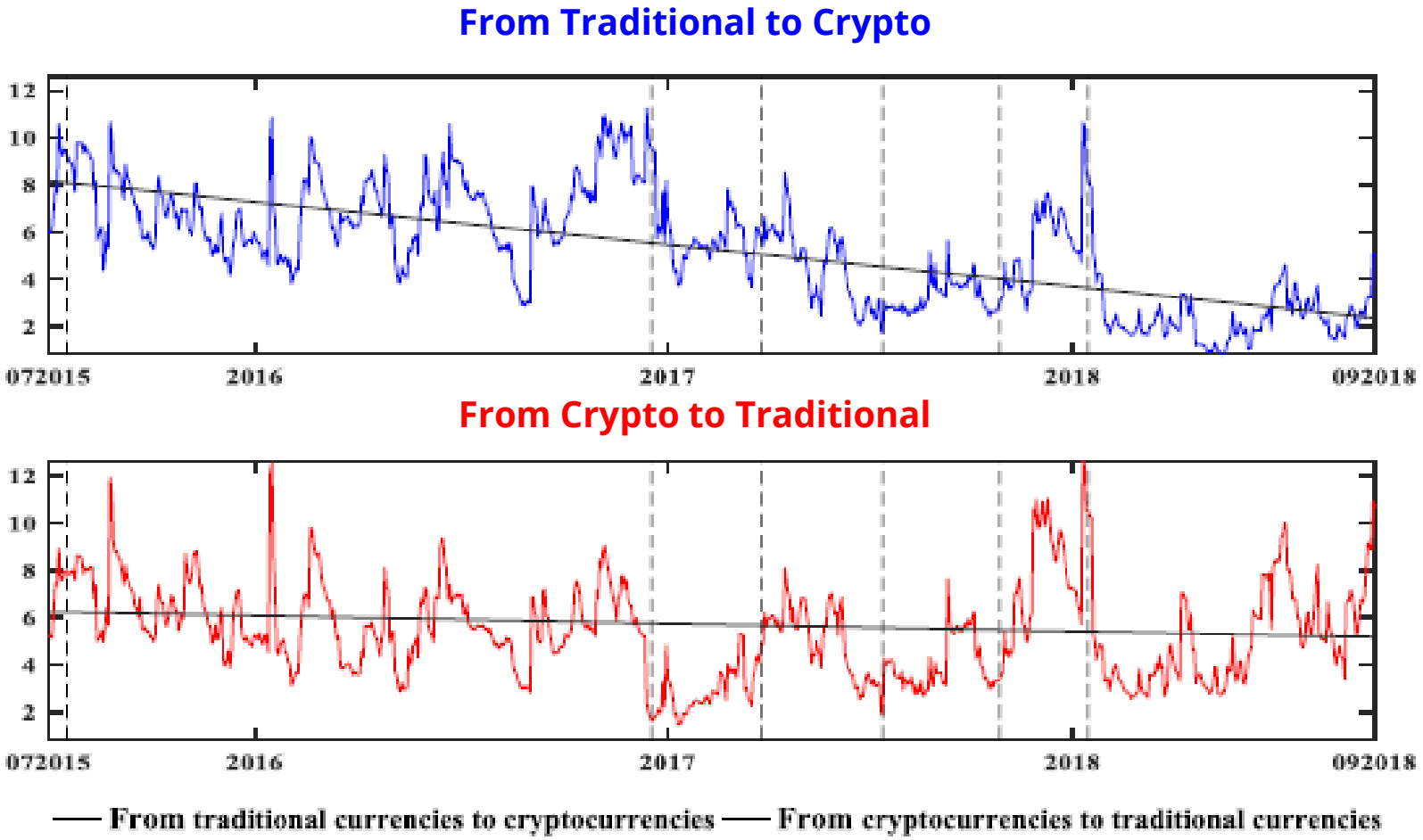

Fig. 5. Dynamic directional volatility connectedness from the block of traditional currencies to the block of cryptocurrencies and *vice versa*. Note: The vertical lines delimit the following episodes: I: July 2015-November 2016, II: November 2016-March 2017, III: March 2017-July 2017, IV: July 2017-October 2017, V October 2017-January 2018, VI: January 2018-Sep 2018. The black straight lines represent the trends in both directional connectedness.

Determinants of the total and net dynamic connectedness

Determinants of exchange rate volatility:

1. openness of an economy,
2. domestic and foreign money supplies,
3. exchange rate regime,
4. interest rates,
5. central bank independence,
6. inflation,
7. unpredictable events.

Determinants of cryptocurrencies volatility:

1. market capitalization,
2. transaction processing speed,
3. total number of coins produced,
4. cryptographic algorithms,
5. not cryptocurrency-specific variables (global real economic activity, economic policy uncertainty, gold markets).

Determinants of the total and net dynamic connectedness

Tot. connectedness within the traditional currencies: financial markets variables (10,9%), business cycle (1,84%);

Tot. connectedness within the crypto*:* cryptocurrency-specific variables (74,80%);

Directional volatility connectedness from crypto to the traditional currencies: business cycle (16,56%), cryptocurrency-specific variables (11,93%);

Directional volatility connectedness from traditional currencies to crypto: cryptocurrency-specific variable (9,47%), business cycle (6,9%)

Conclusion

- 34.43% is the total connectedness between the eight examined currencies, indicating that 65.57% of the variation is due to idiosyncratic shocks
- Both block of currency are high intra-connected but disconnected to each other.
- Volatility connectedness varies over time; increasing in periods of increasing economic and financial instability.

Conclusion

- Financial market variables are the main drivers of connectedness between traditional currencies
- Cryptocurrency-specific variables are the main drivers of connectedness between cryptocurrencies
- A combination business cycle and cryptocurrency-specific variables explains the directional connectedness between both blocks

Thank you for your attention