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Reference Prices, Export Duties, and Export Levies: An ARDL Analysis of Crude Palm Oil Production in Indonesia from 2020 to 2024

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ABSTRACT

Indonesia's palm oil sector is shaped by export duty and export levy schedules that are administratively tied to the crude palm oil reference price, yet their joint association with national output remained unclear. This study examined the conditional level relationship among national crude palm oil production, the reference price, export duty, and export levy, the short-run adjustment of production, and the sensitivity of individual estimates to model specification. Monthly data from January 2020 to December 2024 (60 observations; 56 after lag initialization) were analyzed using an autoregressive distributed lag model with lag structure (3,0,0,0), selected by the Bayesian information criterion with seasonal controls. Finite-sample bounds tests indicated a level relationship within the system, and the adjustment coefficient was negative and significant (−1.1996; $p < 0.001$). However, robust inference showed no significant individual coefficients for the reference price, export duty, or export levy, and the two fiscal instruments were jointly insignificant ($p = 0.417$). The reference price and export duty were highly correlated ($r = 0.939$), and every regressor became significant when estimated alone. The evidence supports a system-level conditional association rather than separately identified causal effects. Policymakers should not treat either instrument as a stand-alone production lever.

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INTRODUCTION

Indonesia's palm oil sector supplies food, oleochemical, and biodiesel markets while generating export revenue and rural employment. Its production process is nevertheless biologically and operationally inertial. Oil palm is a perennial crop, and monthly CPO output reflects fresh fruit bunch availability, harvest timing, oil extraction rates, mill utilization, and management decisions made in earlier periods. Changes in prices, export duty, or export levy therefore need not produce an immediate change in physical output (Monzon et al., 2023; Murphy et al., 2021).

Indonesia applies two distinct fiscal instruments to palm oil exports: export duty (ED) and export levy (EL). Export duty affects export incentives and government revenue, while export levy finances sectoral programs, including biodiesel support and oil palm replanting. Both schedules are administratively linked to the official CPO reference price. Consequently, the reference price, export duty, and export levy do not represent fully independent policy shocks. Their mechanical linkage can generate multicollinearity and make separate coefficients unstable even when the variables jointly form part of a long-run system (Nurfatriani et al., 2019; Sahara et al., 2022; Silalahi et al., 2020).

The sample period sharpens this identification problem. Between 2020 and 2024 the sector experienced the COVID-19 pandemic, the 2021–2022 commodity-price surge, the temporary export ban that began on 28 April 2022, domestic market and price measures, changes in the biodiesel mandate, and revisions to fiscal schedules (Cabinet Secretariat of the Republic of Indonesia, 2022). Because these events overlapped, changes in production cannot be cleanly assigned to a single intervention, and the question is better framed as one about conditional association within a system than about isolated policy shocks. This setting is demanding but informative: large movements in the reference price and in the duty and levy schedules create the variation needed to study the system, while the short monthly sample and the policy overlaps warn against strong causal readings.

The plausible transmission mechanism is indirect. The reference price determines applicable fiscal charges, while the charges can affect domestic CPO and fresh fruit bunch prices. These prices influence producer income, input use, field maintenance, investment, and replanting. Production may respond only after those decisions and biological processes have operated for several periods. Evidence on Indonesian oil palm shows that nutrient management, harvest practices, financing constraints, and replanting participation are central to attainable output (Petri et al., 2024; Sibhatu et al., 2022; Siregar et al., 2024). The present model does not observe these intermediate channels directly.

The related literature targets different margins of the palm oil system. Rifin et al. (2020) examine a restriction on exports to the European Union, whereas Gultom et al. (2023) examine domestic CPO price formation. Sahara et al. (2022) use a computable general equilibrium simulation to assess biodiesel policy, and Mayandi and Suharjito (2024) model food, energy, and export allocation trade-offs. These designs do not estimate observed monthly national CPO production within the complete reference-price, duty, and levy system. This study makes a moderate, data-oriented contribution by combining a consistent production series, day-weighted policy coding, parsimonious seasonality controls, finite-sample bounds values, alternative inference estimators, collinearity diagnostics, and transparent sensitivity checks. It does not claim a new causal identification strategy or a new theory of production response.

