

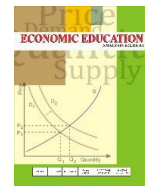


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The Effect Of Palm Oil Exports, Machinery Imports, And Foreign Debt On Foreign Exchange Reserves In Indonesia 2005–2024

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Abstract

This study examines the influence of crude palm oil (CPO) exports, machinery imports, and external debt on Indonesia's foreign exchange reserves during the 2005–2024 period amid fluctuating global economic conditions. Using a quantitative explanatory approach, this research analyzes the short-run and long-run relationships between external sector variables and foreign exchange reserve stability in Indonesia. Secondary time-series data were obtained from Bank Indonesia and the Central Statistics Agency, then analyzed using the Error Correction Model (ECM). The findings reveal that CPO exports have a negative but insignificant effect on foreign exchange reserves in both the short and long run, indicating that export earnings are not fully accumulated as reserve assets. Machinery imports show a positive but insignificant effect in the short run, while exerting a positive and significant effect in the long run through increased industrial productivity and export capacity. External debt positively and significantly affects foreign exchange reserves in both periods through foreign capital inflows. Simultaneously, all variables significantly influence Indonesia's foreign exchange reserves. This study contributes empirically by integrating trade and external financing variables within a long-run ECM framework in a developing economy context.

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INTRODUCTION

Indonesia's foreign exchange reserves constitute a critical component of external sector stability because they function not only as instruments for financing international transactions, but also as buffers against external shocks, capital reversals, and exchange rate volatility. In emerging economies such as Indonesia, reserve adequacy has become increasingly important under conditions of global financial uncertainty characterized by commodity price fluctuations, tightening international liquidity, and unstable capital movements. Although international standards generally consider reserves adequate when they are capable of covering at least three months of imports, reserve sustainability cannot be evaluated solely from the nominal size of reserve holdings. A substantial proportion of reserve accumulation in developing economies is frequently associated with external financing sources, including foreign debt and short-term capital inflows, which are highly sensitive to global market sentiment and external monetary shocks. Consequently, strong reserve positions may coexist with underlying external vulnerabilities, particularly when reserve accumulation depends excessively on volatile financial inflows rather than sustainable trade performance and productive external sector activities. Within this context, understanding the determinants of Indonesia's foreign exchange reserves becomes increasingly important for evaluating long-term macroeconomic resilience and external sector sustainability (World Bank, 2022; Dieppe et al., 2020; Witoelar & Utomo, 2022).

The period 2005–2024 represents a strategically important phase for evaluating Indonesia's reserve sustainability because it encompasses several major global and domestic

economic disruptions that significantly affected external sector dynamics. During this period, Indonesia experienced the commodity boom of the mid-2000s, the 2008 global financial crisis, the 2013 taper tantrum, the COVID-19 pandemic, and the subsequent post-pandemic commodity recovery. These events generated substantial fluctuations in capital flows, export performance, exchange rate stability, and external financing conditions. Indonesia's foreign exchange reserves increased considerably during commodity expansion periods and episodes of strong capital inflows, yet reserve pressures intensified during periods of global financial tightening and external shocks. For instance, the taper tantrum in 2013 triggered significant capital outflows from emerging markets, causing Indonesia's reserves to decline sharply from 112.78 billion USD in 2012 to 99.38 billion USD in 2013. Such fluctuations indicate that reserve accumulation in Indonesia is shaped not only by trade performance, but also by broader interactions between commodity dependence, external financing, and global financial conditions. Therefore, examining reserve dynamics within this period provides important insights into the sustainability and structural resilience of Indonesia's external sector (Suryahadi et al., 2021; World Bank, 2022).

From the perspective of international macroeconomics, foreign exchange reserves are closely associated with balance of payments performance, particularly through trade surpluses generated by export activities. Mercantilist theory argues that export expansion strengthens national wealth through the accumulation of external reserves, while modern balance of payments theory emphasizes that export revenues constitute a major source of foreign exchange inflows within the current account structure. In the Indonesian

context, crude palm oil (CPO) exports represent a strategically important commodity because Indonesia is the world's largest palm oil exporter and heavily depends on commodity-based exports as a source of foreign exchange earnings. Unlike aggregate export indicators commonly used in previous studies, CPO exports possess distinctive structural characteristics due to their high exposure to global commodity price volatility, environmental sustainability campaigns, and international trade restrictions. Consequently, the contribution of palm oil exports to reserve accumulation may not always be stable or proportional. This condition reflects broader debates concerning commodity dependence in developing economies, where export expansion may simultaneously increase foreign exchange earnings while also intensifying external vulnerability due to excessive reliance on primary commodities and global market fluctuations (Pratomo & Rosdiana, 2018; Trade Map, 2022; Borin & Mancini, 2019; World Bank, 2022).

Although export growth theoretically contributes positively to reserve accumulation, empirical evidence in developing economies frequently demonstrates nonlinear and asymmetric relationships between commodity exports and foreign exchange reserves. In Indonesia, substantial increases in palm oil exports during 2005–2024 were not consistently followed by proportional reserve accumulation. This condition indicates that export-generated foreign exchange earnings are not automatically transformed into sustainable reserve assets. Several structural factors may explain this phenomenon, including export revenue leakages, external debt obligations, exchange rate stabilization policies, and the limited domestic downstream processing structure of Indonesia's palm oil industry.

Furthermore, sustainability campaigns and trade restrictions related to environmental concerns, particularly within the European market, have increased uncertainty surrounding Indonesia's palm oil export performance. As a result, the relationship between CPO exports and reserve accumulation cannot be interpreted solely through conventional trade surplus mechanisms, but must also consider institutional factors, commodity dependence risks, and external political pressures affecting developing economies (Borin & Mancini, 2019; World Bank, 2022).

Besides exports, imports also play an essential role in shaping foreign exchange reserves, especially imports of capital goods such as machinery. According to the Heckscher–Ohlin factor proportion theory, countries tend to import goods requiring production factors that are relatively scarce domestically. In Indonesia, machinery imports are closely related to industrialization processes and technological transformation aimed at increasing production efficiency and economic productivity (Sari & Ekaputri, 2024). The increasing adoption of automation, robotics, and industrial technology has intensified the demand for imported machinery, particularly in manufacturing and infrastructure sectors. The International Labour Organization (2019) explained that industrial automation and technological transformation significantly alter production structures and increase investment requirements for machinery and technology. Recent studies further emphasize that productivity upgrading and industrial competitiveness in developing economies increasingly depend on technological capability accumulation and integration into global production networks (Dieppe et al., 2020; Borin & Mancini, 2019; World Bank, 2022).

