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Research article

Asymmetric Impact of Exchange Rate and Industrial Production on Indonesian Agricultural Exports

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A B S T R A C T

The agricultural sector plays a pivotal role in the economies of agrarian nations. This study investigates the asymmetric impact of both the exchange rate and the industrial production index on Indonesian agricultural exports from January 2010 to August 2023. Employing the Non-Linear Autoregressive Distributed Lag (NARDL) model, we captured the nuanced asymmetric effects of these predictors. Our findings reveal that both positive (depreciation) and negative (appreciation) exchange rate asymmetries significantly influence agricultural exports in the long run. The exchange rate multiplier effect suggests that depreciation will lead to increased agricultural exports in the short run, partly due to future exchange rate interventions. Furthermore, a positive industrial production index consistently and significantly impacts agricultural exports in both the short and long run, demonstrating steady growth over time. These findings carry important policy implications. Policymakers should consider these findings when controlling and maintaining the exchange rate at an optimal level. Policymakers should prioritize the development and strengthening of the industrial sector to enhance agricultural export performance.

A R T I C L E I N F O

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1. INTRODUCTION

Exporting is a cornerstone of the global economy, allowing countries to sell goods and services internationally. This activity not only expands markets and boosts national income but also significantly enhances a nation's competitiveness on the world stage. Beyond simple transactions, a country's export performance is a key indicator of its economic stability, driving nations to prioritize exporting high-quality products to foster economic growth (Osama & Walid, 2018; and Eniekezimene et al., 2023). Indonesia has been a significant player in global exports, particularly within its agricultural sector. As an emerging nation, Indonesia's agricultural contributions have been vital to its economic growth, achieving a notable 13.53% increase in 2017 (Permana et al., 2022). This substantial growth has also been instrumental in creating labor-intensive jobs (Ani & Hidayah, 2023).

Figure 1 illustrates the impressive growth of agricultural exports from Indonesia, starting at 244 thousand tons in January 2010 and nearly doubling to 440 thousand tons by January 2019. Even as many sectors faced downturns during the COVID-19 pandemic, the agricultural sector demonstrated remarkable resilience, with exports climbing to 527 thousand tons and peaking at 628.32 thousand tons in August 2023. This consistent upward trend highlights the strong international demand for Indonesian agricultural commodities. Despite this positive trend, a closer examination of the data in Figure 1 reveals significant fluctuations in agricultural exports over time. Empirically, such fluctuations in the export of goods and services are often linked to exchange rates (Arize et al., 2017; and Zhu et al., 2022). An exchange rate represents the value of one country's currency in relation to another's (Iheanachor, et al., 2021), with the US dollar frequently serving as a reference. Indonesia operates under a free-floating exchange rate system, which, unlike fixed systems, does not necessitate maintaining large foreign exchange reserves. This approach has gained traction since the collapse of the Bretton Woods system (Sugiharti et al., 2020). However, the inherent sensitivity of a free-floating system often leads to frequent fluctuations in the exchange rate (Setiawan et al., 2024).

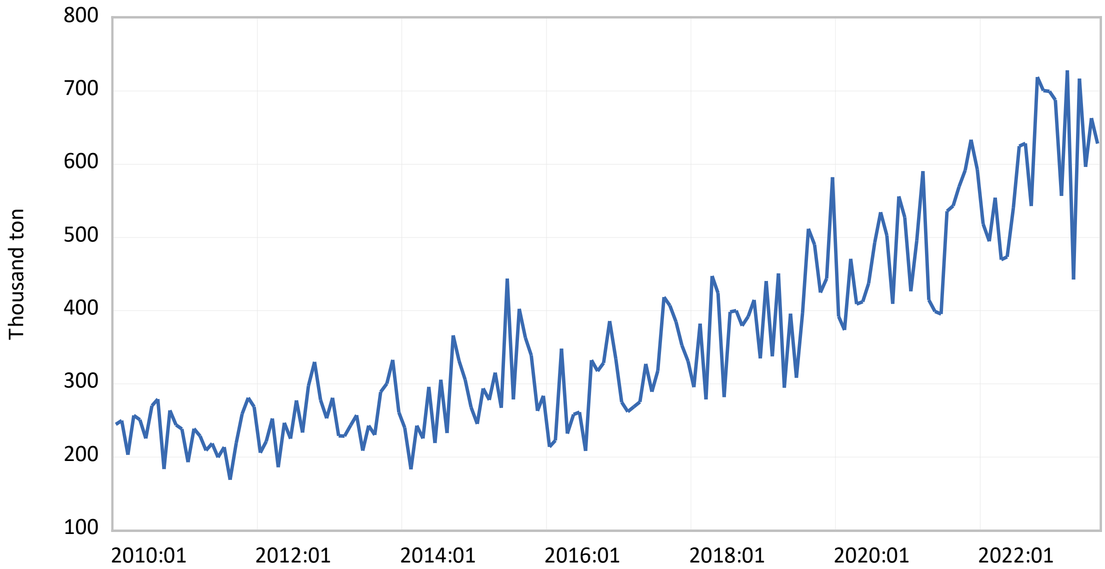

Figure 1. Indonesian Agricultural Exports for the Period January 2010 – August 2023.
Source: Bank Indonesia (2024), (Author calculation).

