

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

Price Integration Analysis of Tuna in Aceh Province

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Abstract

This study aims to analyze the price integration of tuna in Aceh Province by examining the relationship among export prices, fishermen's prices, and world tuna prices. The study employed a quantitative descriptive approach using secondary time-series data covering the period from 2014 to 2023. Data were analyzed using the Vector Error Correction Model (VECM), preceded by the Augmented Dickey–Fuller (ADF) unit root test, the Johansen cointegration test, and the Granger causality test. The results indicate that export prices are cointegrated with both fishermen's prices and world tuna prices, implying the existence of long-run equilibrium relationships. The Granger causality test reveals bidirectional predictive relationships between export prices and fishermen's prices as well as between export prices and world tuna prices. Furthermore, the VECM estimation demonstrates that the three price variables are linked in the long run. However, the short-run price adjustment mechanism is not uniform, indicating that price changes at one market level are not always immediately transmitted to other market levels. These findings suggest that the tuna market in Aceh Province is connected to both domestic and international markets. Therefore, strengthening the price information system and improving coordination among stakeholders throughout the marketing chain are essential to enhance market integration.

Keywords: Price Integration; Tuna; Vector Error Correction Model (VECM)

1. INTRODUCTION

Aceh Province is one of Indonesia's regions endowed with substantial marine and fisheries resources. The province possesses approximately 295,370 km² of marine waters, comprising territorial waters, archipelagic waters, and an exclusive economic zone (PEMA, 2024). This considerable marine potential has made the fisheries sector one of the key contributors to the regional economy. Among capture fisheries commodities, tuna represents one of the most valuable species due to its high economic value. In addition to serving domestic markets, tuna has significant opportunities in international trade because global demand for this commodity remains consistently high (Ekonomi & Dan, 2019; Campling, 2012).

Tuna from Aceh Province has entered international markets in various product forms, including fresh, frozen, and processed tuna. The major export destinations include Thailand, Japan, Singapore, Malaysia, South Korea, and Hong Kong (Comtrade, 2023). Nevertheless, Aceh's tuna export volume remains relatively small compared with its production potential, indicating a considerable gap between production capacity and export realization (BPS, 2023). Beyond export volume, price plays a crucial role in tuna marketing. Price functions as a market signal that influences the decisions of business actors, exporters, and fishermen. For fishermen, tuna prices directly affect the income generated from fishing activities (Dewi Asrini, 2016; Guillen et al., 2019).

In the context of export commodities, local tuna prices cannot be separated from the dynamics of export prices and world market prices. Changes in international market prices may influence the prices received by exporters and fishermen (Pertanian, 2019). Likewise, price changes at the fishermen level may affect the availability of raw material supplies for exporters (Batubara et al.,

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

2026). Such interactions highlight the importance of market integration analysis. A market is considered integrated when price changes occurring at one market level are followed by corresponding changes at other market levels (Magfiroh et al., 2017).

Market integration serves as an important indicator for evaluating the extent of price linkages among markets. When prices at the fishermen, exporter, and world market levels move in the same direction and adjust to one another, price information is considered to be transmitted efficiently throughout the marketing system. Conversely, if price changes in one market are not fully transmitted to other markets, this indicates imperfect market integration. Such conditions may arise due to limited market information, imperfect market structures, transaction costs, distribution delays, or differences in the bargaining power of market participants (Kustiari et al., 2018; Goodwin & Piggott, 2001; Asche et al., 2007).

Based on these considerations, this study focuses on analyzing tuna price integration in Aceh Province. Specifically, the study investigates whether price integration exists between the export price of tuna from Aceh Province and the fishermen's price in Aceh Province, as well as between the export price of tuna from Aceh Province and the world tuna price. Understanding these relationships is essential for assessing the extent to which Aceh's tuna prices are integrated with both domestic and international markets.

