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Factors Affecting the Crude Palm Oil Production and Prices: Evidence from Indonesian Economy

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Crude palm oil (CPO) production has been a pivotal factor in the economic growth of CPO production companies, influenced by various determinants and necessitating further research. This study investigates the impact of labour wage rate, workers' education, production land, interest rate, and inflation rate on CPO production and prices in Indonesia. Utilizing secondary data from STATISTA and World Development Indicators (WDI) covering the period from 1994 to 2023, the study employs the dynamic autoregressive distributed lag (DARDL) approach to analyse the relationships among these variables. The findings indicate that labour wage rate, workers' education, production land, interest rate, and inflation rate are positively correlated with CPO production and prices in Indonesia. The study offers policy recommendations, suggesting that regulators should focus on increasing labour wages, improving workers' education, and expanding production land to enhance CPO production and prices.

Keywords: Labour Wage Rate, Workers' Education, Production Land, Interest Rate, Inflation Rate, CPO Production, CPO Prices.

Introduction

Given the interdependent factors determining the production and prices of CPO in the Indonesian economy, this research delves into a complex and nuanced analysis. As the world's largest producer of palm oil, Indonesia has integrated the palm oil industry as a crucial component of its economy, holding significant and competitive positions in both domestic and international markets (Kadarusman & Herabadi, 2018). This study aims to evaluate the multifaceted determinants affecting CPO production and prices, with a particular focus on labour wage rates, worker education levels, production land, loan interest rates, and overall inflation rates. Palm oil is a cornerstone of Indonesia's socio-political and economic framework, providing employment opportunities, generating export revenues, and facilitating rural transformation (Córdoba, Abrams, & Selfa, 2022). Fluctuations in CPO production and prices have far-reaching impacts across various sectors of the economy, influencing survival strategies, business decisions, and governmental policies. In this context, analysing the interactions between the fundamental drivers of CPO production and prices is invaluable for a wide range of stakeholders, including policymakers, industry participants, and investors.

The labour wage rate is a critical component in the cost structure of the palm oil industry. There is a strong relationship between the wages offered to plantation employees and the overall competitiveness, profitability, and long-term viability of the sector. According to Pickard, Draganova, Nakova, and Chengelova (2022), labour wage rates can influence the mechanization-to-manual labour ratio, employment trends, and productivity levels. Furthermore, the education and training of workers significantly impact the quality of inputs and the efficiency of transforming these inputs into outputs. Higher levels of education and training among workers lead to increased productivity, innovation, and the ability to handle technological advancements, which in turn enhance the production capacity and global competitiveness of CPO (Lim, Jeffree, Saupin, Giloi, & Lukman, 2022).

Purnomo et al. (2020) suggest that the quality and availability of production land are crucial determinants of CPO production in Indonesia. The future of palm oil production is closely tied to the availability of additional land for cultivation, often regulated by standards concerning land use, environmental conservation, and indigenous land rights. The inability of developers to access new areas for expansion poses a significant challenge to the industry's growth. Moreover, the quality of the land, including soil fertility, land structure, and climate, directly affects CPO yields and production costs (Paterson & Lima, 2018). Therefore, introducing sustainable land management practices and enhancing land productivity are essential for boosting CPO production in Indonesia.

Interest rates play a crucial role in shaping investment decisions and capital capabilities within the palm oil industry. Variations in interest rates affect the cost of capital needed for plantation establishment, equipment acquisition, and the adoption of efficient, environmentally friendly farming practices (Tey, Brindal, Darham, Sidique, & Djama, 2020). Currently, low interest rates can enhance investment in the palm oil industry by increasing production capacity and, consequently, the supply of palm oil. Conversely, high interest rates may deter investment, limiting expansion strategies and capital-intensive developments (Batlle et al., 2021). Interest rate policies significantly influence CPO production through their effects on inflation, exchange rate variability, and broader monetary policy measures, adding complexity to the economic interdependencies involved.