Figure 2 demonstrates the notable fluctuations in the rupiah's exchange rate against the US dollar. From January 2010 to June 2013, the rupiah showed relative stability, trading below IDR 10,000 per dollar. However, a significant shift occurred thereafter, with the rupiah depreciating sharply to reach IDR 16,400 per dollar by February 2020. This trend showcases two key exchange rate movements: appreciation and depreciation. A depreciating rupiah, as observed, generally benefits exports by making Indonesian commodities more competitively priced in the global market. Conversely, an appreciating exchange rate increases the cost of domestic goods, which can lead to a decrease in export volumes (Putra et al., 2021; and Setiawan et al., 2024).

Figure 2. Rupiah Exchange Rate for the Period January 2010 – August 2023.
Source: Federal Reserve Economic Data (FRED) 2024, (Author calculation).

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Beyond exchange rates, the quality of agricultural commodities profoundly impacts their success in global trade. This factor not only dictates the selling price of these products but also directly influences a country's overall competitiveness in agricultural exports (Sankaran et al., 2021). In the realm of international trade, high quality is paramount for attracting buyers and securing sustainable export opportunities (Lestari et al., 2021). Historically, countries exporting raw agricultural commodities often face lower market values compared to those exporting processed products. The challenges of exporting raw materials have grown over time, exacerbated by intensified competition among nations offering similar agricultural goods and a growing preference among importing countries for value-added products. To boost competitiveness and maximize profits, an increasing number of nations are now processing their commodities into semi-finished or finished goods (Bashir et al., 2019). For example, while crude palm oil is in high demand internationally, its value significantly increases when processed into cooking oil or other refined products. The availability of high-quality commodities is intrinsically linked to the growth of the processing industry, which plays a strategic role in adding value to products, generating employment, and facilitating the expansion of exports into wider markets (Ding et al., 2024). However, many developing countries face significant hurdles in effectively cultivating their industrial sectors, primarily due to technological challenges (Sankaran et al., 2021).

Indonesia's industrial growth has shown a significant upward trend over time, with the average industrial production index nearing 10% in recent years (see Figure 3). However, the sector faced a substantial setback during the COVID-19 pandemic, experiencing a 30% decline. This downturn was largely due to restrictions on production, widespread disruptions in supply chains, and a sharp drop in export demand from key markets. Despite these challenges, the industrial sector has demonstrated remarkable resilience during the subsequent economic recovery, highlighting its crucial role in supporting agricultural exports.

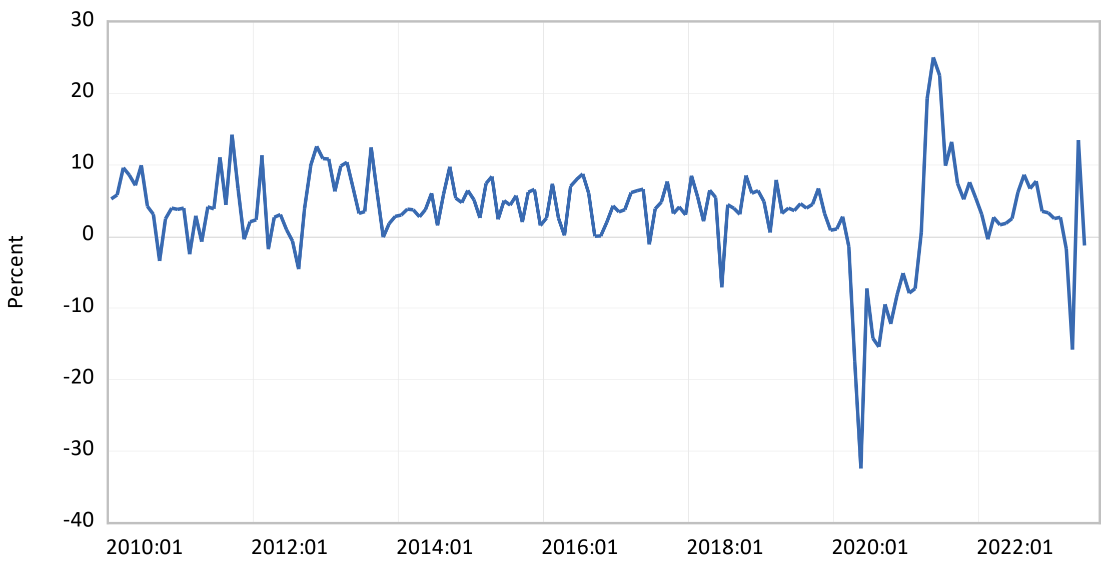

Figure 3. Industrial Production Index for the Period January 2010 – August 2023.
Source: CEIC Global Database, 2024, (Author calculation).

Numerous studies in Indonesia have investigated the complex relationship between agricultural exports, exchange rates, and the industrial sector, often yielding varied conclusions. For example, Permana et al. (2022) found that despite inherent fluctuations, the exchange rate did not significantly influence chili commodity exports in the international market. In contrast, Oktaviani & Shrestha (2021) argued that exchange rate variations could actually enhance exports and positively impact supply chains within ASEAN. However, other research presents conflicting findings. Ilmas et al. (2022) revealed that inflation and exchange rate fluctuations could hinder export performance in Indonesia. Similarly, Mehdi et al. (2025) concluded that the exchange rate had no discernible relationship with either exports or imports in Indonesia, suggesting it had no effect on international trade. Further complicating the picture, Sugiharti et al. (2020) examined five key export destination countries, discovering that the exchange rate notably influenced export increases to Japan and India, while growth in the industrial sector had a more pronounced effect on exports to China. Research by Labibah et al. (2020), utilizing the ARDL method, also indicated that the exchange rate did not significantly affect exports; instead, economic conditions in China and Japan emerged as the primary drivers for exports to these nations. Meanwhile, Setiawan et al. (2024) identified a continuous decline in agricultural exports, even when employing a non-linear approach, emphasizing that factors other than the exchange rate significantly contributed to trends in Indonesia's agricultural exports. The inconsistency across these studies highlights the need for further rigorous testing to fully understand the intricate dynamics between agricultural exports, exchange rates, and industrial growth in Indonesia.