2. METHODS

The object of this study is the tuna commodity in Aceh Province, with a particular focus on price integration among fishermen's prices in Aceh Province (HN), export prices of tuna from Aceh Province (HE), and world tuna prices (HD). The study employed a quantitative descriptive approach using annual secondary time-series data covering the period from 2014 to 2023. Annual data were selected because they represent the most consistent and comparable official data available across all variables, enabling the analysis of long-run price relationships. Export price data were obtained from UN Comtrade and Trade Map, while fishermen's price data were collected from Statistics Indonesia (BPS) and the Aceh Provincial Marine and Fisheries Agency.

To ensure comparability in the price integration analysis, all price variables were standardized according to the same commodity characteristics. The analysis was limited to yellowfin tuna (*Thunnus albacares*) in the form of frozen tuna. Export prices and world prices were calculated as annual average export prices by dividing the annual export value by the corresponding export volume using data from UN Comtrade and Trade Map. The resulting values were subsequently converted into Indonesian rupiah per kilogram (IDR/kg) using the annual average exchange rate (Tveteras et al., 2012). Meanwhile, fishermen's prices were derived from monthly average prices aggregated into annual averages. Export prices and world prices represent transactions with all export destination countries (world market), ensuring that all variables share the same data frequency, unit of measurement, and commodity characteristics.

The study employed the Vector Error Correction Model (VECM) because it is appropriate for analyzing both short-run and long-run relationships among variables that are cointegrated (Fitrianti, 2024). Prior to estimating the VECM, several preliminary tests were conducted. The Augmented Dickey-Fuller (ADF) unit root test was used to examine data stationarity (Putri & Nuryaman, 2023), the Johansen cointegration test was performed to identify the existence of long-run equilibrium relationships (Vecm-x, 2024), and the Granger causality test was applied to assess predictive relationships among the price variables (Hutagalung & Kunci, 2020). The VECM estimation was subsequently used to examine short-run dynamics and the adjustment mechanism toward long-run equilibrium. The analysis focused on two models: the relationship between export prices and fishermen's prices (HE–HN), and the relationship between export prices and world tuna prices (HE–HD).

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

3. RESULTS AND DISCUSSION

3.1 Tuna Prices

Yellowfin tuna is one of the leading capture fisheries commodities in Aceh Province, characterized by its high economic value and strong demand in both domestic and international markets. Throughout the study period, tuna production and prices exhibited considerable fluctuations. According to Aprianty (2019), these fluctuations are largely influenced by seasonal fishing patterns that affect the balance between supply and demand. During peak fishing seasons, increased landings tend to expand market supply and exert downward pressure on prices. Conversely, reduced catches during the lean fishing season decrease supply, leading to higher market prices. The trends in fishermen's prices, export prices, and world tuna prices in Aceh Province over the period 2014–2023 are presented in Figure 1.

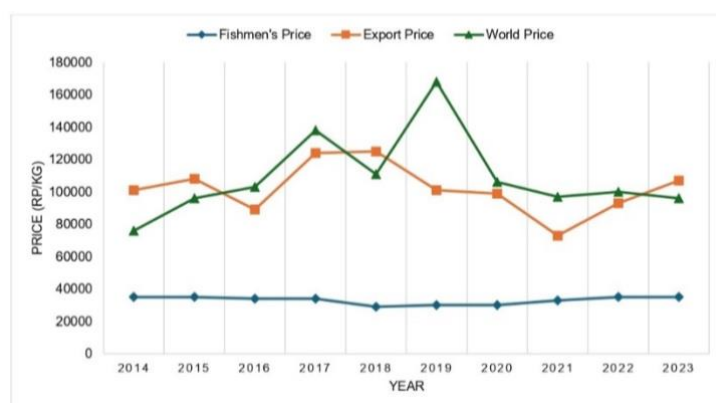


Figure 1. Trends in Fishermen's Prices, Export Prices, and World Tuna Prices, 2014–2023

Figure 1 illustrates the trends in fishermen's prices, export prices, and world tuna prices over the period 2014–2023. Overall, all three price series exhibited annual fluctuations while generally moving in the same direction, suggesting the existence of price linkages among the local, export, and international markets (Rosyid et al., 2021)

. Compared with export prices and world prices, fishermen's prices displayed relatively smaller fluctuations throughout the observation period.

