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Uncovering Interdependencies between Crude Palm Oil Commodity and ASEAN-5 Equity Markets: A Time-Frequency Connectedness Analysis

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Abstract

This study investigates the time varying relationship between the Crude Palm Oil Commodity and ASEAN-5 Equity Markets during the period of 1 June 2007 to 31 May 2023 by examining their returns and volatilities using a novel time-varying parameter vector autoregression-based frequency connectedness approach. The empirical findings reveal distinct behaviors in return connectedness and volatility connectedness between these markets. Specifically, the return connectedness is primarily driven by shock transmissions in the short run, with the equity markets act as the net transmitter while the crude palm oil market acts as the net receiver in terms of net connectedness. Conversely, volatility connectedness is driven by shock transmissions in the long run, with crude palm oil being the net transmitter of volatility spillover. These results hold significant implications for investors and policymakers concerned with commodity prices, enabling them to better understand the interconnections and potential risks in these markets.

Keywords: Crude palm oil, equity market, ASEAN-5, connectedness analysis

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1. Introduction

Palm oil is a versatile product that has found widespread use in various applications, particularly as a vegetable oil. In recent years, there has been a significant surge in the utilization of palm oil for biofuel production. This increased demand for palm oil has led to a remarkable expansion in its production over the past few decades. Specifically, global palm oil production has surged by 35 times, from 2 million tonnes in 1970 to 71 million tonnes in 2018 (Ritchie & Roser, 2021).

Palm oil is derived from the oil palm, the world's leading oil crop that only grows in tropical regions. The major producers of palm oil are Malaysia and Indonesia, both situated in tropical Southeast Asia. As a number of studies have pointed out, the commodities and financial markets often exist spillover relationships (see, for example, Babar et al., 2023; Garcia-Jorcano and Sanchis-Marco, 2022). As such, it is anticipated that the palm oil market will play an increasingly vital role in the Southeast Asian region's economic and financial conditions, given it is the primary region for palm oil production and consumption. However, research about the spillover effects of crude palm oil on the region's financial markets remains limited.

Against such a backdrop, this article aims to investigate the spillover of returns and volatilities between the crude palm oil commodity and equity markets in five of the Association of Southeast Asian Nations' (ASEAN-5) member countries, including Malaysia, Indonesia, Philippines, Singapore, and Thailand. Following robust economic performance and a continued trend of economic integration within the ASEAN bloc, the equity markets in the region have experienced tremendous growth in market capitalization. As of 2017, the regional stock exchanges hosted a combination of over 3,400 listed companies with a total market capitalization of USD 2.7 trillion (CEIC, n.d.). Therefore, it is essential to examine the impact of crude palm oil, one of the most significant commodities in the region, on the equity markets of these countries.

Using a time-varying parameter vector autoregression (TVP-VAR)-based frequency connectedness approach, our result findings reveal different patterns in how returns and volatilities are linked between the crude palm oil and equity markets of ASEAN-5 nations. In particular, return connectedness is primarily influenced by shock transmissions in the short run, with the equity markets being a net transmitter and the crude palm oil being a net receiver of return spillovers. Conversely, volatility connectedness is driven by shock transmissions in the long run, in which the crude palm oil is the net transmitter, and the equity markets are the net receivers of volatility spillovers.

This work presents two significant contributions. Firstly, it is the first comprehensive study to explore the relationship between the equity markets of the ASEAN-5 countries and crude palm oil prices over an extended period. In contrast to traditional VAR-based approaches that are limited to analyzing the time domain, our method excels in tracking dynamic spillovers at different time-frequency bands. Leveraging the time-frequency domain grants us valuable insights into how the interconnectedness between these markets evolves across different frequency bands, offering a more comprehensive understanding of the intricate interactions between equity markets and commodity prices amid the COVID-19 crisis. Secondly, while this study is related to Lim et al.'s (2014) analysis of spillovers between commodities and ASEAN-5 countries using a static method, our research stands apart by focusing specifically on crude palm oil and extensively exploring the time-varying

connectedness. By delving deeply into the dynamics of crude palm oil market interrelationships with equity markets, we provide a deeper understanding of the fluctuations and temporal variations in their connectedness, shedding light on the changing nature of their interactions.

The remainder of this article is organized as follows. Section 2 provides the literature review of spillover analysis of commodity and financial markets. Section 3 outlines the methodology of TVP-VAR based frequency connectedness framework. Section 4 describes the data used in this study. Section 5 presents the empirical results. Finally, Section 6 concludes.

2. Literature Review

Our research closely aligns with existing literature on time varying spillovers among diverse commodities. For example, Luo and Ji (2018) study the interconnections between crude oil prices in the US and agricultural commodity futures in China, while Fasanya and Akinbowale (2019) examine the links between crude oil and food prices in Nigeria. Notably, our findings reveal that return spillovers demonstrate a consistent trend without bursts, whereas volatility spillovers exhibit both trend and burst patterns over the study period. Guhathakurta et al. (2020) explore the connectedness and directional spillovers between oil and various agricultural commodities, emphasizing a robust volatility connectedness between oil prices and agricultural products. Similarly, Maitra et al. (2021) investigate the connectedness between oil and 21 commodity futures, including the palm oil market, uncovering substantial evidence of asymmetric volatility spillovers, where negative shocks dominate positive ones. Furthermore, Akyildirim et al. (2022) delve into the connectedness among different agricultural commodities, documenting the influence of COVID-19-induced uncertainty on agricultural commodity returns. Additionally, Chandrarin et al. (2022) employ innovative approaches, using frequency connectedness analysis, to measure volatility spillovers among exchange rates, consumer price index, crude palm oil price, and coal price in Indonesia, providing valuable insights into the complex relationships between these indicators and commodity prices.

Our research builds upon several relevant studies and makes a substantial contribution to the understanding of the interconnections between equity and commodity markets. For example, Lin et al. (2021) investigate the risk spillovers between Chinese, American, and European equities markets and the global crude oil market. Similarly, Mensi et al. (2021a) explore the volatility spillovers between strategic commodities futures markets and equity markets in both advanced and emerging economies. Meanwhile, Mensi et al. (2021b) analyze the time-frequency relationship between major rare earth elements markets and the stock indexes of their exporting and importing nations. Notably, Billah et al. (2023) focus on agribusiness and find that the degree of inverse shocks determines the connectedness of returns, with larger impacts of anticipated shocks on the left and right tails compared to estimated shocks on the average. Moreover, Mensi et al. (2022) and Cagli et al. (2023) study frequency volatility spillovers among crude oil, gold, and ten sector indices, as well as volatility spillovers for ten agribusiness equity prices and different types of agricultural commodities in the US context, using innovative approaches. Furthermore, Wen et al. (2021) examine the connectedness among rare earth elements, non-ferrous metals, energy, chemicals, grains, oil, soft goods, and equity markets, revealing a significant dependency between equity and commodity markets. Chang and Fang (2022) support Wen et al.'s (2021) findings by showing a positive linkage between the equity market and the commodity market,

analyzing various types of commodity and equity connectedness. Adopting a time-frequency approach, Qi et al. (2022) study the time-varying association between renewable energy equity markets and energy commodity markets in China. On the other hand, Rehman et al. (2023) use the Quantile connectedness method to investigate the connectedness of equity and commodity markets in the Chinese context, revealing spillovers that vary across different quantiles. Additionally, Bossman and Agyei (2022) analyze the connectedness among various classes of commodities and African equity markets, noting that commodity and equity markets can produce safe returns, but high commodity price volatility and financialization suggest that the behavior of commodity returns may vary.

Although other academics have identified a link between commodities prices and equity market volatility, many studies tend to concentrate on the US and Chinese markets. The ASEAN market has received very little research attention. The relationship between the ASEAN-5 stock markets and commodities including rice, rubber, gold, palm oil, and gasoline is examined by Lim et al. (2014). The goal of this study is to build on the work of Lim et al. (2014) by examining the relationship between the ASEAN-5 stock markets and crude palm oil. The choice of crude palm oil is made since Malaysia and Indonesia, two ASEAN nations, account for more than half of the palm oil's output⁴. Besides that, Yeap and Lean (2022) also state that crude palm oil serves as significant contributor to the gross national income (GNI) of Malaysia. In addition, Lim et al. (2014) also find that palm oil prices significantly affect the stock market returns of Indonesia and Malaysia.

Our work differs from Lim et al. (2014) in several aspects. First, we aim to examine the connectedness in different frequencies, an aspect that was neglected in their study. Mensi et al. (2021a) have found evidence indicating that spillovers are more prominent in the short term compared to the long term across crude oil, gold, and stock markets. Similarly, Mensi et al. (2021b) show that short-run contagion dominates long-run contagion between rare earth elements and equity markets. Additionally, Mensi et al. (2022) demonstrate that the responsiveness of stocks to commodity price shocks may vary across different frequencies. These findings underscore the importance of examining connectedness in various frequency bands. Second, while Lim et al. (2014) employed a static method to investigate spillovers, we recognize the limitations of this approach in capturing the time varying fluctuations of real markets. Hence, our study employs a time-varying approach that can account for extreme events such as the Global Financial Crisis (GFC) and the COVID-19 pandemic. By incorporating the time varying dimension, our research aims to fill this gap and provide a more comprehensive understanding of the connectedness between crude palm oil and ASEAN-5 equity markets over different time frames, thus offering valuable insights for investors and policymakers.

3. Methodology

By merging the work of Baruník and Křehlík (2018) and Antonakakis et al. (2020), this research employs the TVP-VAR-based frequency connectedness approach presented by Chatziantoniou et al. (2021) to examine the interconnectivity between the crude palm oil and stock markets. We employ a TVP-VAR model with a p -order lag, which is similar to the

⁴ Source: Oil Seeds: World Markets and Trade, Global Oil Seeds Report, US Department of Agriculture, January 2023

strategy utilised in the works of Chatziantoniou et al. (2021), Antonakakis et al. (2020), and Cui and Maghyreh (2023):

$$\mathbf{x}_t = \Phi_{1t}\mathbf{x}_{t-1} + \Phi_{2t}\mathbf{x}_{t-2} + \dots + \Phi_{pt}\mathbf{x}_{t-p} + \xi_t \quad \xi_t \sim N(\mathbf{0}, \Sigma_t) \quad (1)$$

where $\mathbf{x}_t$ and ξ_t are $N \times 1$ dimensional vectors. By incorporating time-varying coefficients denoted by Φ_{it} , we allow for changes in the relationship between variables over time, providing a more realistic depiction of the time varying nexus between the crude palm oil and equity markets. Additionally, we account for the time-varying nature of the data by using the variance-covariance matrix Σ_t , which captures changes in volatility and correlations among the variables.

