How the change in crude oil price impacts the financial markets in BRICS: The tale of wavelet-based copula

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Overview

Crude oil plays a significant role in the economic activities of several countries. Higher prices of energy commodities lead to an increase in inflation and production costs, which results in declined output, demand, and trade in the economy. Therefore, several studies examine the relationship of oil price shocks and its effect on the financial markets in developed economies. However, the economic landscape has dramatically changed over the last two decades with the international trade and growth in economic activities of emerging economies. Despite this fact, there are relatively fewer studies on the dependence dynamics between crude oil and the financial markets of emerging economies. Furthermore, the existing literature on correlation quantification mainly relies on standard time series econometric model to provide an estimate of linkage. The time series models account for information from time and frequency domain as segregate, thereby neglecting information from either domain. Whereas, the financial and commodity markets comprise of agents with distinctive term objectives and different investment horizons. Therefore, in this study, we employ wavelet-based copula to evaluate the temporal and spectral dependence between crude oil and the financial markets of five emerging countries namely Brazil, Russia, India, China, and South Africa. Specifically, we implement maximal overlap discrete wavelet transform (MODWT) to decompose the underlying return series into various signals. Furthermore, to evaluate the frequential connectedness, we employ time-varying student-t copula on each series. Our findings indicate moderate level dependence between crude oil and stock markets of Brazil, Russia, and South Africa over the original returns, short-, and medium-run investment horizon. The correlation between crude oil and the financial market of India and China is relatively low over the original returns and short-run trend. Whereas, the level of dependence increases significantly over the long-run investment horizon.

Methods

We employ maximal overlap wavelet transform (MODWT) analysis to decompose the underlying return series to short-, medium-, and long-run trend. Wavelet transform is an effective tool as it enables us to simultaneously study the time and the frequency component of the underlying time series. We employ the modified version of discrete wavelet transform (DWT). The DWT requires two types of filters to decompose the underlying return series (X_t) into subsequent signals i.e. the wavelet filter and the scaling filter. Let us denote these filters as h_l and g_l, where $l = 0, ..., L - 1$, respectively. The jth level wavelet and scaling coefficient, $W_{j,t}$ and $V_{j,t}$, for the DWT can be obtained as follows:

$$W_{j,t} = \sum_{l=0}^{L-1} h_{j,l} X_{t-1} \qquad \text{and} \qquad V_{j,t} = \sum_{l=0}^{L-1} g_{j,l} X_{t-1}. \qquad\qquad 1$$

Whereas, the MODWT wavelet and scaling filter, $\tilde{h}_l$ and $\tilde{g}_l$, at jth level are defined as:

$$\tilde{h}_{j,l} = h_{j,l}/2^{j/2} \qquad \text{and} \qquad \tilde{g}_{j,l} = g_{j,l}/2^{j/2}. \qquad\qquad 2$$

Similarly, the MODWT wavelet and scaling coefficients can be directly from Eq.1 as follows:

$$\widetilde{W}_{j,l} = \frac{1}{2^{j/2}} \sum_{l=0}^{L-1} \tilde{h}_{j,l} X_{t-1} \qquad \text{and} \qquad \tilde{V}_{j,l} = \frac{1}{2^{j/2}} \sum_{l=0}^{L-1} \tilde{g}_{j,l} X_{t-1}. \qquad\qquad 3$$

We chose the daily spot price of crude oil and the national stock market data of Brazil, Russia, India, China, and South Africa. The data is obtained from DataStream for the period of Jan 2000 to March 2015. The total number of observations for each series is 3785. We decompose each series into a set of wavelets characterizing short-, medium-, and long-run trends. Furthermore, we utilize these series in time-varying student-t copula to evaluate the dynamic dependence between crude oil and the BRICS countries.

Results

Table 1 shows the correlation analysis of undecomposed and decomposed returns series between crude oil and the financial markets of BRICS by employing three alternative measures of correlation, i.e., Pearson, Kendall, and Spearman. Based on the correlation analysis of undecomposed return series, it is apparent that the financial markets of Brazil, Russia, and South Africa exhibits largest degrees of connectedness with crude oil. Whereas, the correlation of crude oil with the financial markets of India and China is rather moderate. It is surprising as both countries are among the top oil importing and consuming countries of the world. Given this fact, we expect a greater level of integration of crude oil impact among these economies. This highlights the need to study the dependence dynamics between crude oil and BRICS at various frequencies. Therefore, we decompose the returns series into wavelets by employing MODWT as proposed by Percival and Walden (2000) and using Daubechies (1992) least asymmetric LA(8) filters. Based on the filtered returns, we evaluate how the dependence structure varies between short-, medium-, and long-run investment horizons. These trends are based on 2-4, 32-64, and 256-512 days investment horizon. The correlation analysis between different frequencies indicates an increase in level of connectedness between crude oil and BRICS economies. The dependence structure of short- and medium-run trend closely follows the dependence of original return series. Whereas, the linkage structure of long-run trend exhibits a significant upsurge in the dependence coefficients for all the BRICS economies. These findings highlight the significance to account for both temporal and spectral connectedness between crude oil and the BRICS.

Table 1. Correlation analysis of original and decomposed series between crude oil and BRICS

Correlation coefficients from Pearson, Kendall, and Spearman are presented in the table for the undecomposed and decomposed series between crude oil and the BRICS economies. The correlation coefficients presented in Panel B, C, and D represents the short-, medium-, and long-run trend based on the decomposed returns series.

a) Original returns series	Pearson	Kendall	Spearman	**b)** Short-run trend	Pearson	Kendall	Spearman
Brazil	27.23%	16.33%	23.80%	Brazil	25.78%	13.69%	19.86%
Russia	23.90%	14.93%	21.63%	Russia	19.45%	10.56%	15.40%
India	14.59%	8.05%	11.85%	India	15.32%	7.85%	11.59%
China	12.65%	6.89%	10.16%	China	6.93%	3.09%	4.54%
South Africa	25.28%	14.65%	21.42%	South Africa	22.35%	11.84%	17.33%

c) Medium-run trend	Pearson	Kendall	Spearman	**d)** Long-run trend	Pearson	Kendall	Spearman
Brazil	27.04%	18.91%	27.63%	Brazil	61.75%	30.70%	41.50%
Russia	46.06%	30.02%	43.05%	Russia	77.19%	39.83%	55.17%
India	18.64%	14.62%	21.12%	India	44.99%	11.99%	17.55%
China	22.58%	17.65%	25.44%	China	49.54%	25.12%	36.26%
South Africa	28.82%	18.90%	27.47%	South Africa	52.38%	19.80%	28.76%

Conclusion

In this paper, we study the dependence between crude oil and the financial markets of BRICS. We add to the literature on co-movement by employing MODWT and time-varying copula. Our analysis indicates that the correlation between crude oil and BRICS varies over time and across different investment horizons. This highlights the need to account for both spectral and temporal components of time series when assessing dependence with BRICS.

References

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