Throughout the study period, fishermen's prices consistently remained lower than both export prices and world prices. This price differential reflects the value added generated along the marketing chain, whereas world prices represent the prices established in the international market (Mulazzani et al., 2023; Hospido et al., 2024).

. Price fluctuations during the study period were also influenced by both global and domestic economic conditions. The COVID-19 pandemic in 2020–2021 disrupted international trade activities, affecting the movement of tuna prices, while prices gradually stabilized during the subsequent economic recovery period. In addition, fluctuations in the exchange rate of the Indonesian rupiah against the US dollar influenced both export prices and world prices after they were converted into Indonesian rupiah.

3.2 Stationarity Test Results

The stationarity test was conducted to ensure that the time-series data used in the analysis were free from unit roots. Non-stationary data may lead to biased and spurious estimation results. Therefore, before performing the Johansen cointegration test and estimating the Vector Error Correction Model (VECM), all variables were required to satisfy the stationarity assumption.

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhishthina Atikah, Noratun Juliaviani. 2026

a. Export Prices

Dickey-Fuller test for unit root		Number of obs = 8	
----- Interpolated Dickey-Fuller -----			
Test	1% Critical	5% Critical	10% Critical
Statistic	Value	Value	Value
Z(t)	-3.162	-3.750	-2.630
MacKinnon approximate p-value for Z(t) = 0.0223			

Figure 2. Results of the Export Price Stationarity Test Using the Augmented Dickey–Fuller (ADF) Unit Root Test

The results of the stationarity test indicate that the export price series is stationary. The Augmented Dickey–Fuller (ADF) test statistic is -3.162 , which is lower than the 5% critical value of -3.000 , while the p-value is 0.0223 , which is below the 0.05 significance level. Therefore, the null hypothesis (H_0) of a unit root is rejected. These results confirm that the export price series of tuna in Aceh Province is stationary, indicating that it satisfies the stationarity requirement for subsequent cointegration and VECM analyses.

b. Fishermen's Prices

Dickey-Fuller test for unit root			Number of obs = 8	
----- Interpolated Dickey-Fuller -----				
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	
Z(t)	-3.991	-3.750	-3.000	-2.630
MacKinnon approximate p-value for Z(t) = 0.0015				

Figure 3. Results of the Fishermen's Price Stationarity Test Using the Augmented Dickey–Fuller (ADF) Unit Root Test

The stationarity test results indicate that the fishermen's price series is stationary. The Augmented Dickey–Fuller (ADF) test statistic is -3.991 , which is lower than the 1% critical value of -3.750 , while the p-value is 0.0015 , which is below the 0.05 significance level. Therefore, the null hypothesis (H_0) of a unit root is rejected. These findings confirm that the fishermen's price series for tuna in Aceh Province is stationary, indicating that it meets the stationarity requirement for subsequent cointegration and VECM analyses.

c. World Tuna Prices

Dickey-Fuller test for unit root		Number of obs = 8		
----- Interpolated Dickey-Fuller -----				
Test	1% Critical	5% Critical	10% Critical	
Statistic	Value	Value	Value	
Z(t)	-3.813	-3.750	-3.000	-2.630
MacKinnon approximate p-value for Z(t) = 0.0028				

Figure 4. Results of the World Tuna Price Stationarity Test Using the Augmented Dickey–Fuller (ADF) Unit Root Test

The stationarity test results indicate that the world tuna price series is stationary. The Augmented

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

Dickey–Fuller (ADF) test statistic is -3.813 , which is lower than the 1% critical value of -3.750 , while the p-value is 0.0028 , which is below the 0.05 significance level. Therefore, the null hypothesis (H_0), which states that the series contains a unit root, is rejected. These results confirm that the world tuna price series is stationary.

