Agro Bali : Agricultural Journal
Vol. 8 No. 2: 665-680, July 2025

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

Indonesia's Mangosteen Export Risk Management Strategy to China

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Article history: submitted: May 20, 2025; accepted: July 28, 2025; available online: July 30, 2025

Abstract. Indonesia is one of the leading global producers of mangosteen, with China absorbing over 70% of its export volume. Despite this, Indonesia's market share remains limited compared to its competitors, such as Thailand. This study examines the short- and long-term relationships between key macroeconomic variables—mangosteen export price (HEC), export value (NE), Yuan to USD exchange rate (NTC), Rupiah to USD exchange rate (NTI), Indonesia's real exchange rate (NTR), and export volume (VE)—and the performance of exports to China using the Vector Error Correction Model (VECM), which is appropriate for examining both long-run equilibrium (cointegration) and short-run dynamics among the macroeconomic variables. The model captures cointegration, causal interactions, impulse responses, and variance decomposition. Findings indicate that, in the long run, NTC, NTI, NTR, and VE have a significant influence on export prices, while no statistically significant short-run causality is observed. Key risks identified include exchange rate volatility, over-reliance on the Chinese market, price fluctuations, high logistics costs, and inconsistent product quality. To mitigate these issues, the study recommends exchange rate stabilization, export market diversification, investment in cold chain logistics, and the adoption of Good Agricultural Practices (GAP) with digital traceability systems. The findings support the formulation of evidence-based policies to strengthen the global competitiveness of Indonesia's horticultural exports.

Keywords: export price; mangosteen export; real exchange rate; risk management strategy; VECM

INTRODUCTION

Indonesia is one of the world's largest mangosteen-producing countries, with a total annual production exceeding 200,000 tons (Baroh, 2022). China has emerged as the dominant export destination, absorbing more than 70% of Indonesia's total mangosteen export volume. However, despite this growing dependence, Indonesia's market share in China remains relatively low compared to competitors like Thailand, suggesting unresolved competitiveness and structural challenges (Situmorang et al., 2023).

Furthermore, Indonesia's mangosteen exports to China are marked by high volatility in both volume and value. Price instability, non-tariff measures, and stringent sanitary and phytosanitary (SPS) regulations have created significant uncertainty for exporters. Baroh (2022) found that fluctuations in mangosteen prices had a negative and significant impact on export performance, indicating vulnerability to market and policy shocks from China. While several studies have explored factors influencing export performance, few have adopted a comprehensive risk-based approach that integrates both economic dynamics and external trade disruptions. This reveals a research gap in understanding how interrelated economic variables and external risks jointly affect export outcomes to China, and how these insights can inform a strategic risk management framework.

This gap underscores the need for a study that not only examines the economic relationships but also frames the findings within a risk management perspective to inform more resilient export strategies. To fill this gap, this study employs the Vector Error Correction Model (VECM), which is suitable for analysing cointegrated time series data. This method enables the examination of both long-term equilibrium and short-term causal relationships between economic variables, including export prices, trade costs, exchange rates, and volume. By identifying the underlying risks and their dynamic

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

interactions, this study aims to formulate a data-driven risk management strategy to improve the resilience and competitiveness of Indonesia's mangosteen exports to China (Rahman & Vu, 2021; Vieira & MacDonald, 2016).

METHODS

This study employs the Vector Error Correction Model (VECM) to analyze both the short-term dynamics and long-term equilibrium relationships among key economic variables that affect Indonesian mangosteen exports to China. VECM is chosen over standard VAR models because preliminary tests indicate the presence of cointegration among the non-stationary variables. Unlike VAR, VECM accounts for this cointegration through an error correction term, making it more appropriate for capturing how short-run shocks adjust toward long-run equilibrium, as suggested by Engle & Granger, (1987). The variables used in this research include mangosteen export price to China (HEC), export value of mangosteen to China (NE), Yuan to Dollar exchange rate (NTC), Rupiah to Dollar exchange rate (NTI), Indonesian real exchange rate (NTR), mangosteen export volume (VE).

The data were obtained from Indonesia's Central Bureau of Statistics (BPS), Trade Map, UN Comtrade Database, and World Bank. The data were also collected in the form of time series, quarterly from 2010 to 2024, and analyzed using the VECM model. This analysis began with stationarity and cointegration tests, followed by the estimation of short- and long-term relationships, as well as causality analysis, impulse response analysis, and variance decomposition. The steps of VECM analysis are carried out in several stages:

Stationarity Test (Unit Root Test)

Stationarity testing aims to verify that all variables analyzed have non-stationary properties at the initial level but become stationary after the first differentiation. In Equation (1), the commonly used tests are the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.

$$\Delta Y_t = \beta_0 + \beta_1 t + \emptyset Y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

Description:

Y_t : Variables used in the study HEC, log(NE), NTC, log(NTI), NTR, log VE

Johansen Cointegration Test

Equation (2) describes the cointegration used to identify long-term equilibrium relationships between variables, employing two statistical approaches: the Trace Test and the Maximum Eigenvalue Test.

