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THE DYNAMICS OF INDONESIAN CPO PRICE INTEGRATION WITH EUROPEAN AND INDIAN MARKETS (Empirical Insights)

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ABSTRACT

Dynamic price interconnections and external market influences characterize the global crude palm oil (CPO) market. As the world's largest producer, Indonesia faces challenges in stabilizing prices amidst regulatory pressures from European markets and the significant role of India as a key export destination. This study aims to analyze the integration and dynamics of Indonesian CPO prices with European and Indian markets using advanced econometric tools, including Vector Auto Regression (VAR) and Vector Error Correction Model (VECM). Monthly price data from January 2016 to December 2022 were sourced from reliable databases such as BAPPETI and UN Comtrade. The findings highlight significant price volatility in the Indonesian spot market (CV = 46.18%) compared to Europe (CV = 39.22%) and India (CV = 29.74%), with the latter serving as a stabilizing force. Granger causality tests reveal mutual influence between Indonesia and Europe, while India's unidirectional causality underscores its role in mitigating external shocks. Cointegration analysis confirms long-term equilibrium relationships among the markets, with European and Indian markets contributing 33.61% and 29.35%, respectively, to Indonesian price variability over 12 months. These insights emphasize the importance of establishing a domestic futures market to manage volatility and diversifying export destinations to reduce reliance on traditional markets. This study provides actionable recommendations for policymakers and stakeholders to strengthen Indonesia's resilience and competitiveness in the global CPO market.

Keywords: CPO prices; market integration; price transmission; price volatility; VAR-VECM.

INTRODUCTION

The global crude palm oil (CPO) market is pivotal in international trade and is heavily influenced by interconnected dynamics and external market forces. As the largest producer of CPO, Indonesia contributes over 50% of the global supply, making it a cornerstone of this commodity's trade network (Sulaiman, 2024). Together with Malaysia, which excels in downstream processing, Indonesia accounts for approximately 85% of global CPO production (Annas et al., 2020; Husin, 2023). Despite its dominance, Indonesia has faced significant challenges, evidenced by a 20.8% decline in export volumes in 2022, driven by high export taxes, fluctuating global demand, and intensified competition from emerging producers like Thailand and Colombia (Nurcahyani et al., 2018; Yahya & Gunawan, 2019). Moreover, globalization and the growing emphasis on agricultural exports continue to influence Indonesia's environmental and economic dynamics, further complicating its trade performance (Putri & Tan, 2024). To address these challenges, understanding the dynamics of Indonesia's integration with its major trading partners, particularly Europe and India, is essential, as it plays a critical role in shaping its trade stability. To date, limited research has explored how Indonesian CPO markets integrate with its key trading partners, Europe and India, particularly in short-term versus long-term contexts.

European markets, mainly through the Rotterdam futures market, are critical benchmarks for global CPO pricing due to their transparency and liquidity (Sofilda, 2022). However, stringent

environmental policies, such as the European Union's Renewable Energy Directive (RED), have imposed significant challenges on Indonesian exporters by restricting palm oil usage in biofuels due to concerns over indirect land-use change emissions (Alamsyah, 2024; Bentivoglio et al., 2018). These regulatory constraints impact Indonesia's market access and contribute to heightened price volatility. This volatility underscores the need to analyze how European market dynamics influence Indonesia's CPO pricing and trade, especially when juxtaposed with other key markets like India. Existing studies often focus on regulatory impacts but lack insights into their role in bidirectional price transmission and resilience mechanisms.

India, as Indonesia's largest export destination for CPO, offers a contrasting dynamic. India provides a stable demand base supported by policies such as minimum support prices (MSP) and public distribution systems (Yahya & Gunawan, 2019). Unlike the European market, where stringent regulations drive price volatility, India's demand for CPO is primarily driven by its robust consumption patterns in the food and energy sectors, ensuring relatively stable prices (Harpy, 2024; Itamary, 2022). This comparative stability highlights India's pivotal role in buffering the impacts of global market disruptions, providing Indonesia with a critical counterbalance to European regulatory pressures. This dual dynamic invites further exploration into how India's stabilizing influence complements or contrasts with Europe's regulatory challenges.