The reasons for addressing this gap are practical as well as analytical. Export levy proceeds finance biodiesel support and replanting, and export duty generates government revenue, so evidence on whether national output moves with the fiscal system inform how these instruments are designed and monitored. At the same time, short and policy-intensive samples are prone to overstated precision: when regressors are administratively linked, individual coefficients can appear significant or insignificant depending on which variables are included. Documenting this sensitivity openly helps readers judge how far monthly national data can support policy inference, and it provides a transparent baseline for later work that uses richer data or sharper identification. The study therefore addresses a specific and bounded question: what the monthly national record can and cannot reveal about the fiscal system and physical output.

The research question is whether national CPO production, the CPO reference price, export duty, and export levy display evidence of a conditional level relationship, how national CPO production adjusts in the short run, and whether the individual estimates are sensitive to alternative model specifications. Accordingly, this study aims to examine the conditional level relationship among national CPO production, the CPO reference price, export duty, and export levy; to characterize the short-run adjustment dynamics of national CPO production; and to assess the sensitivity of the individual estimates across alternative model specifications. Because the data are observational and policy rates respond to prices and market conditions, all coefficients are interpreted as conditional associations rather than structural causal effects.

RESEARCH METHODS

Research Design and Scope

This explanatory, quantitative time-series study uses Indonesia as the unit of analysis and monthly secondary data from January 2020 through December 2024. The raw dataset contains 60 consecutive months, and the selected model uses 56 observations, from May 2020 through December 2024, after lag initialization. Data processing and estimation used Stata 18.

Data and Operational Variables

National CPO production is aggregate CPO output in metric tons per month, not plantation productivity in tons per hectare. The series was transcribed from the monthly production tables in the annual oil palm publications of BPS-Statistics Indonesia, which combine the Estate Crop Company Survey with smallholder data from the Directorate General of Estate Crops. Publication revisions were checked before the annual series were concatenated, and no monthly observation was missing (BPS-Statistics Indonesia, 2021, 2022, 2023, 2024, 2025). Table 1 defines the variables, and Table 2 documents the official statistical and regulatory sources, coverage, and access dates.

Table 1 Operational Definitions and Transformations

Variable	Definition and transformations	Unit	Role
lnNCP	Natural log of national CPO output	Metric tons per month	Dependent variable
lnCP	Natural log of the official CPO reference price	USD per metric ton	Price regressor
ED	Applicable export duty for CPO; day-weighted within month when needed	USD per metric ton	Fiscal regressor
EL	Applicable export levy for CPO; day-weighted within month when needed	USD per metric ton	Fiscal regressor
season_sin	sin(2πm/12), where m is the monthly time index	Index	Seasonal control
season_cos	cos(2πm/12), where m is the monthly time index	Index	Seasonal control

Source: Authors' compilation.

Table 2 Official Sources, Regulatory Coverage, and Access Points

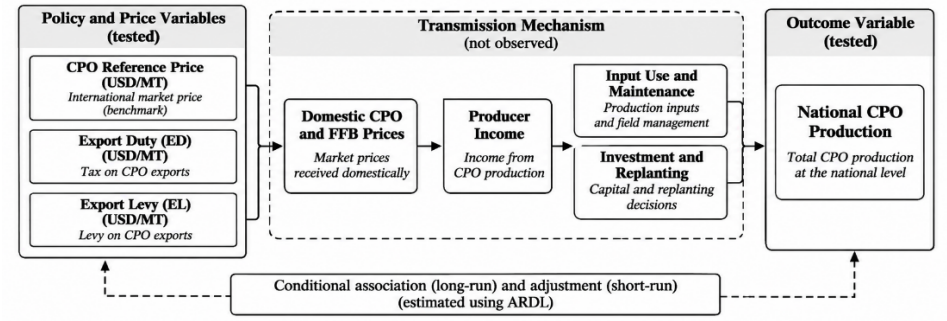
Series	Official source and coverage	Access point	Access date
National CPO production	BPS, Statistics of Indonesian Oil Palm 2020-2023 (publication nos. 05100.2111, 05100.2209, 05100.2312, and 05100.24024); Statistics of Annual Estate Crops of Indonesia 2024 (05100.25014)	https://www.bps.go.id/id/publication	7 Aug 2026
CPO reference price	Monthly or submonthly Decrees of the Minister of Trade on the CPO reference price, 2020-2024	https://jdih.kemendag.go.id/peraturan	7 Aug 2026
Export duty	PMK 13/2017 as amended by PMK 164/2018, PMK 166/2020, and PMK 1/2022; PMK 39/2022 as amended by PMK 98/2022, PMK 123/2022, and PMK 71/2023; PMK 38/2024	https://jdih.kemenkeu.go.id	7 Aug 2026
Export levy	PMK 57/2020 as amended by PMK 191/2020, PMK 76/2021, and PMK 23/2022; PMK 103/2022 as amended by PMK 115/2022, PMK 130/2022, and PMK 154/2022; PMK 62/2024	https://jdih.kemenkeu.go.id	7 Aug 2026