This study aims to investigate the relationship between exchange rates and the agricultural export industry in Indonesia. We seek to address inconsistencies found in prior research and deepen our understanding of the dynamics influencing agricultural exports. The novelty of this research is threefold: first, we address an evidence gap by tackling the existing inconsistencies in findings; second, we close a methodological gap by moving beyond the predominantly linear approaches of previous studies; and third, we explore an empirical gap by examining the relationship between exchange rates and the industry within an asymmetric context, while also analyzing the multiplier effect. This approach offers a more nuanced perspective for policymakers. The study is structured as follows: the next section outlines the data and research methodology, followed by the presentation and discussion of our findings, and finally, the concluding remarks.

2. RESEARCH METHODS

This empirical study utilizes secondary data covering the period from January 2010 to August 2023, comprising 164 observations. The research data were selected based on availability. Monthly data for Indonesia were sourced from Bank Indonesia, FRED, and CEIC. Details of the variables are presented in Table 1. The study focuses on agricultural sector exports as the dependent variable, with exchange rates and industrial production index as the independent variables.

Table 1. Data and Sources

Variables	Notation	Definition	Source
Agricultural sector exports	AGRIEX	Export volume of the agricultural sector in thousand tons	Bank Indonesia (SEKI)
Exchange rate	EXR	The rupiah exchange rate against the foreign currency dollar is measured in rupiah	FRED
Industrial Production Index	IPI	Manufacturing growth y-o-y in percent	CEIC Global Database

Note: SEKI (Indonesian Economic and Financial Statistics), FRED (Federal Reserve Economic Data)

The model is formed in semi-natural logarithms. All abbreviations are shown in Table A1. The research model is structured as follows:

$$lnAGRIEX_t = \gamma_0 + \gamma_1 lnEXR_t + \gamma_2 IPI_t + \epsilon_t \quad (1)$$

To investigate the potential non-linear relationship between exchange rates and industrial production index in the case of Indonesia, we used the Non-Linear Autoregressive Distributed Lag (NARDL) method. The NARDL model is an extension of the ARDL model, as introduced by Shin et al. (2014). The ARDL model treats relationships symmetrically, allowing for the prediction of both short-run and long-run effects (Sama et al., 2025). In this model, increases and decreases in predictor coefficients are interpreted similarly for research purposes. In contrast, the NARDL model allows for asymmetric effects, meaning that the impact of predictor variables can differ. This distinction is important as it can influence policy decisions (Thampanya et al., 2021).

The NARDL model offers several advantages over other cointegration methods. First, it is more reliable than asymmetric calculations performed in Excel (Uzar & Eyuboglu, 2024). Second, this model provides clearer visual representations of asymmetries in the long run (Ngoma et al., 2024). Lastly, the error correction model derived from ARDL allows for the simultaneous assessment of short-run and long-run impacts (Truong & Van Vo, 2023). Although this model is advanced, it has specific requirements. NARDL can be used when the variables are integrated at the *I*(0) and *I*(1) levels, but not at *I*(2) (Mesagan et al., 2022; and Deng & Xu, 2024). Additionally, it is essential to conduct an asymmetric cointegration test to demonstrate its existence. Shin et al. (2014) stated that positive and negative impacts must be separated in the following form:

$$lnEXR_t = lnEXR_0 + lnEXR_t^+ + lnEXR_t^- \tag{2}$$

$$IPI_t = IPI_0 + IPI_t^+ + IPI_t^- \tag{3}$$

where, EXR_0 and IPI_0 is constant, EXR_t^+ and EXR_t^- is the partial sum of positive and negative processes in the exchange rate. IPI_t^+ and IPI_t^- is the partial sum of positive and negative processes in industrial production index. The two signs are calculated as follows:

$$lnEXR_t^+ = \sum_{j=1}^{t} \Delta lnEXR_j^+ = \sum_{j=1}^{t} \max(\Delta lnEXR_j^+, 0) \tag{4}$$

$$lnEXR_t^- = \sum_{j=1}^{t} \Delta lnEXR_j^- = \sum_{j=1}^{t} \min(\Delta lnEXR_j^-, 0) \tag{5}$$

$$IPI_t^+ = \sum_{j=1}^{t} \Delta IPI_j^+ = \sum_{j=1}^{t} \max(\Delta IPI_j^+, 0) \tag{6}$$

$$IPI_t^- = \sum_{j=1}^{t} \Delta IPI_j^- = \sum_{j=1}^{t} \min(\Delta IPI_j^-, 0) \tag{7}$$