Inflation rates are also critical in influencing CPO production and pricing in Indonesia. Inflation increases the cost of products domestically, which can reduce demand both locally and in export markets (Khatiwada, Palmén, & Silveira, 2018). Additionally, inflation raises production costs by increasing expenses for labour, fertilizers, and energy. According to Kilian and Zhou (2022), the

inflationary impact on production costs can negatively affect profit margins for producers. To mitigate these effects, palm oil producers must enhance efficiency to reduce costs. However, the challenges posed by inflation to CPO production require a combination of demand management tools, such as monetary and fiscal policies, alongside supply-side strategies to control prices and promote industry growth (Lugo-Arias et al., 2024).

The study endeavours to forecast the determining factors influencing CPO production and pricing within the Indonesian economy. It scrutinizes parameters including labour wage rates, worker education, production land availability, interest rates, and inflation rates. The research aims to elucidate the interrelation of these determinants with CPO production and prices, assessing their impact on the palm oil sector and proposing policy implications to foster enhanced performance and sustainable development. Furthermore, the study addresses gaps in existing literature by employing cross-sectional analysis to explore various factors shaping CPO generation and pricing in Indonesia. By bridging these knowledge lacunae and shedding light on the complexities inherent in the palm oil industry, this work endeavours to furnish valuable insights for policymakers, industry stakeholders, and prospective investors keen on understanding the challenges and prospects within this pivotal sector of the economy.

In the following section of this study, we will review the relevant literature, outline the research methodology, and conduct a comprehensive empirical analysis to test the proposed hypotheses.

Literature Review

The labour wage rate is positively associated with crude palm oil production, primarily due to the significant contribution of labour inputs in regions where palm oil cultivation is intensive (Shahiri, Cheng, & Al-Hadi, 2021). However, this association has implications for the profitability of palm oil producers, as higher labour wages increase production costs. Consequently, organizations may face pressure to invest in new technologies or adopt better practices to mitigate these costs and potentially reduce product prices (Shahiri et al., 2021).

Conversely, Agénor and Lim (2018) argue that lower labour wages can effectively reduce production costs, thereby enhancing profit margins. Nevertheless, it is crucial to maintain wages at a reasonable level, as this can impact the quality and sustainability of production practices. Well-compensated employees tend to exhibit positive attitudes, leading to increased productivity and adherence to sustainable farming methods, ultimately improving palm oil yields and quality (Pickard et al., 2022).

In contrast, inadequate wages may lead to negative consequences such as staff shortages, high turnover rates, and working conditions that place undue pressure on employees. These factors not only pose reputational risks but also attract regulatory scrutiny, potentially affecting the industry's long-term sustainability (Agénor & Lim, 2018). Additionally, cheap labour wages can influence the socio-economic dynamics of palm oil-producing regions. Higher wages contribute to improved living standards and stimulate local economic activities, fostering social stability (Pickard et al., 2022).

Therefore, we propose that,

H1: Labour wage rate has a relation with crude palm oil production.

CPO is a vital source of vegetable oil and food globally, and worker education significantly impacts the productivity and profitability of the industry. Educated workers are more likely to adopt advanced farming techniques, leading to higher oil yields (Cock, Prager, Meinke, & Echeverria, 2022). They are adept at managing machinery, pest control, and disease prevention while employing environmentally sustainable practices. Moreover, Lim et al. (2022) suggest that higher education standards in the workplace enhance safety, reducing accidents and violence, and promote better communication and cooperation among employees, which are essential for improving production outcomes (Cock et al., 2022).

Additionally, well-educated workers tend to be more aware of their rights and the importance of fair treatment, fostering a positive and productive workforce (D'Cruz et al., 2022). This can create a market advantage by attracting investors and buyers who prioritize ethical sourcing practices. Thus, investing in worker education benefits the individual employees and is crucial for the overall sustainability and viability of the CPO industry. Therefore, we say that,

H2: Worker education has a relation with crude palm oil production.