The dynamics of price stability in India are closely tied to the policies that govern its agricultural sector. For instance, the MSP framework in India guarantees minimum prices for agricultural products, fostering consistent demand and reducing price fluctuations ((Tripathi, 2024). This mechanism indirectly influences the competitiveness of Indonesian CPOs by providing a stable pricing environment for Indian importers (Bhattacharya, 2023). As a result, CPO's competitive edge over alternative vegetable oils, such as soybean and sunflower, is enhanced, particularly during periods of global market volatility (Harpy, 2024). This interplay of policy-driven stability underscores the need for Indonesia to align its trade policies to maximize resilience and competitiveness strategically.

Existing studies have extensively analyzed global CPO trade, focusing on futures markets and general price trends (Fitriani et al., 2019; Gandhy et al., 2022). However, limited research has addressed short-term and long-term integration mechanisms between Indonesia's spot market and key trading partners. Studies often neglect the bidirectional impacts of price shocks between Indonesia, Europe, and India, leaving critical questions about Indonesia's ability to respond to external market forces unanswered. This study seeks to address these gaps by systematically analyzing short-term responsiveness and long-term equilibrium relationships, offering actionable insights for policymakers.

This study aims to fill these gaps by analyzing the dynamics of Indonesian CPO price integration with European and Indian markets using advanced econometric tools, including Vector Auto Regression (VAR) and Vector Error Correction Mechanism (VECM). By capturing both short-term responsiveness and long-term equilibrium relationships, this research provides actionable insights for policymakers and stakeholders. The findings aim to guide strategic trade policies, price stabilization efforts, and sustainability alignment to bolster Indonesia's leadership in the global CPO market amidst increasing global challenges.

MATERIALS AND METHODS

This study employs secondary data on monthly crude palm oil (CPO) prices across three key markets: the Indonesian spot market (Medan), the European market (Rotterdam), and the Indian market. From January 2016 to December 2022, data were obtained from reliable sources, including BAPPETI, BPS, and UN Comtrade. These markets are chosen for their strategic relevance—Medan as the domestic hub, Rotterdam as the global price reference, and India as a significant export destination. The variables used, summarized in Table 1, directly address the research focus on price transmission and market integration.

Table 1. Categories and origin of sources of data information

No	Variable Name	Market	Role in Analysis	Unit	Data Source
1	IDN_SPOT	Medan Spot Market (Domestic)	Domestic price indicator	USD/Kg	BAPPETI
2	EUROPE_ROTT	Rotterdam Market (Europe)	International reference price benchmark	USD/Kg	BAPPETI
3	IND_PRC	Indian Market (Export)	Export market dynamics	USD/Kg	UN Comtrade

The methodology adopted in this study is designed to rigorously analyze the integration and dynamics of crude palm oil (CPO) prices among the Indonesian, European (Rotterdam), and Indian markets. Using a combination of descriptive statistics, stationarity tests, cointegration analysis, and advanced econometric modeling, the study provides a comprehensive framework for understanding price transmission mechanisms and interdependencies.

1. Descriptive Statistics

A descriptive analysis calculated the Coefficient of Variation (CV) to measure relative price volatility across the three markets, providing foundational insights into price fluctuations. This metric is pivotal for understanding risk exposure and informing strategies for producers and exporters. The formula for CV is as follows:

$$\mathrm{CV} = \frac{\mathrm{S}}{\bar{X}} \quad (1)$$

Where: CV = Coefficient of Variation, indicating relative price fluctuations. S = Standard Deviation, measuring dispersion from the mean. $\bar{X}$ = Average price over the observation period.

The standard deviation formula is expressed as:

$$\mathrm{S} = \sqrt{\frac{1}{\mathrm{n}-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (2)$$

Where: n = Total number of observations. x_i = Individual price observation. $\bar{x}$= Mean price.

By quantifying relative volatility, the analysis highlights key risk factors in each market, focusing on the Indonesian spot market, which has exhibited higher volatility than Europe and India.

2. Stationarity Testing

The Augmented Dickey-Fuller (ADF) test was applied to confirm the stationarity of price data, a prerequisite for reliable time-series modeling. Differencing was used to achieve stationarity where required, ensuring robust parameter estimation and mitigating spurious regression risks. Stationarity underpins valid econometric analysis, particularly in dynamic systems (Enders, 2015). The ADF test formula is specified as follows:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \epsilon_t \quad 3)$$

Where: y_t = The variable being tested for stationarity. Δy_t = First difference of the variable. α = Constant term. βt = Trend component. γy_{t-1} = Coefficient of lagged variable. $\sum_{i=1}^{p} \delta_i \Delta y_{t-i}$ = Coefficients of first-difference lagged terms. ϵ_t = Error term.