Overall, the stationarity test results for export prices, fishermen's prices, and world tuna prices demonstrate that all price variables satisfy the stationarity requirement. Consequently, the data are suitable for the subsequent stage of analysis, namely the Johansen cointegration test, to examine the existence of long-run equilibrium relationships among the variables (Bailey et al., 2016).

3.3 Cointegration Test Results

The cointegration test was conducted to examine whether long-run equilibrium relationships exist between export prices and fishermen's prices as well as between export prices and world tuna prices. In this study, cointegration was assessed using the Johansen Cointegration Test. The decision criterion was based on comparing the trace statistic with the corresponding 5% critical value. A cointegrating relationship is considered to exist when the trace statistic exceeds the critical value at the 5% significance level. The results of the Johansen cointegration test are presented below.

a. Export Prices and Fishermen's Prices

Johansen tests for cointegration					
Trend : constant			Number of obs = 7		
Lags = 2					
maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	6	-66.222392	.	228.3072	15.41
1	9	40.692173	1.00000	14.4781	3.76
2	10	47.931217	0.91046		

Figure 5. Results of the Johansen Cointegration Test for Export Prices and Fishermen's Prices

The results of the Johansen cointegration test indicate the existence of a long-run equilibrium relationship between the export price of tuna in Aceh Province and the fishermen's price. The trace statistic is 228.3072 , which exceeds the 5% critical value of 15.41 . Therefore, the null hypothesis of no cointegration is rejected, indicating that export prices and fishermen's prices are cointegrated. This finding suggests that, despite possible short-run fluctuations, the two price series tend to move together and converge toward a common long-run equilibrium over time.

b. Export Prices and World Tuna Prices

Johansen tests for cointegration					
Trend : constant			Number of obs = 7		
Lags = 2					
maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	6	-26.879463	.	218.0509	15.41
1	9	77.493208	1.00000	9.3055	3.76
2	10	82.145977	0.78795		

Figure 6. Results of the Johansen Cointegration Test for Export Prices and World Tuna Prices

The relationship between the export price of tuna in Aceh Province and the world tuna price also exhibits cointegration. The trace statistic is 218.0509 , which exceeds the 5% critical value of 15.41 . Therefore, the null hypothesis of no cointegration is rejected, indicating that export prices and world tuna prices share a long-run equilibrium relationship.

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

Table 1. Results of the Johansen Cointegration Test for Tuna Market Variables

Variable Relationship	Trace Statistic	Critical Value (5%)	Result
Export Prices and Fishermen's Prices	228.3072	15.41	Cointegrated
Export Prices and World Tuna Prices	218.0509	15.41	Cointegrated

The findings indicate that the tuna market in Aceh does not operate independently but is closely linked to both the fishermen's market and the international tuna market. The cointegration between export prices and fishermen's prices suggests that long-run changes in export prices are associated with corresponding changes in the prices received by fishermen. Conversely, fishermen's prices may also contribute to the export price formation process, as procurement prices constitute one of the key components influencing exporters' pricing decisions.

Similarly, the cointegration between export prices and world tuna prices indicates that Aceh's export prices are closely associated with international price dynamics. As an export-oriented commodity, Aceh's tuna is influenced by developments in the global market, including changes in international demand, supply conditions, and quality standards. Consequently, fluctuations in world tuna prices provide important market signals for exporters and other stakeholders in Aceh's tuna industry, supporting long-run price integration between domestic export markets and the global tuna market.