Production land is a significant factor influencing CPO production, encompassing both the availability and quality of land in the region. Palm oil cultivation typically requires large tracts of land with suitable environmental conditions, including optimal soil type, climate, and water regimes (Jelsma, Woittiez, Ollivier, & Dharmawan, 2019). For instance, Malaysian land, known for its suitability for palm oil production, has high yield expectations due to its conducive environmental factors, such as rich, well-drained soil and adequate rainfall. These conditions enhance the efficiency and production capacity of palm oil, thereby contributing to the industry's profitability (Khatiwada et al., 2018).

Conversely, if the land is less productive, the yield and economic returns will be lower, as the crop may require additional resources like fertilizers and water to thrive (Siderius et al., 2021). Furthermore, Jelsma et al. (2019) highlight that the establishment of palm oil plantations, along with the processing and consumption of palm oil products, impacts deforestation and land-related issues, raising environmental concerns and prompting legislative scrutiny. Balancing the need for increased production with sustainable land management practices is crucial to address these environmental and regulatory challenges. Therefore, we hypothesize that.

H3: Production land has a relation with crude palm oil production.

Based on the findings of Tey et al. (2020), the interest rate significantly influences the cost of capital for plantation

investments and operations, thereby directly impacting CPO production. Low interest rates, as noted by Syahza (2019), facilitate easier access to credit for expanding existing palm oil plantations, acquiring modern machinery and equipment, and implementing advanced techniques in oil palm cultivation. This, in turn, enhances production capacity, efficiency, and competitiveness.
Conversely, high interest rates, as highlighted by In, Manav, Venereau, and Weyant (2022), diminish the feasibility of leveraging, potentially reducing investments in essential infrastructure and technology needed to improve output and competitiveness. Moreover, periodic fluctuations in interest rates affect the broader economy, influencing the flow and level of economic activity, as well as market prices, including those of palm oil. Therefore, we propose that,

H4: Interest rate has a relation with crude palm oil production.

Given the research by Batlle et al. (2021), inflation rates play a significant role in the annual and economic planning of CPO production. High inflation can elevate production costs for palm oil, as it often leads to increases in the prices of factors of production such as fertilizers, labour, and machinery. This scenario may narrow profit margins and discourage investment in maintaining or expanding plantations. Conversely, moderate inflation can be advantageous for palm oil producers, as product prices may escalate at a faster rate than production costs, thereby enhancing profitability (Ng et al., 2022).
However, sustained increases in the inflation rate can disrupt economic conditions, potentially impeding production and supply chain momentum (Batlle et al., 2021). Moreover, according to Chandrarin, Sohag, Cahyaningsih, Yuniawan, and Herdhayinta (2022), inflation influences price levels in a country, affecting demand for products derived from palm oil. Therefore, it is essential to manage inflation and minimize its positive correlation with production and market risks to foster the development of the crude palm oil sector. Therefore, we make a hypothesis that,

H5: Inflation rate has a relation with crude palm oil production.

The cost price of CPO is influenced by labour wage rates, as highlighted by Hoaihongthong and Kwiecien (2022). This dynamic presents a dilemma for palm oil producers, as higher labour costs may compel them to raise the price of the final product to offset losses, potentially undermining the intended benefits of providing higher wages. Conversely, lower labour costs can contribute to reduced production expenses, enabling the possibility of offering lower-priced products in the market (Chen, Kumara, & Sivakumar, 2021).
However, as noted by Greenwald (2018), low wages can lead to labour shortages and unfavourable working conditions, which can ultimately hinder commodity production and inflate costs in the long term. Additionally, appropriate wages have the potential to enhance worker productivity and retain top talent, thereby promoting business efficiency and product quality (Kryscynski, Coff, & Campbell, 2021). Achieving this balance may require small and medium-sized enterprises (SMEs) to align worker compensation with industry profitability to ensure the stability of CPO prices and the sustainable expansion of the sector. Therefore, we say that,

H6: Labour wage rate has a relation with crude palm oil prices.