$$\Delta Y_t = \prod Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \mu + \varepsilon_t \quad (2)$$

Description:

Y_t : Vector of endogenous variables, Π : αβ' is a cointegration matrix, where β denotes the long run relationship and α denotes the adjustment coefficient, Γi : Captures short-run dynamics

VECM Model Formation

The VECM model combines short-run and long-run relationships. The VECM form is described in equation (3):

$$\Delta Y_t = \alpha + \prod Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \quad (3)$$

Description:

Y_t : HEC_t, $\log(NE)_t$, NTC_t, $\log(NTI)_t$, NTR_t, $\log(VE)_t$

or in the form of equation (4), specifically for each variable (e.g., HEC as the dependent variable):

$$\Delta HEC_t = \beta_0 + \beta_1 . ECT_{t-1} + \sum_{i=1}^{k} \theta_i \Delta HEC_{t-i} + \sum_{j=1}^{k} \gamma_j \Delta \log(NE)_{t-j} + \cdots + \varepsilon_t \quad (4)$$

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

Description:
ECt_{-1} : Error correction term that shows the deviation of the cointegration result, β1: Speed of adjustment to long-run equilibrium, γj;θi : The short-term relationship between variables

Granger Causality Test

The Granger Causality test determines the direction of the causal relationship between variables. In equation (5), the Indonesian Real Exchange Rate (NTR) variable affects the mangosteen export price (HEC) variable in the short term. Granger Causality Model between NTR and HEC variables:

$$HEC_t = \alpha_0 \sum_{i=1}^{k} \alpha_1 HEC_{t-i} + \sum_{i=1}^{k} \beta_j NTR_{t-j} + \varepsilon_t \quad (5)$$

Hypothesis tested:
H_0 : $\beta_1 = \beta_2 = ... = \beta_k = 0$; NTR does not cause HEC, H_1 : At least one $\beta_j \neq 0$; NTR causes HEC

Variance Decomposition

Variance decomposition is used to determine the proportion of variation in endogenous variables that shocks from other variables in the VECM system as shown in equation (6). In general, the variance decomposition (VD) of variable yt at horizon h:

$$V\,D_{HEC}(h) = \frac{\sigma^2_{HEC} + \Psi^2_{HEC,HEC}(h) + \sigma^2_{NE} + \Psi^2_{HEC,NE}(h) + \sigma^2_{NTC} + \Psi^2_{NTC,HEC}(h)\sigma^2_{NTI} + \Psi^2_{NTI,HEC}(h) + \sigma^2_{NTR} + \Psi^2_{NTR,HEC}(h)\sigma^2_{VE} + \Psi^2_{VE,HEC}(h)}{Var(HEC_{t+h})} \quad (6)$$

Description:
$\Psi^2_{HEC,VAR}(h)$: HEC variable impulse response to shocks from VAR variables at horizon h, σ^2_{VAR}: Variance of shock on each variable (VAR = HEC, NE, NTC, NTI, NTR, VE), $Var(HEC_{t+h})$: Total variance of HEC at horizon h

Impulse Response Function (IRF)

The Impulse Response Function (IRF) describes how a unit shock to the NTI variable affects the dynamics of changes in the HEC variable at various future periods. Mathematically, the formula is shown in equation (7).

$$IRF_{HEC,NTI}(h) = \frac{\partial HEC_{t+h}}{\partial \varepsilon_{NTI,t}} \quad (7)$$

Description:
HEC_{t+h} : HEC variable value at period t+h, $\varepsilon_{NTI,t}$: One unit shock on the residuals of variable NTI at time t

The VECM model is designed not only to test the direct influence between variables but also to evaluate the stability of Indonesian mangosteen export dynamics in the face of domestic and external macroeconomic fluctuations. This method has been widely used in agricultural and horticultural commodity export research, as shown in studies by Handoyo et al. (2023) and Sugiharti et al. (2020), proving the effectiveness of VECM in identifying the effect of exchange rate volatility on export performance.

Risk Management Strategy Based on VECM Results

After the results from the aforementioned analysis are obtained, risks are identified. These risks are considered to have the capacity to exert a deleterious effect on Indonesia's mangosteen exports to China. In the risk determination process, risks are classified based on probability, impact, and risk level. Probability can be categorized into three levels: low, medium, and high. The impact is classified as low, medium, high, or extreme, while the risk level is categorized as low, medium, or high. Determining risk, probability, impact, and risk level is not solely based on VECM analysis; empirical and theoretical studies or data also inform it. Consequently, the formulation of risk management strategies is informed by empirical studies, data, and theoretical frameworks.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

RESULTS AND DISCUSSION

Johansen Cointegration Test

The root test is the first step in ensuring the validity of the VECM model estimation. The VECM model is appropriate when non-stationary variables have a cointegrating relationship (Engle & Granger, 1987). Studies conducted by Vieira & MacDonald (2016) also emphasize the importance of the unit root test to ensure that the relationship between variables is structural.