From equation (1), it can be rewritten as follows:

$$lnAGRIEX_t = \gamma_0 + \gamma_1^+ lnEXR_t^+ + \gamma_2^- lnEXR_t^- + \gamma_3^+ IPI_t^+ + \gamma_4^- IPI_t^- + \epsilon_t \tag{8}$$

Equation (8) is reformulated with the NARDL model so that:

$$\begin{aligned}\Delta lnAGRIEX_t = {} & \beta_0 + \beta_1 lnAGRIEX_{t-1} + \beta_2 lnEXR_{t-1}^+ + \beta_3 lnEXR_{t-1}^- + \beta_4 IPI_{t-1}^+ + \beta_5 IPI_{t-1}^- + \\ & \sum_{j=1}^{p-1} \delta_1 \Delta lnAGRIEX_{t-j} + \sum_{j=0}^{q1} \delta_2 \Delta lnEXR_{t-j}^+ + \sum_{j=0}^{q2} \delta_3 \Delta lnEXR_{t-j}^- + \\ & \sum_{j=0}^{q3} \delta_4 \Delta IPI_{t-j}^+ + \sum_{j=0}^{q4} \delta_5 \Delta IPI_{t-j}^- + \epsilon_t\end{aligned} \tag{9}$$

where, p,q (1,2,3,4) is the lag operator on each variable. Determining the optimal lag is based on the Akaike Information Criteria (AIC) approach. The lag obtained in the NARDL model will vary. Unlike the VAR and VECM methods which remain optimal lag for all research variables. Determining the long-run coefficient of the EXR in the form of positive and negative is identified by calculating $\lambda_1^+ = -(\beta_2^+/\beta_1)$ and $\lambda_1^- = -(\beta_3^-/\beta_1)$. A similar calculation applies to the long-run coefficient of industrial production index (IPI), namely $\lambda_1^+ = -(\beta_4^+/\beta_1)$ and $\lambda_1^- = -(\beta_5^-/\beta_1)$.

To estimate NARDL, we follow the procedure carried out by Ha & Ngoc (2020). The empirical stages are carried out in four stages. First, equation (8) is estimated using the Ordinary Least Square (OLS method. Second, identify the bound test cointegration with the approach by Pesaran et al. (2001). Third, test the long-run asymmetry with the Wald test. The null hypothesis of the long-run asymmetry test is H_0: H_{LR}: $\lambda_1^+ = \lambda_1^-$, while the alternative hypothesis H_1: H_{LR}: $\lambda_1^+ \neq \lambda_1^-$. Short-run asymmetry is formed by the null hypothesis with H_0: H_{SR}: $\sum_{i=0}^{m2} \alpha_{2i}^+ = \sum_{i=0}^{m2} \alpha_{2i}^-$ and its alternative hypothesis H_0: H_{SR}: $\sum_{i=0}^{m2} \alpha_{2i}^+ \neq \sum_{i=0}^{m2} \alpha_{2i}^-$. Fourth, we test the asymmetric cumulative dynamic multiplier effect of Banerjee et al. (1996) for each EXR_t^+, EXR_t^-, IPI_t^+, and IPI_t^- on $h = 0, 1, 2, \ldots$.

With the note that $h \rightarrow \infty$ so that $m_h^+ \rightarrow \lambda_1^+, m_h^- \rightarrow \lambda_1^-$. This explains the fluctuating response of the positive and negative asymmetry of the independent variable to the dependent variable (Kriskkumar et al., 2022). It is also possible to see a constant dynamic change from the initial equilibrium point to the new adjustment point (Xu et al., 2022). The NARDL uses OLS estimation so that a number of diagnostic tests are needed, such as tested are normality, autocorrelation, heteroscedasticity, and model misspecification. In addition to diagnostic tests, researchers apply model stability tests with cumulative sum of recursive residuals (CUSUM) and cumulative sum of square recursive residuals (CUSUMSQ). This test follows the application of previous studies such as Shahbaz (2013); Ahmad et al. (2022); Nusair & Olson (2021); Xu et al. (2022); Jung et al. (2020); and Ha & Ngoc (2020). The steps for analyzing the NARDL model are presented in Figure A1.

3. RESULTS AND DISCUSSION

3.1. Results

Table 2 presents the descriptive statistics for the variables examined in this study. The average agricultural sector export was found to be 10.678, while the exchange rate averaged 9.361, and the IPI stood at 4.604. Notably, the standard deviation of the IPI (3.544), was considerably higher than that of agricultural sector exports (0.158) and the exchange rate (0.187), indicating greater variability in industrial production. Regarding data distribution, both agricultural sector exports and the IPI exhibited a normal distribution, whereas the exchange rate is not normally distributed.

Table 2. The Results of Descriptive Statistics

Variables	Mean	Std. Dev	Min	Max	JB	Prob. JB
lnAGRIEX	10.678	0.158	10.325	11.059	2.35	0.308
lnEXR	9.361	0.187	9.048	9.630	14.31	0.000
IPI	4.604	3.544	-7.121	14.260	3.40	0.182

To avoid spurious regression, we conducted a stationarity test on our variables using the DF-GLS method. Time series data frequently exhibit instability due to various internal and external macroeconomic shifts, including economic policies, oil price fluctuations, inflation, and natural disasters. Consequently, performing this stationarity test is crucial to ensure accurate analytical steps. A key requirement for time series models, including the Non-linear Autoregressive Distributed Lag (NARDL) model, is that the research variables should not be stationary at level *I*(2) (Meo et al., 2018). If variables are stationary at *I*(2), the resulting analysis will be flawed. Based on Table 3, our DF-GLS stationarity test results indicate that agricultural exports and exchange rates are not stationary at the level, whereas the IPI is already stationary at I(0). Therefore, we proceeded to test the first difference, or *I*(1) stage. The results confirm that both agricultural sector exports and exchange rates become stationary at *I*(1). Given this mix of integration orders, where some variables are *I*(0) and others are *I*(1), the NARDL method is appropriate and its requirements have been met, allowing us to proceed with the analysis. The optimal lag for the variables in equation (8) was determined using the Akaike information criteria (AIC) approach.