Worker education significantly influences CPO prices by shaping production rates, efficiency, and quality. According to Lee, Suh, Roy, and Baucus (2019), educated workers are more adept at adopting innovative production techniques, operating machinery, and adhering to best practices, resulting in increased CPO yields and improved quality. This enhanced efficiency can potentially reduce production costs, leading to lower product prices for consumers.
Furthermore, better-educated human capital explores sustainable farming methods, which enhances the prestige of the farming industry and the final product (Nordin et al., 2022). This may either support product prices or increase demand due to the ethical considerations associated with sustainably produced oil. Conversely, inadequate worker education may result in poor working methods, increased losses, reduced returns, and higher production costs, leading to elevated product prices in the market (Sekaran, Lai, Ussiri, Kumar, & Clay, 2021).
Hence, prioritizing investments in worker education is crucial for achieving competitive and stable demand for CPO prices. Therefore, we propose that,

H7: Worker education has a relation with crude palm oil prices.

According to Syahnur, Majid, Zulham, Saputra, and Badli (2019), production land is identified as a crucial determinant of CPO prices, primarily influenced by its availability and quality. Favourable geographical locations with suitable land for oil palm plantations tend to yield higher productivity, thereby contributing to lower production costs and potentially more stable or even lower market prices (Varkkey, Tyson, & Choiruzzad, 2018). However, the scarcity of sufficient land can drive up the costs of purchasing and establishing plantations, consequently leading to an increase in palm oil prices.
Furthermore, the expansion of palm oil plantations often accompanies deforestation and changes in land use, attracting regulatory attention and environmental concerns, both of which have implications for supply and its impact on prices (Potter, 2020). Effective stewardship of the soil base can enhance production while mitigating negative environmental impacts, thereby promoting price stability (Varkkey et al., 2018). Therefore, we say that,

H8: Production land has a relation with crude palm oil prices.

Interest rates directly impact CPO prices due to their influence on the cost of capital. Higher inflation rates can lower the cost of capital, enabling palm oil producers to expand and upgrade operations, potentially increasing supply and reducing prices. Conversely, high interest rates increase borrowing costs, limiting investment in innovation and infrastructure, leading to lower production rates and supply. Additionally, fluctuations in exchange rates, driven by changes in interest rates, affect the competitiveness of palm oil in international markets. Therefore, maintaining sustainable interest rates is crucial for encouraging production and stabilizing CPO prices. Therefore, we say that,

H9: Interest rate has a relation with crude palm oil prices.

Fluctuations in exchange rates play a crucial role in influencing

CPO prices, as highlighted by Go and Lau (2024). CPO, being a global commodity, is traded in international markets where exchange rate fluctuations can impact producers' and traders' business transactions. Additionally, low interest rates may attract investors to commodities like crude palm oil, increasing demand and consequently raising prices.

Furthermore, fluctuations in interest rates, as noted by Lugo-Arias et al. (2024), can affect the value of currencies relative to each other, thereby influencing the competitiveness of palm oil exports. Higher interest rates may discourage investment in commodities, leading to reduced demand and lower prices (Kilian & Zhou, 2022). These insights underscore the importance of closely monitoring monetary policy changes and their interrelated economic attributes for market players in the CPO industry. Therefore, we propose that,

H10: Inflation rate has a relation with crude palm oil prices.

The study has identified five predictors: labour wage rate, workers' education, production land, interest rate, and inflation rate, alongside two predictive variables: CPO production and CPO prices. Drawing from the literature reviewed, the study has formulated the model depicted in Figure 1.

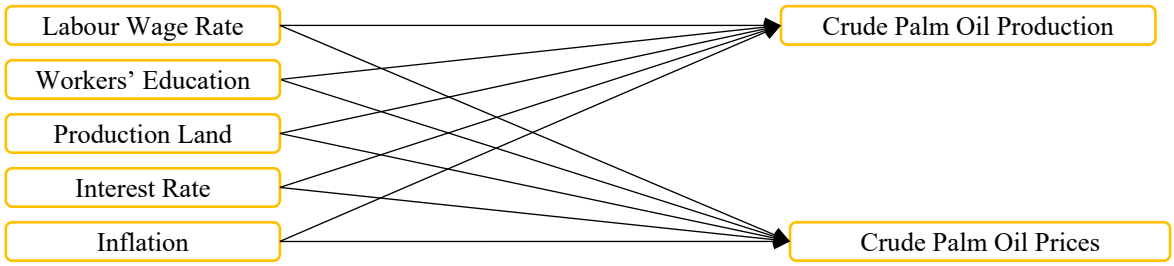

Figure 1: Theoretical Model.