To estimate the generalised forecast error variance decomposition (GFEVD), it is necessary to convert the TVP-VAR model into a TVP vector moving average (TVP-VMA) representation according to the Wold representation theorem. The forecast error variance of the endogenous variables is quantified by the GFEVD by accounting for the contributions of each shock. It has the following representation:

$$\psi_{ij,t}(H) = \frac{\sum_{h=0}^{H-1} (e_i' \mathbf{A}_{ht} \Sigma_t e_j)^2}{(e_j' \Sigma_t e_j) \sum_{h=0}^{H-1} (e_i' \mathbf{A}_{ht} \Sigma_t \mathbf{A}_{ht}' e_i)} \quad (2)$$

$$\tilde{\psi}_{ij,t}(H) = \frac{\psi_{ij,t}(H)}{\sum_{j=1}^K \psi_{ij,t}(H)}$$

where e_i is a $K \times 1$ zero selection vector with a value of 1 in its i -th position. The term $\psi_{ij,t}(H)$ denotes the proportional reduction of the H -step forecast error variance of variable i resulting from conditioning on the future shocks of variable j . Diebold and Yilmaz (2012, 2014) suggest the normalization method, the connectedness table represented as $\tilde{\psi}_{ij,t}(H)$, is transformed into a range of $[0,1]$, making it more readily interpretable.

The generalized spillover table is used to compute summary measures of spillover effects. These measures include the total directional connectedness from other variables to variable i , which quantifies the network's influence on variable i . It helps understand the collective impact of other variables on variable i . Additionally, the total directional connectedness to other variables resulting from a shock in variable i indicates variable i 's impact on the entire network. It measures how much variable i contributes to the time-dependence dynamics and volatilities of other variables. These metrics can be expressed as:

$$S_{i \leftarrow \bullet, t}^{From} = \sum_{j=1, j \neq i}^K \tilde{\psi}_{ij,t}(H) \quad (3)$$

$$S_{\bullet \leftarrow i, t}^{To} = \sum_{j=1, j \neq i}^K \tilde{\psi}_{ji,t}(H) \quad (4)$$

The net total directional connectedness of variable i is an important fundamental statistic in the connectedness method in addition to the metrics described above. This metric is employed to assess whether variable i exerts more influence on the network compared to being influenced by it, or vice versa. It can be calculated using the formula:

$$S_{i,t}^{Net} = S_{\bullet \leftarrow i,t}^{To} - S_{i \leftarrow \bullet,t}^{From} \quad (5)$$

For portfolio and risk managers, the total connectedness index (TCI) is a crucial tool for determining the degree of network interconnectivity or market risk. The total directional connectedness *FROM* (or *TO*) other variables is averaged to create the TCI. It may be described using the equation below:

$$TCI_t = \frac{1}{K} \sum_{i=1}^K S_{i \leftarrow \bullet,t}^{From} = \frac{1}{K} \sum_{i=1}^K S_{\bullet \leftarrow i,t}^{To} \quad (6)$$

The equations previously discussed form the core of the TVP-VAR-based connectedness method and provide the basis for our connectedness metrics in the time domain. The frequency response function is introduced first before moving on to the connectedness metrics in the frequency domain:

$$\psi(e^{-i\omega}) = \sum_{h=0}^{\infty} e^{-i\omega h} \psi_h, i = \sqrt{-1} \quad (7)$$

Following that, the Fourier Transformation of the TVP-VMA model may be used to describe the spectral density of x_t at the frequency as follows:

$$S_x(\omega) = \sum_{h=-\infty}^{\infty} E(x_t x'_{t-h}) e^{-i\omega h} = \psi(e^{-i\omega h}) \Sigma_t \psi'(e^{+i\omega h}) \quad (8)$$

By combining the spectral density and the GFEVD, the frequency GFEVD and normalized frequency GFEVD are presented as follows:

$$\begin{aligned} \psi_{ij,t}(\omega) &= \frac{(\Sigma_t)_{jj}^{-1} \left| \sum_{h=0}^{\infty} (\Psi(e^{-i\omega h}) \Sigma_t)_{ij,t} \right|^2}{\sum_{h=0}^{\infty} (\Psi(e^{-i\omega h}) \Sigma_t \Psi(e^{i\omega h}))_{ii}} \\ \tilde{\psi}_{ij,t}(\omega) &= \frac{\psi_{ij,t}(\omega)}{\sum_{k=1}^N \psi_{ij,t}(\omega)} \end{aligned} \quad (9)$$

where $\tilde{\psi}_{ij,t}$ represents the proportion of market i 's spectrum that can be attributed to the shock originating from market j at the specific frequency ω . To assess the connectedness at different frequency bands, we integrate across all frequencies within a particular range, denoted as $d = (a, b)$, where a and b lie in the interval $(-\pi, \pi)$, with $a < b$. This integration enables us to measure the level of connectedness at various frequency bands using the following approach:

$$\tilde{\psi}_{ij,t}(d) = \int_a^b \tilde{\psi}_{ij,t}(\omega) d\omega \quad (10)$$

The frequency connectedness measurements are now presented as follows:

$$S_{i \leftarrow \bullet, t}^{From}(d) = \sum_{j=1, j \neq i}^K \tilde{\psi}_{ij,t}(d) \quad (11)$$

$$S_{\bullet \leftarrow i, t}^{To}(d) = \sum_{j=1, j \neq i}^K \tilde{\psi}_{ji,t}(d) \quad (12)$$

$$S_{i, t}^{Net}(d) = S_{\bullet \leftarrow i, t}^{To}(d) - S_{i \leftarrow \bullet, t}^{From}(d) \quad (13)$$

$$TCI_t(d) = \frac{1}{K} \sum_{i=1}^K S_{i \leftarrow \bullet, t}^{From}(d) = \frac{1}{K} \sum_{i=1}^K S_{\bullet \leftarrow i, t}^{To}(d) \quad (14)$$

4. Data Description

For the purpose of this study, the crude palm oil commodities market is represented by the daily settlement prices of crude palm oil traded on the Malaysia Derivatives Exchange (MDEX). The information was extracted from the website of Bursa Malaysia Derivatives. In addition, five ASEAN nations—Malaysia, Indonesia, Philippines, Singapore, and Thailand—had their equities markets chosen for examination. The different stock markets of each nation are represented by the stock indexes of the Kuala Lumpur Stock Exchange (KLSE), Indonesia Stock Exchange (IDX), Philippine Stock Exchange, Singapore Exchange (SGX), and The Stock Exchange of Thailand (SET).

This study covers a sample period ranging from 1 June 2007 to 31 May 2023, consisting of a total of 4094 observations. This time frame encompasses significant events such as the GFC in 2008 and the impact of the COVID-19 pandemic on equity markets. It also includes the effects of structural changes that occurred in 2012, resulting from supply and demand factors, as well as the shortage of supply caused by the COVID-19 pandemic in the palm oil market. To mitigate the unit root problem, all the data in this study were transformed into log returns.