3.4 Granger Causality Test Results

The Granger causality test was conducted to determine the direction of the predictive relationships between export prices and fishermen's prices, as well as between export prices and world tuna prices. The results of the Granger causality analysis are presented below. Export Prices and Fishermen's Prices

Vector autoregression						
Number of obs = 7						
Log likelihood = . AIC = .						
FPE = -1.17e-11 HQIC = . SBIC = .						
Det(Sigma_ml) = -9.66e-14						
Equation	Parms	RMSE	R-sq	chi2	P>chi2	
HargaEkspor	5	.072513	0.9998	25763.01	0.0000	
D_HargaNelayan	5	1125.08	0.9674	178.0733	0.0000	
	Coef.	Std. Err.	z	P> z	[95% Conf.	Interval]
-----+-----						
HargaEkspor						
HargaEkspor						
L1.	.0049258	.005893	0.84	0.403	-.0066242	.0164759
L2.	-.9627857	.0132331	-72.76	0.000	-.9887221	-.9368493
HargaNelayan						
LD.	-.0010126	.0000128	-79.16	0.000	-.0010377	-.0009875
L2D.	.0009576	6.90e-06	138.85	0.000	.0009441	.0009712
_cons	11.05801	.077791	142.15	0.000	10.90554	11.21047
-----+-----						
D_HargaNelayan						
HargaEkspor						
L1.	-1057.061	91.43314	-11.56	0.000	-1236.267	-877.8556
L2.	-646.3896	205.3187	-3.15	0.002	-1048.807	-243.9723
HargaNelayan						
LD.	-.223166	.1984819	-1.12	0.261	-.6121834	.1658515

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

L2D.		.0012022	.1070072	0.01	0.991	-.208528	.2109325
_cons		9712.863	1206.972	8.05	0.000	7347.241	12078.48

. vargranger							
Granger causality Wald tests							
-----+-----							
	Equation	Excluded		chi2	df	Prob > chi2	
-----+-----							
	HargaEkspor	D.HargaNelayan		19339	2	0.000	
	HargaEkspor	ALL		19339	2	0.000	
-----+-----							
	D_HargaNelayan	HargaEkspor		168.72	2	0.000	
	D_HargaNelayan	ALL		168.72	2	0.000	
-----+-----							

Figure 7. Results of the Granger Causality Test for Export Prices and Fishermen's Prices

The results indicate the existence of a bidirectional predictive relationship between export prices and fishermen's prices. The probability values for both the relationship from fishermen's prices to export prices and from export prices to fishermen's prices are statistically significant at the 1% significance level. These findings suggest that changes in export prices in the previous period can be used to predict subsequent changes in fishermen's prices, while past changes in fishermen's prices also provide useful information for predicting future export prices. The results demonstrate a dynamic interaction between the two variables; however, the Granger causality test identifies predictive relationships rather than economic causality.

a. Export Prices and World Tuna Prices

Vector autoregression					
Number of obs = 7					
Log likelihood = 106.0644		AIC = -32.02147			
FPE = 1.83e-16		HQIC = -33.41081			
Det(Sigma_ml) = 1.52e-18		SBIC = -32.36854			
Equation	Parms	RMSE	R-sq	chi2	P>chi2
HargaEkspor	5	2.28975	0.7678	19.84345	0.0005
D_HargaDunia	5	.281243	0.9979	2915.669	0.0000

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
-----+-----					
HargaEkspor					
HargaEkspor					
L1.	-.1777126	.2273997	-0.78	0.435	-.6234079 .2679826
L2.	.5497666	.2277515	2.41	0.016	.1033819 .9961514
HargaDunia					
LD.					
L1.	-.4639102	.2306718	-2.01	0.044	-.9160186 -.0118018
L2D.	-.7862167	.2290407	-3.43	0.001	-1.235128 -.3373052
_cons	2.958913	1.865807	1.59	0.113	-.6980021 6.615828
-----+-----					
D_HargaDunia					
HargaEkspor					
L1.	-.1384857	.0279308	-4.96	0.000	-.1932291 -.0837423
L2.	1.255222	.027974	44.87	0.000	1.200394 1.31005
HargaDunia					
LD.					
L1.	-.4610436	.0283327	-16.27	0.000	-.5165747 -.4055125
L2D.	-1.090911	.0281324	-38.78	0.000	-1.146049 -1.035772
_cons	-6.726082	.2291714	-29.35	0.000	-7.17525 -6.276915

