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# **ANALYZING THE IMPACT OF MACROECONOMIC FACTORS ON RENEWABLE AND NON-RENEWABLE ENERGY MARKETS POST COVID-19**

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## **Overview**

The economic shock brought in by COVID-19 has caused global energy markets to destabilize due to the change in energy demand structure. Governments worldwide are coping with having to deal with energy security issues and simultaneously, striving to meet the targets of carbon neutrality by 2030 (Paris Agreement Intended National Determined Contributions). Thus, investment patterns have widely changed towards Renewable Energy (RE) and Non-Renewable Energy (NRE) markets. Additionally, the oil market destabilization caused by the Ukraine-Russia crisis, can be thought of as a twin-shock to RE and NRE markets. In the aftermath of these crises, energy policies need to depend on how macroeconomic factors have differentially affected RE and NRE markets globally. To ensure continued commitment towards carbon neutrality, key factors that are stabilizing RE markets need to be extracted, as per the nature of the interactions in individual nations. This can only be addressed in tri-variate nexuses of RE-NRE-macroeconomic factor, for individual nations, which has not been studied in existing literature. The time-frequency domain improves the noisy results of time-series analyses of stochastic markets.

## **Method**

In a previous analysis on India, by the lead author (currently submitted to a journal), it was revealed that oil prices, gold prices and exchange rates stabilized RE market in India during periods of financial uncertainty. In the current study, the analysis is extended to the COVID-19 and Russia-Ukraine shocks, for India, European Union, United States, China and Japan (the highest global emitters and GDPs). The RE and NRE indices of each country are treated as independent variables, while macroeconomic factors of BRENT Oil price, XAU Gold price and Foreign Exchange (FOREX) rates are assumed dependent variables in the country-wise tri-variate nexuses (3 nexuses for each country). The time bounds for the analysis is January 1, 2020 to March 31, 2023, sampled daily, covering both aforementioned shocks. Time-frequency coherence is tested by Wavelet Coherence (WTC) -Equation below.

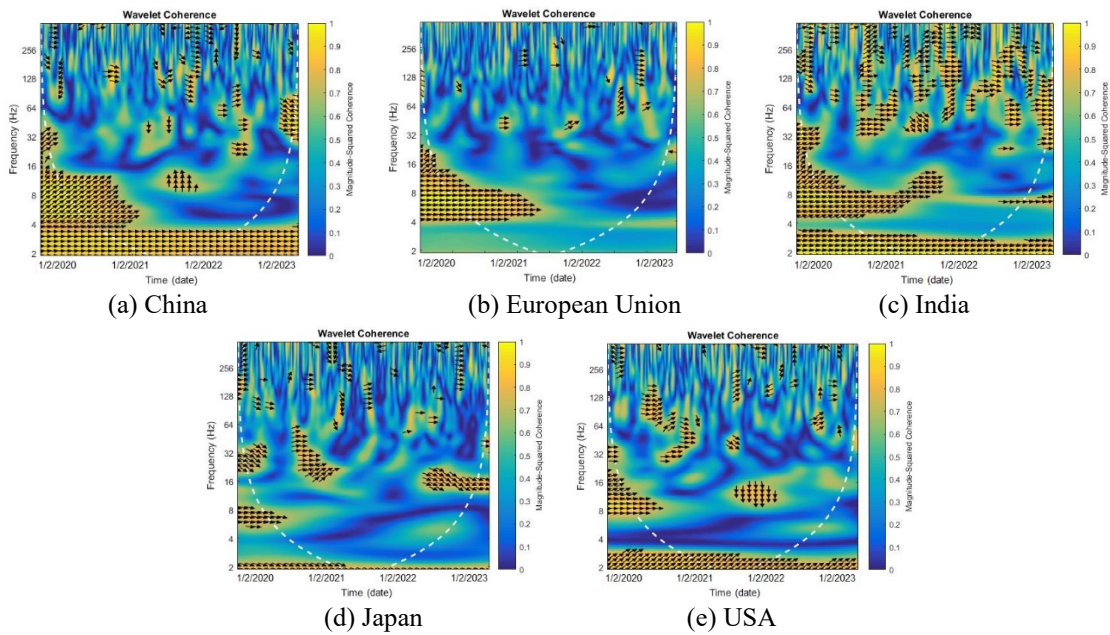
$$\frac{|S(C_x^*(a,b)C_y(a,b))|^2}{S(|C_x(a,b)|^2) \cdot S(|C_y(a,b)|^2)}$$

Where,  $C_x(a,b)$  and  $C_y(a,b)$  denote the continuous wavelet transforms of  $x$  and  $y$  at scales  $a$  and positions  $b$ . The superscript  $*$  is the complex conjugate and  $S$  is a smoothing operator in time and scale. Any low frequency interaction (less volatile, long-run interaction) in the coherence of a macroeconomic factor with either RE or NRE indices will indicate a flow from the macroeconomic market to the respective RE or NRE market, rendering stability to the latter.