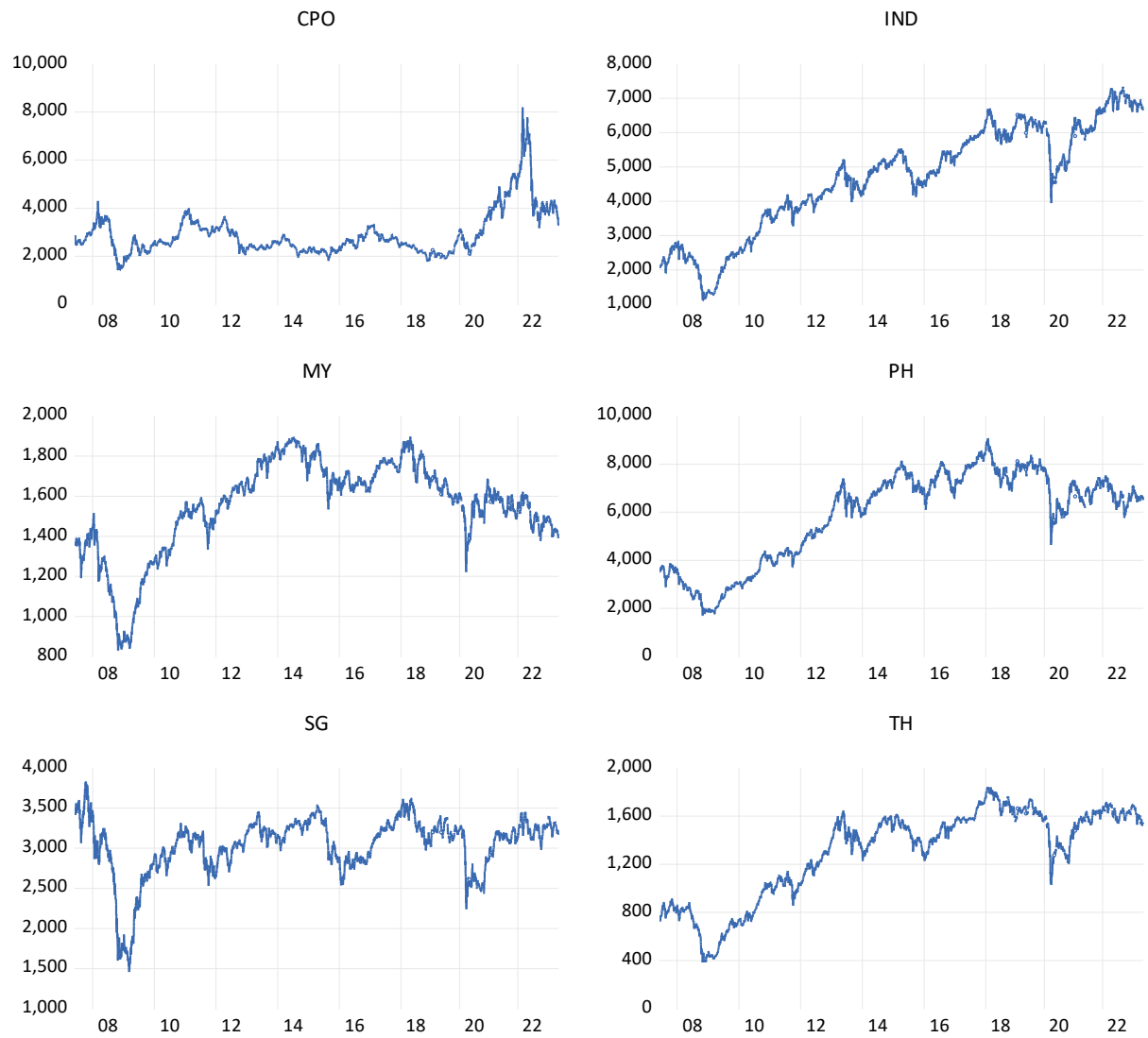


Fig. 1. Price plot for the crude palm oil and equity markets

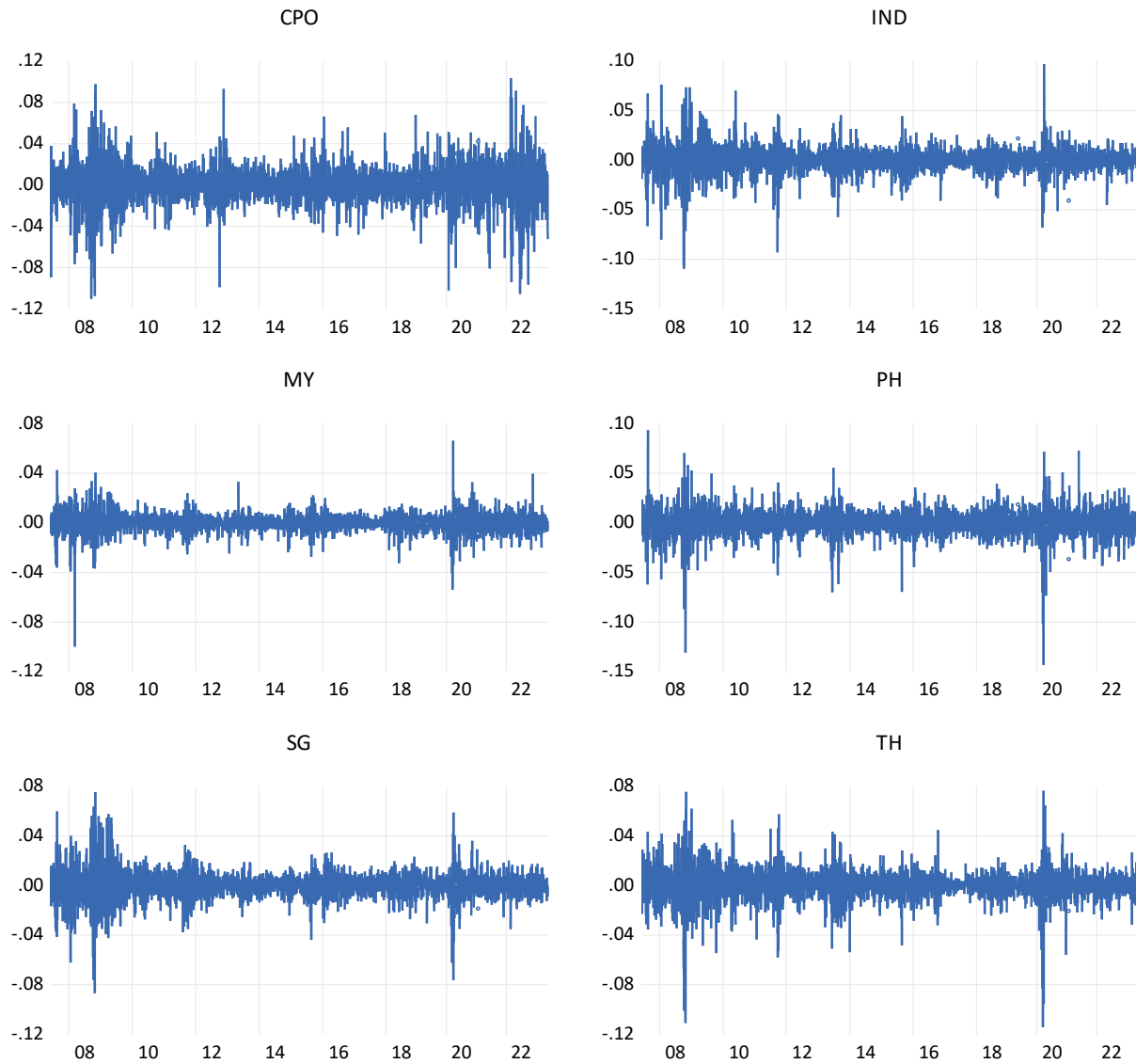


Fig. 2. Return plot for the crude palm oil and equity markets

Figures 1 and 2 present the price and return plots for crude palm oil alongside the equity markets of the five ASEAN nations. Figure 1 illustrates that the GFC caused a decline in crude palm oil prices between 2008 and 2012. Moreover, during the COVID-19 epidemic, crude palm oil prices experienced a significant surge followed by a sharp decline due to overpricing. The equity markets of the ASEAN nations also exhibited notable falls during both the COVID-19 outbreak and the GFC, as evident in Figure 1. Additionally, Figure 2 demonstrates that both the crude palm oil market and the equity markets showed higher return volatility during these significant events, reflecting increased market uncertainty and fluctuations. These observations emphasize the interconnectedness between the crude palm oil market and the ASEAN-5 equity markets, wherein global events influence both markets, leading to comparable price and volatility patterns during major crises.

Table 1: Descriptive statistics

	CPO	Indonesia	Malaysia	Philippines	Thailand	Singapore
Mean	4.38×10^{-5}	2.83×10^{-4}	4.81×10^{-6}	1.47×10^{-4}	1.74×10^{-4}	-2.37×10^{-5}
SD	0.0182	0.0124	0.0074	0.0128	0.0115	0.0106
Skewness	-0.2566	-0.5655	-0.7599	-0.9493	-0.9603	-0.2466

Kurtosis	7.6448	12.5862	16.6884	14.9464	15.5081	11.1013
Jarque-Bera	3723***	15886***	32341***	24948***	27304***	11232***
Ljung-Box	24.3138***	26.8368***	48.1890***	11.0027*	42.3041***	19.0193***
ARCH	498***	508***	292***	520***	569***	1044***
ADF	-14.3892***	-15.7408***	-16.1508***	-15.7874***	-14.7021***	-15.9090***

Notes: ***, **, * denotes the significance at the 1%, 5% and 10% level, respectively.

Table 1 presents an overview of the descriptive statistics for the daily returns of crude palm oil and the equity markets in the five ASEAN countries. Indonesia stands out among the ASEAN countries with the highest average return, while Malaysia exhibits the lowest average return in equity markets. Furthermore, the crude palm oil market demonstrates greater volatility compared to the equity markets. Both the palm oil and equity markets show negative skewness, indicating a higher occurrence of extreme negative returns compared to extreme positive returns. Moreover, both markets display kurtosis values exceeding three, which suggests a leptokurtic distribution characterized by heavier tails and a lower, broader central peak. The normality test conducted using the Jarque and Bera (1987) method reveals they are different from the normal distribution, yielding statistically significant results. Additionally, the Ljung-Box test shows the existence of autocorrelation in the series and the ARCH test confirms the presence of heteroskedasticity in the error terms for all the series. The presence of autocorrelation and heteroskedasticity supports the utilization of the TVP-VAR framework to model the time-varying variance-covariance structure (Li et al., 2023). Furthermore, the ADF unit root tests verify that all variables are stationary, thereby preventing any spurious regression outcomes.

5. Empirical Result

5.1. Connectedness between crude palm oil and ASEAN-5 stock returns

Table 2 displays the results of the static return connectedness analysis conducted for crude palm oil and ASEAN-5 equity. Each square in the connectedness table contains four numerical values: overall connectedness, short-run connectedness (1-5 days), medium-run connectedness (5-22 days), and long-run connectedness (22-Inf days). The overall connectedness value is further divided into short-run, medium-run, and long-run connectedness, representing the connectedness within specific frequency ranges. This breakdown allows us to examine the varying degrees of connectedness across different time periods. Moreover, the diagonal elements of the connectedness table indicate the connectedness resulting from the shocks originating within each asset itself. They represent the impact that each asset's own shocks have on its returns. Conversely, the off-diagonal elements capture the connectedness arising from the interactions between assets within the network. These off-diagonal elements reveal the extent to which other assets influence the returns of a specific asset or vice versa.

Table 2: Return connectedness

	CPO	Indonesia	Malaysia	Philippines	Thailand	Singapore	FROM
CPO	80.85(63.87) [12.47]{4.52}	3.6(2.75) [0.62]{0.23}	4.12(3.24) [0.64]{0.24}	2.96(2.29) [0.49]{0.18}	4.35(3.41) [0.69]{0.25}	4.13(3.35) [0.57]{0.21}	19.15(15.03) [3.02]{1.10}
Indonesia	2.51(1.93) [0.43]{0.16}	56.29(45.09) [8.23]{2.96}	11.14(8.77) [1.74]{0.63}	8.92(7) [1.41]{0.51}	9.03(6.8) [1.63]{0.59}	12.11(9.36) [2.02]{0.73}	43.71(33.87) [7.22]{2.62}
Malaysia	2.93(2.26) [0.49]{0.18}	11.5(8.46) [2.22]{0.82}	54.95(43.31) [8.54]{3.09}	9.11(6.85) [1.66]{0.61}	8.97(6.45) [1.84]{0.68}	12.54(9.06) [2.54]{0.94}	45.05(33.08) [8.75]{3.23}
Philippines	2.42(1.83) [0.43]{0.16}	10.8(7.68) [2.28]{0.84}	10.25(7.54) [1.98]{0.73}	59.31(47.07) [8.99]{3.25}	7.85(5.33) [1.83]{0.68}	9.37(6.34) [2.2]{0.82}	40.69(28.74) [8.72]{3.23}
Thailand	3.04(2.41) [0.46]{0.17}	9.42(7.2) [1.62]{0.6}	8.99(7.12) [1.37]{0.5}	6.36(4.87) [1.09]{0.4}	58.92(46.77) [8.92]{3.24}	13.27(10.27) [2.2]{0.81}	41.08(31.88) [6.73]{2.47}

Singapore	2.77(2.28) [0.36]{0.13}	11.62(9.22) [1.77]{0.64}	11.8(9.45) [1.73]{0.62}	6.94(5.35) [1.17]{0.42}	12.4(9.54) [2.1]{0.76}	54.47(43.57) [8.01]{2.89}	45.53(35.83) [7.13]{2.57}
TO	13.67(10.72) [2.16]{0.79}	46.95(35.32) [8.51]{3.13}	46.3(36.12) [7.46]{2.71}	34.29(26.35) [5.82]{2.12}	42.59(31.53) [8.09]{2.97}	51.42(38.38) [9.53]{3.51}	235.22(178.42) [41.57]{15.22}
Inc.Own	94.52(74.59) [14.63]{5.3}	103.23(80.4) [16.74]{6.09}	101.25(79.44) [16.01]{5.8}	93.6(73.42) [14.81]{5.37}	101.51(78.3) [17]{6.21}	105.89(81.95) [17.55]{6.39}	TCI
NET	-5.48(-4.31) [-0.86]{-0.32}	3.23(1.45) [1.28]{0.5}	1.25(3.05) [-1.29]{-0.52}	-6.4(-2.39) [-2.9]{-1.11}	1.51(-0.35) [1.35]{0.5}	5.89(2.55) [2.41]{0.93}	39.2(29.74) [6.93]{2.54}

Notes: In the connectedness table, numerical results were obtained using Chatziantoniou et al. (2021) innovative time-varying parameter frequency connectedness approach. The approach employs a TVP-VAR model with an optimized lag length determined by AIC, BIC, and SC criteria. A 100-step-ahead forecast error variance decomposition is used. Values in the upper-left square are time-domain connectedness results from the traditional DY connectedness approach. Values in (), [], and {} denote short-run, medium-run, and long-run frequency connectedness results, respectively. "FROM" column shows total connectedness received by market i, "TO" row displays total connectedness transmitted by market i. The "NET" row shows net connectedness, and "TCI" at the bottom right measures overall spillover effects within the system.