Table 1. Unit Root Test Results (Panel Unit Root Test)

Test Method	Test Statistic	Probability	Unit Root Assumption
Levin, Lin & Chu t*	-12.1966	0.0000	Common unit root process
Im, Pesaran and Shin W-stat	-14.2596	0.0000	Individual unit root process
ADF - Fisher Chi-square	163.325	0.0000	Individual unit root process
PP - Fisher Chi-square	178.515	0.0000	Individual unit root process

Source: Data processing results, 2025

Table 1 shows that the variables used in this study, namely mangosteen export price (HEC), export value (NE), Yuan to Dollar exchange rate (NTC), Rupiah to Dollar exchange rate (NTI), Indonesian real exchange rate (NTR), and export volume (VE), are non-stationary at the level, but become stationary after the first differentiation (I(1)). This is evidenced by probability values <0.01 from various stationarity test methods such as Levin-Lin-Chu, ADF, and PP.

The cointegration test results for lag 3 (significant lag based on VAR procedure) of HEC, NE, NTC, NTI, NTR, and VE variables using trace statistics and maximum Eigenvalue statistics can be seen in Table 2 and Table 3. In Table 2, it can be seen that the results of hypothesis testing using trace statistics for the hypothesis: H0: There is no cointegration equation, the p-value is 0.00; 0.00; 0.0041; 0.0488 smaller than ∝ =5% (The value of trace statistics 149.2894 is greater than the value of 95.75366 table at∝ =5%; The trace statistical value 99.7815 is greater than the value 69.81889 table at∝ =5%; The trace statistical value 58.06906 is greater than the value 47.85613 table at ∝ =5%; The trace statistical value 29.88601 is greater than the value 29.79707 table at ∝ =5%). This means that the hypothesis H0 is rejected. Thus, it can be concluded that there is a cointegrating equation. For this reason, the following hypothesis is examined.

Based on Table 2, the following hypothesis test results will be examined:
H_0 : There is co-integration equation and
H_0 : There are 3 co-integration equations
In Table 2, the p-values for each hypothesis are 0.1373 and 0.1262, greater than ∝=5%, respectively (the trace statistic is greater than its critical value when ∝ =5% for each hypothesis). This implies that H0 is accepted. Thus, based on the analysis, it can be concluded that the cointegration test results using trace statistics indicate that at least three cointegrating equations can be formed.

Table 2. Cointegration Test (Trace)

Hypothesized Number of CE(s)	Trace Statistic	Critical Value (5%)	p-value
None	149.2894	95.75366	0.00
At most 1	99.7815	69.81889	0.00
At most 2	58.06906	47.85613	0.0041
At most 3	29.88601	29.79707	0.0488
At most 4	12.4335	15.49471	0.1373
At most 5	2.338584	3.841465	0.1262

Source: Data processing results, 2025

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

Table 3. Cointegration test (maximum eigenvalue)

Hypothesized Number of CE(s)	Eigen Value	Max-Eigen Statistic	Critical Value (5%)	p-value
None	149.2894	49.54123	40.07757	0.0033
At most 1	99.7815	41.67909	33.87687	0.0048
At most 2	58.06906	28.18305	27.58434	0.0419
At most 3	29.88601	17.45251	21.13162	0.1517
At most 4	12.4335	10.9491	14.2646	0.2508
At most 5	2.338584	2.338584	3.841465	0.1262

Source: Data processing results, 2025

In Table 3, we can see the results of hypothesis testing using the maximum Eigenvalue statistics, namely the p-value of trace statistics for each hypothesis:

Ho: There is no cointegration equation; H0: There is one cointegration equation and H0: There are two cointegration equations, respectively 0.0033; 0.0048; and 0.0419 are smaller than the critical value when $\propto$ =5% for each hypothesis. This implies that each hypothesis is accepted. Thus, the conclusion obtained from the hypothesis test based on the maximum Eigenvalue is that a cointegration equation exists.

Model Estimation and Examination

An important procedure in estimating the VECM equation is the selection of the optimum lag. The optimum lag selection procedure in VECM can use information criteria, namely AIC and SC. The results of data processing on both information for lags 1 to 6 can be seen in Table 4; please note that the use of lags 1 to 6 is due to the principle of parsimony (model simplicity) in statistical modelling, because the more lags used, the more coefficients of the model parameters.

Table 4. Information criteria

Lag	AIC	SC
1	6.326525	6.917633
2	5.537654	6.128762
3	0.240407	0.831515
4	-4.118206	-3.527098
5	3.975580	4.566688
6	5.658486	6.249594

Source: Data processing results, 2025

Table 5. VECM Estimation Model

Variable	Coefficient	Standard Error	t-statistic
D(HEC)	1.0000	-	-
D(LOG(NE))	0.644789	0.74203	0.86896
D(NTC)	36.7134	6.74574	5.44246
D(LOG(NTI))	-266.1692	51.4083	-5.17755
D(NTR)	-4.837239	0.59161	-8.17633
D(LOG(VE))	1.3394	0.80949	1.65461

Source: Data processing results, 2025

Table 4 shows that lag 3 has the smallest AIC value, while lag 4 has the smallest SC value. Thus, Lag 3 and Lag 4 will be used for the VECM parameter estimation process. Based on the optimum lag analysis results, the estimated VECM equation forms are

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

VECM (3) and VECM (4), each with one cointegration equation. Then, a model check is performed to select the best VECM model.