Table 3. The Results of DF-GLS Stationarity test

Variables	Level	First-Diff	Conclusion
lnAGRIEX	-1.277	-14.140***	*I*(1)
lnEXR	0.367	-10.783***	*I*(1)
IPI	-8.253***	-	*I*(0)

Note: *** means significance at the 1% level.

The next crucial step involves conducting a Bound test for cointegration, which aims to determine the long-run relationship among all variables. The null hypothesis for this test posits no cointegration, while the alternative hypothesis suggests its existence. Table 4 presents the results of our cointegration analysis. We initially performed the cointegration test using a linear method.

It's important to note that even if cointegration isn't detected in a linear model, there's still a possibility it exists within a non-linear framework.

Table 4. Results of Linear and Non-Linear Cointegration test

Model	F-Statistic	Conclusion
$lnAGRIEX = f(lnEXR, IPI)$	1.043	No cointegration
$lnAGRIEX = f(lnEXR^{+}, lnEXR^{-}, IPI^{+}, IPI^{-})$	13.28***	Cointegration

Note: *** means significance at the 1% level. Lower bound 1% (3.060) and Upper bound 1% (4.150).

In our linear model, the Bound test yielded an F-statistic of 1.403. This value falls below both the upper and lower critical bounds, leading us to accept the null hypothesis of no cointegration. Consequently, we could not proceed with a symmetric model and shifted our focus to testing the non-linear model. Remarkably, the cointegration test results for the non-linear model showed an F-statistic of 13.28. This value significantly surpasses the upper and lower critical bounds at the 1 percent level. This strong evidence allows us to reject the null hypothesis, confirming the presence of a non-linear long-run relationship among all five variables under investigation.

Table 5. Long and Short-run Non-Linear Estimation Results

Variables	Coefficient	t-stat
Long-run ($_{LR}$)		
$lnEXR^{+}$	1.684***	8.533
$lnEXR^{-}$	-0.697*	-1.873
IPI^{+}	0.015***	3.547
IPI^{-}	-0.005	-1.220
Short-run ($_{SR}$)		
Ect_{t-1}	-0.631***	-7.948
$\Delta lnEXR^{+}$	0.022	0.038
$\Delta lnEXR^{-}$	-0.071	-0.101
ΔIPI^{+}	0.009*	1.896
ΔIPI^{-}	-0.001	0.647
Asymmetric test	**Short-run**	**Long-run**
$Wald_{EXR}$	5.90**	11.14***
$Wald_{IPI}$	2.03	71.62***
Diagnose test	**Statistics**	
Normality	0.668	
Serial Correlation	0.289	
Heteroscedasticity	1.244	
Ramsey RESET	0.095	
Stability Model (CUSUM & CUSUMSQ)	Stable	

Note: The signs *, **, and *** are represented by significance levels of 10%, 5%, and 1%.

Following the stationarity and cointegration tests, we proceeded with the estimation of the NARDL model. Table 5 presents the estimated short-run and long-run coefficients. The Wald asymmetric test results are particularly insightful, indicating that the exchange rate (EXR) exhibits significant asymmetry in both the short and long run. In contrast, the IPI shows asymmetry only in the long run. Furthermore, the significance indicators reveal that positive and negative shocks have distinct effects on agricultural exports. For the long-run exchange rate estimates, a positive EXR (depreciation of the rupiah) shows a coefficient of 1.684, significant at the 1 percent level. This implies that a 1 percent depreciation of the rupiah leads to a 1.684 percent increase in agricultural exports, all else being equal. Conversely, a negative EXR (appreciation of the rupiah) has an impact of -0.697, significant at the 10 percent level, meaning a 1 percent appreciation of the rupiah causes a 0.697 percent decrease in agricultural exports, ceteris paribus. Regarding the IPI, the long-run estimate for a positive IPI is 0.015, which significantly affects agricultural exports. Specifically, a 1 percent increase in positive IPI in the long run leads to a 0.0015 percent increase in agricultural exports, assuming ceteris paribus. In the short run, the IPI also has a positive effect, with a coefficient of 0.009 and a 10 percent significance level. Notably, a negative IPI (decline in industrial production) does not have a significant impact on agricultural exports in either the short or long run. Finally, the error correction term (ECT) is -0.631 and is statistically significant at the 1 percent level. The negative sign of the ECT indicates a convergence mechanism, implying that any short-run deviations from the long-run equilibrium will adjust at a rate of 63.1 percent over the subsequent year.

