Measuring Multi-Scale Connectedness Between Green Bond and Green Equity using a Thick Pen Method

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This paper in a nutshell

- Increased environment friendly investment
- Concurrently, increased investment in green bond and green equity
- Green bond can be an effective diversification tool for stock and energy markets Reboredo (2018)
- Investigate co-movement between green bond and green equity
- Use of a novel non-parametric approach called **Thick Pen Transform**
- Co-movement across different investment horizons
- Potential interest to investors, policy makers

Data

- Daily log-returns on prices of
  - Green Bond: S&P Green Bond index
  - Green Equity: NASDAQ OMX- Green building, Water, Transportation, Clean energy focused, Solar, Wind
  - Stock, Energy and Environment: MSCI world index, MSCI world energy index, MSCI global environment
  - Global Bond: Bloomberg Treasury, Bloomberg Corporate
- US economic policy uncertainty index
- Dow Jones sustainability world composite index
- 01 Aug 2014 - 05 Jul 2022 (2045 observations)

Data

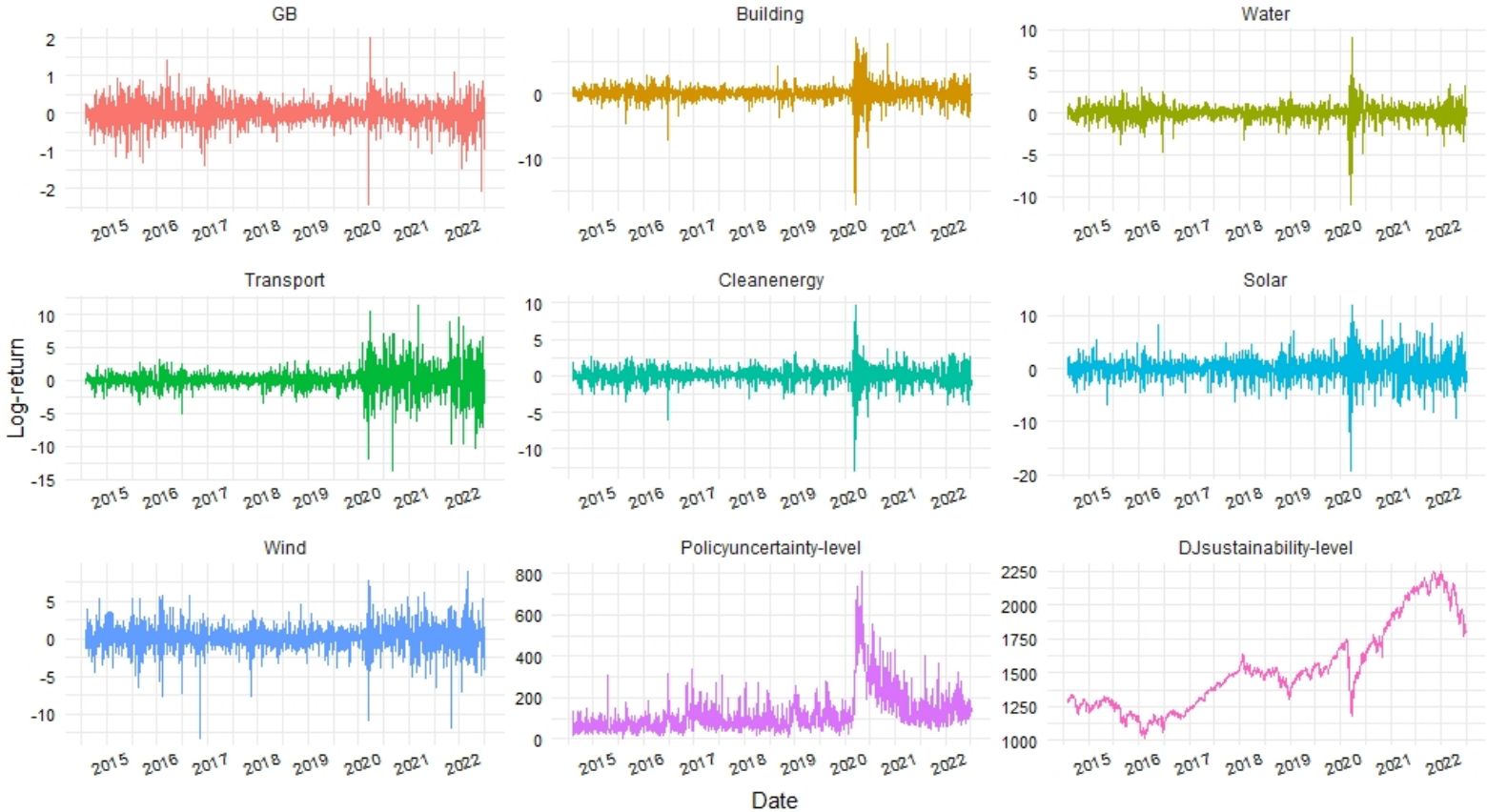

Figure 1: Daily log returns of green bond and green equities, US economic policy uncertainty index and Dow Jones sustainability world composite index.