The null hypothesis (H_0) of the ADF test is that the series is non-stationary$(\gamma = 0)$. The null hypothesis is rejected if the test statistic is smaller than the critical value, indicating stationarity.

3. Cointegration Analysis

The Johansen Cointegration Test explored long-term equilibrium relationships, which is critical for understanding market integration. This analysis identifies whether variables, despite volatility, maintain stable relationships, offering insights into the interconnectedness of Indonesia's spot market with European and Indian markets. The Johansen Cointegration Test formula is specified as follows:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \epsilon_t \quad (4)$$

Where: ΔY_t = First, there are differences in the vector of variables. Y_{t-1} = Lagged level of the vector of variables. Π = Long-term impact matrix, capturing cointegration relationships. It can be decomposed as $\Pi = \alpha\beta'$, where: α = Adjustment coefficients matrix. β = Cointegration coefficients matrix. Γ_i= Short-term adjustment coefficients for lagged differences. ϵ_t = Residuals or error terms.

To perform the Johansen Cointegration Test, the first step involves estimating the Vector Error Correction Model (VECM) to compute the eigenvalues of the long-term impact matrix (Π). These

eigenvalues are then used in either the trace or maximum eigenvalue tests to determine the number of cointegration relationships among the variables. The null hypothesis (H_0) assumes no cointegration and is rejected if the test statistic exceeds the critical value. A rejection of H_0 indicates that the variables share a long-term equilibrium relationship, confirming cointegration.

4. Econometric Modeling

a. Vector Autoregression (VAR)

The VAR model analyzed market interdependencies, treating variables as endogenous to capture causal linkages. Equations for each market were structured to reflect short-term dynamics and their interplay, providing a basis for understanding responsiveness to external shocks. The VAR equations are specified as follows:

$$\mathrm{IDN}_{\mathrm{SPOT}_t} = a_{01} + \sum_{i=1}^{p} a_{i1}\mathrm{IDN}_{\mathrm{SPOT}_{t-1}} + \sum_{i=1}^{p} \alpha_{i1}\mathrm{EROPA}_{\mathrm{ROTT}_{t-1}} + \sum_{i=1}^{p} a_{i1}\mathrm{IND}_{\mathrm{PRC}_{t-1}} + \varepsilon_{1t} \quad (5)$$

$$\mathrm{EROPA}_{\mathrm{ROTT}_t} = a_{02} + \sum_{i=1}^{p} a_{i2}\mathrm{EROPA}_{\mathrm{ROTT}_{t-1}} + \sum_{i=1}^{p} \beta_{i2}\mathrm{IDN}_{\mathrm{SPOT}_{t-1}} + \sum_{i=1}^{p} a_{i1}\mathrm{IND}_{\mathrm{PRC}_{t-1}} + \varepsilon_{2t} \quad (6)$$

$$\mathrm{IND}_{\mathrm{PRC}_t} = a_{02} + \sum_{i=1}^{p} a_{i1}\mathrm{IND}_{\mathrm{PRC}_{t-1}} + \sum_{i=1}^{p} \beta_{i2}\mathrm{IDN}_{\mathrm{SPOT}_{t-1}} + \sum_{i=1}^{p} a_{i2}\mathrm{EROPA}_{\mathrm{ROTT}_{t-1}} + \varepsilon_{3t} \quad (7)$$

Caption: $\mathrm{IDN}_{\mathrm{SPOT}_t}$ = CPO price in Indonesia spot market (Medan) in period t (USD /kilogram). $\mathrm{IDN}_{\mathrm{SPOT}_{t-1}}$ = CPO price lag on the Indonesian spot market (Medan) period t (USD/kilogram). $\mathrm{EROPA}_{\mathrm{ROTT}_t}$ = CPO price in the reference market (Rotterdam) period t (USD/kilogram). $\mathrm{EROPA}_{\mathrm{ROTT}_{t-1}}$ = lag CPO price in the reference market (Rotterdam) period t ((USD/kilogram). $\mathrm{IND}_{\mathrm{PRC}_t}$ = Indonesian CPO price in the Indian market period t (USD/kilogram). $\mathrm{IND}_{\mathrm{PRC}_{t-1}}$= Indonesian CPO price lag in the Indian market period t (USD/kilogram). P' = Previous period used in the time series analysis model. ε = sized residual vector n x 1

