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Analysis of Poultry Product Market Integration at the Producer, Wholesaler, and Retail Levels in Jambi Province, Indonesia

Firmansyah[1]*, Fachroerrozi Hoesni[2], Afriani Harahap[1], and Lailal Gusri[3]

[1]Department of Animal Husbandry Socio-Economics, Faculty of Animal Husbandry, Jambi University, Indonesia
[2]Department of Animal Production, Faculty of Animal Husbandry, Jambi University, Indonesia
[3]Faculty of Science and Technology, Jambi University, Indonesia

*Corresponding author's E-mail: firmansyah_fapet@unja.ac.id

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ABSTRACT

Price increases in poultry products remain inevitable, with a significant price disparity persisting between consumer and producer levels. This condition results from an unhealthy oligopolistic livestock market, leading to low purchase prices for farmers. The present study aimed to analyze market integration at the producer, wholesale, and retail levels for poultry products (chicken meat and eggs) and to develop a price-forecasting model for these products at the producer, wholesale, and retail levels for the future. A quantitative approach was used to analyze secondary data on average weekly prices for chicken meat and eggs at producer, wholesale, and retail levels in Jambi Province, Indonesia. The present data were obtained from the Center for Strategic Food Price Information from January 2020 to July 2023. The present results indicated a long-term cointegration relationship among chicken meat and egg prices at producer, wholesale, and retail levels in Jambi Province, Indonesia. The prices of chicken meat and eggs at the producer, wholesale, and retail levels influence each other not only in the current period but also concerning prices over the previous 2-6 weeks. Wholesale and retail chicken prices affect producer prices, and retail prices affect wholesale prices. For eggs, wholesale prices affect producer prices, and retail prices also affect producer and wholesale prices. The Vector Error Correction forecasting model for chicken and egg prices at producer, wholesale, and retail levels in Jambi Province demonstrated strong forecasting performance. Market integration occurs across different market levels, producer, wholesale, and retail, for chicken meat and eggs, both in the short and long term. This integration contributed to improving the efficiency of poultry marketing in Jambi Province, Indonesia.

Keywords: Market integration, Producer, Retail, Wholesaler

INTRODUCTION

The stability of poultry supply in Indonesia is influenced by its diverse farming structure, where small-scale farms, which often lack advanced biosecurity and climate control, contribute 40% of the national production (Sumiati et al., 2025). However, price increases for poultry products remain unavoidable, and a wide price gap persists between consumer and producer levels. This condition results from the oligopolistic nature of the poultry market, which is considered inefficient and uncompetitive. Profit distribution along the marketing chain, among producers, wholesalers, and retailers, is perceived as unfair, as farmers often receive disproportionately low purchase prices (Fitriani et al., 2014). Under these conditions, wholesalers hold market power over retailers, as retail prices generally respond more rapidly to positive shocks than to negative ones in the long-run retail-wholesale equilibrium. Conversely, wholesale prices tend to adjust more slowly in response to negative deviations from the long-run equilibrium between wholesale and farmgate markets (Zamani et al., 2021). This asymmetric price adjustment pattern, frequently described as the rockets and feathers effect, has been widely documented in both agricultural and other markets (Peltzman, 2000; Loy et al., 2014; Surathkal and Chung, 2017). Additionally, the

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rockets and feathers phenomenon is consistent with evidence on price dynamics in agricultural products in Los Angeles and Iran (Hassouneh et al., 2012; Richards et al., 2014). Such price disparity creates price inconsistency from producer to wholesaler to retailer and reduces the efficiency of the marketing system (Suganda et al., 2024). Imperfect price transmission in the poultry industry results from limited transportation, product perishability, and an imbalance of market power (Karim et al., 2017). Differences in price movements at each market level (producer, wholesaler, and retailer) may create negative effects for market participants. Market participants with greater power tend to control the supply chain, price, and product availability, to increase their profitability (Bakucs et al., 2013). However, wholesalers, who possess greater market power, often set the prices of chicken meat and eggs at the expense of other market participants, namely, producers and retailers, or limit their flexibility to set prices (MacDonald and Key, 2015).

An efficient market is where price signals are transmitted vertically and symmetrically throughout the meat value chain (Pozo et al., 2021). Market integration generally leads to more efficient outcomes, yet many real-world markets fail to integrate (Pukthuanthong and Roll, 2009). Additionally, market integration may negatively affect many traders (Kumar et al., 2022). Market integration competition results can increase market dominance by large participants functioning within an oligopoly (Hou and Song, 2021). A non-integrated market leads to suboptimal marketing efficiency due to slow information transfer, inadequate physical infrastructure, and the transmission of inaccurate information, which collectively distort producer decisions and the flow of livestock commodities (Nugroho, 2021; Evalia et al., 2022). Moreover, transportation and communication systems require time to achieve full price integration (Mohapatra and Singh, 2021). Transportation costs between producers and wholesalers are a vital part of expenses in the poultry supply chain (Zamani et al., 2021). In the poultry value chain, such as chicken meat and eggs, profits are often distributed unevenly among producers, wholesalers, and retailers. Wholesalers tend to capture a larger profit margin due to their greater control over selling prices, particularly during periods of market price fluctuations. Producers and retailers might be forced to sell livestock products at lower prices, so consumers encounter higher prices than expected.