The estimation results in Table 5 show that NTC, NTI, and NTR have statistically significant coefficients at the 5% level ($p < 0.05$), indicating a robust long-term relationship with mangosteen export prices. The long-term significance of NTI, NTC, and NTR confirms the first research question regarding the structural influence of macroeconomic variables on mangosteen export prices.In contrast, the coefficient of export value (NE) and export volume (VE) are not statistically significant, which may suggest that price fluctuations are not directly driven by value or quantity exported, but rather by macroeconomic exchange dynamics. This finding aligns with research by Vieira & MacDonald (2016), which found that exchange rate fluctuations directly influence export performance in the long run through the price mechanism.

Generally, the Yuan exchange rate (NTC) has a positive relationship with the export price of mangosteen, indicating that when the Yuan exchange rate strengthens against the dollar, the export price of mangosteen from Indonesia also tends to increase. This is possible due to the increasing purchasing power of the Chinese people towards imported products, including mangosteen fruit (Situmorang et al., 2023). In contrast, the Rupiah's exchange rate against the Dollar (NTI) significantly affects export prices. A weakening Rupiah against the dollar may cause mangosteen export prices to decline in the long run, possibly because production costs in foreign currency become cheaper, allowing exporters to offer lower prices. Handoyo et al., (2023) showed that domestic exchange rate depreciation significantly impacts the selling price of export commodities. A similar pattern is also seen in Indonesia's real exchange rate (NTR), which negatively influences export prices, reflecting the sensitivity of price competitiveness to macroeconomic fluctuations (Sugiharti et al., 2020).

Thus, the form of the VECM equation based on Table 5, namely:

$$D(HEC)_t = 0.144846\ CointEq1_{t-1} - 1.125906\ D(HEC_{t-1}) - 0.296530\ D(HEC_{t-2}) + 0.499607\ D(LOG(N1E_{t-1})) - 0.467630\ D(LOG(NE_{t-2})) - 6.889535\ D(NTC_{t-1}) - 8.725567\ D(NTC_{t-2}) + 68.72843\ D(LOG(NTI_{t-1})) + 61.48456\ D(LOG(NTI_{t-2})) + 0.087237\ D(NTRt-1) + 0.320281\ D(NTR_{t-2}) - 0.646469\ D(LOG(VE_{t-1})) + 0.671910\ D(LOG(V_{Et-2})) + 0.133128 \quad (8)$$

The estimation results in equation (8) show that the export price variable (HEC) is highly sensitive to exchange rate fluctuations and export volume, indicating that changes in these two factors play a significant role in determining the dynamics of Indonesian mangosteen export prices. Equation (8) shows that the VECM for changes in mangosteen export prices (D(HEC)) reflects the short-term adjustment mechanism to long-run disequilibrium, as indicated by the positive coefficient in the error correction term (CointEq1). The exchange rate of the Rupiah against the Dollar (NTI), which has a positive impact on HEC, supports the theory of price competitiveness. This theory posits that the depreciation of the domestic currency increases export competitiveness by raising the exchange rate, thereby benefiting exporters.

Granger Causality Analysis

As shown in Table 6, most causal relationships are statistically significant at the 5% level ($p < 0.05$), such as NTI → NE and NTR → NTI. However, the Granger causality from HEC to other variables and vice versa is not statistically significant ($p > 0.05$), suggesting that, in the short-term, export prices are likely influenced by exogenous shocks, such as trade regulations or seasonal factors, rather than by the modelled variables. The absence of a short-run causal link between HEC and VE, as indicated by the Granger causality test ($p > 0.05$), shows that export price changes do not statistically affect export volume in the short term. This indicates that the dynamics of export prices

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

may be more influenced by other structural and external factors, such as logistics costs and bilateral trade policies, as suggested by Situmorang et al., (2023).

Table 6. Short-Term Granger Causality Relationship

Causality Relationship	F-statistic	p-value	Interpretation
NE - NTC	3.57638	0.0239	NE causes a change in NTC value
NTI - NE	3.24372	0.0339	NTI affects NE value
NTI - NTC	2.88820	0.0497	NTI affects the value of NTC
NTR - NTI	3.28097	0.0325	NTR affects the value of NTI

Source: Data processing results, 2025

The causality test results in Table 6 show several significant causal relationships at the 5% significance level. First, the nominal exchange rate of the Rupiah against the US Dollar (NTI) is statistically proven to affect the export value of mangosteen (NE) with a p-value = 0.0339. This finding is in line with the results of research by Handoyo et al. (2023), which showed that the depreciation of the domestic exchange rate increases the competitiveness of Indonesian horticultural export products, including mangosteen, because the price of the product becomes relatively cheaper in the destination market. Exchange rate fluctuations can affect Indonesia's export performance (Juliansyah et al., 2022).