We performed a series of diagnostic tests to ensure the validity of our research model, with the results detailed in Table 5. We used the Jarque-Bera (JB) test to assess the normality of the residuals and the Ramsey RESET test to examine the functional form of the model. To detect any autocorrelation issues, we applied the Lagrange Multiplier (LM) test, and for heteroscedasticity concerns, we utilized the Breusch-Pagan-Godfrey (BPG) test. Crucially, the results from each of these tests were found to be insignificant, meaning we accepted their respective null hypotheses. This confirms that our research model is free from classical violation problems, such as non-normal residuals, incorrect functional form, autocorrelation, and heteroscedasticity. Furthermore, the CUSUM and CUSUMSQ tests for the NARDL model, illustrated in Figure 4, show that the blue line consistently stays within the red boundaries. This visual confirmation indicates that the model's coefficient estimates are stable in the long run, adding further confidence in our findings.

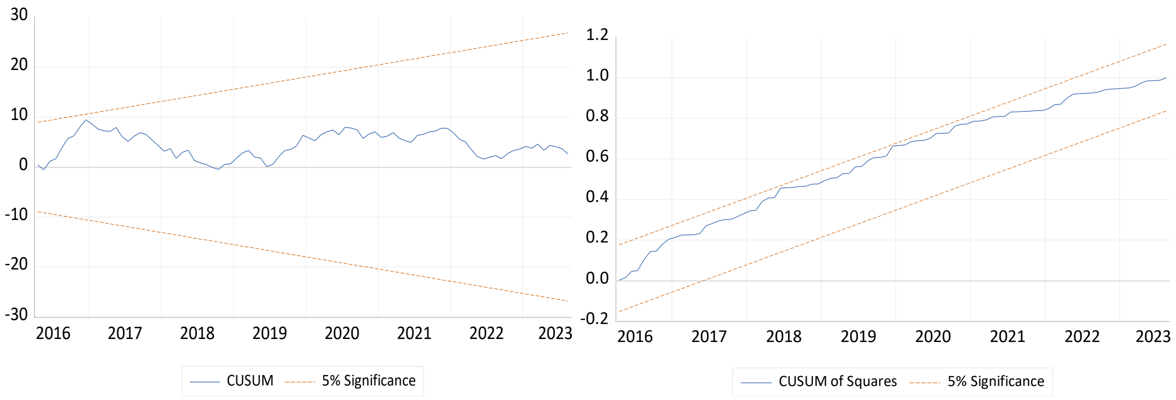

Figure 4. The Results of CUSUM and CUSUMSQ test

Finally, our analysis of the dynamic multiplier adjustment on agricultural exports reveals a new equilibrium influenced by both the positive and negative impacts of the exchange rate and the industrial production index. Figure 6 visually represents these dynamic multiplier effects: the solid black line denotes the positive effect, the dashed black line illustrates the negative effect, and the dashed red line depicts the asymmetric effect.

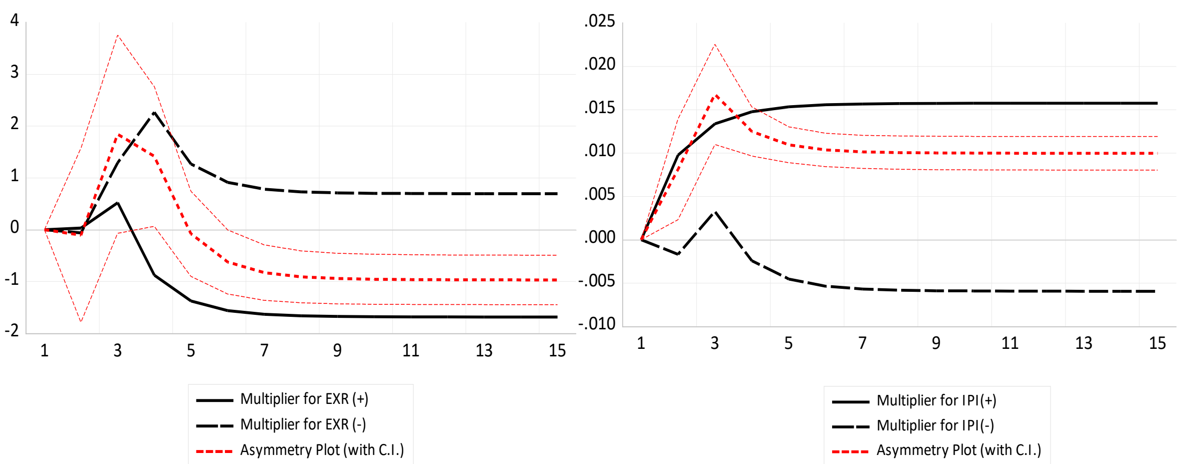

Figure 5. Cumulative Effect of EXR on AGRIEX and Cumulative Effect of IPI on AGRIEX on AGRIEX

Figure 5 specifically highlights that the asymmetric shock of the exchange rate on agricultural exports emerges between horizons 2 and 3. Positive shocks (depreciation) are most pronounced from horizons 4 to 5 and begin to stabilize from horizon 7 onward. Conversely, negative shocks (appreciation) occur at horizon 4 and also stabilize from horizon 7 onward. This suggests that changes in the exchange rate have an immediate impact on agricultural exports, with the potential for continued export growth stemming from rupiah depreciation, which remains volatile in the long run. The observed asymmetry tends to lean towards a negative value, implying that the exchange rate will likely need to be managed within specific parameters to maintain stability in agricultural exports. In contrast to the exchange rate's multiplier effect, the impact of the IPI on agricultural exports, as illustrated in Figure 6, presents a different dynamic. Positive IPI shocks demonstrate an exponential growth rate from horizon 1 to horizon 5, subsequently stabilizing at a level below 1 percent. Conversely, negative IPI effects exhibit volatility from horizon 1 to horizon 3 before stabilizing thereafter. This pattern suggests that positive shocks from the IPI have a more substantial impact on agricultural exports, as evidenced by the asymmetric line consistently remaining in the positive range. Therefore, it is predicted that consistent positive growth in the IPI will lead to increased agricultural exports in both the short and long run.