Note: PMK = *Peraturan Menteri Keuangan* (Minister of Finance Regulation). Source: BPS-Statistics Indonesia (2021, 2022, 2023, 2024, 2025); Ministry of Trade and Ministry of Finance regulations.

Fiscal rates were coded from the applicable regulations, and each month was matched to its reference-price bracket and regulatory effective date. For month m with D_m calendar days, the day-weighted rate is $T_m = \Sigma_r(T_r \times d_{rm})/D_m$, where T_r is rate r and d_{rm} is the number of days that rate applied in month m. For example, USD 55/MT for 10 days and USD 65/MT for 20 days in a 30-day month gives USD 61.67/MT; this is a coding illustration, not an observed value.

Conceptual Framework

Picture 1 separates the variables estimated in the model from channels that are not observed. The model estimates associations among the reference price, export duty, export levy, and national CPO production only. Domestic CPO and fresh fruit bunch (FFB) prices, producer income, input use, maintenance, investment, and replanting are not estimated, so their discussion draws on earlier research.



Picture 1 Conceptual Transmission from the CPO Reference Price and Export Fiscal Instruments to National CPO Production

Empirical Specification

Let y(t) = lnNCP(t), p(t) = lnCP(t), d(t) = ED(t), and l(t) = EL(t). After searching a maximum of four lags, the Bayesian information criterion (BIC) selected ARDL (3,0,0,0), written as the following unrestricted error-correction representation:

$$\Delta y_t = \alpha + \lambda y_{t-1} + \beta_1 p_t + \beta_2 d_t + \beta_3 l_t + \psi_1 \Delta y_{t-1} + \psi_2 \Delta y_{t-2} + \gamma_1 \sin(2\pi m/12) + \gamma_2 \cos(2\pi m/12) + u_t \quad (1)$$

The short-run component reflects adjustment dynamics in national CPO production through the lagged changes in lnNCP. Because no differenced terms for lnCP, ED, or EL were retained, the model provides no distributed short-run coefficients for these predictors. Long-run coefficients are $\theta_j = -\beta_j/\lambda$, with delta-method robust standard errors. Because production and price are logged, θ_1 is the long-run price elasticity, whereas for ED and EL (USD/MT), $100 \times \theta_j$ approximates the percentage change in production per USD 1/MT. These are conditional associations, not causal policy effects. A value of λ between -2 and -1 indicates convergence with alternating adjustment.

Estimation, Diagnostics, and Robustness

Stationarity was screened with Augmented Dickey-Fuller (ADF) tests (intercept, BIC lag selection up to four lags), Phillips-Perron (PP) tests (four Newey-West lags), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests (bandwidth four) at levels and first differences. Tests with different null hypotheses give a clearer screen for an I(2) series (Kwiatkowski et al., 1992; Phillips & Perron, 1988). The bounds test uses Case 3, an unrestricted intercept with no trend, with finite-sample critical values and approximate p-values from Kripfganz and Schneider (2020) (see also Pesaran et al., 2001). Huber-White and Newey-West inference (four-month bandwidth) was obtained from equivalent error-correction regressions, and long-run standard errors were computed with the delta method.