The export value variable (NE) influences the Yuan to Dollar exchange rate (NTC) with a p-value of 0.0239. This result shows that the dynamics of Indonesian exports can contribute to the movement of the Yuan exchange rate in the context of bilateral trade. Third, there is also a causal relationship between the real exchange rate of the Rupiah (NTR) and the exchange rate of the Rupiah against the Dollar (NTI), with a p-value of 0.0325, which strengthens the evidence that real exchange rate pressures also affect the nominal stability of the Rupiah.

In contrast, export volume (VE) does not show any causal relationship with other variables, either as cause or effect. This suggests that in the short run, export volume is more influenced by structural factors such as global demand, logistics infrastructure, or trade agreements, which may not be directly reflected in the short-run model based on quarterly data.

Forecasting and Structural Analysis

Impulse–Response Analysis

Based on the impulse response function (IRF) data processing results, Indonesia's mangosteen export price (HEC) is most influenced by itself. In the first period, the response reaches the highest value of 3.687, then decreases gradually but remains relatively high until the 10th period (1.577). The IRF results indicate that NTI has no statistically significant effect on HEC over the forecast horizon. This is likely due to the stabilising influence of government intervention and hedging practices, which buffer short-term exchange rate volatility.

In Table 7, mangosteen's export price does not significantly impact the export value (LOG(NE)). The effect tends to be negative, as seen in the fifth period, with a value of -0.074. This shows that the competitiveness of Indonesian mangosteen in the Chinese market is still weak compared to Thailand, which controls most of the market share (Situmorang et al., 2023). A price increase can reduce this competitiveness, hindering the increase in export value.

In contrast, the export value of mangosteen (LOG(NE)) shows a powerful effect on itself, with a response of 2.131 in the first period. In addition, LOG(NE) also has a strong positive influence on export volume (LOG(VE)), reaching a value of 1.504 in the sixth period. This is in line with Ganda Sukmaya et al. (2022) findings, stating that

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

the tropical fruit group, including mangosteen, has a significant export contribution to the Chinese market, and the increase in export value is closely related to the actual export volume shipped.

For the mangosteen commodity exchange rate (NTC), the highest response also comes from itself, which is 0.234 in the first period. The value tends to be stable until the 10th period. This suggests that fluctuations in the exchange rate of mangosteen commodities are relatively unaffected by export prices or values but rather reflect the stability of the horticultural sector's exchange rate system.

Table 7. Impulse Response Function (IRF)

Response Variable	Main Influence Source Variable	Highest Response Value	Period	General Response Pattern
HEC	HEC	3.687	1	Decrease slowly to 1.577 in period 10
LOG(NE)	LOG(NE)	2.131	1	Fluctuating, negative influence of HEC
LOG(VE)	LOG(NE)	1.054	6	Positive and strong
NTC	NTC	0.234	1	Stable and consistent
NTR	LOG(NE)	1.862	4	Strengthened sharply in the middle period
LOG(NTI)	Not Significant (Stable)	0.0020	1	Very slow stable (0.018 – 0.020)

Source: Data processing results, 2025

Interestingly, Indonesia's real exchange rate (NTR) strongly responded to the value of mangosteen exports. The highest response occurred in the fourth period, with a value of 1.862 due to LOG(NE). This finding strengthens the results of the study by Sayekti et al. (2023), which states that mangosteen exports not only play an important role in increasing farmers' income but also contribute to strengthening macroeconomic indicators such as Indonesia's real exchange rate through the growth of the non-oil and gas export sector.

In contrast, the import exchange rate (LOG(NTI)) appears very stable, with small changes in value ranging from 0.018 to 0.020. Other variables have almost no significant effect on LOG(NTI), which suggests that the import exchange rate is determined more by external factors such as global trade policies and international market prices rather than by the dynamics of mangosteen exports.

Variance Decomposition

The results of the *variance decomposition* analysis reveal the existence of dynamic interactions between variables in the constructed economic system. The Real Exchange Rate (NTR) variable in the early period is fully explained by itself, indicating no external influence. However, in the following period, the contribution of the logarithm of Export Value (LOG(NE)) increased significantly to more than 27% in the 10th period. This reflects that in the medium to long term, the stability of the real exchange rate is determined mainly by the performance of national exports. This finding is reinforced by a study by Juliansyah et al. (2022), which shows that exports have a long-term influence on Indonesia's economic growth through the VECM approach.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