Research Methods

The research investigates the influence of labour wage rate, workers' education, production land, interest rate, and inflation rate on both the production of CPO and its prices within the Indonesian context. Secondary data sourced from STATISTA and the World Development Indicators (WDI) spanning the period from 1994 to 2023 were utilized for analysis. The study formulated a comprehensive equation to elucidate these relationships:

$$CPOP_t = \alpha_0 + \beta_1 LWR_t + \beta_2 WE_t + \beta_3 PL_t + \beta_4 IR_t + \beta_5 INF_t + e_t \quad (1)$$

$$CPOPR_t = \alpha_0 + \beta_1 LWR_t + \beta_2 WE_t + \beta_3 PL_t + \beta_4 IR_t + \beta_5 INF_t + e_t \quad (2)$$

Where

CPOP = Crude Palm Oil Production

CPOPR = Crude Palm Oil Prices

t = Time Period

LWR = Labour Wage Rate

WE = Workers' Education

PL = Production Land

IR= Interest Rate

INF = Inflation

The study incorporated two predictive variables: CPO production, quantified as production volume in million metric tons, and CPO prices, expressed in US dollars per metric ton. Additionally, the study integrated five predictors: labour wage rate, gauged by wage and salaried workers, male (% of male employment); workers' education, assessed by labour force with advanced education (% of total working-age population with advanced education); production land, quantified as permanent cropland (% of land area); interest rate, measured as real interest rate (%); and inflation, indicated by consumer prices (annual %). Table 1 outlines these measurements.

Table 1: Variables with Measurements.

S#	Variables	Measurement	Sources
01	CPO Production	Production volume in million metric ton	Statista
02	CPO Prices	US dollar in per metric ton	Statista
03	Labour Wage Rate	Wage and salaried workers, male (% of male employment)	WDI
04	Workers' Education	Labour force with advanced education (% of total working-age population with advanced education)	WDI
05	Production Land	Permanent cropland (% of land area)	WDI
06	Interest Rate	Real interest rate (%)	WDI
07	Inflation	Inflation, consumer prices (annual %)	WDI

Descriptive statistics were employed to examine the details of the constructs, including average values, standard deviations, as well as maximum and minimum values. Furthermore, a correlation matrix was utilized to assess the relationships among variables. Additionally, the Phillips-Perron (PP) and augmented Dickey–Fuller (ADF) tests were conducted to investigate the presence of unit root. The equation utilized in the study is outlined below:

$$d(Y_t) = \alpha_0 + \beta t + YY_{t-1} + d(Y_t(-1)) + \varepsilon_t \quad \textbf{(3)}$$

Furthermore, the study applied the approach proposed by Westerlund and Edgerton (2008) to investigate co-integration within the model. The equations corresponding to this approach are provided below:

$$LM_{\varphi}(i) = T\hat{\varphi}_i\,(\hat{r}_i/\hat{\sigma}_i) \quad (4)$$

$$LM_{\tau}(i) = \hat{\varphi}_i/SE(\hat{\varphi}_i) \quad (5)$$

In equations (4) and (5), $\hat{\varphi}_i$, exposed the estimate beside standard error, while r^2_i exposed the long-run measured variance, while $\varphi i\ (L) = 1 - \sum \varphi_{ij} L^j$ exposed the scalar polynomial with L lag length, and ρ_i exposed the factor loading parameters vector.