. vargranger					

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

Granger causality Wald tests					
Equation	Excluded	chi2	df	Prob > chi2	
HargaEkspor	D.HargaDunia	13.401	2	0.001	
HargaEkspor	ALL	13.401	2	0.001	
D_HargaDunia	HargaEkspor	2040.5	2	0.000	
D_HargaDunia	ALL	2040.5	2	0.000	

Figure 8. Results of the Granger Causality Test for Export Prices and World Tuna Prices

The Granger causality test also reveals a bidirectional predictive relationship between the export price of tuna in Aceh Province and the world tuna price. The results indicate that the historical values of each variable contain statistically significant information for predicting subsequent movements in the other variable within the estimated model. However, these findings should not be interpreted as evidence of direct economic causality, as world tuna prices are influenced by a wide range of global factors, while Aceh's tuna exports account for only a relatively small share of the global tuna market. Nevertheless, the observed relationship suggests that the tuna market in Aceh is integrated with international markets. World tuna prices serve as an important benchmark in the formation of export prices, particularly because tuna is a globally traded commodity.

Table 2. Results of the Granger Causality Test for Tuna Market Variables

Variable Relationship (β)	pz	Granger Causality Result
Fishermen's Prices – Export Prices	0.000***	Bidirectional predictive relationship (Export Prices $\longleftrightarrow$ Fishermen's Prices)
Export Prices - Fishermen's Prices	0.000***	
World Tuna Prices – Export Prices	0.044**	Bidirectional predictive relationship (Export Prices $\longleftrightarrow$ World Tuna Prices)
Export Prices - World Tuna Prices	0.000***	

Note: *** Significant at the 1% level; ** Significant at the 5% level.

The bidirectional Granger causality results indicate that historical values of fishermen's prices improve the prediction of export prices, while historical export prices likewise improve the prediction of fishermen's prices. These findings suggest that price information is transmitted between the two market levels; however, they should not be interpreted as evidence of a direct cause-and-effect relationship. From an economic perspective, this relationship is reasonable because exporters rely heavily on tuna supplied by fishermen. Changes in fishermen's prices affect exporters' procurement costs, whereas changes in export prices may lead exporters to adjust the purchasing prices offered to fishermen.

3.5 VECM Estimation Results for Export Prices and Fishermen's Prices

The Vector Error Correction Model (VECM) was employed to examine both the short-run and long-run relationships between the price variables. Based on the estimation results for export prices and fishermen's prices, the cointegrating equation indicates the existence of a long-run equilibrium relationship between the two variables. The VECM estimation results for export prices and fishermen's prices are presented below.

Vector error-correction model					
Number of obs = 7					
Log likelihood = 44.57462					
Det(Sigma_ml) = -1.21e-09					
AIC = -11.85821					
HQIC = -13.10861					
SBIC = -12.17057					
Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_HargaEkspor	4	.171348	0.9993	2932.667	0.0000
D2_HargaNelayan	4	2658.56	0.8140	8.752745	0.0676

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
-----+					
D_HargaEkspor					
_ce1					
L1.	-1.885552	.054544	-34.57	0.000	-1.992457 -1.778648
HargaEkspor					
LD.	.8852589	.0506561	17.48	0.000	.7859747 .984543
HargaNelayan					
LD2.	-.0009523	.0000397	-23.97	0.000	-.0010301 -.0008744
_cons	.4150656	.0750979	5.53	0.000	.2678764 .5622547
-----+					
D2_HargaNelayan					
_ce1					
L1.	-581.5586	846.2802	-0.69	0.492	-2240.237 1077.12
HargaEkspor					
LD.	-556.483	785.958	-0.71	0.479	-2096.932 983.9665
HargaNelayan					
LD2.	.0820221	.616296	0.13	0.894	-1.125896 1.28994
_cons	-.0013457	1165.186	-0.00	1.000	-2283.724 2283.721
Cointegrating equations					
Equation	Parms	chi2	P>chi2		

_ce1	1	.0001296	0.9909		

Identification: beta is exactly identified					
Johansen normalization restriction imposed					

beta	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
-----+					
_ce1					
HargaEkspor	1	.	.	.	.
HargaNelayan					
D1.	-.0000129	.0011307	-0.01	0.991	-.002229 .0022033
_cons	-5.420213	.	.	.	.