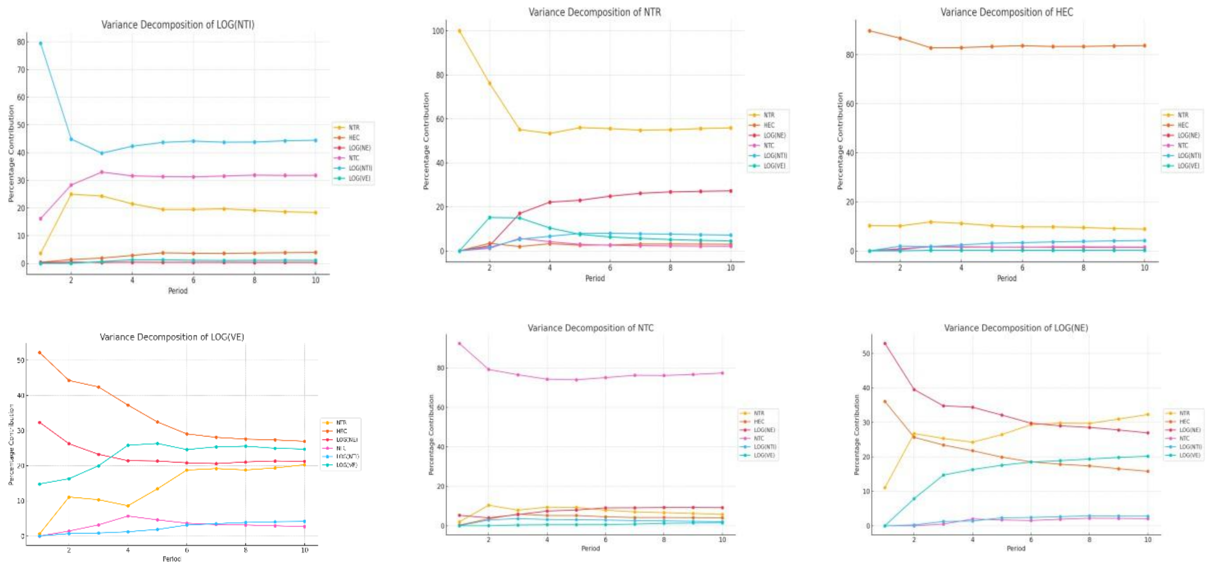

Figure 1. Variance decomposition of HEC, NTI, NE, NTC, NTR, and VE
Source: Data processing results, 2025

As shown in Figure 1, the commodity Export Price (HEC) variable shows a dominant contribution from itself above 83% throughout the observation period, indicating that export price fluctuations are endogenous. Although the exchange rate has a small contribution, it is still an important factor in shaping export price competitiveness in the global market. Therefore, exchange rate stabilization is an important policy instrument in strengthening Indonesia's export position. LOG(NE) shows high sensitivity to NTR and Export Volume (LOG(VE)), contributing 32.27% and 20.16%, respectively. This condition shows a close relationship between the real exchange rate and export performance in shaping the value of foreign trade. In addition, this result also supports the findings of Basuki & Rudiana (2024), showing that exports and exchange rates influence foreign direct investment flows, reinforcing the importance of macroeconomic stability.

The study of variance decomposition becomes significant in the context of certain commodities, one of which is mangosteen. Figure 1 also illustrates the dynamics of such inter-variable influences, which are relevant to Indonesia's position as a leading exporter of mangosteen to the Chinese market but are still less competitive than other countries, such as Thailand. Situmorang et al. (2023) noted that although Indonesia's mangosteen exports continue to increase, the national market share remains relatively small. Therefore, besides strengthening product quality, exchange rate stabilization and logistics efficiency are important prerequisites in maintaining and expanding export markets. The China Exchange Rate (NTC) variable remains dominated by internal influences (>77%) but has begun to show linkages with exports and exchange rates. Meanwhile, LOG(NTI) is influenced by both NTR and NTC, showing the complexity of the relationship between the import exchange rate and the structure of the national trade balance.

Risk Management Strategies for Indonesian Mangosteen Exports

These insights contribute to answering the next research question, which aims to identify dominant risks and recommend mitigation strategies for Indonesia's export resilience, especially under volatile exchange rate conditions and market dependency.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

Table 8. Identification and Risk Management Strategies for Indonesian Mangosteen Exports

No.	Risk	Probability	Impact	Risk Level	Risk Management Strategy
1	Real Exchange Rate (NTR)	High	High	High	Real exchange rate stabilization through monetary policy coordination and export incentives
2	Volatility of Rupiah Exchange Rate (NTI)	High	High	High	Hedging and export market diversification
3	Export Price Fluctuation (HEC)	Medium	Medium	Medium	Downstream product development to stabilize export added value
4	Export Market Dependence on China	High	High	High	Diversify export markets to South Asia, Middle East
5	Embargo or Import Ban (China Regulation)	Low	Extreme	High	Harmonization of quarantine standards and bilateral SPS agreements
6	Export Logistics Cost High	Medium	High	High	Cold chain investment and distribution chain trimming
7	Inconsistent Fruit Quality	High	High	High	Implementation of GAP standards and post-harvest training for farmers

Source: Data processing results, 2025

Real Exchange Rate (NTR) Fluctuation and Rupiah Exchange Rate Volatility (NTI)

The real exchange rate (NTR) is key to export competitiveness. The results of the VECM model analysis show that strengthening the NTR significantly reduces the export price of mangosteen (HEC). NTR fluctuations are highly likely due to their dependence on inflation, monetary policies of trading partner countries, and global exchange rate movements (IMF, 2025; Wahid & Chaidir, 2025). Table 8 also states that the impact is high because it directly affects the competitiveness of Indonesian commodities in the international market. The nominal exchange rate of the Rupiah against the US Dollar (NTI) is highly volatile, especially in unstable geopolitical and global economic situations. In this study, NTI affects export variables indirectly through perceived risk and transaction costs.