In the short term, machinery

imports tend to reduce foreign exchange reserves because import transactions require payments in foreign currency. Higher imports therefore increase foreign exchange outflows and create pressure on reserve positions. Payapo et al. (2024) argued that import activities directly increase foreign currency expenditures because imported goods must be settled using international currencies. Empirically, Indonesia's machinery imports reached their highest level in 2012 at approximately 65.64 billion USD, coinciding with substantial industrial expansion and investment growth. Nevertheless, the long-term impact of machinery imports may differ from the short-term effect. Productive capital goods imports may improve industrial efficiency, increase domestic output, and eventually strengthen export competitiveness, thereby contributing positively to foreign exchange reserves in the future (Sinaga et al., 2025). Therefore, the relationship between machinery imports and foreign exchange reserves is dynamic and highly dependent on the effectiveness of capital utilization within the domestic economy (Dieppe et al., 2020; World Bank, 2022).

Another important determinant of foreign exchange reserves is external debt. In the short term, foreign debt inflows contribute positively to reserves because borrowed funds enter the economy in the form of foreign capital inflows. However, in the long term, external debt may weaken reserve positions due to increasing debt servicing obligations, including interest and principal repayments. According to Pattillo et al. (2002), excessive debt accumulation may create a debt overhang condition that suppresses future economic performance and burdens external stability. Similarly, Krugman in 1988 emphasized that high external debt levels may reduce investor confidence and limit productive investment growth. In Indonesia, external debt increased

significantly from 134.5 billion USD in 2005 to 424.85 billion USD in 2024. Although debt inflows contributed to reserve accumulation in certain periods, debt repayments and external financing pressures also generated reserve instability during other periods. Previous empirical studies show inconsistent findings regarding the relationship between external debt and foreign exchange reserves. E. Ayunku & Markjackson (2020), Keinan & Muturi (2023) and Dong Sun (2024) found that foreign debt negatively affects reserves in the long run due to rising debt service obligations. Conversely, Andriyani et al. (2022) and Riana et al. (2023) concluded that external debt may positively strengthen reserves when allocated toward productive economic sectors. These contrasting findings suggest that the reserve impact of foreign borrowing depends heavily on debt quality, allocation efficiency, and the broader macroeconomic environment (World Bank, 2022; Suryahadi et al., 2021).

Previous studies examining the determinants of foreign exchange reserves have generally focused on aggregate export-import indicators and broad macroeconomic variables, thereby providing limited explanation regarding the role of strategically important sectors within external reserve dynamics. In addition, empirical findings concerning the effects of exports, imports, and external debt on reserve accumulation remain inconsistent across countries and periods. Some studies argue that export growth and external borrowing strengthen reserve positions, while others emphasize the risks of commodity dependence, debt vulnerability, and external fragility in developing economies. Furthermore, limited studies have simultaneously integrated trade variables and external financing variables within a dynamic long-run framework, particularly in the context

of Indonesia's commodity-based economy during periods of global uncertainty. This study therefore contributes to the literature by specifically examining crude palm oil exports and machinery imports as strategic external sector variables rather than relying solely on aggregate trade indicators. Moreover, the study applies the Error Correction Model (ECM) to capture both short-run disequilibrium adjustments and long-run equilibrium relationships among trade performance, external financing, and reserve accumulation in Indonesia during 2005–2024. This approach is expected to provide a more comprehensive understanding of how trade competitiveness, industrial transformation, and external financing jointly shape reserve sustainability in a commodity-dependent emerging economy.

METHOD

Research Design

This study employed a quantitative explanatory research design using annual time-series data to analyze the dynamic relationship between crude palm oil (CPO) exports, machinery imports, external debt, and Indonesia's foreign exchange reserves during the 2005–2024 period. The explanatory approach was selected because the study aims to investigate both the short-run adjustment mechanism and the long-run equilibrium relationship among external sector variables within Indonesia's macroeconomic structure. Quantitative time-series analysis is particularly relevant for examining macroeconomic fluctuations because it allows the identification of intertemporal relationships and dynamic adjustments among variables over time (Setiawan & Aditya, 2014)

The dependent variable in this study was Indonesia's foreign exchange reserves, measured in million USD. The independent variables consisted of crude

palm oil exports, machinery imports, and external debt. Crude palm oil exports were measured in thousand tons to capture the physical export performance of Indonesia's strategic commodity sector, while machinery imports and external debt were measured in million USD to reflect foreign exchange outflows related to capital goods acquisition and external financing activities. The selection of these variables was theoretically based on balance of payments dynamics, where export activities generate foreign exchange inflows, imports create foreign exchange outflows, and external debt contributes to capital account inflows that may influence reserve accumulation.

The observation period of 2005–2024 was selected because it captures several important structural events affecting Indonesia's external sector, including the 2008 global financial crisis, the 2013 taper tantrum, the COVID-19 pandemic, and the post-pandemic commodity recovery period. These events generated substantial fluctuations in trade performance, capital flows, and reserve positions, thereby providing a relevant macroeconomic context for analyzing reserve sustainability in Indonesia. In addition, the use of annual data was intended to maintain data consistency and comparability across official institutional sources, particularly because several variables related to palm oil exports and external debt were more consistently available on an annual basis. Nevertheless, the study acknowledges that the relatively limited number of observations may reduce the statistical power of estimation and therefore constitutes one limitation of the research.

This study applied the Error Correction Model (ECM) approach developed by Engle and Granger to estimate both short-run dynamics and long-run equilibrium relationships among the variables. The ECM approach was

selected because the study focuses on identifying how short-term disequilibrium adjustments converge toward long-run equilibrium within Indonesia's external sector structure. Compared to static regression models, ECM provides a more comprehensive framework for analyzing macroeconomic time-series relationships because it simultaneously captures temporary fluctuations and long-term equilibrium adjustments Engle & Granger (1987).

The Engle–Granger cointegration approach was specifically chosen because the study employs a relatively limited number of observations and focuses on a single long-run equilibrium relationship among the variables. Although alternative approaches such as Johansen cointegration and ARDL bounds testing are frequently applied in macroeconomic time-series analysis, the Engle–Granger ECM framework was considered appropriate for this study because of its simpler specification and suitability for examining equilibrium correction mechanisms in small-sample contexts. Nevertheless, the study acknowledges that alternative cointegration approaches may provide additional robustness and therefore represent potential directions for future research.

Prior to ECM estimation, all variables were transformed into natural logarithmic form to reduce heteroskedasticity problems, stabilize variance, and facilitate elasticity interpretation among macroeconomic variables. Logarithmic transformation is commonly employed in macroeconomic time-series analysis because it improves data normality and minimizes scale differences among variables.

The functional form of the model used in this study can be expressed as follows:

$$\Delta CDV_t = \beta_0 + \beta_1 \Delta EKSPOR_t + \beta_2 \Delta IMPOR_t + \beta_3 \Delta ULN_t + \beta_4 \Delta ECT_{t-1} + \varepsilon_t$$

The long-run econometric equation

used in this study is formulated as follows:

$$\ln(CDV_t) = \beta_0 + \beta_1 \ln(EKSPOR_t) + \beta_2 \ln(IMPOR_t) + \beta_3 \ln(ULN_t) + \varepsilon_t$$

Meanwhile, the short-run ECM equation is formulated as follows:

$$\Delta CDV_t = \beta_0 + \beta_1 \Delta EKSPOR_t + \beta_2 \Delta IMPOR_t + \beta_3 \Delta ULN_t + \beta_4 \Delta ECT_{t-1} + \varepsilon_t$$

The Error Correction Term (ECT) represents the speed of adjustment toward long-run equilibrium after short-run disequilibrium occurs. A negative and statistically significant ECT coefficient indicates the existence of a long-run equilibrium relationship among variables.