Additionally, the study employed the ARDL approach to examine the relationships among the variables under investigation. The ARDL method is considered appropriate when the variables exhibit no unit root at I(0) and I(1) levels

(Nazir, Nazir, Hashmi, & Ali, 2018). Moreover, this approach effectively addresses the effects of heteroscedasticity and autocorrelation on the outcomes (Zaidi & Saidi, 2018). The equation utilized in the analysis is provided below:

$$\Delta CPOP_t = \alpha_0 + \sum\delta_1\Delta CPOP_{t-1} + \sum\delta_2\Delta LWR_{t-1} + \sum\delta_3\Delta WE_{t-1} + \sum\delta_4\Delta PL_{t-1} + \sum\delta_5\Delta IR_{t-1} + \sum\delta_6\Delta INF_{t-1} + \varphi_1 CPOP_{t-1} + \varphi_2 LWR_{t-1} + \varphi_3 WE_{t-1} + \varphi_4 PL_{t-1} + \varphi_5 IR_{t-1} + \varphi_6 INF_{t-1} + \varepsilon_t \quad (6)$$

$$\Delta CPOPR_t = \alpha_0 + \sum\delta_1\Delta CPOPR_{t-1} + \sum\delta_2\Delta LWR_{t-1} + \sum\delta_3\Delta WE_{t-1} + \sum\delta_4\Delta PL_{t-1} + \sum\delta_5\Delta IR_{t-1} + \sum\delta_6\Delta INF_{t-1} + \varphi_1 CPOPR_{t-1} + \varphi_2 LWR_{t-1} + \varphi_3 WE_{t-1} + \varphi_4 PL_{t-1} + \varphi_5 IR_{t-1} + \varphi_6 INF_{t-1} + \varepsilon_t \quad (7)$$

Lastly, the study employed the DARDL approach to examine the associations among variables, as established by Jordan and Philips (2018). This approach addresses additional issues that the ARDL model may not cover. The DARDL equation is presented below:

$$\Delta CPOP_t = \alpha_0 + \sum\delta_1\Delta CPOP_{t-1} + \sum\delta_2\Delta LWR_t + \sum\delta_3\Delta LWR_{t-1} + \sum\delta_4\Delta WE_t + \sum\delta_5\Delta WR_{t-1} + \sum\delta_6\Delta PL_t + \sum\delta_7\Delta PL_{t-1} + \sum\delta_8\Delta IR_t + \sum\delta_9\Delta IR_{t-1} + \sum\delta_{10}\Delta INF_t + \sum\delta_{11}\Delta INF_{t-1} + \varepsilon_t \quad (8)$$

$$\Delta CPOPR_t = \alpha_0 + \sum\delta_1\Delta CPOPR_{t-1} + \sum\delta_2\Delta LWR_t + \sum\delta_3\Delta LWR_{t-1} + \sum\delta_4\Delta WE_t + \sum\delta_5\Delta WR_{t-1} + \sum\delta_6\Delta PL_t + \sum\delta_7\Delta PL_{t-1} + \sum\delta_8\Delta IR_t + \sum\delta_9\Delta IR_{t-1} + \sum\delta_{10}\Delta INF_t + \sum\delta_{11}\Delta INF_{t-1} + \varepsilon_t \quad (9)$$

Research Findings

Descriptive statistics were conducted to analyse the characteristics of the variables. The results revealed that the average value of CPOP was 34.901 million metric tons, while the average CPOPR stood at 1454.382 US dollars per metric ton. Additionally, the average LWR was 44.537 percent, and the average percentage of WE was 84.179 percent. Furthermore, the average value of LP was 10.945 percent, the IR averaged at 14.482 percent, and INF averaged at 8.442 percent. Table 2 presents these findings in detail.

Table 2: Descriptive Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
CPOP	30	34.901	3.291	27.871	48.769
CPOPR	30	1454.382	32.021	903.053	1754.462
LWR	30	44.537	6.445	35.693	53.577
WE	30	84.179	3.055	78.84	89.028
LP	30	10.945	2.531	7.201	15.381
IR	30	4.482	6.995	-24.600	12.322
INF	30	8.442	10.255	1.560	58.451

Furthermore, a correlation analysis was conducted to examine the relationships among variables using a correlation matrix. The results indicated that LWR, WE, LP, IR, and INF exhibited positive correlations with both CPOP and CPOPR. Table 3 provides a detailed overview of these findings.