Diagnostics comprised Breusch-Godfrey, Breusch-Pagan, ARCH-LM, skewness-kurtosis, Ramsey RESET, and recursive CUSUM tests, together with correlations, variance inflation factors (VIFs), and Wald tests of ED = EL = 0. Robustness checks, summarized in Table 10, comprised a Supremum Wald unknown-break test with 20% trimming, a January 2022 level-shift control, ln(1 + x) transformations of the fiscal variables, alternative regressor sets, and removal of observations above the Cook's distance threshold of 4/N. The design uses no instruments or break-adjusted unit-root tests, so reverse causality and overlapping shocks remain identification limits.

RESULTS AND DISCUSSION

Descriptive Statistics

Descriptive statistics provide an initial overview of the distribution and variability of the variables during the study period. Table 3 summarizes their central tendencies and ranges across the 60 monthly observations.

Table 3 Descriptive Statistics, January 2020–December 2024

Variable	N	Mean	SD	Minimum	Maximum
National CPO production (tons/month)	60	3,870,038	458,548.60	2,803,456	4,855,506
CPO reference price (USD/MT)	60	957.0772	275.9873	568.94	1,787.50
Export duty (USD/MT)	60	67.2167	74.8665	0	200
Export levy (USD/MT)	60	115.3748	80.8156	0	375

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

Average national CPO output was 3.87 million tons per month. The large ranges in the reference-price, duty, and levy series reflect the exceptional market conditions and policy changes during the sample period. These descriptive patterns do not show an independent policy effect because duty and levy rates are linked to the same reference-price schedule.

Integration Order

Table 4 Augmented Dickey-Fuller Unit-Root Results

Series	ADF Level	Prob. Level	ADF Δ	Prob. Δ	Order used
lnNCP	-3.455	0.0092	-7.356	<0.001	I(0)
ED	-1.768	0.3967	-7.185	<0.001	I(1)
EL	-1.434	0.5660	-6.88	<0.001	I(1)
lnCP	-2.479	0.1208	-7.567	<0.001	I(1)

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

The ADF results indicate that lnNCP is stationary at level, with a p-value of 0.0092, and is therefore classified as I(0). In contrast, lnCP, ED, and EL are nonstationary at level but become stationary after first differencing, indicating I(1) processes. These preliminary classifications are consistent with the integration-order requirements of the ARDL bounds-testing framework, which accommodates a combination of I(0) and I(1) variables but excludes I(2) variables.

To further assess the integration properties of the variables, the ADF analysis is complemented by Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Table 5 reports these results, allowing the stationarity classifications to be evaluated using tests with different null hypotheses.

Table 5 Complementary Phillips-Perron and KPSS Results

Series	PP level p-value	PP Δ p-value	KPSS level lag 4	KPSS Δ lag 4	Indicative order
lnNCP	0.0314	<0.001	0.0359	0.0298	I(0)
lnCP	0.6358	<0.001	0.2060	0.0894	I(1)
ED	0.4517	<0.001	0.1840	0.1380	I(1)
EL	0.0872	<0.001	0.1500	0.0478	I(1)

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

The PP and KPSS results support the ADF classification used for the ARDL screen. Production is stationary in levels, while the reference price, export duty, and export levy are treated as stationary after first differencing. KPSS results at level are consistent with that interpretation for the latter three variables, and every first-difference statistic is below the 5% KPSS critical value at bandwidth four. No result points to an I(2) series. The mix of I(0) and I(1) variables is compatible with ARDL bounds testing (Pesaran et al., 2001). It does not remove the possibility of structural breaks during 2020-2024.

Model Selection and Bounds Test

BIC selected ARDL (3,0,0,0) with two seasonal harmonic terms. The effective sample runs from May 2020 to December 2024 (N = 56). The model has an R-squared of 0.5674, an adjusted R-squared of 0.4938, and a root mean squared error of 0.0738. BIC did not retain differenced terms for lnCP, ED, or EL. Accordingly, the selected model does not provide distributed short-run coefficients for the three predictors. Its short-run component instead primarily reflects adjustment dynamics in national CPO production through the lagged changes in lnNCP, with the seasonal harmonic terms included as controls.