Analyzing and comparing price transmission patterns improves the understanding of market integration in Indonesia (Jojo et al., 2021). In Indonesia, the poultry industry faces significant challenges, particularly volatile input and output prices. Producers perceive their influence over pricing as limited and are consequently required to comply with dominant market trends in the absence of external support mechanisms (Chapot et al., 2014).

Market integration has received considerable attention from academics and policymakers over the past few decades (Roman, 2020). Economists studying markets have also shown interest in the issue of market integration (Lence et al., 2017; Pan and Li, 2019; Popat et al., 2022). Market integration continues to be a significant area of interest for those focusing on the dynamics and performance of agricultural markets (von Cramon-Taubadel, 2017). Having access to price information can assist in predicting profits and planning effective policies (Hoshino et al., 2021). Therefore, effective and integrated markets are crucial for traded products and services domestically.

Assessing market integration at the producer, wholesale, and retail levels to determine the marketing efficiency of livestock products in Jambi Province, Indonesia, has become increasingly important. Moreover, consumers, producers, wholesalers, and retailers are experiencing increasingly unstable livestock product prices, with greater irregularities in price patterns. These conditions have been exacerbated by the post-COVID-19 economic recovery challenges and the ongoing global food crisis. The present study aimed to analyze market integration across producer, wholesale, and retail levels for poultry products (chicken meat and eggs) and to develop a price-forecasting model for chicken meat and eggs at the producer, wholesale, and retail levels for the future.

MATERIALS AND METHODS

A quantitative approach was employed to analyze secondary data from Jambi Province, Indonesia. The present study utilized 558 weekly average price data for chicken meat and 558 price data for chicken eggs, covering three levels of the market structure, namely producers (186 data), wholesalers (186 data), and retailers (186 data). The data were obtained from the Center of Strategic Food Price Information (PIHPS) from January 2020 to July 2023. The first step was to test whether the chicken meat and egg price data at the producer, wholesaler, and retailer levels had unit roots, so a stationarity test was applied. The Augmented Dickey-Fuller (ADF) test was used to compare the ADF statistic with the 1% Mackinnon critical value using Formula 1 (Dickey and Fuller, 1981).

$$\Delta P_t = \alpha_0 + \gamma P_{t-1} + \beta_i \sum_{j=1}^{m} \Delta P_{t-j} + \varepsilon_t \quad \text{(Formula1)}$$

ΔP_t represent the first difference of the variable P_t, capturing short-run changes in price. α_0 is the constant term, while P_{t-1} is the lagged level of the variable, capturing long-run adjustment effects. The coefficients β_i measures the short-run dynamic effects of past changes in P_t, and ε_t is the white noise with zero mean and constant variance.

The determination of optimal lag length is important because lag length has a significant effect in time series analysis. The optimal lag of poultry product prices at the producer, wholesaler, and retailer levels was determined by several criteria. The present study determined the optimal model specification by applying several statistical selection measures, namely Akaike information criterion (AIC), Schwarz information criterion (SC), Hannan-Quinn criterion (HQ), likelihood ratio (LR), and final prediction error (FPE). To determine long-term market integration for poultry products at the producer, wholesaler, and retailer levels, a cointegration test was employed. The cointegration testing method was Johansen's (1988), using the following formula.

$$\Delta Y_t = K_0 + \prod_1 \Delta Y_{t-1} + \prod_{p-1} \Delta Y_{t-p+1} + \prod Y_{t-1} + \mu_t \quad \text{(Formula 2)}$$

ΔY_t represents the first difference of the dependent variable, capturing short-run changes. K_0 is the constant term, while $\Pi_1, \ldots, \Pi_{p-1}$ is the coefficients of lagged differences, reflecting short-run dynamics. The term ΠY_{t-1} is the long-run equilibrium component (error correction term), indicating adjustment toward equilibrium. μ_t is the stochastic error term, assumed to be the white noise.

The Johansen cointegration approach is a standard method for identifying long-run equilibrium linkages among variables that are nonstationary over time. This method can detect multiple cointegration relationships simultaneously and is suitable for multivariate analysis (Fernández-Polanco and Llorente, 2019). Cointegration is a statistical property observed in time series data, based on the stationarity and integration levels of the involved variables. Cointegration occurs among two or more non-stationary time series when they have the same order of integration and a linear combination (weighted average) of these series is stationary (Ankamah-Yeboah and Bronnmann, 2018).