3.2 Discussion

Over the long run, a positive exchange rate shock, indicating a depreciation of the rupiah, significantly boosts agricultural exports, leading to an increase of 1.68 percent. This suggests that Indonesian agricultural commodities become more competitively priced in the international market, driving increased demand from foreign buyers. This finding aligns with research by Khaligi & Fadaei (2015); and Zhu et al. (2022), both of whom identified a positive correlation between currency depreciation and increased exports. However, it contrasts with the study by Fadillah et al. (2022). Conversely, an appreciation of the rupiah—represented by a negative exchange rate shock—leads to a 0.69 percent decline in agricultural exports. This indicates that a stronger rupiah makes domestic agricultural products relatively more expensive for international buyers, diminishing the competitiveness of Indonesian exports in the global market. A comparison of these two impacts reveals that the effects of rupiah depreciation on exports are more pronounced than the effects of rupiah appreciation on reducing exports. This disparity may suggest that Indonesian agricultural products possess a high degree of export elasticity, where price changes resulting from depreciation are more readily absorbed by the international market than by the domestic one (Putra et al., 2021).

According to Ürkmez & Bölükbaşı (2021), marketing certainty is crucial for producers of high-quality goods. In this regard, exports serve as a vital mechanism, enabling producers to maintain stability in domestic prices. When agricultural production surpasses domestic demand, exporting provides an effective solution by redirecting surplus goods into the global market. This alleviates pressure on local prices, allowing producers to operate with more predictable profit margins and ultimately supporting the long-term sustainability of the agricultural sector (Ikenna et al., 2023). However, it is important to recognize that the effects of currency depreciation on exports are not permanent. Initially, a depreciation of the rupiah can indeed raise the foreign exchange rate and stimulate exports (Khaligi & Fadaei, 2015). Yet, prolonged depreciation can have detrimental impacts on other economic sectors. For example, the increasing costs of importing raw materials and agricultural equipment can reduce profit margins for producers who rely on foreign inputs. As illustrated in Figure 6, the most pronounced effects of depreciation on agricultural exports are observed within the initial 3 to 5 months. Beyond this period, stabilization measures become essential to prevent potentially damaging economic imbalances.

An intriguing aspect to consider is that fluctuations in the exchange rate do not have an immediate impact on agricultural exports in the short run. This delay may stem from the fact that agricultural commodity prices do not adjust instantly in response to exchange rate changes; such adjustments require time (Hatzenbuehler et al., 2016). Furthermore, agricultural exports typically operate within a framework of international cooperation that involves pre-established pricing. This allows prices to align before any alterations in export volumes occur. This observation aligns with the exchange rate multiplier effect illustrated in Figure 6, where agricultural exports demonstrate minimal response during the first and second periods.

This study revealed that only a positive IPI significantly influences the increase in agricultural exports, both in the short and long run. These findings align with those of Labibah et al. (2020) and Sugiharti et al. (2020), while differing from the results presented by Pradina & Adhitya (2023). Industrial development serves as a crucial indicator in fostering growth within the agricultural sector, particularly in enhancing the added value of agricultural products. According to Ding et al. (2024), the expansion of the industrial sector enhances the processing capacity of agricultural products, transforming raw materials into semi-finished and finished goods. This transformation yields significant advantages for exports, as processed goods typically command a higher selling price and are more readily accepted in international markets. Supporting this notion, research indicates that exports of processed agricultural commodities rise in tandem with the growth of the industrial sector (Sugiharti et al., 2020). As the number of industrial facilities dedicated to processing agricultural products increases, the quality and diversification of export offerings also expand, thereby bolstering the competitiveness of Indonesian exports in the global marketplace.

The influence of the IPI on agricultural exports is less pronounced than that of the exchange rate, its positive impact is notably more consistent and sustainable over the long run, as illustrated in Figure 6. This suggests that the sustainability of the domestic industry plays a crucial role in supporting the growth of agricultural exports, even if the effects are not immediately apparent. A robust industrial sector can reinforce the agricultural supply chain and create opportunities for agribusiness stakeholders to enhance the quality of exported products (Elfira et al., 2022). Conversely, the stagnation of the industrial sector has been found to have an insignificant negative effect on agricultural exports. In other words, limited growth in the industrial sector does not necessarily lead to a decline in the value of agricultural exports. Several factors may contribute to this phenomenon. First, many agricultural commodities do not rely heavily on industrial processing, as most products can still be marketed in their raw forms (Tulasombat & Ratanakomut, 2015). Second, stable global demand for certain agricultural commodities allows exports to persist, even in the absence of optimal industrial sector support (Thorbecke & Sengonul, 2023). Therefore, while industrial growth can certainly expedite the expansion of processed agricultural product exports, agricultural exports can still be sustained despite stagnation in the industrial sector.