From Table 2, the analysis reveals that the total connectedness index between crude palm oil and ASEAN-5 equity is 39.20%. This connectedness can be further broken down into specific time periods, with 29.74% attributed to short-run factors, 6.93% to medium-run factors, and only 2.54% to long-run factors. These findings indicate that the return connectedness is primarily driven by shock transmissions in the short run, with relatively less influence from medium and long-run factors. The finding is similar to Mensi et al. (2022) that short-run contagion dominates the long-run contagion. Besides that, from the diagonal elements of the table, we observe that 80.85% of the connectedness in crude palm oil can be attributed to its own shocks, while the remaining 19.15% originates from the equity markets. This suggests that the majority of return connectedness in crude palm oil is caused by its own shocks, indicating a higher level of self-influence. In contrast, the return connectedness resulting from idiosyncratic shocks in each ASEAN-5 equity market is as follows: Indonesia (56.29%), Malaysia (54.95%), Philippines (59.31%), Thailand (58.92%), and Singapore (54.47%). This indicates that the equity markets in the ASEAN-5 countries are more responsive to shocks originating from other markets within the system, as compared to the crude palm oil market that is less susceptible to other markets' shocks.

When considering the total connectedness transmitted "TO" others, it is observed that the ASEAN-5 equity markets contribute a relatively higher level of return connectedness to the overall system compared to the crude palm oil market. A similar pattern is observed for the connectedness received "FROM" others. In addition, with the exception of the Philippines, all equity markets act as net transmitters, while the crude palm oil market acts as a net receiver (as indicated by a negative net connectedness value of -5.48%). The reason for the higher "TO" and "FROM" metrics in the ASEAN-5 equity markets is likely due to the high interdependency within the equity market itself. This suggests that the equity markets have a stronger influence on the overall connectedness within the system, compared to the crude palm oil market. To further examine the connectedness between crude palm oil and the equity markets, we can focus on the values in the first row and column of the connectedness table. It is observed that the transmission of shocks from crude palm oil to the equity markets (13.67%) is less significant compared to the transmission of shocks from the equity markets to the crude palm oil market (19.15%). This implies that the equity markets may have a greater influence on the crude palm oil market in terms of return connectedness, rather than the other way around.

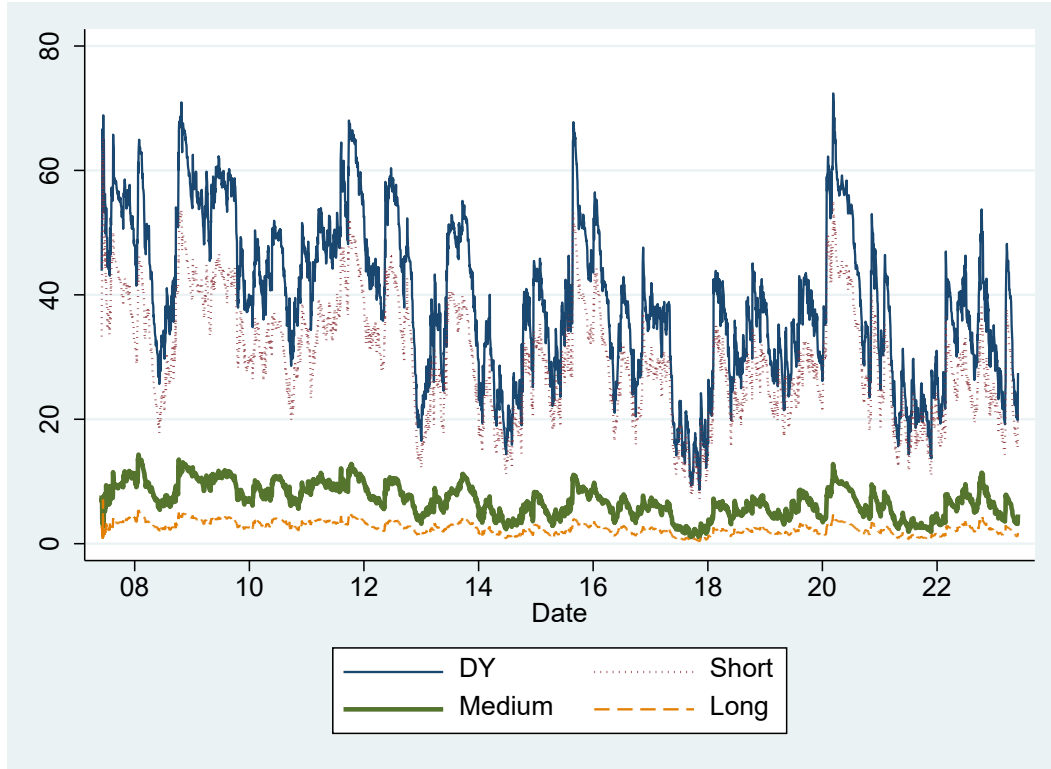


Fig. 3. Time varying total connectedness: return

Table 2 presents the static connectedness analysis and does not account for the time-varying nature of the connectedness over time. To address this limitation, we conduct an in-depth analysis of the time-varying evolution trajectories of connectedness based on TVP-VAR approach, aiming to highlight the significant effects of major political and economic events on the overall connectedness. Figure 3 displays the results for the time-varying total connectedness of returns. The thin solid line represents the entire interconnectivity in the time domain, calculated using the approach developed by Diebold and Yilmaz (2012, 2014). Additionally, the dashed line, thick solid line, and dotted line illustrate the short-run, medium-run, and long-run ranges of the TVP-VAR-based frequency connectedness results, respectively.

As depicted in Figure 3, the time varying total return connectedness indices exhibit time-varying patterns and are significantly influenced by major events. These results align with recent findings by Niu and Hu (2021) and Rehman et al. (2023), highlighting that the magnitude and direction of spillovers between stocks and commodities change over time. Throughout the sample period, the total return connectedness varies between approximately 10% and 70%, illustrating a wide range of interconnectedness levels. The time varying total return connectedness indices display significant volatility over time, consistent with the findings from Table 2. Additionally, in line with the results in Table 2, the analysis reveals that connectedness is primarily driven by the short run shock, indicating no evidence of long-run cointegration between the crude palm oil and equity markets based on the return connectedness analysis.

The analysis of the time-varying total return connectedness indices reveals noteworthy peaks, with the first one occurring after the GFC at approximately 70%. Another significant peak is observed in 2012, which aligns with structural changes in the crude palm oil market driven by supply and demand factors, as discussed by Rahman et al. (2013).

During this period, there was a substantial decline in crude palm oil prices, impacting major producers like Malaysia and Indonesia, and leading to increased connectedness in other ASEAN countries. The third peak in the time varying total return connectedness indices occurs in late 2015, resulting from the turbulence in the Chinese stock market. The significant decline in equity markets in response to the Chinese stock market turmoil contributed to heightened connectedness in the ASEAN-5 stock markets. The final peak coincides with the COVID-19 pandemic, which brought widespread lockdown measures impacting both equity and crude palm oil markets. Stock markets experienced volatility and declines due to pandemic-related uncertainties, while government restrictions on foreign labour created labour shortages affecting the crude palm oil market. These shared events led to increased connectedness between the equity and crude palm oil markets.

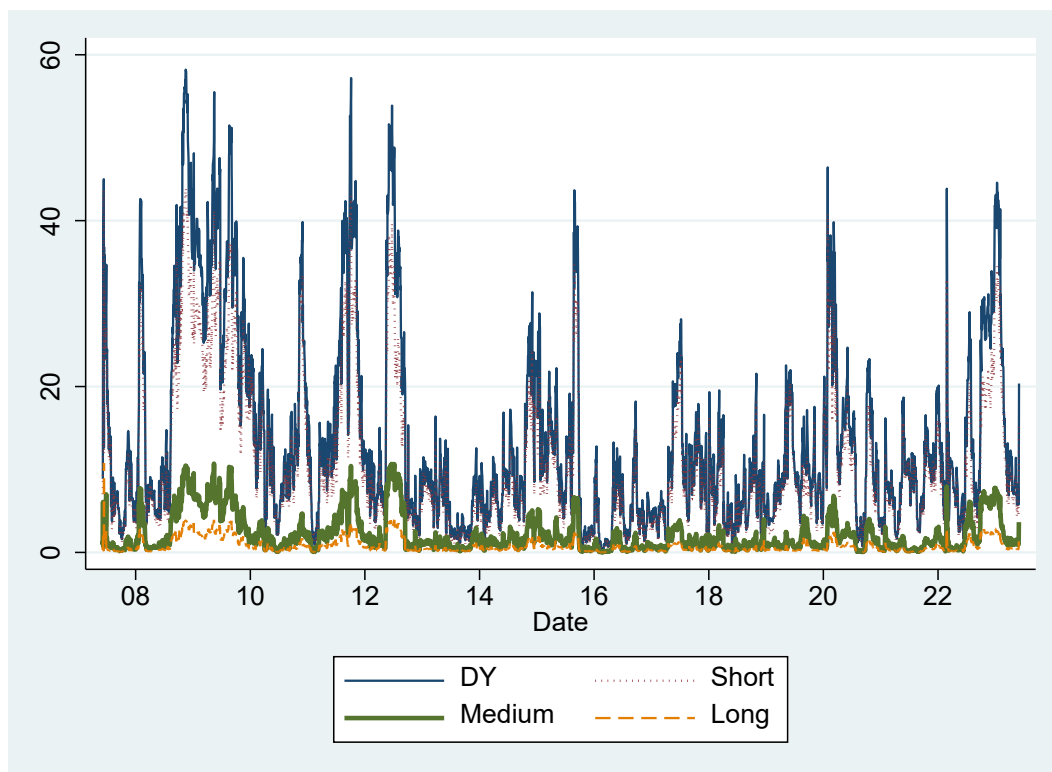


Fig. 4. Time varying TO connectedness: return (crude palm oil market)