Figure 9. VECM Estimation Results for Export Prices and Fishermen's Prices

The short-run estimation results indicate that changes in fishermen's prices are negatively and significantly associated with changes in export prices. These findings suggest that short-run price dynamics at the fishermen's level are linked to changes in export prices. This relationship implies that an increase in fishermen's prices may reduce exporters' profit margins if higher procurement costs are not accompanied by a corresponding increase in export selling prices. Conversely, changes in export prices are also associated with adjustments in the prices received by fishermen. However, price adjustments across market levels do not necessarily occur completely or simultaneously, resulting in different price responses at each market level.

Table 3. VECM Estimation Results for Export Prices and Fishermen's Prices in Aceh Province

Estimated Parameter	Export Prices	Fishermen's Prices
Long-run Equilibrium	1	-0,000
Relationship (β)		
Speed of Adjustment (α)	-1,886	-581,559
Short-run Relationship (r)		
• Export Prices (t-1)	0,885	-556,483***

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

Estimated Parameter	Export Prices	Fishermen's Prices
• Fishermen's Prices _(t-1)	-0,001 ***	0,082

Note: *** Significant at $\alpha = 1\%$.

The estimation results show that the error correction term (ECT) in the export price equation is -1.886 and is statistically significant. The negative coefficient indicates that changes in export prices respond to deviations from the long-run equilibrium. The absolute value of the coefficient, which exceeds one, suggests a relatively rapid adjustment process, implying that deviations from equilibrium are corrected within one adjustment period before the system returns to its long-run equilibrium. In contrast, the error correction term in the fishermen's price equation is -581.559 , but it is not statistically significant ($p > 0.05$). This finding indicates that adjustments toward the long-run equilibrium cannot be identified through changes in fishermen's prices during the observation period.

Overall, the estimation results indicate that export prices and fishermen's prices are linked through a long-run equilibrium relationship, such that changes in one market level tend to be accompanied by price adjustments at the other market level. This finding provides evidence of long-run market integration. However, the adjustment process is neither instantaneous nor necessarily proportional, suggesting that factors beyond those included in the estimated model may also influence the price transmission mechanism.

3.6 VECM Estimation Results for Export Prices and World Tuna Prices

The VECM estimation results indicate that the export price of tuna in Aceh Province and the world tuna price share a long-run equilibrium relationship. This finding suggests that changes in international tuna prices are associated with long-run adjustments in Aceh's export prices. In the short run, however, export prices do not necessarily adjust immediately to changes in world prices within the same period. This result implies that factors not included in the estimated model, such as distribution lags and transaction costs, may also influence the short-run adjustment of export prices to world price movements (Asche et al., 2022; Natanael et al., 2023).

Vector error-correction model						
Number of obs = 7						
Log likelihood = 83.59112			AIC	= -24.86371		
Det(Sigma_ml) = 2.72e-15			HQIC	= -26.11411		
			SBIC	= -25.17607		
Equation	Parms	RMSE	R-sq	chi2	P>chi2	
D_HargaEkspor	4	3.51603	0.7130	4.969689	0.2904	
D2_HargaDunia	4	.431863	0.9968	622.2205	0.0000	
	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
-----+-----						
D_HargaEkspor						
_{ce1}						
L1.	.6398072	.6734377	0.95	0.342	-.6801064	1.959721
HargaEkspor						
LD.	-1.193534	.6861886	-1.74	0.082	-2.538439	.1513711
HargaDunia						
LD2.	.8205548	.861059	0.95	0.341	-.8670897	2.508199
_cons	-2.2481706	1.446464	-0.17	0.864	-3.083188	2.586847
-----+-----						
D2_HargaDunia						
_{ce1}						
L1.	1.272451	.0827163	15.38	0.000	1.11033	1.434572
HargaEkspor						
LD.	-1.334294	.0842825	-15.83	0.000	-1.499485	-1.169104