Sampling Process

This study used a saturated sampling technique because all available annual data within the observation period were included as research samples. The sample consisted of annual macroeconomic data from 2005 to 2024, resulting in a total of 20 observations for each variable. The use of annual time series data was intended to provide a comprehensive overview of long-term movements and macroeconomic adjustments in Indonesia's external sector.

The observation period was selected based on several considerations. First, the period reflects important global and domestic economic events, including the 2008 global financial crisis, the 2013 taper tantrum, the COVID-19 pandemic, and the post-pandemic commodity boom. Second, the selected period provides sufficient variability in macroeconomic indicators to support econometric estimation using the ECM approach. Third, data availability and consistency across institutions also supported the selection of the 2005–2024 period.

The study focused exclusively on Indonesia as the unit of analysis because Indonesia is one of the world's largest exporters of crude palm oil and simultaneously experiences substantial machinery imports and external debt accumulation. These characteristics make

Indonesia a relevant case for analyzing the determinants of foreign exchange reserves in emerging economies.

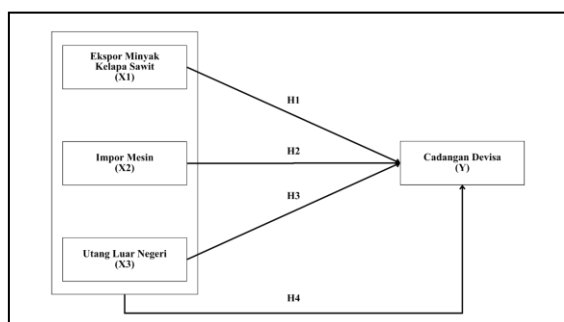


Figure 1. Framework Research

Instruments & Data Collection

This study relied entirely on secondary data obtained from official institutions and international databases. According to Nashrullah et al. (2023), data collection techniques refer to the systematic procedures that researchers apply to obtain information that aligns with the study objectives. The data used consisted of annual data on foreign exchange reserves, crude palm oil exports, machinery imports, and external debt in Indonesia from 2005 to 2024.

Foreign exchange reserve data were obtained from Bank Indonesia and the Central Bureau of Statistics (Badan Pusat Statistik/BPS). Crude palm oil export data were collected from BPS and Trade Map databases. Machinery import data were sourced from BPS international trade statistics, while external debt data were obtained from Bank Indonesia and related macroeconomic reports. The use of official institutional data aimed to ensure data reliability, consistency, and validity.

Data collection was conducted through documentation techniques by compiling published statistical reports, annual economic reports, and macroeconomic databases. All data were organized and tabulated using spreadsheet software before being processed for econometric analysis.

The instruments used in this study

consisted of statistical and econometric software, namely Microsoft Excel and EViews 12. Microsoft Excel was utilized for data tabulation and preliminary descriptive analysis, while EViews 12 was used to estimate econometric models and conduct statistical testing, including stationarity tests, cointegration tests, classical assumption tests, and ECM estimation.

Data Analysis

The data analysis technique employed in this study was the Error Correction Model (ECM). Before estimating the ECM model, several econometric procedures were conducted to ensure that the data fulfilled the required assumptions.

The first stage involved descriptive statistical analysis to describe the characteristics and development patterns of each variable during the observation period. Descriptive analysis included the calculation of mean, maximum value, minimum value, and standard deviation.

The second stage involved the stationarity test using the Augmented Dickey-Fuller (ADF) test. The stationarity test was conducted to determine whether the data contained unit roots. According to Gujarati & Porter (2009), non-stationary data may produce spurious regression results; therefore, stationarity testing is essential in time series analysis. Variables were considered stationary if the probability value was smaller than the significance level of 0.05.

The ADF equation used in this study can be expressed as follows: $\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^n \delta_i \Delta Y_{t-1} + e_t$. The third stage involved determining the optimal lag length using criteria such as Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ). The optimal lag was selected based on the smallest information criterion value.

The fourth stage was the cointegration test using the Engle-Granger cointegration approach. Cointegration testing was performed to identify whether a long-run equilibrium relationship existed among the variables. If the residuals from the long-run equation were stationary at level, then the variables were considered cointegrated.

The fifth stage involved classical assumption testing, consisting of normality tests, multicollinearity tests, heteroscedasticity tests, and autocorrelation tests. These tests were conducted to ensure that the regression model fulfilled the Best Linear Unbiased Estimator (BLUE) assumptions.

The sixth stage involved estimating the long-run equation and the short-run ECM equation. The ECM estimation aimed to identify both the short-term effects and the long-term equilibrium relationships among variables. The significance of variables was evaluated using the t-test and F-test at a significance level of 5%.

The coefficient of determination (R^2) was also used to measure the ability of independent variables to explain variations in foreign exchange reserves. Meanwhile, the Error Correction Term (ECT) coefficient was interpreted as the speed of adjustment toward long-run equilibrium. A negative and significant ECT coefficient indicates that deviations from long-run equilibrium can be corrected over time.

Several econometric considerations were taken into account in interpreting the ECM estimation results. First, the study acknowledges the possibility of structural disturbances arising from major global economic events such as the 2008 global financial crisis and the COVID-19 pandemic, which may influence stationarity and long-run equilibrium relationships among variables. Second, although the ECM framework is capable of capturing dynamic adjustments, the study

recognizes the potential existence of endogeneity and omitted variable bias because foreign exchange reserves may also indirectly influence trade flows and external financing conditions. Third, due to the relatively limited number of observations, the empirical findings should be interpreted as indicative rather than fully generalizable across all developing economies. Nevertheless, the ECM framework remains relevant for analyzing the dynamic interaction between external sector variables and reserve accumulation within the Indonesian context

RESULTS AND DISCUSSION

Stationarity Test

The stationarity test was conducted using the Augmented Dickey-Fuller (ADF) approach to identify the order of integration of each variable prior to estimating the Error Correction Model (ECM). Stationarity testing is essential in time-series econometric analysis because non-stationary variables may produce spurious regression results and unreliable statistical relationships. The empirical results indicate that foreign exchange reserves, crude palm oil (CPO) exports, and machinery imports achieved stationarity after the first differencing process, while the external debt variable remained non-stationary at the same level. Therefore, an additional differencing procedure was conducted until all variables achieved stationarity.