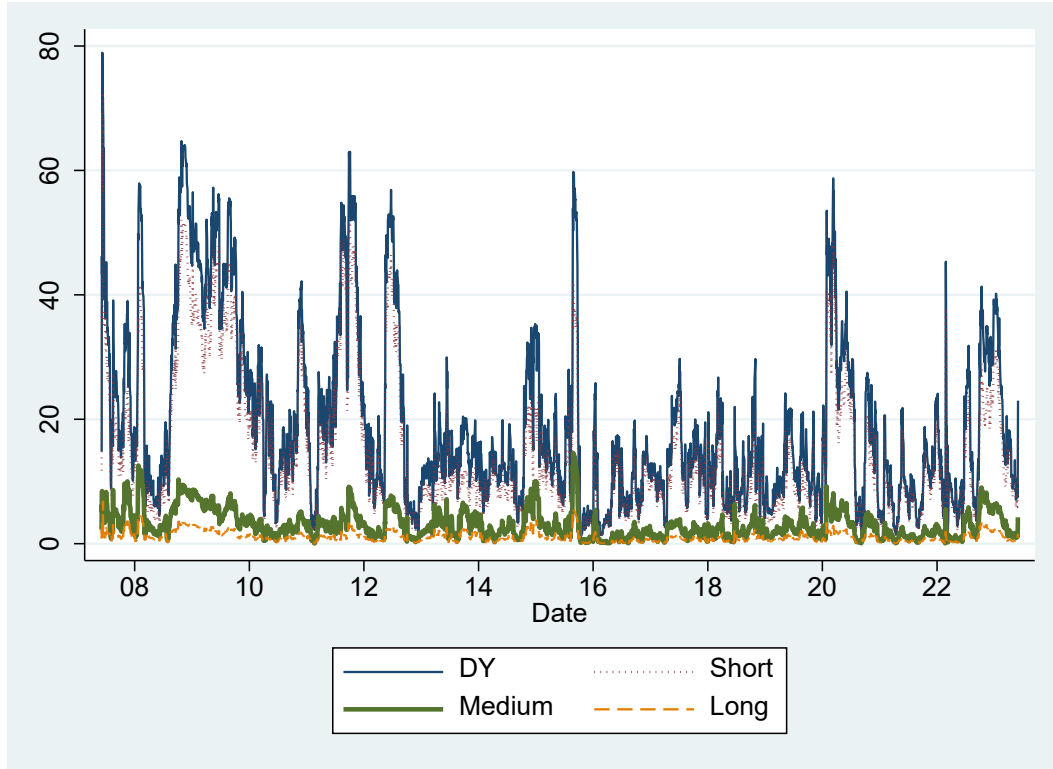


Fig. 5. Time varying FROM connectedness: return (crude palm oil market)

One limitation of the time varying total return connectedness indices presented in Figure 3 is that they do not explicitly identify which market within the system dominates the transmission of shocks in the time domain and across the frequency bands. Additionally, while these indices capture the interconnectedness among the ASEAN-5 equity markets, our specific focus is on understanding the connectedness between the crude palm oil market and the equity market. To address this, we analyze the TO connectedness and FROM connectedness of the crude palm oil in Figure 4 and Figure 5, respectively. These figures exhibit similar patterns, with peaks corresponding to significant events such as the GFC in 2008, the crude palm oil shock in 2012, the Chinese stock market crash in 2015, and the COVID-19 pandemic in 2020. Notably, we observe that the TO connectedness metric is lower than the FROM connectedness metric, indicating that the equity markets may exert a greater influence on the crude palm oil market compared to the reverse. This finding is consistent with the results presented in Table 2, which highlight the higher degree of influence from the equity markets on the crude palm oil market.

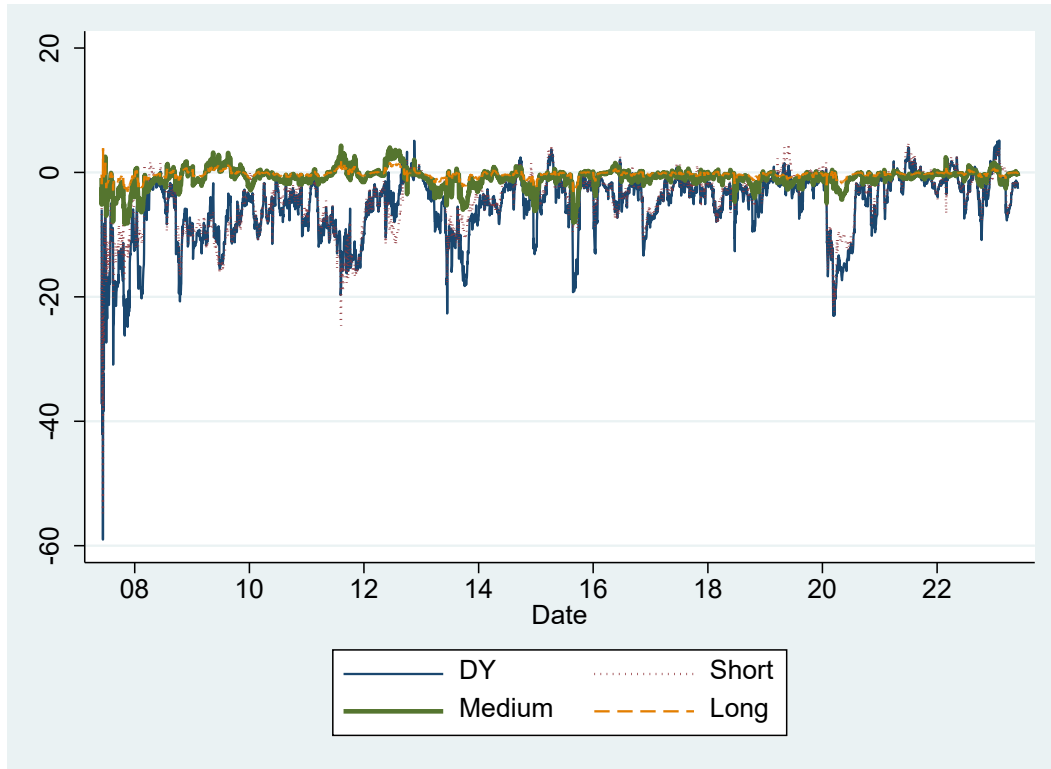


Fig. 6. Time varying NET connectedness: return (crude palm oil market)

To further validate the conclusion regarding the greater influence of equity markets on the crude palm oil market, we analyze the time varying net connectedness of the crude palm oil market. This analysis allows us to determine whether the crude palm oil market functions as a net transmitter or net recipient of connectedness within the system. By studying the time varying net connectedness, we can gain insights into the directional flow of influence and ascertain whether the crude palm oil market is predominantly influenced by other markets or if it exerts more influence on them. As illustrated in Figure 6, the time varying net return connectedness results exhibit typical characteristics of being time-varying and event-dependent. we can confirm that for the majority of the sample period, the crude palm oil market acts as a net recipient in the system. This suggests that the crude palm oil market is predominantly influenced by the ASEAN-5 equity markets in terms of return spillover transmission. This finding is consistent with previous studies by Zhang et al. (2020), Wu (2021), and Qi et al. (2022), which indicate that commodities can be easily impacted by other financial assets.

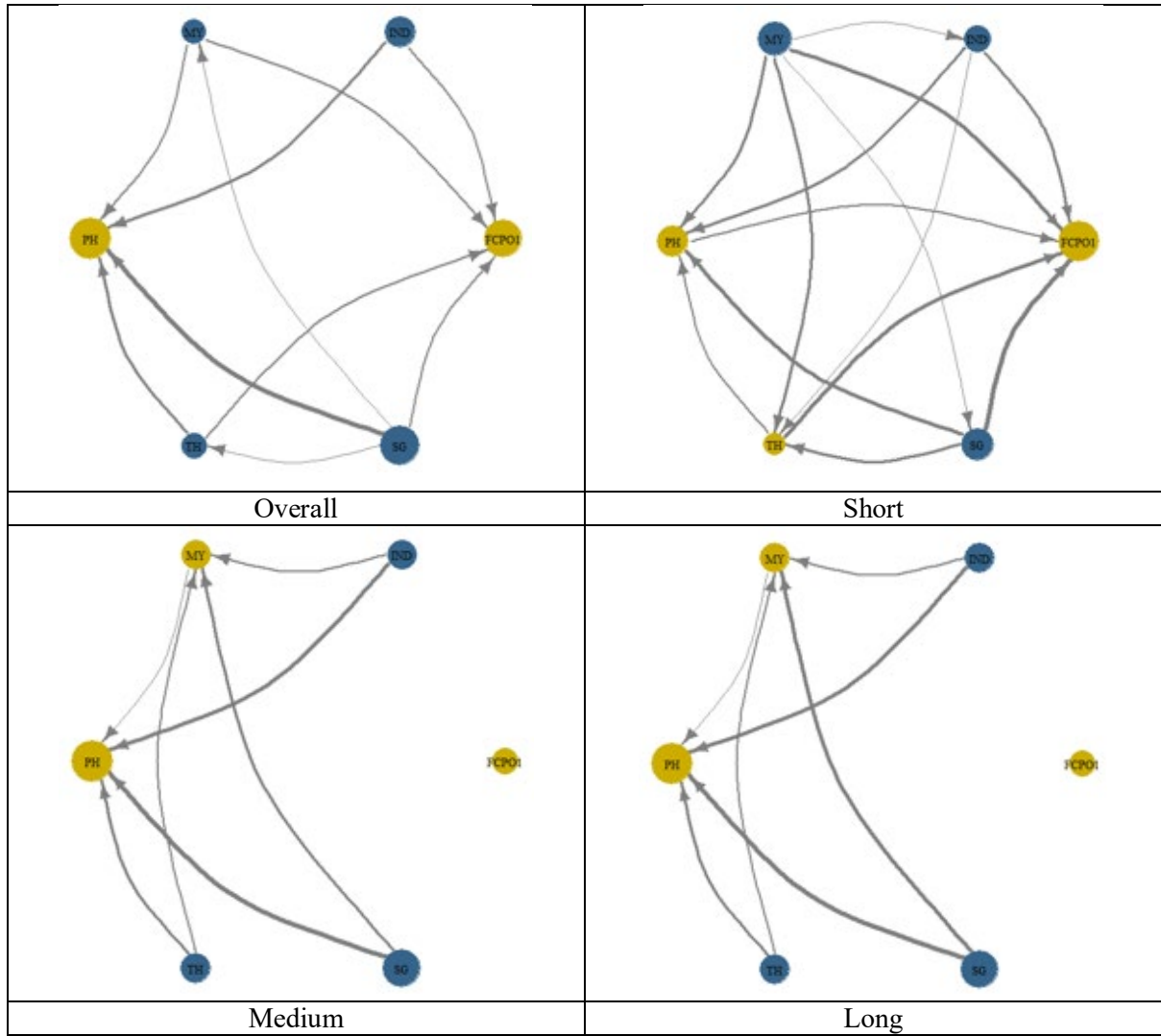


Fig. 7. Directional net-pairwise connectedness network: return

Figure 7 presents a connectedness network that provides evidence of the directional net-pairwise connectedness from the crude palm oil market to individual equity markets. The visual representation in the network supports the conclusion that, in terms of overall connectedness, all the equity markets, except for the Philippines, have a significant impact on the crude palm oil market. This finding aligns with previous research by Maitra and Dawar (2019), Hernandez et al. (2021), and Cagli et al. (2023), confirming the existence of connectedness between commodity and stock markets. Notably, during the short term, all the equity markets exert a discernible influence on the crude palm oil market, corroborating the findings of Lin et al. (2021) on the presence of spillovers from the equity market to the commodity market in the short run. However, as we transition to the medium and long term, the connection between the crude palm oil market and the equity markets becomes insignificant. These observations shed light on the time varying and time-dependent nature of the interconnections between these markets.