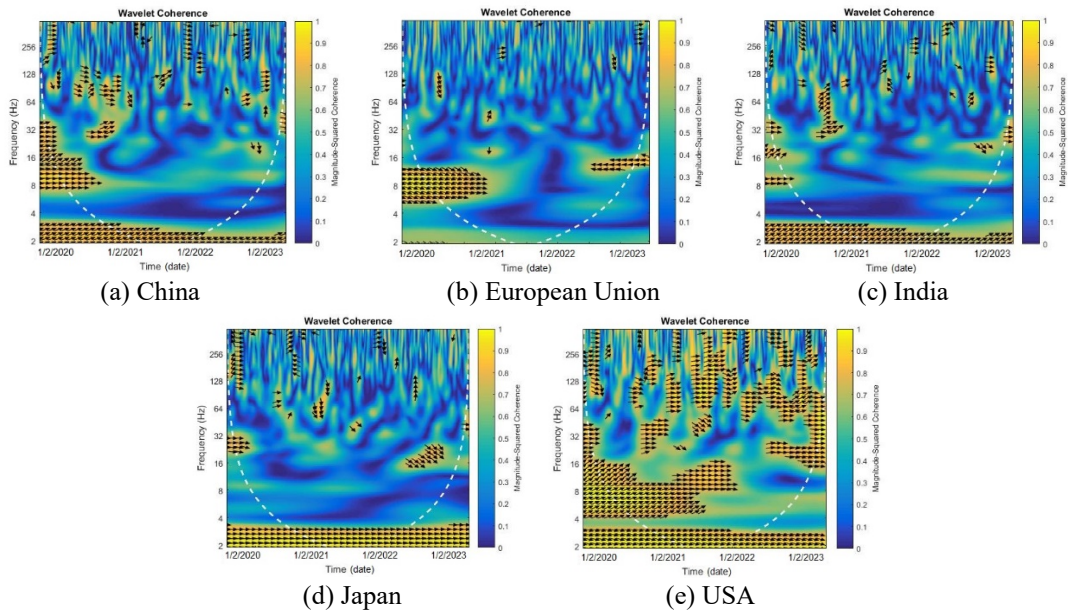
## **Results**

The nexuses that we propose delineates the financial policies that individual countries should make to achieve a stable RE market in the after math of the two crises. The developed economies of Europe and USA showed long-run (low frequency) interactions between BRENT and RE markets at the onset of COVID-19 and after lifting of COVID induced restrictions, showing that hedging can be done between them for stabilizing RE markets (*Figure 2*). Several long-run and short-run (high frequency) interactions dominated the NRE-BRENT interactions of India and China, showing that developing economies are more focused on energy security issues, strengthening the NRE markets (*Figure 1*). Gold prices showed long-run interactions with RE markets in India and China, showing the stable diversifying option that investors have by coupling the two markets. For Japan, which is struck by a devaluing currency after the Russia-Ukraine crisis, showed long-and short-run interactions with FOREX, but had no significant interactions with RE market and macroeconomic factors.

Thus, further study is required to identify factors that can render stability to RE market in Japan (and economically similar nations with a falling currency, like Pakistan, Zimbabwe, etc.). *BRENT-RE-NRE interactions are shown as an example, below.*



**Figure 1:** Interactions of country-wise NRE market index and BRENT Oil Price



**Figure 2:** Interactions of country-wise RE market index and BRENT Oil Price

## Conclusion

This study provides pathways, for countries at different economic maturity, for financial policy development towards carbon neutrality in the aftermath of COVID-19. NRE markets showed more stability in developing countries of China and India, while RE markets showed more stability for developed economies of USA and Europe. The main pathway for developed countries is counterintuitive, as they have to maintain a stable crude oil market investment, which is structurally coupled to their RE markets. Investors in developing nations need to be given attractive opportunities to invest long-term in RE markets, which they may couple with the stable Gold market. However, for other developed and developing countries with growing inflation (devaluing currency), policies must address reducing inflation, else RE markets cannot be stabilized.

## References

- Farid, S., Karim S., Naem, M.A., Nepal, R., Jamasb, T. (2023) "Co-movement between dirty and clean energy: A time-frequency perspective", *Energy Economics* 119, #106565.
- Tiwari, A.K., Mutascu, M.I., Albuлесcu, C.T. (2013) "The influence of the international oil prices on the real effective exchange rate in Romania in a wavelet transform framework", *Energy Economics* 40, 714-733.
- Grinsted, A. J., Moore, C., Jevrejeva, S. (2004) "Application of the cross wavelet transform and wavelet coherence to geophysical time series." *Nonlinear Processes in Geophysics* 11(5/6), 561–566.