The findings demonstrate that all variables became stationary after the second differencing process, indicating the presence of strong stochastic trends and persistent long-term movements within Indonesia's external sector variables. Such conditions are relatively common in macroeconomic time-series data characterized by structural economic transitions, commodity price fluctuations,

and external financial shocks. Although conventional ECM applications are generally associated with variables integrated at the first difference level, the stationarity results in this study suggest that Indonesia's reserve dynamics and external sector indicators exhibit substantial persistence over time. Therefore, the stationarity findings should be interpreted cautiously within the context of the study's econometric limitations and long-term macroeconomic characteristics.

Since external debt had not yet achieved stationarity at the first difference level, the test was continued at the second difference level. The results show that all variables, namely foreign exchange reserves, CPO exports, machine imports, and external debt, became stationary with probability values below 0.05. These findings confirm that all variables share the same order of integration and satisfy the prerequisite for further cointegration testing within the ECM framework.

Table 1. Results of the Degree of Integration Test at the 2nd Difference Level

Series	Probability
Ekspor CPO	0.0000
Impor Mesin	0.0001
Utang Luar Negeri	0.0008
Cadangan Devisa	0.0001

Source: Processed Primary Data

The achievement of stationarity at the second difference level indicates that the variables contain long-term stochastic trends and require differencing to eliminate non-stationary components. This condition is common in macroeconomic time series data, particularly variables associated with external sector performance such as

foreign exchange reserves, exports, imports, and external debt. The findings therefore provide an adequate econometric basis for proceeding to the cointegration test and ECM estimation.

Cointegration Test

After identifying the integration properties of the variables, the next stage involved testing for cointegration to determine whether a long-run equilibrium relationship existed among foreign exchange reserves, crude palm oil exports, machinery imports, and external debt. Within the ECM framework, cointegration testing is important because it verifies whether short-term deviations among variables tend to converge toward equilibrium conditions over time. The cointegration test produced a probability value of 0.0426, which is below the 5 percent significance level, indicating the existence of a statistically significant long-run relationship among the variables.

Economically, this result suggests that fluctuations in trade performance and external financing variables are not entirely temporary, but instead maintain long-run equilibrium interactions with Indonesia's foreign exchange reserve dynamics. This finding supports the argument that reserve accumulation in Indonesia is structurally linked to broader external sector activities, including export performance, productive imports, and foreign capital inflows. The existence of cointegration therefore provides empirical support for analyzing reserve sustainability through a dynamic macroeconomic framework rather than through isolated short-term indicators alone.

Table 2. Results of the Cointegration Test

Hypothesized No. of CE(S)	Probability
None*	0.0426
At Most 1	0.2706
At Most 2	0.2140
At Most 3	0.0611

Source: Processed Primary Data

Classical Assumption Test

Before interpreting the regression results, several classical assumption tests were conducted to ensure that the Error Correction Model (ECM) fulfilled the required econometric assumptions. The tests included normality, multicollinearity, heteroskedasticity, and autocorrelation tests for both short-run and long-run models.

The normality test using the Jarque–Bera method showed probability values of 0.517486 for the short-run model and 0.663707 for the long-run model, indicating that the residuals were normally distributed because both values exceeded the 0.05 significance level. Furthermore, the multicollinearity test based on the Variance Inflation Factor (VIF) indicated that all independent variables had VIF values below 10, confirming the absence of strong linear correlations among explanatory variables.

The heteroskedasticity test using the Breusch–Pagan–Godfrey method also showed probability values above 0.05 for both models, indicating homoscedastic residual variances. In addition, the Durbin–Watson statistics suggested that the models were free from serious autocorrelation problems because the residuals remained independent across time periods. Overall, these findings confirm that the ECM estimation satisfied the major classical assumptions and therefore produced statistically reliable estimations for analyzing the effects of crude palm oil exports, machinery imports, and external debt on Indonesia's

foreign exchange reserves.

Estimation Test

The Error Correction Model (ECM) estimation was employed to analyze both the short-run dynamics and long-run equilibrium relationships between crude palm oil exports, machinery imports, external debt, and Indonesia's foreign exchange reserves. The ECM framework is particularly relevant for this study because reserve accumulation in emerging economies is influenced not only by temporary fluctuations in trade and financial flows, but also by structural adjustments occurring over time. Consequently, the ECM approach enables the analysis to capture how short-term disequilibrium conditions gradually adjust toward long-run macroeconomic equilibrium.

The estimation results demonstrate that the selected external sector variables exert heterogeneous effects on Indonesia's foreign exchange reserves across different time horizons. These findings indicate that reserve accumulation dynamics in Indonesia cannot be explained solely through conventional trade surplus mechanisms, but must also consider broader structural factors such as commodity dependence, industrial transformation, and external financing vulnerability.

Dependent Variable: D(CD)
Method: Least Squares
Date: 04/18/26 Time: 17:43
Sample (adjusted): 2006 2024
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2196.580	3293.276	-0.666989	0.5156
D(CPO)	-1.568252	1.008583	-1.554906	0.1423
D(IM)	0.572690	0.287137	1.994484	0.0659
D(ULN)	0.544810	0.169016	3.223423	0.0061
ECT(-1)	-0.970018	0.311010	-3.118932	0.0075
R-squared	0.544007	Mean dependent var		6368.158
Adjusted R-squared	0.413723	S.D. dependent var		10622.07
S.E. of regression	8133.182	Akaike info criterion		21.06623
Sum squared resid	9.26E+08	Schwarz criterion		21.31476
Log likelihood	-195.1291	Hannan-Quinn criter.		21.10829
F-statistic	4.175551	Durbin-Watson stat		1.839067
Prob(F-statistic)	0.019710			

Figure 2. Short-Term Equation Estimation Test Results

The short-run ECM estimation produced an ECT coefficient of -0.9700 with a probability value of 0.0075, indicating that the coefficient was negative and statistically significant. This result confirms the validity of the ECM specification because the negative ECT coefficient demonstrates the existence of a correction mechanism toward long-run equilibrium. Economically, the coefficient implies that approximately 97 percent of short-run disequilibrium in foreign exchange reserves can be corrected within one period. The high speed of adjustment indicates that fluctuations in Indonesia's foreign exchange reserves caused by temporary shocks in exports, imports, or external debt tend to return relatively quickly to their long-run equilibrium path.

In the short-run estimation, crude palm oil (CPO) exports were found to have no statistically significant effect on Indonesia's foreign exchange reserves. This finding indicates that short-term increases in palm oil export activities do not immediately translate into reserve accumulation. One possible explanation is the high volatility of global commodity prices, which frequently causes fluctuations in export earnings despite increases in export volume. As a result, temporary improvements in export performance may not generate stable foreign exchange inflows within short observation periods.

In addition, short-run reserve dynamics in Indonesia are strongly influenced by external financial conditions, exchange rate stabilization policies, and international capital movements, thereby reducing the immediate impact of commodity exports on reserve accumulation. The insignificant short-run effect may also reflect export revenue leakages and limited foreign exchange repatriation mechanisms, where portions of export earnings are not fully

retained within domestic reserve assets. Consequently, strong short-term export performance alone may be insufficient to strengthen reserve positions under conditions of global market uncertainty and commodity dependence.