4. CONCLUSIONS

This study concludes that both the exchange rate and the industrial production index have an asymmetric impact on agricultural exports in Indonesia. Specifically, agricultural exports increase when the exchange rate depreciates in the long run, while industrial growth contributes positively in both the short and long run. Conversely, when the exchange rate appreciates, agricultural exports experience a significant decline, though this decline is not as substantial as the increase caused by depreciation. Interestingly, the surge in agricultural exports resulting from exchange rate depreciation is temporary and tends to decline gradually over the long run. This contrasts with the industrial multiplier effect, which exhibits a more consistent increasing trend over time. The asymmetric estimates offer important insights for policy formulation. First, the depreciation of the rupiah exchange rate can provide a positive stimulus for the agricultural sector, thereby benefiting the national economy and global trade. However, continuous depreciation signals risks to other sectors. Therefore, Bank Indonesia, as the monetary policy maker, needs to maintain exchange rate stability and intervene when the exchange rate experiences sharp depreciation. Second, industry plays a crucial role in supporting the agricultural sector and enhancing the quality and competitiveness of agricultural products. The government should encourage industrialization in Indonesia by building adequate infrastructure and providing incentives for the development of the agro-industry. This will foster a mutually supportive ecosystem between the industrial and agricultural sectors, driving sustainable export growth.

This study examined the interplay between the exchange rate, industrial production index, and agricultural exports from an asymmetric perspective. Future research could expand upon this analysis by focusing on specific agricultural commodities or sub-sectors to gain more granular insights. Additionally, incorporating more recent data and employing causality methods would be beneficial to determine the causal relationships or threshold effects of exchange rate pressures, which could help establish criteria for optimizing agricultural exports. Further research could also explore the impact of exchange rates on the destination countries of exports, providing a more comprehensive analysis of the global trade dynamics.

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Appendix

Table A1. Abbreviations and acronyms

Abbreviation	Full Form
EXR	Exchange rate
IPI	Industrial Production Index
AGRIEX	Agricultural sector exports
EXR+	Partial sum of positive change in EXR
EXR-	Partial sum of negative change in EXR
IPI+	Partial sum of positive change in IPI
IPI-	Partial sum of negative change in IPI
OLS	Ordinary Least Square
ARDL	Auto Regressive Distributed Lag
NARDL	Non-Linear Auto Regressive Distributed Lag
CUSUM	Cumulative Sum
CUSUMSQ	Cumulative Sum of Squares
DF-GLS	Dickey-Fuller Generalized Least Squares
ECT	Error Correction Term
JB	Jarque–Bera
AIC	Akaike Information Criteria
VAR	Vector Autoregressive
VECM	Vector Error Correction Models
BPG	Breusch-Pagan-Gold
LM	Lagrange Multiplier
FRED	Federal Reserve Economic Data
SEKI	Indonesian Economic and Financial Statistics

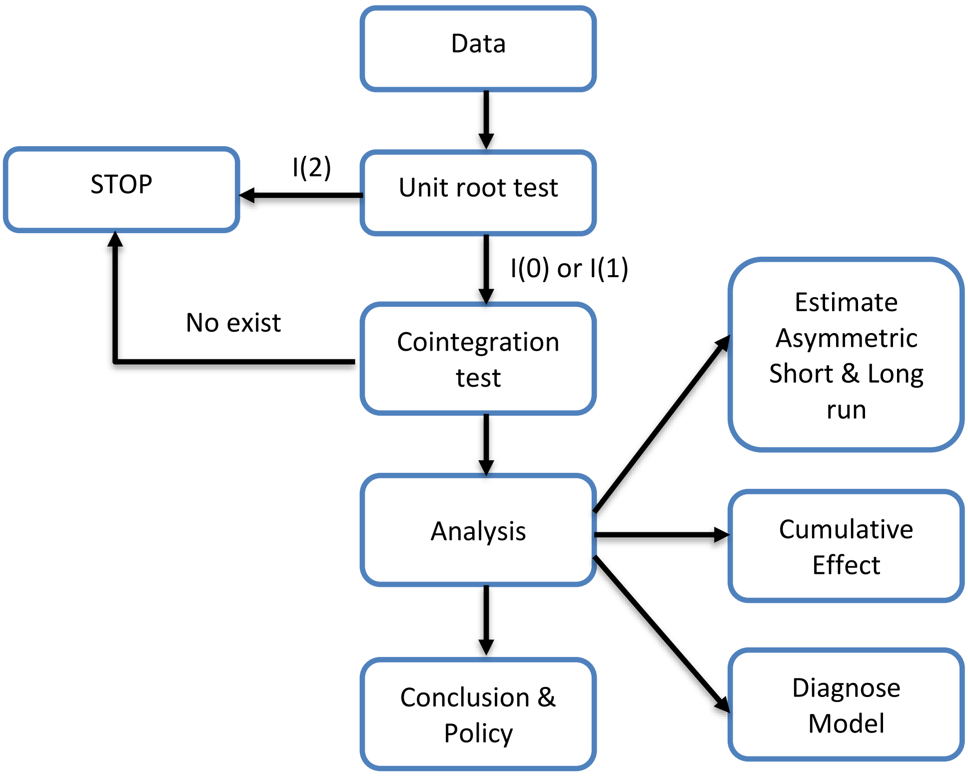

Figure A1. Framework research