Model

- Thick Pen Measure of Association (TPMA) by Fryzlewicz and Oh (2011)
- Multi-thickness Thick Pen Measure of Association (MTTPMA) by Jach (2021)

Why?

- Non-parametric
- Stationary and non-stationary time series
- More than two time series (multivariate)
- Time-evolving
- Given time scale
- Across different time scale (cross-scale/cross-frequency)
- Visually interpretable

Thick Pen Transform (TPT)

Let,

- $X = (X_t)_{t=1}^{T}$ - a univariate time series;
- $\mathcal{T}$ - set of positive constant thickness parameters i.e. $\tau_i \in \mathcal{T}, i = 1, 2, \ldots, |\mathcal{T}|$ ($|\mathcal{T}|$ is the cardinality of $\mathcal{T}$);
- lower boundaries of the area

$$L_t^{\tau}(X) = min(X_t, X_{t-1}, \ldots, X_{t-\tau})$$

- upper boundaries of the area

$$U_t^{\tau}(X) = max(X_t, X_{t-1}, \ldots, X_{t-\tau})$$

- A collection of n pairs of boundaries ($2.n.T$ random variables in total) denoted as

$$TP_{\mathcal{T}}(X) = \{(L_t^{\tau}(X), U_t^{\tau}(X))_{t=1}^{T}\}_{\tau \in \mathcal{T}}$$

Thick Pen Measure of Association (TPMA)

- Quantify co-movement between two/more time series for a given time scale

$$\rho_t^{\tau}(X^{(1)}, X^{(2)}, \ldots, X^{(K)}) = \frac{\min\limits_k(U_t^{\tau}(X^{(k)})) - \max\limits_k(L_t^{\tau}(X^{(k)}))}{\max\limits_k(U_t^{\tau}(X^{(k)})) - \min\limits_k(L_t^{\tau}(X^{(k)}))}$$

Multi-thickness Thick Pen Measure of Association (MTTPMA)

- Quantify co-movement between two/more time series for multi-time scale

$$\rho_t^{(\tau^{(1)},\tau^{(2)},\ldots,\tau^{(K)})}(X^{(1)}, X^{(2)}, \ldots, X^{(K)}) = \frac{\min\limits_k(U_t^{\tau^{(k)}}(X^{(k)})) - \max\limits_k(L_t^{\tau^{(k)}}(X^{(k)}))}{\max\limits_k(U_t^{\tau^{(k)}}(X^{(k)})) - \min\limits_k(L_t^{\tau^{(k)}}(X^{(k)}))}$$

- This measure is restricted to interval $\rho_t^{\tau}(X^{(1)}, X^{(2)}) \in (-1, 1]$ and is time-varying.

Thick Pen Measure of Association (TPMA)

- Plot time series observations by hand on a piece of paper
- Scatterplot of point over time
- Connect using a pen
- TPM: re-do using pens of different thickness
- Various thickness captures different features of data
- Small thickness pen: higher frequency movements
- Thicker pen: low frequency movements

In comparison with other standard methods

- Correlation: time domain, time-invariant
- Coherence/coherency: Correlation in frequency domain, time-invariant
- TPMA: range of time scales, time-varying
- MTTPMA: cross-scale/cross-frequency