Table 6 Finite-Sample Bounds Test for a Level Relationship

Statistic	Value	1% I(0)	1% I(1)	Approx. p-value	Decisions
F	9.075	4.731	6.261	0.001 (I(1))	Reject no-level relationship
t	-5.622	-3.535	-4.518	0.001 (I(1))	Reject no-level relationship

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

Both test statistics exceed the absolute upper-bound critical value at the 1% level. Within this sample and specification, the result supports a level relationship in the estimated system. It does not establish a stable individual long-run association for every regressor or identify causal effects.

Long-Run Coefficients and Production Adjustment Dynamics

Following the bounds test, the analysis examines the estimated long-run associations and production adjustment dynamics within the selected ARDL specification. Table 7 reports the corresponding coefficients, robust standard errors, significance levels, and confidence intervals.

Table 7 Long-Run Coefficients and Production Adjustment Dynamics

Term	Coefficient	Robust SE	z/t	p-value	95% confidence interval
Panel A. Long-run coefficients					
lnCP	0.0291	0.0828	0.35	0.726	[-0.1332, 0.1913]
ED	-0.00047	0.000335	-1.39	0.166	[-0.001122, 0.000192]
EL	0.000048	0.000157	0.31	0.759	[-0.000259, 0.000355]
Panel B. Production Adjustment Dynamics					
Adjustment coefficient	-1.1996	0.2952	-4.06	<0.001	[-1.7934, -0.6057]
ΔlnNCP(t−1)	0.4993	0.1600	3.12	0.003	[0.1774, 0.8212]
ΔlnNCP(t−2)	0.3956	0.1617	2.45	0.018	[0.0704, 0.7209]
Season_sin	-0.0924	0.0251	-3.69	0.001	[-0.1428, -0.0420]
Season_cos	0.0560	0.0231	2.43	0.019	[0.0096, 0.1024]

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

None of the individual long-run coefficients for the reference price, export duty, or export levy is statistically significant. The estimated price elasticity is small and imprecise. For scale only, the ED point estimate corresponds to approximately -0.0465% for a USD 1/MT increase, but its confidence interval includes zero. This estimate is not evidence of a verified policy effect.

With a value of -1.1996, the adjustment coefficient indicates stable but alternating convergence. It should not be read as a literal 119.96% monthly correction. The positive production lags show persistence, and the significant seasonal terms show that seasonality belongs in the model.

BIC did not retain differenced terms for lnCP, ED, or EL. Therefore, the selected model does not provide distributed short-run coefficients for any of the three predictors. The short-run component should instead be interpreted primarily as adjustment dynamics in national CPO production, as reflected in the lagged changes of lnNCP. A supplementary robust Wald test of the contemporaneous lnCP term gives $F(1,47) = 0.13$ ($p = 0.7219$). This test is reported to address the requested price restriction and is not interpreted as a cumulative short-run price effect.

Collinearity and Joint Policy Test

The administrative linkage between the CPO reference price and export fiscal rates raises concerns about potential multicollinearity among the regressors. Table 8 presents pairwise correlations and variance inflation factors (VIFs) to assess these relationships. The analysis also examines the joint statistical significance of export duty and export levy through Wald tests.

Table 8 Correlations and Variance Inflation Factors for Policy Regressors

Measure	lnCP	ED	EL
Correlation with lnCP	1.0000	0.9393***	0.7685***
Correlation with ED	0.9393***	1.0000	0.7449***
Correlation with EL	0.7685***	0.7449***	1.0000
VIF in full model	9.91	8.7	3.25

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

The correlation between lnCP and ED is 0.9393, and their VIFs approach the common threshold of 10. This is substantively important because the reference price administratively selects the applicable export-duty and export-levy brackets. The resulting co-movement limits the stability and economic separability of the individual coefficients. The Huber-White Wald test of ED = EL = 0 gives $F(2,47) =$

0.89 and p = 0.4174, while the Newey-West test gives F(2,47) = 1.03 and p = 0.3660. The fiscal coefficients are therefore jointly insignificant under both inference estimators. A mechanically summed ED-EL index was not constructed because the two instruments have distinct legal schedules and share a common administrative link to the reference price; aggregation would obscure rather than resolve the identification problem.