A sharp appreciation of the Rupiah causes the price of mangosteen in foreign currency to become more expensive, thereby reducing purchasing interest from partner countries such as China. Exchange rate volatility also creates uncertainty in export planning and financing, particularly for horticultural SMEs that do not have access to hedging instruments. Dependence on foreign currency-based production inputs and weak export market diversification further exacerbate this risk. To address this, strategies to strengthen export institutions through cooperatives, aggregation schemes, and business clusters continue to be

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

developed. The IMF (2023), emphasizes the need for an exchange rate stabilization mechanism integrated with trade policy to maintain the resilience of commodity exports.

Export Price Fluctuations (HEC)

The export price of mangosteen is greatly influenced by product quality, market conditions, and logistics costs. Price fluctuations reflect the weak control of producers over the international market structure. In Table 8, it is stated that the impact is moderate to high because it is directly related to export earnings. Fluctuations in mangosteen export prices are categorized as a risk with moderate probability and impact. Although they occur periodically, their effects are manageable compared to structural risks such as exchange rates or import embargoes. Mangosteen export prices fluctuate following harvest seasons and international market demand dynamics. However, the global market tends to respond to Southeast Asian supplies, especially Indonesia, Thailand, and Vietnam (FAO, 2022). Although seasonal, the effect is still manageable compared to structural risks such as exchange rates or import embargoes. Risks increase when international prices plummet during the harvest season alongside the influx of products from competing countries like Thailand and Vietnam (Baroh, 2022; Chen et al., 2023).

Price fluctuations are also not random shocks because they can still be predicted based on seasonality and harvest patterns, so exporters have the opportunity to carry out mitigation strategies. Recommended mitigation strategies include diversifying processed products (FAO, 2024), strengthening the role of aggregators or cooperatives in the absorption system during the harvest season and using forward contracts and cold chain logistics systems and storage facilities (FAO, 2022). Therefore, while the risk of price fluctuations is present regularly, its mitigation capacity and predictability make it classified as medium risk in the mangosteen export management framework.

Market Dependence of Indonesian Mangosteen Exports to the Chinese Market

Most of Indonesia's mangosteen exports are destined for the Chinese market, making the market structure highly concentrated. Based on Table 8, the probability is high due to the lack of diversification, and the impact is high because it can stop the flow of exports in the short term. High dependence on a single export market, especially China, is a structural risk with a high probability, high impact, and high-risk level in Indonesia's mangosteen exports. Based on the estimation results of the VECM model in this study, there is a significant long-term relationship between Indonesia's mangosteen export volume and demand from China, which means that any shocks from this market will directly impact total national exports. This risk is exacerbated by the fact that alternative markets in the short term cannot yet absorb the volume of exports previously destined for China.

The risk probability of Indonesian mangosteen exports to China is high because the Chinese government regularly updates quarantine and Sanitary and Phytosanitary (SPS) policies and applies strict controls on incoming food products. China applies the principle of zero tolerance to quarantine pest contamination and technical violations such as improper labelling. In recent years, there have been cases of rejections and delays in Indonesian mangosteen shipments due to quarantine pests and heavy metal findings. The high dependence on a single destination market makes Indonesia's mangosteen exports vulnerable to external shocks. The Trade and Development Report by UNCTAD (UNCTAD, 2021a) emphasizes that export market concentration is a significant structural vulnerability that developing countries face. Even in the State of Commodity Dependence (UNCTAD, 2021b).It is mentioned that countries that are overly dependent on a few destinations risk export volatility and significant losses when partner countries' trade policies change.

The recommended risk management

 e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

strategy is to diversify export markets, especially to countries with high demand for tropical fruits, such as the United Arab Emirates, India, and Malaysia. In addition, bilateral negotiations need to be conducted to harmonize SPS protocols and expand export quota agreements. In the medium term, strategies should include trade promotion in multilateral forums, strengthening the branding of Indonesian mangosteen outside the Chinese market, and developing a traceability system that meets international standards such as ASEAN Good Agricultural Practices (ASEAN GAP) and Codex Alimentarius (OECD-FAO Agricultural Outlook 2022-2031, 2022).

Embargo or Import Ban on Indonesian Mangosteen in the Chinese Market

In Table 8, an embargo or import ban by China on Indonesian mangosteen could have extreme consequences, as in 2013–2017, due to technical violations such as high heavy metal content, the discovery of mealybugs, and quarantine document non-compliance. This policy is part of implementing strict SPS standards, including maximum food contamination limits in regulation GB 2762-2012. The impact causes economic losses, damages the image of Indonesian products in the global market, and creates instability in export trade. Strengthening quality tracking systems based on digital technology such as blockchain and barcodes is very important for the government and business actors to implement to anticipate similar risks. These systems have proven effective in ensuring the quality and safety of export products. Additionally, enhancing the capacity of farmers and exporters to implement Good Agricultural Practices (GAP), along with the use of data-driven risk prediction systems, are relevant mitigation strategies (Yusianto et al., 2019).