This framework captures short-term causal linkages and the interplay between variables, enabling a detailed examination of market responsiveness to external shocks.

b. Granger Causality (GC) Analysis

Granger causality tests were applied to identify the direction of causality between variables. The GC test equations are as follows:

Formula 1: Testing Causality from X to Y $Y_t = \alpha_0 + \sum_{i=1}^{k} \beta_i Y_{t-i} + \sum_{i=1}^{k} \gamma_i X_{t-i} + \epsilon_t$ (8)

Formula 2: Testing Causality from Y to X $X_t = \delta_0 + \sum_{i=1}^{k} \emptyset_i X_{t-i} + \sum_{i=1}^{k} \theta_i Y_{t-i} + \mu_t$ (9)

Explanation of Terms: $Y_t \; and \; X_t$ = Variables being tested. $\alpha_0 \; and \; \delta_0$ = Constants. $\beta_i \; and \; \emptyset_i$ = Coefficients of lagged dependent variables. $\gamma_i \; and \; \theta_i$ = Coefficients of lagged independent variables, representing causality. k = number of lags. $\epsilon_t \; and \; \mu_t$ = Error terms.

The Granger causality test evaluates whether past values of one variable can predict another. The null hypothesis (H_0) states that there is no Granger causality, represented as $H_0: \gamma_i = 0$, meaning X does not Granger-cause Y, and $H_0: \theta_i = 0$, meaning Y does not Granger-cause X. To test this, first, estimate the unrestricted model, which includes lagged terms of both variables. Next, estimate the restricted model, excluding the lagged terms of the independent variable. Finally, an F-test will be performed to compare the restricted and unrestricted models. If the F-statistic is significant, the null hypothesis (H0H_0H0) is rejected, indicating Granger causality between the variables.

c. Vector Error Correction Mechanism (VECM)

Upon detecting cointegration, the VECM model was applied to capture both short-term adjustments and long-term equilibrium relationships. The VECM framework allows for correcting deviations from equilibrium while accommodating short-term dynamics (Lütkepohl, 2005). This dual approach provides a comprehensive understanding of price transmission mechanisms and the role of external markets in shaping domestic prices.

d. Advanced Analysis Techniques

Variance Decomposition and Impulse Response Functions (IRF) were employed to quantify external market influences and visualize dynamic interdependencies. These methods reveal how shocks propagate through the system, providing actionable insights into market resilience.

RESULTS AND DISCUSSION

CPO Price Trends and Market Dynamics

The crude palm oil (CPO) market exhibits significant variations in price trends and volatilities across the Indonesian spot market (Medan), European market (Rotterdam), and Indian market during the period from 2016 to 2022. The Indian market demonstrated the highest average price (1.345 USD/kg) and the lowest volatility (CV = 29.742%), underscoring its stability as a primary export destination for Indonesia. This stability stems from India's robust trade policies, such as minimum support prices and public distribution systems, which reduce volatility by 29.7% compared to Europe (CV = 39.224%) and 46.2% compared to Indonesia (CV = 46.181%) (Gouel et al., 2016; Vijayakumar & Bozward, 2021). Additionally, India's economic growth and increasing population drive sustained demand for vegetable oils, making it a consistent importer of Indonesian CPO (Yahya & Gunawan, 2019). These findings align with global trade theories emphasizing the importance of policy-driven market stability, reinforcing India's dual role as a stabilizing market and a key contributor to Indonesia's trade resilience.

The favorable trade environment in India contrasts sharply with other regions. Indonesia has leveraged India's structured market policies to buffer against global market fluctuations, mainly through long-term trade agreements that reduce exposure to external shocks by ensuring consistent demand. Additionally, India's ability to maintain low volatility reflects effective market interventions (Destiarni et al., 2021), which reduce the propagation of global price shocks by up to 20% compared to Europe. These mechanisms enhance Indonesia's trade resilience, reinforcing India's role in stabilizing global CPO trade. This interplay supports price transmission models and showcases India's critical contribution to reducing price volatility in domestic markets.