5.2. Connectedness between crude palm oil and ASEAN-5 stock volatilities

The investigation of volatility connectedness between crude palm oil and ASEAN-5 equities yields significant findings, as shown in Table 3. The overall connectedness index for

volatility is found to be 58.89%, which is lower than the return connectedness previously observed, indicating a higher level of interconnection in terms of the transmission of volatility. Further analysis of the volatility connectedness reveals that a substantial percentage of 41.68% is attributed to long-run causes, while the remaining 10.91% and 6.29% are attributed to short-run and medium-run factors, respectively. This underscores the importance of considering long-term temporal variations and interactions when assessing the level of volatility connectedness between different commodity and equity markets.

Table 3: Volatility connectedness

	CPO	Indonesia	Malaysia	Philippines	Thailand	Singapore	FROM
CPO	73.51(2.52) [5.97]{65.01}	5.4(0.26) [0.42]{4.72}	4.53(0.25) [0.42]{3.86}	4.27(0.22) [0.39]{3.66}	6.61(0.36) [0.58]{5.66}	5.68(0.3) [0.5]{4.88}	26.49(1.39) [2.32]{22.78}
Indonesia	22.8(0.75) [0.97]{21.08}	34.19(12.96) [6.25]{14.99}	8.62(2.66) [1.32]{4.63}	7.57(1.92) [1.29]{4.36}	15.68(4.04) [1.98]{9.66}	11.14(2.72) [1.72]{6.7}	65.81(12.1) [7.28]{46.44}
Malaysia	23.08(1.11) [0.92]{21.05}	9.2(2.69) [1.51]{5}	34.61(17) [6.67]{10.94}	7.39(2.47) [1.14]{3.78}	14.23(4.39) [1.48]{8.36}	11.49(3.76) [1.64]{6.08}	65.39(14.42) [6.69]{44.28}
Philippines	23.32(0.71) [0.85]{21.75}	9.96(2.22) [1.84]{5.9}	7.59(2.23) [1.4]{3.96}	37.98(15.32) [9.25]{13.41}	11.54(2.88) [1.65]{7}	9.61(2.9) [1.53]{5.18}	62.02(10.95) [7.27]{43.8}
Thailand	22.04(0.95) [0.89]{20.21}	12.16(3.7) [1.93]{6.52}	10.24(3.66) [1.49]{5.08}	7.81(2.46) [1.23]{4.12}	36.08(13.52) [5.19]{17.37}	11.66(3.05) [1.54]{7.07}	63.92(13.83) [7.08]{43.01}
Singapore	24.9(1.16) [0.96]{22.78}	11.38(2.94) [1.64]{6.8}	9.82(2.81) [1.57]{5.44}	8.46(2.62) [1.28]{4.55}	15.14(3.25) [1.68]{10.21}	30.3(12.85) [5.05]{12.4}	69.7(12.79) [7.13]{49.78}
TO	116.15(4.68) [4.59]{106.87}	48.1(11.82) [7.34]{28.94}	40.8(11.62) [6.21]{22.98}	35.5(9.69) [5.34]{20.48}	63.21(14.93) [7.37]{40.9}	49.57(12.73) [6.92]{29.92}	353.33(65.48) [37.77]{250.08}
Inc.Own	189.65(7.2) [10.56]{171.89}	82.29(24.77) [13.58]{43.93}	75.41(28.62) [12.88]{33.92}	73.49(25.01) [14.59]{33.89}	99.29(28.46) [12.56]{58.27}	79.88(25.58) [11.98]{42.32}	TCI
NET	89.65(3.29) [2.27]{84.09}	-17.71(-0.28) [0.06]{-17.49}	-24.59(-2.81) [-0.48]{-21.3}	-26.51(-1.25) [-1.94]{-23.32}	-0.71(1.1) [0.29]{-2.11}	-20.12(-0.05) [-0.21]{-19.86}	58.89(10.91) [6.29]{41.68}

Notes: See Table 2 notes.

The volatility connectedness of crude palm oil is largely attributed to shock originating from itself (73.51%). As compared to the case of return connectedness, crude palm oil has a higher attributed shock to the equity market (26.49% vs 19.15%). On the other hand, the volatility connectedness resulting from idiosyncratic shocks in each ASEAN-5 equity market is less than half of the total volatility connectedness. The specific values are as follows: Indonesia (34.19%), Malaysia (34.61%), Philippines (37.98%), Thailand (36.08%), and Singapore (30.30%). These results align with the previous findings, indicating that the equity markets in the ASEAN-5 countries are more responsive to shocks originating from other markets within the system, compared to the crude palm oil market. This finding is consistent with the observations of Kang and Yoon (2019) and Rehman et al. (2023), who report that the equity market acts as the net recipient of spillover in the context of China.

When examining the total connectedness transmitted "TO" others, it is observed that the crude palm oil market contributes a relatively higher level of volatility connectedness to the overall system, contrasting the result found in return connectedness. However, a similar pattern to the finding of return connectedness is observed for the connectedness received 'FROM' others, indicating that the ASEAN-5 equity markets receive a relatively higher level of volatility connectedness from other markets compared to the crude palm oil market, which receives less from other markets. In contrast to return connectedness, the crude palm oil market is found to be a net transmitter of volatility connectedness (as indicated by a positive net connectedness value of 89.65%), while the ASEAN-5 equity markets act as net receivers of volatility connectedness. Additionally, focusing on the values in the first row and column of Table 3, it is evident that the transmission of shocks from the crude palm oil market to the equity markets (116.15%) is more significant compared to the transmission of shocks from the equity markets to the crude palm oil market (26.49%). This suggests that the crude palm

oil market may exert a greater influence on the equity market in terms of volatility connectedness, rather than the other way around.

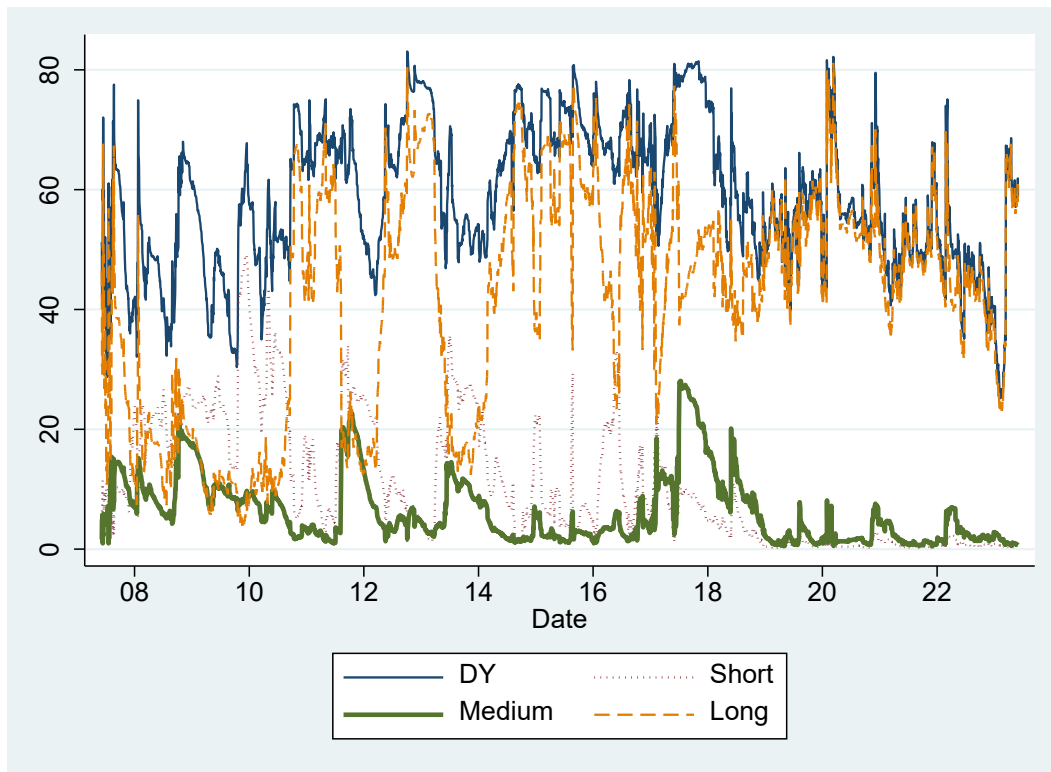


Fig. 8. Time varying total connectedness: volatility

Figure 8 depicts the time varying total connectedness results for volatility, showcasing distinct patterns compared to the time varying total return connectedness results in Figure 3. In contrast to return connectedness, which primarily stems from short-run influences, volatility connectedness is driven by both short and long-run factors. This suggests that analyzing volatility can provide valuable insights to investors seeking to make decisions regarding asset diversification between crude palm oil and equity markets, in both directions. Notably, both short and long-run connectedness exhibit greater fluctuations compared to the return connectedness analysis. The total volatility connectedness ranges from approximately 25% to 80%, indicating a wide spectrum of interconnectedness levels throughout the sample period.

Based on Figure 8, the short-run volatility connectedness reaches its peak between the years 2009 and 2010, reaching approximately 50%. This period corresponds to a time when both the crude palm oil and equity markets were experiencing significant growth and positive performance. However, after the occurrence of the COVID-19 pandemic, the short-run volatility connectedness becomes less significant. One possible reason for this is the increased uncertainty and unpredictability of future market conditions, leading to a greater emphasis on long-run volatility connectedness. Similar to the return connectedness analysis, the total volatility connectedness exhibits peaks in 2012 and during the COVID-19 pandemic. These peaks are primarily driven by the long-run volatility connectedness component. These observations suggest that long-run factors have a more substantial influence on the overall volatility connectedness between the crude palm oil and equity markets during these significant events.