High Logistics Costs of Indonesian Mangosteen Exports

High logistics costs, including mangosteen commodities, are a significant structural barrier to horticultural trade. This condition is caused by limited infrastructure, such as cold chain facilities and efficient distribution systems. Horticultural commodities such as mangosteen face serious challenges in the logistics chain, mainly due to the high cost of cold management, which is crucial for maintaining product freshness during distribution. Perishable and highly temperature-sensitive horticultural products require an integrated refrigeration system from the post-harvest stage to final marketing (Megersa, 2017). Unfortunately, Indonesia's logistics infrastructure, especially production centers, is still inadequate, resulting in high shipping costs for domestic and export markets (Evitha, 2018). Reliance on inter-island transportation and the lack of an efficient logistics network configuration contribute to quality losses and increase the risk of economic losses (Kailaku et al., 2022).

Logistics costs in Indonesia are the highest in the Southeast Asian region, absorbing more than 26% of Gross Domestic Product (GDP), well above competing countries such as Vietnam, Thailand, and Malaysia. These high costs are mainly due to geographical factors, long travel routes, congestion, unbalanced flow of goods, and high fuel consumption in the land transportation system (Anas et al., 2022). To overcome this, an efficient distribution strategy is needed through thoughtful route planning, such as the application of genetic algorithms and the Saving Matrix method, which has been proven to cut travel distances and reduce distribution costs by up to 45% (Asih et al., 2023; Winarno & Azahra, 2024).

The Indonesian government plays a strategic role in improving logistics efficiency by developing bonded logistics centers (PLBs) that strengthen the integration of the national cold supply chain (Handayani et al., 2018). In addition, providing export incentives to small businesses and digitizing the logistics system are expected to reduce costs and speed up the distribution process (Hidayat et al., 2017). Collaboration with the private sector, especially logistics companies and large exporters, is a key element in

Agro Bali : Agricultural Journal
Vol. 8 No. 2: 665-680, July 2025
e-ISSN 2655-853X
https://doi.org/10.37637/ab.v8i2.2418

creating efficiency through service integration and economies of scale.

Inconsistent Quality of Indonesian Mangosteen Fruit

Inconsistent mangosteen quality is one of the main export risks, as it can reduce buyer confidence and hinder market access. Inconsistencies in the size, ripeness level, and post-harvest handling of mangosteens remain a significant challenge in maintaining the quality of Indonesia's exports. These problems are generally caused by low adoption of Good Agricultural Practices (GAP) standards and limited human resource capacity, especially among farmers and exporters. Studies show that quality specifications from buyers, such as size uniformity, maturity level, and pesticide residue content, are determinants of export success; non-compliance with these standards often leads to the risk of product rejection, large price discounts, and significant economic losses in the global market (Fauziana et al., 2023; Julian & Ramdani, 2022; Sayekti et al., 2023).

Sustained GAP training has proven effective in enhancing farmers' capacity, particularly in seed selection, post-harvest handling, and quality classification for entry into premium markets (Oktafa et al., 2024). In this case, farmer groups and horticultural businesses need to strengthen export quality management by using organic materials and applying cultivation and post-harvest techniques per GAP standards (Priyono et al., 2022). On the other hand, the role of the government and export support institutions is vital in providing grading and sorting facilities at the producer level, as well as in encouraging the digitization of traceability systems to ensure quality consistency and supply chain transparency. Developing technology-based traceability systems, such as blockchain and digital sensors, has been recognized as a strategic pillar in strengthening the competitiveness and reputation of Indonesian agricultural products in the export market (Siregar et al., 2025).

CONCLUSION

In the long run, the performance of Indonesian mangosteen exports to the Chinese market is significantly influenced by macroeconomic variables such as NTC, NTI, NTR, and VE, as demonstrated by the VECM estimation and cointegration tests. In contrast, the Granger causality analysis confirms no significant short-term causal relationship, indicating that short-term price dynamics are more influenced by internal factors, including logistics costs, product quality, and supply chain efficiency. Based on these findings, policy strategies to enhance mangosteen export competitiveness should focus on stabilizing exchange rates through coordinated monetary and trade policies, diversifying export markets beyond China to reduce external risk exposure, strengthening cold chain logistics infrastructure to maintain quality, and ensuring consistent implementation of GAP standards and digital traceability technologies to meet international SPS requirements. These recommendations are directly supported by the significant long-run relationships identified in this study and align with the observed internal price volatility patterns.

This study is limited by its reliance on aggregated macro-level quarterly data and the linear assumptions inherent in the VECM framework, which may overlook firm-level and non-linear dynamics. Future research should therefore incorporate micro-level supply chain data, examine comparative competitiveness across key export destinations, and explore innovations in logistics management and certification systems to develop targeted, evidence-based interventions that enhance the resilience and competitiveness of Indonesia's mangosteen exports.

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