Table 2 illustrates the average prices and coefficients of variation (CV) for CPO in the Indonesian, European, and Indian markets during the study period. India's lower volatility (CV = 29.742%) compared to Europe (CV = 39.224%) and Indonesia (CV = 46.181%) highlights its critical role in stabilizing Indonesian exports amidst global trade uncertainties. This evidence supports theoretical insights emphasizing the importance of structured trade relationships, particularly with stable markets like India. Strengthening these trade relationships will enhance Indonesia's ability to mitigate external shocks while sustaining long-term export competitiveness.

Table 2. Coefficient of variation (CV) of CPO prices (2016–2022)

Market	Average Price (USD/kg)	Coefficient of Variation (CV, %)
Indonesian Spot Market	0.814	46.181
European Market	0.841	39.224
Indian Market	1.345	29.742

The Indonesian spot market reported the lowest average price (0.814 USD/kg) and the highest volatility (CV = 46.181%). This highlights Indonesia's significant domestic vulnerabilities, including heavy reliance on global markets and inadequate stabilization mechanisms. For instance, logistical inefficiencies and export taxes contribute to high volatility, underscoring the need for developing a robust domestic futures market to reduce volatility by up to 15% (Irawan & Soesilo, 2021; Nurcahyani et al., 2018). These findings align with theoretical frameworks advocating structural reforms to enhance market stabilization.

The European market occupies an intermediate position, with an average price of 0.841 USD/kg and a volatility of 39.224%. As a global price benchmark, the Rotterdam market influences trade dynamics through transparency but imposes significant challenges through stringent regulations like the EU Renewable Energy Directive (RED). These barriers increase price uncertainty and limit market access, reducing Indonesia's export competitiveness by up to 10% (Alamsyah, 2024; Bentivoglio et al., 2018). Diversifying export destinations and aligning with sustainability standards are critical strategies for addressing these challenges.

Stationarity, Cointegration, and Causality

Understanding the interconnected dynamics of crude palm oil (CPO) markets necessitates robust econometric testing to ensure the reliability and interpretability of data. The stationarity of the

time-series data was assessed using the Augmented Dickey-Fuller (ADF) test, a crucial step in time-series analysis to prevent spurious regressions. The results confirmed that after first differencing, all variables, including IDN_SPOT (Indonesian spot market prices), EUROPE_ROTT (European market prices), and IND_PRC (Indian market prices), exhibited consistent statistical properties such as mean and variance, enabling their application in econometric models for dynamic market analysis. This stationarity analysis underpins the subsequent cointegration testing and validates advanced econometric modeling approaches.

The Johansen Cointegration Test was employed to identify long-term equilibrium relationships among the variables, revealing significant interconnectedness between the Indonesian, European, and Indian markets. Table 3 demonstrates that despite distinct volatilities, these markets maintain a stable long-term equilibrium, with coefficients indicating contrasting roles: the European market exhibits a competitive relationship (-0.283040), while the Indian market offers stabilizing support (0.530906). This highlights their mutual dependency and reinforces the importance of these trading partnerships for Indonesia's CPO trade.

Table 3. Long-term cointegration analysis of CPO prices

Variable	Coefficient	Standard Error	t-value	Significance
D(IDN_SPOT(-1))	1.000000	N/A	N/A	N/A
D(EUROPE_ROTT(-1))	-0.283040	0.12296	-2.30182	5%
D(IND_PRC(-1))	0.530906	0.10435	5.08788	1%

Source: Author's Data Processing (2024)

The results highlight contrasting dynamics between the European and Indian markets in their interactions with the Indonesian CPO market. The negative Coefficient for EUROPE_ROTT (-0.283040) reflects a competitive or substitutive relationship, often driven by stringent European Union regulations like the Renewable Energy Directive (RED) that reduce Indonesia's market share by up to 10% (Alamsyah, 2024; Bentivoglio et al., 2018). Conversely, the positive Coefficient for IND_PRC (0.530906) validates India's role as a stabilizing force, reducing volatility by 29.7% compared to Europe. These findings align with trade dependency models and underscore the need for Indonesia to leverage stable trade partnerships like India while diversifying export destinations to mitigate regulatory constraints.