In the short-run estimation, machinery imports were found to exert a positive and significant effect on Indonesia's foreign exchange reserves. Although imports are generally associated with foreign exchange outflows, the findings suggest that machinery imports in Indonesia primarily function as productive imports that support industrial and export-oriented economic activities. In the short term, the importation of capital goods and industrial machinery may improve production capacity, accelerate industrial operations, and support export competitiveness, thereby indirectly contributing to foreign exchange earnings and reserve stabilization.

The positive short-run effect also reflects the structural characteristics of developing economies such as Indonesia, where domestic industrial sectors remain highly dependent on imported capital goods, production technology, and industrial equipment. Consequently, machinery imports may generate immediate productivity improvements and facilitate industrial expansion within manufacturing and processing sectors. However, the findings should not be interpreted solely as evidence that higher imports automatically strengthen reserve positions because excessive dependence on imported machinery may simultaneously increase external vulnerability and production dependency on foreign technology over time.

In the short-run estimation, external debt was found to exert a positive and significant effect on Indonesia's foreign exchange reserves. This finding indicates that external borrowing may temporarily strengthen reserve positions by increasing

foreign exchange inflows within the capital and financial account. In developing economies such as Indonesia, external debt is frequently utilized to finance fiscal deficits, stabilize exchange rate pressures, support infrastructure development, and maintain external liquidity under conditions of limited domestic financing capacity. Consequently, increases in external borrowing may contribute directly to reserve accumulation in the short term.

However, the positive short-run effect should be interpreted cautiously because external debt simultaneously creates future repayment obligations and debt servicing pressures. Reserve accumulation derived from external borrowing does not necessarily reflect improvements in productive external sector performance, particularly when reserve growth depends heavily on debt-driven capital inflows rather than sustainable export expansion. In addition, reliance on external debt may increase vulnerability to global financial tightening, international interest rate fluctuations, and sudden capital reversals, especially in emerging economies with relatively high exposure to external financing risks.

The overall short-run ECM findings demonstrate that Indonesia's foreign exchange reserves are strongly influenced by interactions between international trade performance and external financing conditions. Export activities, particularly CPO exports, strengthen reserves through foreign exchange inflows, while machine imports create reserve outflows due to import payments. Meanwhile, external debt provides temporary liquidity support that can stabilize reserve levels during periods of economic pressure. The significant ECT coefficient further confirms that any short-term imbalance among these variables will gradually adjust toward long-run equilibrium, indicating that Indonesia's external sector possesses a relatively stable adjustment

mechanism in responding to economic shocks.

Dependent Variable: CD
Method: Least Squares
Date: 04/17/26 Time: 15:52
Sample: 2005 2024
Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2241.037	9243.875	-0.242435	0.8115
CPO	-0.387968	0.994853	-0.389975	0.7017
IM	0.715716	0.168872	4.238227	0.0006
ULN	0.293083	0.056340	5.202060	0.0001
R-squared	0.950729	Mean dependent var	105239.9	
Adjusted R-squared	0.941491	S.D. dependent var	36428.24	
S.E. of regression	8811.476	Akaike info criterion	21.18235	
Sum squared resid	1.24E+09	Schwarz criterion	21.38150	
Log likelihood	-207.8235	Hannan-Quinn criter.	21.22123	
F-statistic	102.9125	Durbin-Watson stat	1.958793	
Prob(F-statistic)	0.000000			

Figure 3. Long-Term Equation Estimation Test Results

Based on the long-run estimation results, the crude palm oil (CPO) export variable obtained a coefficient value of -0.387968 with a probability value of 0.7017. The negative coefficient indicates that an increase in CPO exports tends to be followed by a decline in foreign exchange reserves in the long run. However, the probability value exceeding the 5% significance level indicates that the relationship is statistically insignificant. This finding suggests that fluctuations in Indonesia's palm oil exports were not able to provide a stable contribution to the accumulation of foreign exchange reserves throughout the study period.

In the long-run estimation, crude palm oil (CPO) exports also did not exert a statistically significant effect on Indonesia's foreign exchange reserves. This finding suggests that Indonesia's dependence on commodity-based exports may not provide sustainable support for long-term reserve accumulation. Although palm oil exports contribute substantially to Indonesia's export earnings, the benefits for reserve sustainability appear to be constrained by several structural factors within the external sector.

First, Indonesia's palm oil industry remains heavily dependent on global

commodity market conditions, making export revenues highly vulnerable to international price fluctuations and external demand shocks. Second, the sector is still characterized by limited downstream industrialization and relatively low domestic value-added processing, causing a substantial portion of export activities to rely on raw or semi-processed commodities. Under these conditions, export expansion may increase foreign exchange earnings temporarily without necessarily strengthening long-run reserve resilience.

Furthermore, Indonesia's palm oil exports have increasingly faced external pressures associated with environmental sustainability campaigns, anti-deforestation policies, and trade restrictions in international markets, particularly within the European region. These conditions contribute to uncertainty in long-term export performance and reinforce the structural vulnerability of commodity-dependent economies. Therefore, the insignificant long-run effect of CPO exports in this study supports broader arguments in resource dependence literature suggesting that reliance on primary commodity exports alone may be insufficient to ensure sustainable reserve accumulation without industrial upgrading and stronger external sector management policies. (Bank Indonesia, 2023).

The findings of this study are consistent with several previous studies arguing that commodity-based exports do not always contribute significantly to reserve accumulation in developing economies due to export volatility, external dependency, and weak domestic industrial linkages. However, the results differ from studies that identified a positive relationship between export growth and foreign exchange reserves through trade surplus mechanisms. These differences may arise from variations in

export structures, institutional capacity, exchange rate regimes, and foreign exchange retention policies across countries. In the Indonesian context, the dominance of primary commodity exports and limited downstream industrialization may reduce the effectiveness of export expansion in strengthening long-term reserve sustainability.

In the long-run estimation, machinery imports also demonstrated a positive and significant effect on Indonesia's foreign exchange reserves. This finding indicates that capital goods imports may contribute to long-term reserve sustainability when they are utilized to strengthen domestic industrial capacity and export competitiveness. Unlike consumptive imports, machinery imports are generally categorized as productive imports because they facilitate technological upgrading, industrial modernization, and productivity enhancement within the domestic economy. Over time, improvements in industrial productivity may increase manufacturing output, strengthen export performance, and generate more stable foreign exchange earnings that contribute to reserve accumulation.

The findings support the argument derived from Heckscher–Ohlin trade theory and industrial development perspectives, which emphasize that imports of capital-intensive goods can improve production efficiency and support structural economic transformation in developing economies. In Indonesia's case, machinery imports may have contributed to the expansion of manufacturing and processing industries that possess higher value-added potential compared to commodity-based sectors alone. Consequently, productive imports may indirectly strengthen external sector resilience by reducing excessive dependence on primary commodity exports.