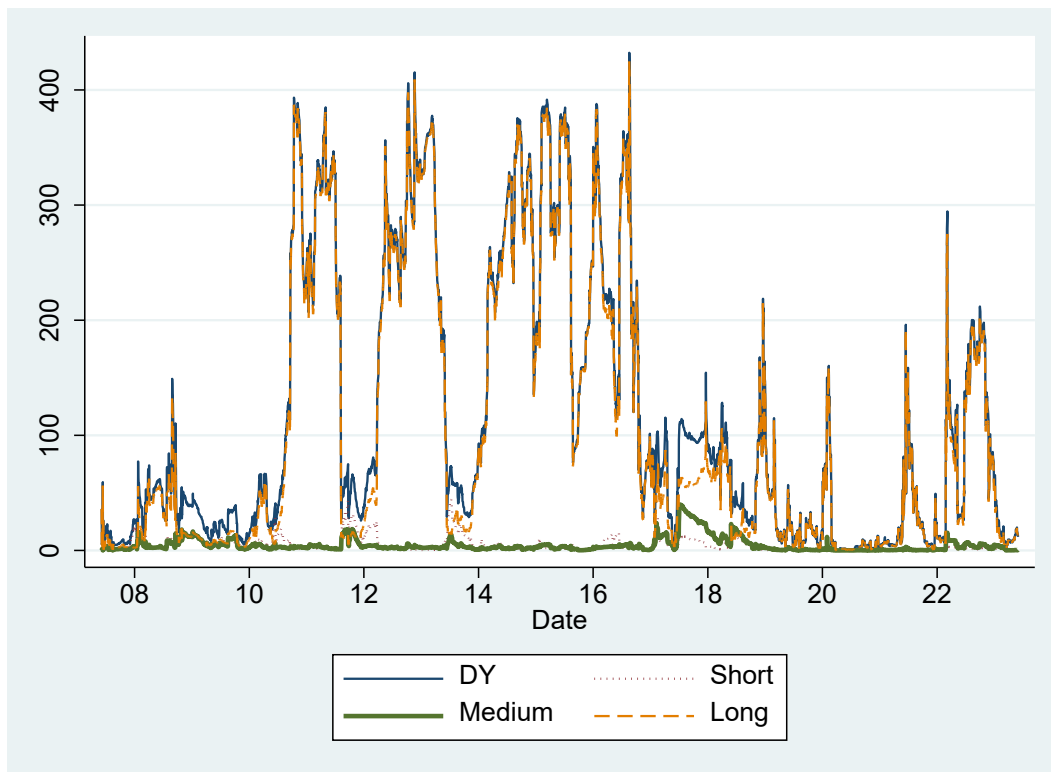


Fig. 9. Time varying TO connectedness: volatility (crude palm oil market)

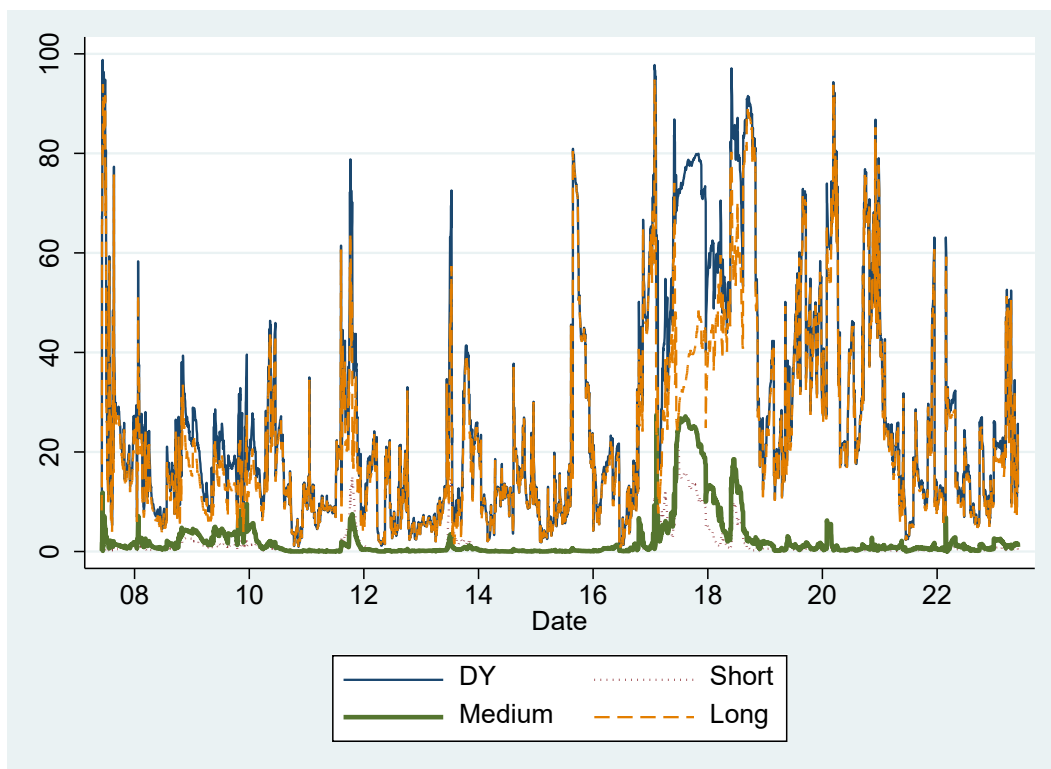


Fig. 10. Time varying FROM connectedness: volatility (crude palm oil market)

In the volatility analysis, we examine the TO connectedness and FROM connectedness of the crude palm oil market, as depicted in Figure 9 and Figure 10,

respectively. In contrast to the return connectedness analysis, these figures reveal a different trend, indicating that the shocks originating from the crude palm oil market to the equity market and vice versa are influenced by different events or factors. Notably, we observe that, for certain periods, the TO connectedness metric is higher than the FROM connectedness metric. This suggests that the crude palm oil market may exert a greater influence on the equity market compared to the reverse direction of influence.

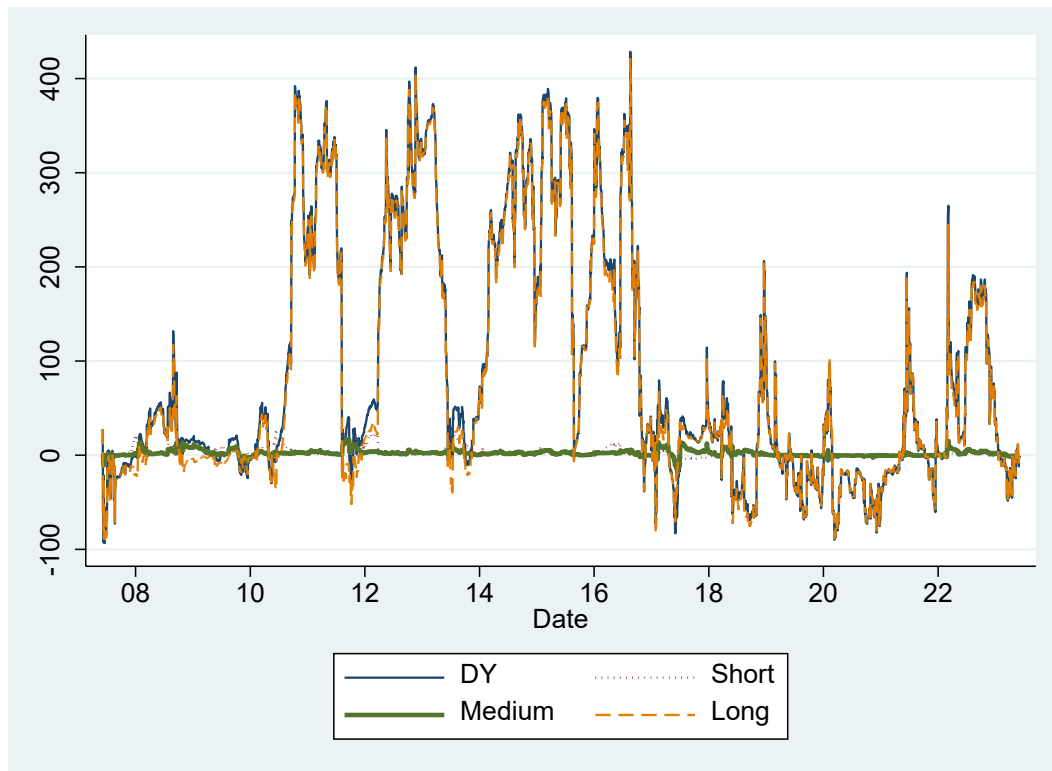


Fig. 11. Time varying NET connectedness: volatility (crude palm oil market)

Figure 11 presents the time varying net volatility connectedness, shedding light on the directional flow of shock transmission between the crude palm oil market and the equity market. From 2011 to 2017, we observe that the crude palm oil market predominantly acts as a net transmitter of shocks to the equity market, with some exceptions during certain periods. This is supported by the finding in Lin et al. (2021) the presence of spillovers from commodity market to equity markets in the long run. One factor contributing to this trend is the structural changes that occurred in the crude palm oil market in 2012, which resulted in a reduced impact on the equity market. Moreover, during the COVID-19 pandemic, the equity market exerted a stronger influence on the crude palm oil market compared to being influenced by it. Furthermore, we find that both the transmission and receipt of shocks by the crude palm oil market are primarily driven by long-run connectedness, as depicted in Figures 9 to 11. This indicates that the interconnectedness between the crude palm oil market and the equity market in terms of volatility is more pronounced in the long run.

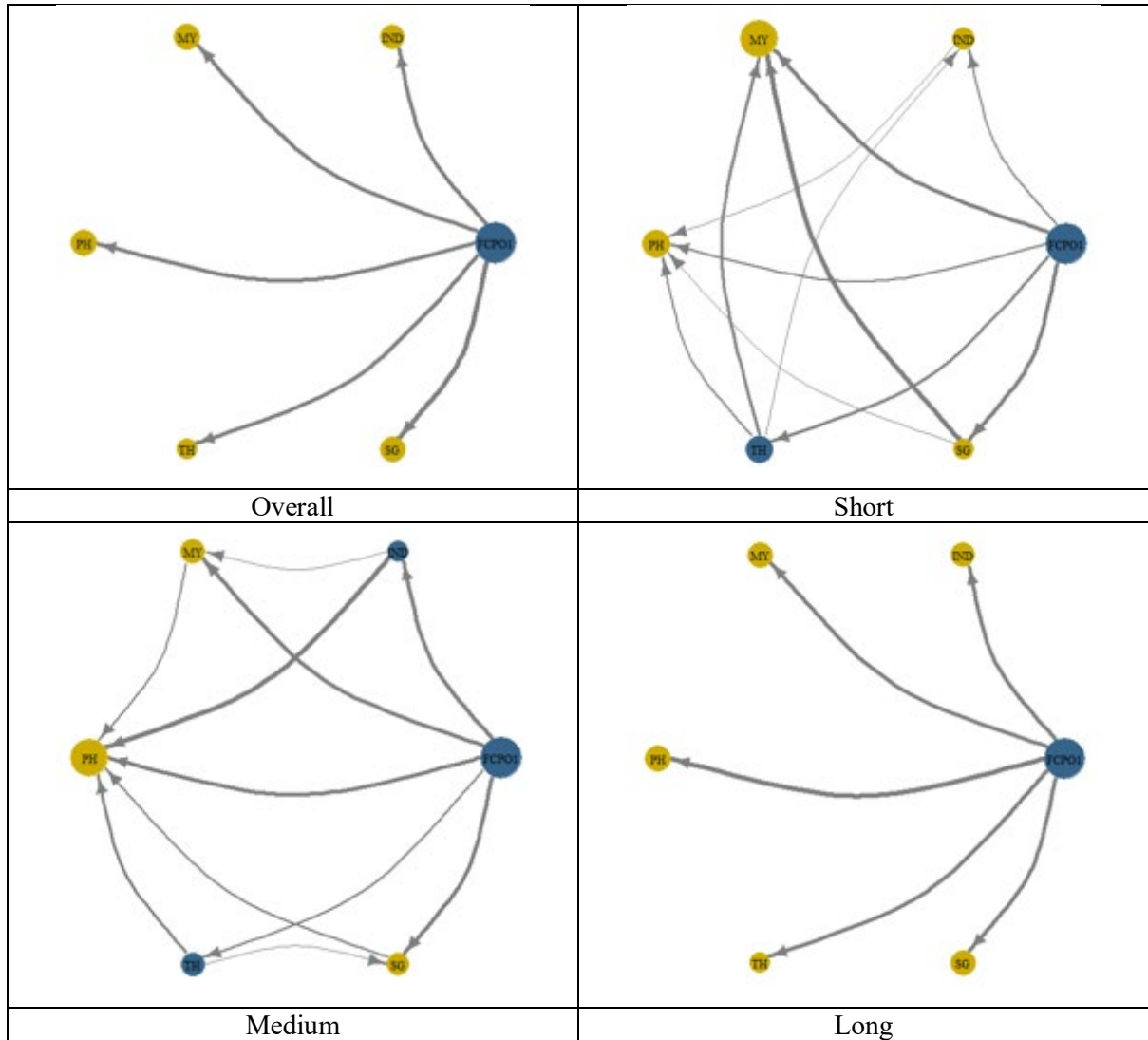


Fig. 12. Directional net-pairwise connectedness network: volatility

Figure 12 showcases the directional net-pairwise connectedness network plot for volatility analysis. Notably, this analysis reveals contrasting results compared to the return connectedness analysis. In the volatility analysis, we observe that the crude palm oil market significantly affects the ASEAN-5 equity markets across all frequency domains (short, medium, and long-run). In terms of overall connectedness, there is no apparent interaction among the equity markets, with the influence primarily stemming from long-run connectedness. However, in the medium and short-run connectedness, we observe the presence of interactions among the equity markets.