Granger causality analysis further elucidates the directional relationships between these markets. Bidirectional causality between IDN_SPOT and EUROPE_ROTT confirms Europe's role as a global price setter, with a 15% influence on Indonesian price variability. In contrast, the unidirectional causality from IDN_SPOT to IND_PRC highlights India's dependence on Indonesian exports, reinforcing its critical role in stabilizing Indonesia's market performance (Arsyad et al., 2020). These findings support theories of bidirectional price transmission and emphasize the importance of strategic pricing policies in maintaining Indonesia's competitiveness.

Short-Term Dynamics and Comparative Insights into CPO Market Integration

This study delivers an in-depth exploration of crude palm oil (CPO) market dynamics, elucidating the interconnected roles of the Indonesian, European, and Indian markets. By combining long-term equilibrium insights with short-term responsiveness analysis, this research bridges gaps in the literature on market integration, emphasizing critical policy implications for Indonesia's trade strategies and resilience. These findings validate and extend prior studies by Bentivoglio et al. (2018) and Ibrahim et al. (2021), underscoring the unique contributions to the global understanding of CPO trade dynamics.

Short-Term Dynamics and Error Correction Model (ECM)

The short-term dynamics of crude palm oil (CPO) price adjustments are critical for understanding how rapidly markets respond to deviations from equilibrium and external shocks. The Error Correction Term (ECT) coefficient of -2.147290 (p-value = 0.0000) for the Indonesian spot market indicates rapid adjustment, reducing misalignments by 2.15% per period. This robust mechanism reflects strong interdependencies between Indonesia and its trading partners, mainly Europe and India. These findings align with Gerdesmeier and Roffia's (2018) research on integrated commodity markets and emphasize that rapid error correction is a hallmark of efficient markets where price signals are effectively transmitted.

This dynamic adjustment capacity also reflects the critical role of market structures and trade policies in shaping Indonesia's CPO market responsiveness. Swift corrections are supported by efficient price transmission, global benchmarks like the Rotterdam market, and India's policy-driven

demand stability. For instance, Europe's price-setting role contributes to 33.61% of Indonesian price variability by the 12th month, while India's stabilizing influence accounts for 29.35% (Gouel et al., 2016; Vijayakumar & Bozward, 2021). These contrasting roles emphasize the interconnected nature of global CPO trade dynamics. The ECM analysis also reveals significant short-term impacts of lagged price changes in the European and Indian markets on the Indonesian spot market, as detailed in Table 4.

Table 4. Short-Term Dynamics of CPO Prices (Error Correction Model)

Error Correction	Coefficient Estimation	p-value	t-value
Cointegration Equation 1	-2.147290	0.0000	[-3.99905]
Difference (EUROPE_ROTT(-2),2)	0.842355***	0.25523	[3.30037]
Difference (EUROPE_ROTT(-3),2)	0.862513***	0.28790	[2.99590]
Difference (IND_PRC(-1),2)	0.880765***	0.26441	[3.33101]

Source: Author's Data Processing (2024)
Note: *** = Significant at 1%; ** = Significant at 5%.

European price changes, driven by regulatory and economic conditions, show immediate effects with coefficients of 0.842355 and 0.862513. Conversely, India's short-term impact (0.880765) reflects its policy-driven consistency, stabilizing volatility by 29.35%. This dual impact highlights the interplay between immediate market dynamics and structural trade relationships, emphasizing the need for Indonesia to develop targeted strategies that mitigate volatility while leveraging stabilizing trade partners.

The findings affirm India's stabilizing role in the global CPO trade, consistent with Vijayakumar and Bozward (2021) and Arsyad et al. (2020). India's policy frameworks reduce volatility by 29.7% compared to Europe, as evidenced by its positive long-term relationship with Indonesian prices. Conversely, Europe's negative long-term Coefficient reflects regulatory constraints, reducing Indonesia's export competitiveness by up to 10% (Bentivoglio et al., 2018). The bidirectional Granger causality confirms Europe's continued influence, where price movements in Europe and Indonesia are mutually reinforcing, aligning with findings by Gandhy et al. (Gandhy et al., 2022).