Table 3: Matrix of Correlations.

Variables	CPOP	CPOPR	LWR	WE	LP	IR	INF
CPOP	1.000						
CPOPR	0.900	1.000					
LWR	0.985	0.924	1.000				
WE	0.209	0.244	-0.169	1.000			
LP	0.939	0.906	0.918	-0.418	1.000		
IR	0.145	0.114	0.199	0.003	0.074	1.000	
INF	0.423	0.493	-0.466	0.282	-0.464	-0.686	1.000

Additionally, the PP and ADF tests were employed to assess the presence of unit root. The results indicated that CPOP, CPOPR, LWR, IR, and INF are stationary at I (0), while WE and LP are stationary at I (1). Table 4 presents these findings.

Table 4: Unit Root Test.

	ADF PP			
Series	Level	First Difference	Level	First Difference
CPOP	-2.986***	------	-2.842***	------
CPOPR	-2.887***	------	-2.171***	------
LWR	-3.021***	-----	-3.664***	------
WE	------	-4.382***	------	-5.463***
LP	------	-4.325***	------	-5.647***
IR	-2.546***	------	-3.221***	------
INF	-3.102***	------	-2.773***	------

Furthermore, the study employed the approach proposed by Westerlund and Edgerton (2008) to investigate co-integration within the model. The results indicated that the p-values did not exceed the threshold of 0.05, and the t-values were greater than 1.96, suggesting the presence of co-integration. Table 5 displays these results.

Table 5: Co-Integration Test.

Model	No Shift		Mean Shift		Regime Shift	
	Test Stat	P-value	Test Stat	p-value	Test Stat	P-value
LM_τ	-3.331	0.000	-3.981	0.000	-4.392	0.000
LM_φ	-3.983	0.000	-3.995	0.000	-4.765	0.000

Finally, the study applied the DARDL approach to investigate the impact of LWR, WE, LP, IR, and INF on CPOP. The results indicated a positive relationship between LWR, WE, LP, IR, INF, and CPOP in Indonesia,

supporting hypotheses H1, H2, H3, and H4. These relationships are summarized in Table 6.

Table 6: Dynamic ARDL Model.

Variable	Coefficient	T-Statistic	Prob.
ECT	-1.492***	-5.764	0.000
LWR_{t-1}	0.282***	5.473	0.000
LWR	0.431**	2.019	0.043
WE_{t-1}	0.321**	2.122	0.035
WE	1.374***	5.894	0.000
LP_{t-1}	0.575***	5.483	0.000
LP	2.982***	5.664	0.002
IR_{t-1}	1.837**	2.011	0.046
IR	1.765**	2.199	0.029
INF_{t-1}	0.464***	5.764	0.000
INF	0.432***	4.389	0.000
Cons	3.272***	4.764	0.000

R square = 64.444 Stimulation = 5000

Finally, the DARDL approach was employed to examine the impact of LWR, WE, LP, IR, and INF on CPOPR. The results indicated a positive relationship between LWR, WE, LP, IR, INF, and CPO prices in Indonesia, supporting hypotheses H5, H6, H7, and H8. These relationships are presented in Table 7.

Table 7: Dynamic ARDL Model.

Variable	Coefficient	T-Statistic	Prob.
ECT	-1.092***	-4.382	0.000
LWR_{t-1}	2.108**	2.102	0.034
LWR	2.191***	4.392	0.000
WE_{t-1}	0.103***	5.493	0.000
WE	0.632***	5.782	0.000
LP_{t-1}	3.804***	5.319	0.000
LP	0.320**	2.019	0.043
IR_{t-1}	1.294***	5.472	0.000
IR	2.325**	2.009	0.048
INF_{t-1}	1.292***	5.654	0.000
INF	2.191***	5.575	0.000
Cons	2.187***	4.873	0.000