Nevertheless, the positive long-run contribution of machinery imports should also be interpreted cautiously. Persistent dependence on imported capital goods may expose developing economies to exchange rate pressures, external financing burdens, and technological dependency if domestic industrial capabilities remain insufficiently developed. Therefore, the long-run benefits of machinery imports for reserve sustainability depend substantially on the effectiveness of industrial policies, technology absorption capacity, and the ability of domestic industries to generate sustainable export competitiveness.

The positive contribution of machinery imports found in this study supports previous empirical findings suggesting that productive imports may strengthen industrial competitiveness and improve export capacity in developing economies. Nevertheless, several studies have also argued that excessive dependence on imported capital goods may increase structural external dependency and weaken domestic industrial self-sufficiency over time. Therefore, the Indonesian case demonstrates that the effectiveness of machinery imports in supporting reserve accumulation depends substantially on the country's ability to transform imported technology into sustainable industrial productivity and export-oriented growth.

In the long-run estimation, external debt also demonstrated a positive and significant effect on Indonesia's foreign exchange reserves. This finding suggests that external borrowing has played an important role in supporting Indonesia's external liquidity and reserve accumulation over time. From a macroeconomic perspective, external debt may provide additional foreign exchange resources that help stabilize balance of payments conditions, finance development programs, and maintain investor

confidence during periods of external economic pressure.

Nevertheless, the positive relationship between external debt and reserve accumulation should not be interpreted solely as evidence of sustainable external sector strength. Excessive dependence on foreign borrowing may generate long-term structural vulnerabilities, particularly when debt expansion is not accompanied by proportional improvements in productive capacity, export competitiveness, and foreign exchange generating activities. Under such conditions, reserve accumulation may become increasingly dependent on continuous capital inflows rather than internally generated external sector performance.

Furthermore, rising external debt levels may increase debt servicing burdens and expose developing economies to greater risks associated with global financial instability, exchange rate depreciation, and international monetary tightening. During periods of higher global interest rates or declining investor confidence, debt-dependent reserve structures may become increasingly fragile due to refinancing pressures and capital outflow risks. Therefore, although external debt may contribute positively to reserve accumulation in the long run, sustainable reserve management ultimately requires stronger export diversification, industrial strengthening, and more balanced external financing structures.

The findings of this study support broader debt sustainability literature arguing that foreign borrowing may simultaneously function as both a source of external liquidity and a potential source of macroeconomic vulnerability. Consequently, the effectiveness of external debt in supporting reserve sustainability depends substantially on how borrowed resources are allocated toward productive

economic sectors capable of generating long-term foreign exchange earnings.

The findings regarding the positive effect of external debt are consistent with studies emphasizing the role of foreign borrowing in supporting liquidity and balance of payments stability in developing economies. However, other empirical studies have highlighted that excessive reliance on external debt may increase financial fragility, debt servicing burdens, and vulnerability to global monetary tightening. These contrasting findings indicate that the relationship between external debt and reserve accumulation is highly dependent on debt allocation efficiency, macroeconomic management quality, and the capacity of the economy to generate sustainable foreign exchange earnings in the long run.

Overall, the long-run estimation results indicate that machine imports and external debt contributed positively to Indonesia's foreign exchange reserves, while crude palm oil exports did not show a significant contribution during the study period. These findings suggest that reserve accumulation in Indonesia was influenced more strongly by productive capital inflows and external financing mechanisms than by commodity export performance alone.

Partial Test (t-Test)

The partial test (t-test) was conducted to determine the individual effect of crude palm oil (CPO) exports, machine imports, and external debt on Indonesia's foreign exchange reserves in both the short run and the long run. The hypothesis testing in this study used a significance level of 5% ($\alpha = 0.05$), where variables with probability values below 0.05 are considered statistically significant.

Based on the short-run estimation results, the crude palm oil (CPO) export variable obtained a probability value

greater than 0.05 which 0.1423 for the probability value, indicating that CPO exports did not have a significant effect on Indonesia's foreign exchange reserves in the short run. This finding shows that short-term fluctuations in palm oil exports were not immediately followed by changes in reserve accumulation. The insignificant short-run effect occurred because export earnings require a transmission process before contributing to reserve accumulation through the balance of payments mechanism. In addition, external factors such as commodity price volatility, exchange rate intervention, and international market uncertainty weakened the short-run contribution of export performance to foreign exchange reserves.

Meanwhile, the machine import variable also showed an insignificant effect in the short run, as indicated by its probability value exceeding the 5% significance level which is 0.0659. This result suggests that increases in machine imports initially generated foreign currency outflows without directly increasing reserve accumulation during the same period. Machine imports generally require a longer adjustment process before generating productive impacts on industrial output and export performance. Therefore, the benefits of imported capital goods were not immediately reflected in short-run reserve growth.

In contrast, the external debt variable showed a significant effect on foreign exchange reserves in the short run, with a probability value below 0.05 which is 0.0061. This result indicates that external borrowing directly contributed to reserve accumulation through immediate foreign capital inflows into the domestic economy. The short-run impact of external debt reflects Indonesia's reliance on foreign financing to support fiscal needs, maintain exchange rate stability, and

strengthen liquidity in the external sector. As external debt enters the financial system in the form of foreign currency inflows, its impact on reserves tends to occur more rapidly compared to trade-related variables.

Based on the long-run partial estimation results, the crude palm oil (CPO) export variable obtained a coefficient value of -0.387968 with a probability value of 0.7017. Since the probability value is greater than 0.05, CPO exports do not have a significant effect on Indonesia's foreign exchange reserves in the long run. Therefore, the hypothesis stating that CPO exports significantly influence foreign exchange reserves is rejected.

The insignificant long-run effect indicates that increases in palm oil export performance were not consistently followed by increases in reserve accumulation throughout the observation period. This condition occurred because export-generated foreign exchange earnings were not fully retained as reserves, but were partly utilized for import financing, external debt payments, exchange rate stabilization, and other international obligations. In addition, fluctuations in global commodity prices and export policy interventions reduced the stability of export contributions to reserve accumulation. These findings support previous studies which explain that export performance alone is insufficient to strengthen foreign exchange reserves when external leakages remain high (Iriani & Setiawati, 2023; Sunarta et al., 2024).

Meanwhile, the machine import variable obtained a coefficient value of 0.715716 with a probability value of 0.0006. Since the probability value is smaller than 0.05, machine imports have a positive and significant effect on Indonesia's foreign exchange reserves in the long run. Therefore, the hypothesis

stating that machine imports significantly affect foreign exchange reserves is accepted.

The significant positive effect indicates that machine imports contributed to long-term reserve strengthening through their role as productive capital goods. Imported machinery supported industrial modernization, increased production efficiency, and enhanced export competitiveness. Over time, these improvements generated additional foreign exchange earnings that contributed to reserve accumulation. This finding indicates that imports do not always weaken foreign exchange reserves, particularly when imported goods are allocated toward productive and export-oriented sectors.