6. Conclusion

In conclusion, this study has provided valuable insights into the dynamics of return and volatility connectedness among the ASEAN-5 equity markets and the crude palm oil market. The findings indicate that short-run factors predominantly influence return connectedness, with the ASEAN-5 equity markets playing a significant role as both contributors and receivers of shock transmission. In terms of net return connectedness, equity markets of all studied ASEAN nations except for the Philippines are the net transmitters, while the crude palm oil market is the net receiver. On the other hand, volatility

connectedness is primarily influenced by long-run factors, with the crude palm oil market acting as the net transmitter of shocks, while the ASEAN-5 equity markets serve as net receivers.

These time- and frequency-dependent characteristics highlight the importance of understanding the interplay between markets. It becomes crucial for investors to consider different factors - whether short-run, medium-run, or long-run - based on their specific investment goals and strategies, as the drivers behind return connectedness and volatility connectedness are distinct. This underscores the need for diversified approaches to risk management and investment decision-making, considering the different channels through which shock transmission propagates in these markets. Overall, this study contributes valuable knowledge for market participants and policymakers in navigating interconnected financial landscapes.

In future research, a promising direction would be to apply the methodology proposed in this paper and extend it to investigate higher-order connectedness, such as skewness and kurtosis, as explored by Cui and Maghyreh (2023) and Bouri (2023), where they have reported the existence of higher-order connectedness. This approach would provide a more comprehensive understanding of the volatility dynamics and risk transmission mechanisms between crude palm oil and ASEAN-5 equity markets, considering not only the mean and variance but also the asymmetry and fat-tailed characteristics of their interconnectedness. Furthermore, another valuable avenue for future investigation would involve exploring the lead-lag connectedness between crude palm oil and the ASEAN-5 stock markets across different frequency bands. By examining the timing and directionality of shock transmissions, this analysis would shed light on the causal relationships and dependencies between these markets. Understanding how the lead-lag relationships vary across different frequency ranges would enhance our insights into the dynamic interactions and interdependencies between crude palm oil and the ASEAN-5 equity markets under various market conditions.

Reference

- Ab Rahman, A. K., Abdullah, R., Balu, N., & Shariff, F. M. (2013). The impact of La Niña and El Niño events on crude palm oil prices: An econometric analysis. *Oil Palm Ind Econ J*, 13, 38-51.
- Akyildirim, E., Cepni, O., Pham, L., & Uddin, G. S. (2022). How connected is the agricultural commodity market to the news-based investor sentiment?. *Energy Economics*, 113, 106174.
- Antonakakis, N., Chatziantoniou, I., & Gabauer, D. (2020). Refined measures of time varying connectedness based on time-varying parameter vector autoregressions. *Journal of Risk and Financial Management*, 13(4), 84.
- Babar, M., Ahmad, H., & Yousaf, I. (2023). Returns and volatility spillover between agricultural commodities and emerging stock markets: new evidence from COVID-19 and Russian-Ukrainian war. *International Journal of Emerging Markets*.
- Baruník, J., & Křehlík, T. (2018). Measuring the frequency time varyings of financial connectedness and systemic risk. *Journal of Financial Econometrics*, 16(2), 271-296.

Billah, M., Balli, F., & Hoxha, I. (2023). Extreme connectedness of agri-commodities with stock markets and its determinants. *Global Finance Journal*, 56, 100824.

Bossman, A., & Agyei, S. K. (2022). Interdependence structure of global commodity classes and African equity markets: A vector wavelet coherence analysis. *Resources Policy*, 79, 103039.

Bouri, E. (2023). Spillovers in the joint system of conditional higher-order moments: US evidence from green energy, brown energy, and technology stocks. *Renewable Energy*, 210, 507-523.

Cagli, E. C., Mandaci, P. E., & Taskin, D. (2023). The volatility connectedness between agricultural commodity and agri businesses: Evidence from time-varying extended joint approach. *Finance Research Letters*, 52, 103555.

CEIC. (n.d.). *ASEAN stock markets*. Retrieved June 1, 2023, from <https://info.ceicdata.com/our-insights-articles-asean-stock-markets>

Chandrarin, G., Sohag, K., Cahyaningsih, D. S., Yuniawan, D., & Herdhayinta, H. (2022). The response of exchange rate to coal price, palm oil price, and inflation in Indonesia: Tail dependence analysis. *Resources Policy*, 77, 102750.

Chang, C. L., & Fang, M. (2022). The connectedness between natural resource commodities and stock market indices: Evidence from the Chinese economy. *Resources Policy*, 78, 102841.

Chatziantoniou, I., Gabauer, D., & Gupta, R. (2021). Integration and risk transmission in the market for crude oil: A time-varying parameter frequency connectedness approach. University of Pretoria Department of Economics Working Paper Series.

Cui, J., & Maghyreh, A. (2023). Time-frequency dependence and connectedness among global oil markets: Fresh evidence from higher-order moment perspective. *Journal of Commodity Markets*, 30, 100323.

Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of forecasting*, 28(1), 57-66.

Diebold, F. X., & Yilmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of econometrics*, 182(1), 119-134.

Fasanya, I., & Akinbowale, S. (2019). Modelling the return and volatility spillovers of crude oil and food prices in Nigeria. *Energy*, 169, 186-205.

Garcia-Jorcano, L., & Sanchis-Marco, L. (2022). Spillover effects between commodity and stock markets: A SDSSES approach. *Resources Policy*, 79, 102926.

Guhathakurta, K., Dash, S. R., & Maitra, D. (2020). Period specific volatility spillover based connectedness between oil and other commodity prices and their portfolio implications. *Energy Economics*, 85, 104566.

Hernandez, J. A., Kang, S. H., & Yoon, S. M. (2021). Spillovers and portfolio optimization of agricultural commodity and global equity markets. *Applied Economics*, 53(12), 1326-1341.

Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review/Revue Internationale de Statistique*, 163-172.

Kang, S. H., & Yoon, S. M. (2019). Financial crises and time varying spillovers among Chinese stock and commodity futures markets. *Physica A: Statistical Mechanics and its Applications*, 531, 121776.

Li, R., Li, S., Yuan, D., Chen, H., & Xiang, S. (2023). Spillover effect of economic policy uncertainty on the stock market in the post-epidemic era. *The North American Journal of Economics and Finance*, 64, 101846.

Lim, K. P., Goh, K. L., & Chong, C. S. (2014). The Effects of Global Commodity Prices on ASEAN-5 Stock Markets. *RJSH*.

Lin, L., Zhou, Z., Jiang, Y., & Ou, Y. (2021). Risk spillovers and hedge strategies between global crude oil markets and stock markets: Do regime switching processes combining long memory and asymmetry matter?. *The North American Journal of Economics and Finance*, 57, 101398.

Luo, J., & Ji, Q. (2018). High-frequency volatility connectedness between the US crude oil market and China's agricultural commodity markets. *Energy Economics*, 76, 424-438.

Maitra, D., & Dawar, V. (2019). Return and volatility spillover among commodity futures, stock market and exchange rate: Evidence from India. *Global Business Review*, 20(1), 214-237.

Maitra, D., Guhathakurta, K., & Kang, S. H. (2021). The good, the bad and the ugly relation between oil and commodities: An analysis of asymmetric volatility connectedness and portfolio implications. *Energy Economics*, 94, 105061.

Mensi, W., Al Rababa'a, A. R., Alomari, M., Vo, X. V., & Kang, S. H. (2022). Time varying frequency volatility spillovers and connectedness between strategic commodity and stock markets: US-based sectoral analysis. *Resources Policy*, 79, 102976.

Mensi, W., Shafiullah, M., Vo, X. V., & Kang, S. H. (2021a). Volatility spillovers between strategic commodity futures and stock markets and portfolio implications: Evidence from developed and emerging economies. *Resources Policy*, 71, 102002.

Mensi, W., Vo, X. V., & Kang, S. H. (2021b). Time and frequency connectedness and network across the precious metal and stock markets: Evidence from top precious metal importers and exporters. *Resources Policy*, 72, 102054.

Niu, H., & Hu, Z. (2021). Information transmission and entropy-based network between Chinese stock market and commodity futures market. *Resources Policy*, 74, 102294.

Qi, H., Ma, L., Peng, P., Chen, H., & Li, K. (2022). Time varying connectedness between clean energy stock markets and energy commodity markets during times of COVID-19: Empirical evidence from China. *Resources Policy*, 79, 103094.

Rehman, M. U., Vo, X. V., Ko, H. U., Ahmad, N., & Kang, S. H. (2023). Quantile connectedness between Chinese stock and commodity futures markets. *Research in International Business and Finance*, 64, 101810.

Ritchie, H., & Roser, M. (2021, February 9). Forests and deforestation. Our World in Data.
<https://ourworldindata.org/palm-oil#citation>

Wen, F., Cao, J., Liu, Z., & Wang, X. (2021). Time varying volatility spillovers and investment strategies between the Chinese stock market and commodity markets. *International Review of Financial Analysis*, 76, 101772.

Wu, B. B. (2021). The time varyings of oil on China's commodity sectors: What can we learn from a quantile perspective?. *Journal of Commodity Markets*, 23, 100158.

Yeap, X. W., & Lean, H. H. (2022). Trading activities and the volatility of return on Malaysian crude palm oil futures. *Journal of Risk and Financial Management*, 15(1), 34.

Zhang, H., Cai, G., & Yang, D. (2020). The impact of oil price shocks on clean energy stocks: Fresh evidence from multi-scale perspective. *Energy*, 196, 117099.