Empirical Results

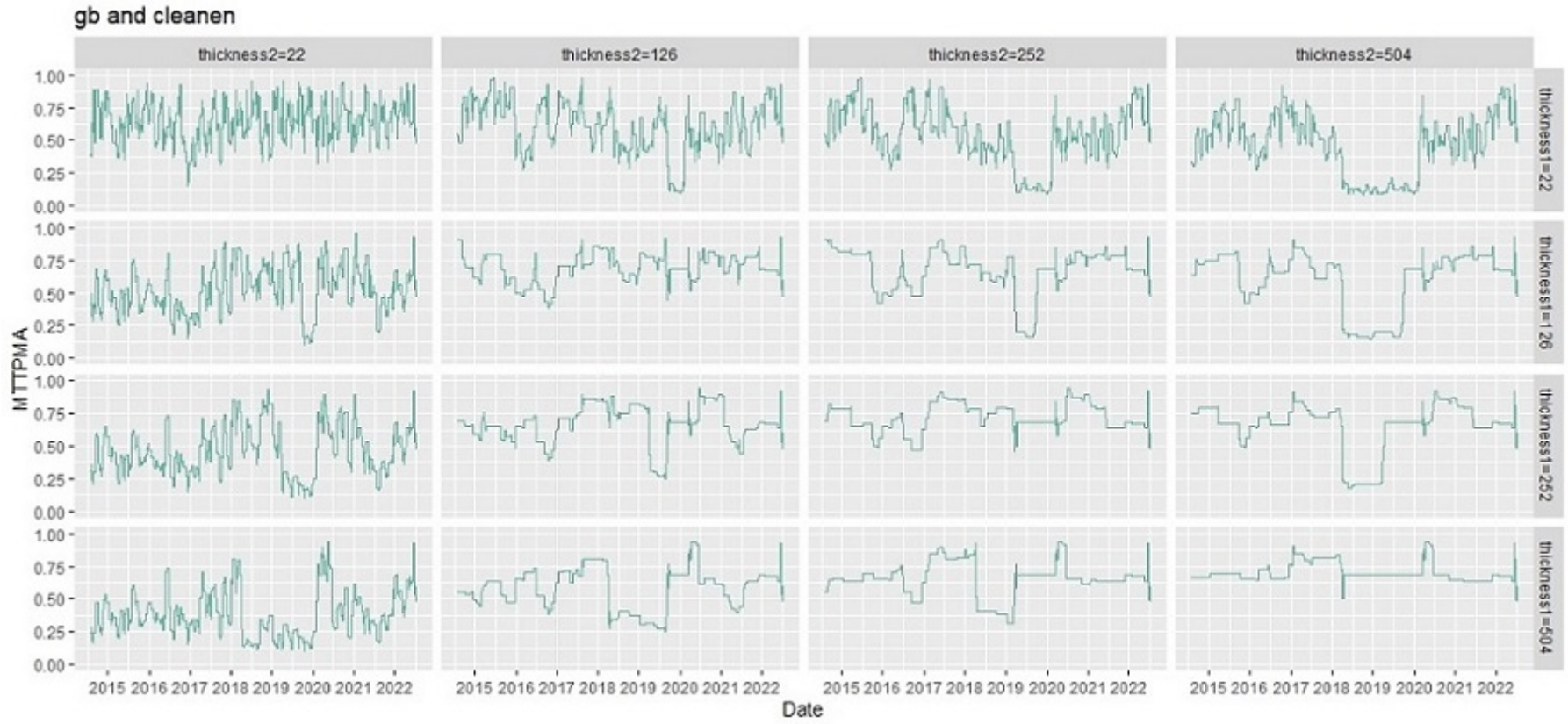

Figure 2: Multi-thickness Thick Pen Measure of Association of daily returns (normalised) of the green bond and green equity (clean energy). Thickness 22, 126, 252 and 504 represents short term (1-month, 6-month) and long-term (1-year, 2-year) component respectively.

Empirical Results

Highest and lowest changing point in co-movement

	short-term		long-term	
	Changing point (L,H)	MTTPMA	Changing point (L,H)	MTTPMA
Green equity				
GB-Building	2016, 2019	0.34, 0.91	2016, 2017	0.46, 0.90
GB-Water	2016, 2015	0.35, 0.98	2018, 2020	0.49, 0.94
GB-Transport	2016, 2020	0.29, 0.95	2016, 2019	0.45, 0.97
GB-Clean Energy	2016, 2019	0.38, 0.92	2018, 2020	0.49, 0.93
GB-Solar	2016, 2019	0.43, 0.97	2018, 2020	0.53, 0.90
GB-Wind	2016, 2018	0.45, 0.97	2022, 2018	0.48, 0.96
Stock, energy and environment				
GB-MSCI	2016, 2015	0.33, 0.98	2018, 2020	0.43, 0.90
GB-MSCI Energy	2019, 2019	0.23, 0.92	2018, 2017	0.27, 0.92
GB-MSCI Environment	2016, 2020	0.29, 0.97	2016, 2018	0.53, 0.97
Global bond				
GB-Bcorporate	2019, 2016	0.60, 0.97	2018, 2017	0.60, 0.96
GB-Btreasury	2019, 2018	0.61, 0.98	2018, 2017	0.61, 0.99

Key Findings

- Higher co-movement in the long-run than in the short run
- The overlaps between the green bond index and the green transportation index are higher in the long run
- The overlaps between the green bond index and the green building and solar index are a bit lower in the long run
- Evidence of asymmetric effects in cross-comovement i.e. MTTPMA
- Co-movement and policy uncertainty
- Co-movement and DJ sustainability index
- Similar to Chatziantoniou et al. (2021) , that the short-term and long-term co-movement do not co-move synchronously, rather it varies depending on financial and economic events.

Conclusions

- Promising technique to quantify cross-dependency
- Short-term and long-term policy perspectives
- Formulate trading strategy

Thanks!

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