Furthermore, the external debt variable obtained a coefficient value of 0.293083 with a probability value of 0.0001. Since the probability value is lower than 0.05, external debt has a positive and significant effect on Indonesia's foreign exchange reserves in the long run. Thus, the hypothesis stating that external debt significantly influences foreign exchange reserves is accepted.

The significant positive relationship between external debt and foreign exchange reserves reflects the important role of foreign capital inflows in supporting Indonesia's external sector stability. External borrowing increased the supply of foreign exchange entering the domestic economy and strengthened reserve positions through the balance of payments mechanism. However, although external debt positively affected reserves during the study period, excessive dependence on external financing may increase vulnerability to future global economic shocks and repayment pressures.

Simultaneous Test

The simultaneous test (F-test) was conducted to determine whether crude palm oil (CPO) exports, machine imports, and external debt simultaneously affect Indonesia's foreign exchange reserves in both the short run and the long run. The hypothesis testing used a significance level of 5% ($\alpha = 0.05$), where a probability value below 0.05 indicates that all independent variables jointly have a significant effect on the dependent variable.

R-squared	0.544007	Mean dependent var	6368.158
Adjusted R-squared	0.413723	S.D. dependent var	10622.07
S.E. of regression	8133.182	Akaike info criterion	21.06623
Sum squared resid	9.26E+08	Schwarz criterion	21.31476
Log likelihood	-195.1291	Hannan-Quinn criter.	21.10829
F-statistic	4.175551	Durbin-Watson stat	1.839067
Prob(F-statistic)	0.019710		

Figure 5. Short Run Simultaneous Test

Based on the short-run estimation results, the probability value of the F-statistic was smaller than 0.05 which is 0.019710, indicating that crude palm oil (CPO) exports, machine imports, and external debt simultaneously had a significant effect on Indonesia's foreign exchange reserves in the short run. Therefore, the hypothesis stating that all independent variables jointly influence foreign exchange reserves in the short run is accepted.

This finding indicates that short-run fluctuations in foreign exchange reserves were influenced by the interaction between export activities, import transactions, and external financing. Although not all variables individually showed significant effects in the short run, their combined interaction contributed significantly to reserve dynamics during the observation period.

R-squared	0.950729	Mean dependent var	105239.9
Adjusted R-squared	0.941491	S.D. dependent var	36428.24
S.E. of regression	8811.476	Akaike info criterion	21.18235
Sum squared resid	1.24E+09	Schwarz criterion	21.38150
Log likelihood	-207.8235	Hannan-Quinn criter.	21.22123
F-statistic	102.9125	Durbin-Watson stat	1.958793
Prob(F-statistic)	0.000000		

Figure 4. Long Run Simultaneous Test

Based on the long-run estimation results, the probability value of the F-statistic was 0.000000, which is smaller than 0.05. This result indicates that crude palm oil (CPO) exports, machine imports, and external debt simultaneously have a significant effect on Indonesia's foreign exchange reserves in the long run. Therefore, the hypothesis stating that all independent variables jointly influence foreign exchange reserves in the long run is accepted.

The significant long-run simultaneous effect demonstrates that Indonesia's foreign exchange reserves were influenced by the combined interaction of international trade activities and external financing mechanisms. The findings indicate that reserve accumulation cannot be explained by a single variable alone, but rather by the overall relationship between export performance, productive imports, and external debt throughout the study period.

Discussion

The findings of this study indicate that crude palm oil (CPO) exports did not have a significant effect on Indonesia's foreign exchange reserves in either the short run or the long run. This result suggests that the increase in Indonesia's palm oil export value during the 2005–2024 period was not consistently followed by an increase in reserve accumulation. Although Indonesia has long been recognized as the world's largest producer and exporter of palm oil, the contribution of export earnings to foreign exchange reserves remained relatively unstable. One of the major causes of this condition was the existence of foreign exchange leakage, where export-generated foreign currency was not fully retained within the domestic financial system. Instead, export revenues were partially allocated for import

financing, external debt obligations, exchange rate stabilization, and other international transactions. As a result, increases in export performance did not automatically strengthen reserve positions. This condition reflects that reserve accumulation is not solely determined by export value, but also by the broader structure of balance of payments transactions and the effectiveness of foreign exchange management policies (World Bank, 2022; Suryahadi et al., 2021).

In addition, the insignificant effect of CPO exports was strongly influenced by the volatility of global commodity markets during the observation period. International palm oil prices experienced substantial fluctuations due to changes in global demand, geopolitical tensions, trade barriers, and environmental campaign pressures from importing countries. During several periods, increases in export volume were offset by declining global prices, causing export earnings to fluctuate significantly. Government intervention policies also contributed to this instability, particularly during the 2022 palm oil crisis when the Indonesian government implemented temporary export restrictions and Domestic Market Obligation (DMO) policies to stabilize domestic cooking oil supply and prices. These policies reduced export activities and affected foreign exchange inflows generated from the palm oil sector. Consequently, the contribution of CPO exports to reserve accumulation became less stable in both the short run and the long run. This finding supports the argument that commodity-dependent economies are highly vulnerable to external shocks and international market instability (World Bank, 2022; Dieppe et al., 2020).

The findings of this study are consistent with the balance of payments theory, which explains that foreign

exchange reserves are influenced not only by export performance, but also by capital flows, import transactions, exchange rate policies, and external financial obligations. Although the mercantilist perspective emphasizes exports as the main source of reserve accumulation through trade surpluses, the empirical evidence in this study indicates that export growth alone is insufficient to strengthen reserves when external leakages remain high. The findings are also in line with previous studies conducted by Iriani & Setiawati (2023) and Sunarta et al. (2024) which found that exports do not always significantly affect foreign exchange reserves due to the existence of external financing pressures and import dependency. Therefore, the effectiveness of export sectors in strengthening reserves depends not only on export growth itself, but also on the country's ability to retain foreign exchange earnings within the domestic economy (World Bank, 2022; Borin & Mancini, 2019).

Meanwhile, machine imports showed a positive and significant effect on Indonesia's foreign exchange reserves in the long run, although their effect was insignificant in the short run. This finding indicates that machine imports initially generated foreign currency outflows, but gradually contributed to reserve accumulation through improvements in industrial productivity and export capacity. Imported machinery and capital goods played an important role in supporting industrial modernization, technological upgrading, and infrastructure development during the study period. As production efficiency improved, domestic industries became more competitive in international markets and generated higher export earnings over time. Consequently, the long-run effect of machine imports became positive because productive imports created multiplier effects on economic growth and foreign

exchange generation. This finding demonstrates that imports should not always be viewed as a source of reserve depletion, especially when imported goods are allocated toward productive sectors capable of generating future economic returns (Dieppe et al., 2020; Borin & Mancini, 2019).