R square = 60.654 Stimulation = 5000

Discussions of the Results

The study explores the intricate relationship between various determinants and the production as well as pricing dynamics of CPO in Indonesia. Among these determinants, labour wage rates emerge as pivotal factors shaping the landscape of palm oil production. This holds significance as elucidated by Pickard et al. (2022), who underscore that higher wages incentivize the adoption of mechanization and cost-saving measures, such as investment in efficiency-enhancing technologies, leading to heightened productivity and output levels. However, the study reveals that escalating labour costs may exert pressure, prompting a commensurate increase in production costs, thereby diminishing profitability and favourability. Moreover, the study underscores the importance of labour-related interventions, such as education attainment and skill development among human assets, in bolstering overall productivity and fostering creativity (Agénor & Lim, 2018). Additionally, worker education levels emerge as a consistent driver for the efficient and sustainable production of CPO. The findings suggest that strategies addressing this issue could involve augmented expenditure on education and training, enabling workers to acquire requisite knowledge in areas such as the adoption of best practices and enhancing work productivity to mitigate the firm's environmental footprint through efficient resource utilization. Education initiatives for plantation workers yield positive outcomes in fostering the adoption of sustainable farming practices, thereby enhancing long-term productivity and resilience against external shocks (Siderius et al., 2021).

This paper highlights the critical role of production land availability and quality in influencing CPO production in Indonesia. Factors such as land tenure rights, environmental considerations, and alternative land uses shape land utilization for palm oil production (Varkkey et al., 2018). However, increasing land complexity, including issues of scarcity and degradation, poses significant limitations to achieving sustainable growth in the palm oil industry (Syahza, 2019). Addressing these challenges necessitates the formulation and implementation of sustainable land management policies. Consequently, the study emphasizes the importance of capital investment in research and development to enhance sustainable land productivity for the sector's progressive future.

Furthermore, the interest rate plays a crucial role in managing investment risk and resource allocation in the palm oil industry. A decrease in interest rates incentivizes investment in plantation expansion, thereby increasing production capacity and supply. Conversely, higher interest rates may dampen investment interest and hinder industry growth (Batlle et al., 2021). Notably, interest rates impact macroeconomic factors such as inflationary pressure and exchange rate fluctuations, illustrating the interconnectedness within the economy (Tey et al., 2020). Moreover, inflation rates are identified as influential factors affecting CPO producer prices and production in Indonesia. International inflation can diminish consumer purchasing power or escalate production costs, thereby impacting the international market (Syahza, 2019). These factors underscore the intricate interdependency within the palm oil industry and its broader economic context. Inflation can escalate production costs by increasing expenses like labour, fertilizers, and energy, thereby threatening profits for palm oil producers (Chandrarin et al., 2022). To mitigate deflationary risks and their adverse impact on CPO production, implementing a comprehensive inflation stabilization policy comprising monetary, fiscal, and supply-side measures is essential to stabilize prices and promote sustainable growth in the palm oil industry.

Implications of the Study

The study offers significant implications for policymakers, industry players, and investors. Firstly, it provides policymakers with valuable insights into the factors driving CPO production and pricing dynamics, enabling them to formulate tailored policies that support sectoral development, enhance productivity, and promote sustainability. Policymakers and industry stakeholders, including palm oil producers and investors, can leverage the findings as a strategic resource to inform their decision-making processes and future investments. Furthermore, by uncovering the multifaceted impacts of factors such as labour wage rates, worker education, production land, interest rates, and inflation on the palm oil industry, the research underscores the complexity of the industry's challenges, necessitating

comprehensive and coordinated solutions.

Limitations and Future Directions

However, like any scholarly work, this study has its limitations, particularly in addressing the research questions regarding the determinants of CPO production and prices in the Indonesian economy. Firstly, the study's reliance on data availability and quality may constrain its breadth and depth, as data sources may not always be comprehensive or reliable. Additionally, external factors such as geopolitical events, weather conditions, and market dynamics could influence the study's findings, potentially impacting its generalizability. Moreover, the study's focus on Indonesia may limit the direct applicability of its findings to other palm oil-producing nations. Finally, the study's objective nature may overlook certain quantitative nuances and contextual factors that influence CPO production rates and prices.

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