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

HargaDunia							
LD2.		1.095128	.1057612	10.35	0.000	.88784	1.302416
_cons		.1247839	.1776648	0.70	0.482	-.2234327	.4730005

Cointegrating equations							
Equation	Parms	chi2	P>chi2				

_ce1	1	1.340813	0.2469				

Identification: beta is exactly identified							
Johansen normalization restriction imposed							

beta		Coef.	Std. Err.	z	P> z	[95% Conf.	Interval]

_ce1							
HargaEkspor		1	.	.	.	.	.
HargaDunia							
D1.		-2.008941	1.734935	-1.16	0.247	-5.409351	1.391469
_cons		-6.068342	.	.	.	.	.

Figure 10. VECM Estimation Results for Export Prices and World Tuna Prices

The VECM estimation results indicate that the export price of tuna in Aceh Province and the world tuna price share a long-run equilibrium relationship. This finding suggests that changes in international tuna prices are associated with long-run adjustments in Aceh's export prices. In the short run, however, export prices do not necessarily adjust immediately to changes in world prices within the same period. This result implies that factors not included in the estimated model may also influence the short-run adjustment of export prices to world price movements (Meyer & von Cramon-Taubadel, 2004).

The cointegration test confirms the existence of a long-run equilibrium relationship between export prices and world tuna prices. However, the VECM estimation indicates that adjustment toward this long-run equilibrium is not significantly captured by the error correction term (ECT) in the world price equation. Therefore, although the two variables are linked in the long run, the adjustment mechanism is not driven by changes in world tuna prices.

Table 4. VECM Estimation Results for Export Prices and World Tuna Prices

Estimated Parameter	Export Prices	World Tuna Prices
Long-run Equilibrium Relationship (β)	1	-2,009
Speed of Adjustment (α)	0,640	1,272
Short-run Relationship (r)		
• Export Prices ($t-1$)	-1,194	-1,334***
• World Tuna Prices ($t-1$)	0,821	1,095

Note: *** Significant at $\alpha = 1$ %.

The error correction term in the world tuna price equation is positive and statistically insignificant, indicating that it does not contribute to the adjustment toward the long-run equilibrium. Accordingly, changes in world tuna prices do not appear to function as a mechanism for correcting deviations from the long-run equilibrium relationship. In the short run, the estimation results indicate a statistically significant relationship between changes in the export price of tuna in Aceh Province and world tuna prices. However, this relationship should not be interpreted as evidence that changes in Aceh's export prices cause changes in world tuna prices, given that Aceh's tuna exports represent only a relatively small share of the global tuna market.

Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhishthina Atikah, Noratun Juliaviani. 2026

4. CONCLUSION

The findings of this study indicate that the export price of tuna in Aceh Province has a long-run equilibrium relationship with both fishermen's prices and world tuna prices. The Johansen cointegration test confirms that both pairs of variables are cointegrated, while the Granger causality test reveals bidirectional predictive relationships between export prices and fishermen's prices, as well as between export prices and world tuna prices. These results suggest that price information at one market level is associated with price movements at other market levels. However, the identified relationships should not be interpreted as evidence of direct economic causality.

The VECM estimation further demonstrates that export prices, fishermen's prices, and world tuna prices are linked through a long-run equilibrium relationship, indicating that price movements across different market levels are interconnected. Nevertheless, the short-run price adjustment process is not uniform, implying that price changes at one market level are not always followed immediately by corresponding adjustments at other market levels. Therefore, strengthening market price information systems and improving coordination among participants throughout the tuna marketing chain are essential to support greater market integration in Aceh Province.

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Linda Santri, Jasmine Mardhina Qamarani FP, Ira Manyamsari, Qhisthina Atikah, Noratun Juliaviani. 2026

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