Diagnostic Test Results

The adequacy of the selected ARDL model is evaluated through diagnostic tests covering residual behavior, functional form, and parameter stability. Table 9 presents the test statistics and their corresponding assessments to identify potential specification and inference limitations.

Table 9 Diagnostic Tests for the Selected Model

Test	Statistic	p-value / critical value	Assessment
Breusch-Godfrey LM, lag 1	chi-square = 1.599	p = 0.2060	No residual autocorrelation
Breusch-Godfrey LM, lag 2	chi-square = 3.681	p = 0.1587	No residual autocorrelation
Breusch-Godfrey LM, lag 3	chi-square = 3.690	p = 0.2970	No residual autocorrelation
Breusch-Godfrey LM, lag 4	chi-square = 4.046	p = 0.3998	No residual autocorrelation
Breusch-Pagan	chi-square = 20.59	p < 0.001	Heteroskedasticity detected
ARCH-LM, lag 1	chi-square = 10.581	p = 0.0011	ARCH effect detected
ARCH-LM, lag 2	chi-square = 13.990	p = 0.0009	ARCH effect detected
ARCH-LM, lag 3	chi-square = 13.982	p = 0.0029	ARCH effect detected
Skewness-kurtosis normality	combined test	p = 0.1672	No rejection of normality
Ramsey RESET	F(3,44) = 8.93	p = 0.0001	Possible misspecification
Recursive CUSUM	0.4165	5% critical value = 0.9479	No rejection of parameter stability

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

The skewness-kurtosis test does not reject residual normality. The Breusch-Pagan and ARCH-LM tests show nonconstant variance, while the Breusch-Godfrey tests do not detect residual autocorrelation. Huber-White and Newey-West standard errors address inference under nonconstant variance, but neither corrects functional-form error, omitted variables, endogeneity, or structural change. RESET strongly rejects the baseline specification (p = 0.0001) and remains significant after the January 2022 shift and log-policy transformations. It is therefore a primary limitation. The unknown-break test selects January 2022 as the candidate date, but the Supremum Wald statistic of 19.735 does not reject parameter stability (p = 0.2023). Recursive CUSUM likewise stays within its 95% confidence bands. These tests do not rule out local or multiple breaks in a sample containing overlapping shocks.

Robustness and Sensitivity Analysis

Because the sample is short, adding indicators for every pandemic, domestic-market, biodiesel, and fiscal-regime event would exhaust degrees of freedom and would not resolve reverse causality. The checks below therefore focus on one candidate break, alternative functional forms and regressor sets, and influential observations.

The robustness analysis examines whether the baseline findings remain consistent under alternative model specifications and sample adjustments. Table 10 summarizes the resulting estimates and statistical evidence, highlighting the sensitivity of the findings to different modeling choices.

Table 10 Sensitivity and Robustness Specifications

Specification	Long-run estimates (p-value)	Bounds or inference evidence	Reading
Full baseline ARDL(3,0,0,0)	lnCP = 0.0291 (.726); ED = −0.000465 (.166); EL = 0.000048 (.759); ECT = −1.1996 (< .001)	F 9.075; t -5.622; joint ED-EL p .417	System-level relation; no strong partial evidence
January 2022 shift fixed ARDL(3,0,0,0)	lnCP 0.0538 (.670); ED -0.000517 (.172); EL approximately 0 (1.000); shift p .725	8.924 F; t -5.557	Bounds decision and partial inference unchanged
January 2022 shift BIC-reselected ARDL(3,3,2,0)	lnCP 0.2222 (.124); ED -0.000935 (.037); EL -0.000114 (.597); shift p .303	F 11.814; t -6.195	ED significance depends on lag specification