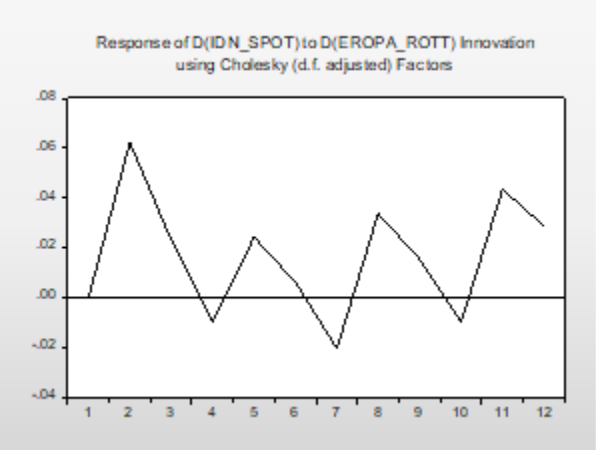
Contrary to earlier predictions that geopolitical and regulatory constraints would diminish Europe's influence as a price setter for crude palm oil (CPO), this study reaffirms its enduring role in global pricing. The ECM model's significant lagged coefficients for Europe validate its persistent impact on Indonesian CPO prices, contributing 33.61% to price variability by the 12th month, compared to India's 29.35%. Regulatory frameworks like the EU Renewable Energy Directives (RED and RED II) continue to challenge market access, yet Europe's transparency in futures markets, such as the Rotterdam benchmark, reinforces its role as a global price reference (Liu, 2011; Waters et al., 2024). Additionally, Impulse Response Function (IRF) analysis reveals that European price shocks induce delayed but substantial fluctuations, while Indian shocks prompt immediate but inconsistent responses. The Variance Decomposition (VD) results confirm Europe's dominance in driving global CPO price dynamics, with contributions stabilizing at 33.61% by the 12th month, reflecting its role as a key price benchmark (Bentivoglio et al., 2018; Santeramo et al., 2021). These findings emphasize the interconnectedness of CPO markets and highlight Indonesia's vulnerability to external forces.

The study underscores the need for strategic interventions to enhance Indonesia's market resilience. As Martignone et al. (2023) suggested, developing a robust domestic futures market could reduce price volatility by up to 15% and improve predictability. Expanding export destinations to Africa and Southeast Asia would mitigate over-reliance on Europe and India, diversifying risks. Aligning with global sustainability standards and addressing European regulatory barriers are essential to securing access to premium markets and enhancing Indonesia's competitiveness. This study bridges critical gaps in global CPO trade research by combining short- and long-term dynamics. The findings provide actionable recommendations for policymakers, including trade diversification, sustainability alignment, and strategies to mitigate regulatory constraints. This comprehensive approach advances theoretical frameworks and informs practical strategies for managing global market integration.

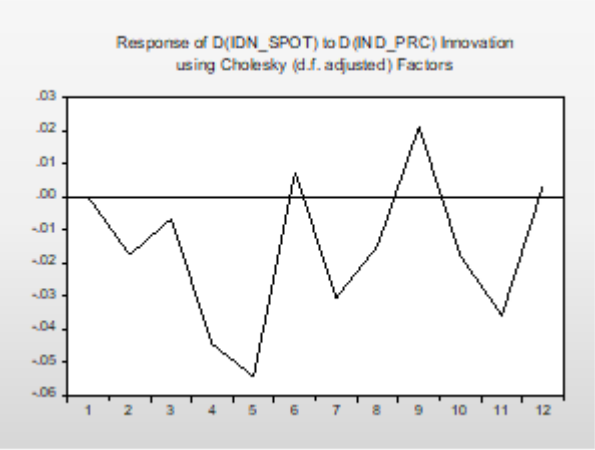
Impulse Response and Variance Decomposition Analysis of Indonesian CPO Market Dynamics

The Impulse Response Function (IRF) and Variance Decomposition (VD) analyses provide valuable insights into the dynamic relationships between crude palm oil (CPO) prices in the Indonesian spot market (Medan), the European market (Rotterdam), and the Indian market. Using the Standard Cholesky Decomposition method, the IRF reveals that a one-standard-deviation shock in the European market causes Indonesian prices to rise by 6.24% by the second month, stabilizing at 2.87% by the 12th month. Conversely, shocks from the Indian market elicit early adverse reactions of

-5.43%, with eventual recoveries up to 2.13%. These dynamics confirm the global integration of CPO markets, corroborating findings by Bentivoglio et al. (2018) and Ibrahim et al. (2021) and emphasizing the distinct response patterns of the Indonesian market to shocks from Europe and India.