The positive contribution of machine imports also reflects Indonesia's structural transformation process during the 2005–2024 period. During this period, Indonesia experienced increasing industrial expansion and infrastructure development, which significantly increased demand for imported machinery and industrial equipment. The manufacturing sector relied heavily on imported capital goods to improve production capacity and support export-oriented industries. This condition explains why machine imports eventually strengthened foreign exchange reserves despite initially increasing foreign currency expenditures. The findings are consistent with the theory proposed by Salvatore (2013), which states that imports of capital goods may improve production efficiency and increase export competitiveness in the long run. In addition, the results support previous empirical studies which found that productive imports contribute positively to economic performance and reserve accumulation when they are directed toward industrial development and export expansion (World Bank, 2022; Dieppe et al., 2020; Borin & Mancini, 2019).

Furthermore, external debt was found to have a positive and significant effect on Indonesia's foreign exchange reserves in both the short run and the long run. This finding indicates that external borrowing played an important role in supporting reserve accumulation throughout the observation period. In the short run, external debt directly increased the inflow of foreign currency into the

domestic economy through government and private sector borrowing activities. These inflows strengthened reserve positions and improved the country's ability to maintain exchange rate stability and fulfill international payment obligations. In the long run, external debt continued to contribute positively to reserve accumulation because foreign financing was extensively utilized to support infrastructure projects, fiscal financing, and economic development programs. Consequently, external debt became one of the major sources of foreign exchange inflows in Indonesia's balance of payments structure (World Bank, 2022; Witoelar & Utomo, 2022).

The positive relationship between external debt and foreign exchange reserves reflects Indonesia's increasing dependence on external financing to maintain macroeconomic stability. During periods of fiscal pressure and global economic uncertainty, foreign borrowing became an important policy instrument used by the government to stabilize domestic economic conditions. Several major infrastructure development programs implemented during the study period relied heavily on external financing from international institutions and foreign creditors. The inflow of foreign loans strengthened reserve positions and increased the availability of foreign currency within the domestic financial system. However, although external debt positively affected reserves, the findings also indicate that Indonesia's reserve accumulation was partly driven by debt-based capital inflows rather than purely by export-generated foreign exchange earnings (World Bank, 2022; Suryahadi et al., 2021).

This condition creates both opportunities and risks for the Indonesian economy. On one hand, external debt can strengthen reserve adequacy and support economic development when it is allocated

toward productive sectors capable of generating long-term economic returns. Productive use of foreign borrowing may increase infrastructure quality, industrial productivity, and export competitiveness, which eventually contribute to sustainable reserve accumulation. On the other hand, excessive dependence on external debt may increase vulnerability to global financial shocks, exchange rate depreciation, and rising international interest rates. As external debt obligations continue to increase, a significant portion of foreign exchange reserves may eventually be used for debt servicing and repayment obligations. Therefore, the sustainability of reserve accumulation depends not only on the amount of external borrowing, but also on the effectiveness and productivity of debt utilization within the domestic economy (World Bank, 2022; Dieppe et al., 2020).

The simultaneous test results further indicate that crude palm oil (CPO) exports, machine imports, and external debt jointly had a significant effect on Indonesia's foreign exchange reserves in both the short run and the long run. These findings demonstrate that reserve dynamics in Indonesia cannot be explained by a single macroeconomic variable alone, but rather by the interaction between international trade activities and external financing mechanisms. Although CPO exports individually did not show a significant effect, their interaction with productive imports and external borrowing significantly influenced reserve movements during the observation period. This result confirms that foreign exchange reserves are determined by the overall structure of the balance of payments, including trade flows, capital inflows, external liabilities, and exchange rate policies (Borin & Mancini, 2019; World Bank, 2022).

Overall, the findings of this study indicate that Indonesia's foreign exchange

reserve accumulation during the 2005–2024 period was influenced more strongly by productive capital inflows and external financing mechanisms than by commodity export performance alone. The insignificant effect of CPO exports suggests that reliance on primary commodity exports is insufficient to guarantee reserve stability, especially when export earnings are highly vulnerable to global market fluctuations and external leakages. Meanwhile, productive machine imports and external debt contributed positively to reserve accumulation because both variables supported industrial expansion, capital inflows, and macroeconomic stabilization. These findings imply that policies aimed at strengthening foreign exchange reserves should not only focus on increasing export value, but also prioritize industrial productivity improvement, productive import allocation, export diversification, and prudent external debt management to achieve sustainable external sector stability (World Bank, 2022; Dieppe et al., 2020; Borin & Mancini, 2019; Witoelar & Utomo, 2022).

CONCLUSION

This study concludes that the dynamics of Indonesia's foreign exchange reserves are influenced not only by trade performance, but also by broader structural interactions between commodity dependence, productive imports, and external financing mechanisms. The empirical findings demonstrate that crude palm oil (CPO) exports did not significantly contribute to reserve accumulation in either the short-run or long-run estimation, indicating that reliance on commodity-based exports alone may be insufficient to ensure sustainable reserve resilience. This condition reflects the structural

vulnerability of developing economies that remain highly dependent on volatile primary commodity markets, limited downstream industrialization, and external market pressures.

In contrast, machinery imports were found to positively influence foreign exchange reserves, suggesting that productive imports may strengthen industrial capacity, technological upgrading, and export competitiveness over time. However, the long-term benefits of productive imports depend substantially on the ability of domestic industries to transform imported capital goods into sustainable productivity gains and higher value-added economic activities. Similarly, external debt demonstrated a positive contribution to reserve accumulation, particularly through capital inflows and external liquidity support. Nevertheless, excessive dependence on foreign borrowing may simultaneously increase debt servicing burdens, refinancing risks, and vulnerability to global financial instability if not accompanied by stronger productive sector development and export diversification.

The findings of this study contribute to the broader literature on reserve sustainability and external sector management by demonstrating that reserve accumulation in emerging economies cannot be interpreted solely through conventional export surplus perspectives. Instead, reserve sustainability is closely associated with the structural quality of export activities, industrial transformation capacity, and the sustainability of external financing mechanisms under conditions of global economic uncertainty.

From a policy perspective, the study highlights the importance of strengthening downstream industrialization, improving foreign exchange retention mechanisms, promoting export diversification, and

reducing excessive dependence on external debt-driven reserve accumulation. Policies aimed at enhancing domestic industrial competitiveness and expanding higher value-added exports are essential for improving long-term external sector resilience in Indonesia. In addition, prudent external debt management remains important to minimize vulnerability to global monetary tightening and external financial shocks.

Nevertheless, this study has several limitations. The relatively limited number of annual observations may reduce estimation robustness, while the use of the Engle–Granger ECM framework may face econometric constraints associated with higher-order integration characteristics within macroeconomic time-series data. Furthermore, the study focuses primarily on selected external sector variables and therefore does not fully capture other potential determinants of reserve dynamics such as exchange rates, interest rates, capital flows, and monetary policy factors. Future research is therefore encouraged to apply alternative econometric approaches, broader macroeconomic indicators, and comparative cross-country analysis to provide deeper understanding regarding reserve sustainability in developing economies

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