Specification	Long-run estimates (p-value)	Bounds or inference evidence	Reading
Log-policy form ARDL(3,0,0,1)	lnCP 0.0115 (.826); ln(1+ED) -0.0122 (.098); ln(1+EL) -0.0160 (.026)	F 12.397; t -6.580; RESET p < .001	Functional form changes partial results but not RESET
Price only ARDL(3,0)	lnCP -0.0884 (.012); ECT -1.2047 (<.001)	F 17.096; t -5.665	Significant only after removing fiscal regressors
Duty only ARDL(3,0)	ED -0.000339 (.003); ECT -1.2239 (<.001)	F 18.735; t -6.058	Confirms strong specification sensitivity
Levy only ARDL(3,1)	EL -0.000302 (.024); ECT -1.1364 (<.001)	F 16.955; t -5.728	Significant only in the single-regressor model
Fiscal only ARDL(3,0,0)	ED -0.000382 (.026); EL 0.000061 (.732)	F 12.307; t -5.883	ED is significant when reference price is excluded
Price and levy ARDL(3,0,0)	lnCP -0.0906 (.087); EL 0.000011 (.954)	F 11.167; t -5.580	Price is marginal only when duty is excluded
Baseline with Newey-West SE lag 4	lnCP 0.0291 (.739); ED -0.000465 (.126); EL 0.000048 (.739)	Joint ED-EL p .366	Inference conclusion matches Huber-White
Without seven influential observations fixed ARDL(3,0,0,0) N = 49; sample with gaps	lnCP 0.0170 (.868); ED -0.000408 (.267); EL 0.000035 (.858); ECT -0.8686 (<.001)	F 6.323; t -4.670; joint p .534	Reject at 5%; inconclusive at 1%; partial results unchanged

Source: Authors' estimation using Stata 18, based on BPS-Statistics Indonesia, Ministry of Trade, and Ministry of Finance data.

Three findings are comparatively robust. First, every reported specification retains evidence of a system-level relationship at 5%. Second, the full model provides no strong individual evidence for any of the three regressors and no joint evidence for export duty and export levy under either Huber-White or Newey-West inference. Third, individual significance is unstable. Price, duty, and levy each become significant when entered alone; ED also becomes significant in the fiscal-only and BIC-reselected shift models, while the log-policy form changes the levy result. These changes cannot identify independent effects because variable inclusion, functional form, and lag selection alter the estimates. The seven influential observations are December 2021, January-March 2022, December 2022, January 2023, and March 2023. Removing them leaves all partial and joint fiscal tests insignificant, but reduces the bounds F statistic to 6.323 and makes the 1% decision inconclusive. They remain in the baseline because they reflect observed conditions, not confirmed data errors.

Interpretation and Policy Relevance

The results support three related conclusions. First, the baseline bounds test indicates a level relationship within the estimated system. Second, the full model provides no strong partial evidence for the CPO reference price, export duty, or export levy. Third, the individual estimates are sensitive to alternative specifications. These findings can coexist because the bounds test evaluates whether the variables jointly form a level relationship, whereas the individual coefficients attempt to distinguish the partial association of each regressor while holding the others constant. This distinction is particularly important because the CPO reference price and export duty are closely correlated and administratively linked. Their strong co-movement leaves limited independent variation for estimating separate coefficients, making individual estimates imprecise and sensitive even when the variables jointly exhibit a level relationship. Functional form, lag selection, influential observations, and unmodelled shocks further affect how the shared variation is allocated across the regressors.

The results should be compared with earlier studies by looking first at the outcome each study measures. Gultom et al. (2023) model domestic CPO prices using international prices, exports, fresh fruit bunch prices, and biodiesel production. Their study concerns price transmission, whereas this study concerns physical national output. A policy can affect domestic prices or export allocation without producing a clearly identifiable change in harvested and processed output within the same monthly framework. Andriyanty and Hutagaol (2024) discuss export duty in relation to exports and environmental sustainability rather than estimate monthly physical production. The present results therefore neither confirm nor contradict those studies; they address a different outcome and time horizon.