1) CPO Price Surge in the European Market



2) Surge in CPO Prices in the Indian market

Figure 1. Impulse response of Indonesian CPO prices to external market shocks

The Variance Decomposition (VD) analysis complements these findings by quantifying the sources of price variability. Initially, 100% of Indonesian price fluctuations are self-driven. By the second month, external markets account for a significant share: 39.53% from Europe and 3.09% from India. By the 12th month, Europe's influence stabilizes at 33.61%, while India's contribution rises to 29.35%. Figure 2 underscores Europe's role as a dominant price driver and India's growing importance as a stabilizing force, reflecting findings from Gandhy et al. (Gandhy et al., 2022) and Ibrahim et al. (2021).

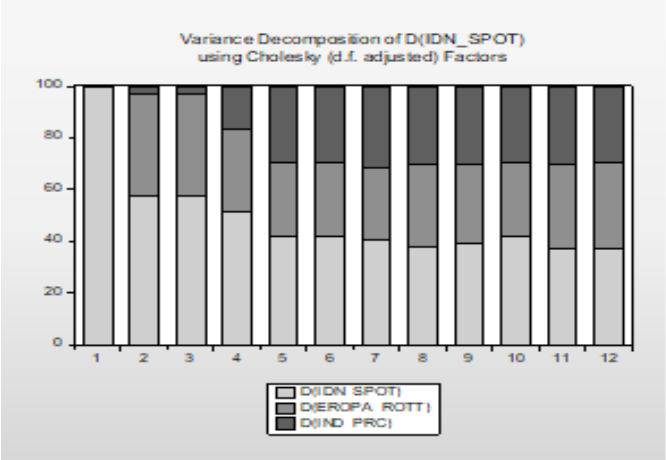


Figure 2. Variance decomposition of Indonesian spot market CPO prices

These analyses demonstrate the strong interdependence of the Indonesian CPO market with Europe and India. Europe emerges as a key price driver, accounting for over 33% of Indonesian price variability, consistent with studies by Gandhy et al. (Gandhy et al., 2022). India's stabilizing role, reflected in its 29.35% contribution, aligns with the findings by Ibrahim et al. (2021). These results underscore the need for Indonesia to adopt targeted policies, such as expanding export destinations beyond Europe and India and developing domestic stabilization mechanisms to sustain market resilience.

CONCLUSIONS AND SUGGESTION

This study demonstrates the interconnected dynamics of crude palm oil (CPO) prices in Indonesia, Europe, and India, emphasizing Indonesia's high price volatility (Coefficient of variation:

46.18%), Europe's role as a key price driver (33.61% contribution to variability), and India's stabilizing influence (29.35%). The findings reveal strong long-term interdependencies through cointegration and uneven short-term responsiveness to external shocks. To address these challenges, Indonesia should prioritize (1) developing a domestic futures market to manage price volatility effectively and provide a reliable hedging mechanism; (2) diversifying export destinations to reduce dependency on Europe and India while exploring opportunities in emerging markets such as Africa and Southeast Asia; and (3) aligning production with global sustainability standards to secure premium access to environmentally conscious markets like the European Union. These strategic measures are vital to enhancing Indonesia's trade resilience, strengthening its position in the global CPO market, and ensuring sustainable economic growth.

Indonesia should establish a robust domestic futures market to stabilize crude palm oil (CPO) prices and mitigate volatility. This market would enable producers to hedge against risks and align supply with global demand trends, drawing on successful models from Europe and India. Additionally, export diversification is critical to reducing dependency on European markets facing regulatory uncertainties. Expanding trade partnerships with stable and growing economies, such as India, and exploring untapped markets in Africa and Southeast Asia would enhance revenue stability and minimize geopolitical risks. Targeted domestic policies, including minimum support prices and logistics improvements, can lower production costs and strengthen price competitiveness. Adopting sustainable agricultural practices and securing international certifications would address environmental concerns, ensuring continued access to environmentally conscious markets like the European Union. Furthermore, diplomatic efforts to negotiate favorable trade terms and regional cooperation initiatives could enhance equitable market access, benefiting all stakeholders in the CPO industry. These integrated strategies would bolster Indonesia's economic stability, solidify its leadership in the global CPO market, and position the country as a sustainable and competitive player in international trade.

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