Other studies also point to channels that operate beyond monthly output. Rifin et al. (2020) model an export restriction through trade and sectoral outcomes. Sahara et al. (2022) use a computable general equilibrium model to assess the macroeconomic, sectoral, and regional effects of biodiesel and trade-ban scenarios. Hidayatno et al. (2025) and Mayandi and Suharjito (2024) use system-dynamics

models to examine the allocation of palm oil between food, energy, and exports. These studies suggest that fiscal policy may operate through allocation, prices, and downstream demand, channels that differ from the monthly physical-output relationship examined here. Research on replanting instead highlights finance, information, program design, and farmer participation as important constraints (Hendrawan & Musshoff, 2024; Nurfatriani et al., 2019; Petri et al., 2024). Any output effect through replanting is likely to emerge more slowly than within one monthly period.

The persistence of production growth and the significant seasonal terms fit the biological and operational features of oil palm. Fruit availability, harvesting, and mill operations carry over from one month to the next. The model does not test whether export fiscal policy changes domestic CPO prices, fresh fruit bunch prices, producer liquidity, fertilizer use, investment, or replanting. Earlier studies support the plausibility of these mechanisms, although the present model does not observe these intermediate channels directly (Monzon et al., 2023; Sibhatu et al., 2022).

Several explanations are possible for the lack of strong partial estimates: weak month-to-month transmission, a longer response horizon, multicollinearity, statutory rates that differ from effective burdens, reverse causality, overlapping interventions, and omitted agronomic or market conditions. The significant RESET result makes the omitted-variable explanation especially relevant. The findings do not show that export duty or export levy is economically irrelevant. They show that this short design cannot estimate their individual production relationships with enough precision.

The direct policy message is limited. This study does not provide enough evidence to treat export duty or export levy as a separately identified lever for changing national CPO production from month to month. The evidence is therefore insufficient to support a directional recommendation to raise, lower, retain, or remove either rate. Policy objectives should instead be matched to their likely timing. Export allocation, domestic-price transmission, and biodiesel absorption may adjust faster than mature area, replanting, and physical output.

Because the reference price administratively determines export-duty and export-levy brackets, the reference price, export duty, and export levy should not be interpreted as independent policy shocks in this design. This is an identification caution, not empirical evidence that treating them as one policy package improves policy outcomes. Monitoring may still follow the institutional sequence from the reference price and the applicable duty and levy brackets to domestic prices, producer margins, input use, biodiesel or replanting disbursement, and output. The sequence is drawn from the literature and was not causally estimated here.

CONCLUSION

For the 2020–2024 sample, the bounds test detects a level relationship within the system of national CPO production, the reference price, export duty, and export levy, which answers the first objective. Production adjusts through a negative and significant adjustment coefficient with alternating convergence, persistent lagged changes, and significant seasonality, which answers the second objective. The individual coefficients, however, are insignificant under Huber-White and Newey-West inference, the two fiscal instruments are jointly insignificant, and significance appears only in reduced or transformed models, which answers the third objective: the estimates are highly specification-sensitive. Collinearity, policy endogeneity, overlapping shocks, aggregate data, omitted agronomic variables, and a persistent specification-test rejection prevent causal attribution.

Future research should use longer series and add domestic CPO and fresh fruit bunch prices, mature area, rainfall, fertilizer prices, exchange rates, biodiesel demand, exports, and realized replanting expenditure, with pre-specified break procedures, designs centered on clear regulatory changes, and regional panel data. For stakeholders, the evidence does not support raising, lowering, or removing either instrument to change monthly production. The reference price, export duty, and export levy should not be read as independent shocks, month-by-month rate coding files should be made public, and monitoring can follow the sequence from fiscal brackets to domestic prices, producer margins, and output.

DECLARATION OF AI USE

Generative AI was used in a limited capacity. Claude (Anthropic) assisted with reformatting the manuscript to the journal template, checking it against the journal's author guidelines, and condensing and restructuring text to meet the journal's word limits. Generative AI was also used for

language editing and readability improvement in earlier drafts. It was not used to generate research data, statistical results, or references; all estimation was conducted in Stata 19. The author reviewed and verified all AI-assisted content and retains full responsibility for the content, analyses, interpretations, and conclusions of this study.

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