Granger causality testing determines the cause-and-effect relationship between two time series variables by analyzing whether one variable can predict the future values of the other (Granger, 1969). The causality test in the vector autoregression (VAR) model is usually conducted using the Granger causality test, which compares an unrestricted model with a restricted one (von Cramon-Taubadel, 2017).

Unrestricted equation is;

$$Y_t = \sum_{i=1}^{m} \alpha_1 Y_{t-i} + \sum_{i=1}^{m} \beta_1 X_{t-i} + \varepsilon_{1t} \quad \text{(Formula 3)}$$

Y_t is the dependent variable and X_t is the explanatory variable. The coefficients α_1 captures the influence of the lagged values of Y_t (the autoregressive component). β_1 measures the effect of the lagged values of X_t on the current value of Y_t. The error term ε_{1t} means the stochastic disturbance, assumed to be white noise with zero mean and constant variance

The restricted equation is;

$$Y_t = \sum_{i=1}^{m} \gamma_1 X_{t-i} + \varepsilon_{2t} \quad \text{(Formula 4)}$$

Y_t is the dependent variable and X_{t-i} represents the lagged values of the explanatory variable. The coefficients γ_1 captures the dynamic effects of past values of X_t on the current value of Y_t, reflecting how changes in X influence Y over time. The term ε_{2t} is the stochastic disturbance, assumed to be the white noise with zero mean and constant variance.

The estimation process for the VAR/VECM model (von Cramon-Taubadel, 2017; Popat et al., 2022) entails constructing a VAR framework, assessing variable stationarity, verifying cointegration relationships, determining the optimal lag length, and evaluating variable suitability for inclusion in the model. The VECM is a restricted version of VAR because additional restrictions are required when data are non-stationary at the level but have cointegration relationships (von Cramon-Taubadel, 2017).

The general model of VAR with lag 1 was;

$$Y_t = \alpha_{1i} + \sum \beta_{1i} Y_{t-1} + \sum \gamma_{1i} X_{t-1} + \varepsilon_t \quad \text{(Formula 5)}$$

Y_t is the dependent variable and X_{t-1} denotes the lagged explanatory variable. The constant term α_{1i} captures the intercept of the relationship, while the coefficients β_{1i} measures the influence of the lagged values of Y_t on its current level (the autoregressive component). The parameters γ_{1i} indicate the impact of the lagged values of X_t on Y_t, reflecting the short-run and possibly long-run dynamic relationship between the two variables. The disturbance term ε_t represents the random error.

$$X_t = \alpha_{2i} + \sum \beta_{2i} Y_{t-1} + \sum \gamma_{2i} X_{t-1} + \varepsilon_t \quad \text{(Formula 6)}$$

X_t is the dependent variable and Y_{t-1} denotes the lagged explanatory variable. The constant term α_{2i} captures the intercept. The coefficients β_{2i} measures the effect of lagged values of Y_t on X_t. The parameters γ_{2i} reflect the influence of lagged values of X_t on its current level, capturing the autoregressive component of the model. The error term ε_t represents the stochastic disturbance.

VECM models;

$$\Delta Y_t = \varphi_1 + \delta_{1t} + \lambda_{1}e_{t-1} + \gamma_{11}\Delta Y_{t-1} + \cdots + \gamma_{1p}\Delta Y_{t-p} + \omega_{11}\Delta X_{t-1} + \cdots + \omega_{1q}\Delta X_{t-q} + \varepsilon_{1t} \quad \text{(Formula 7)}$$

ΔY_t denotes the first difference of the dependent variable, capturing short-run dynamics. The constant term φ_1 and trend component δ_{1t} represent deterministic elements in the model. The term e_{t-1} is the error correction term, and its coefficient λ_1 measures the speed of adjustment toward the long-run equilibrium following a short-run deviation. The parameters γ_{11} capture the short-run effects of past changes in Y_t. ω_{11} represent the short-run impacts of changes in X_t. The disturbance term ε_{1t} is the stochastic error.

$$\Delta X_t = \varphi_2 + \delta_{2t} + \lambda_{2}e_{t-1} + \gamma_{21}\Delta X_{t-1} + \cdots + \gamma_{2p}\Delta X_{t-p} + \omega_{21}\Delta Y_{t-1} + \cdots + \omega_{2q}\Delta Y_{t-q} + \varepsilon_{2t} \quad \text{(Formula 8)}$$

ΔX_t denotes the first difference of variable X_t, capturing short-run dynamics. The constant term ϕ_2 and deterministic trend δ_{2t} represent the intercept and time trend components. The error correction term e_{t-1}, with coefficient λ_2, measures the speed of adjustment toward long-run equilibrium after short-run disequilibrium. The parameters γ_{21} capture the short-run effects of past changes in X_t. ω_{21} represents the short-run influence of changes in Y_t. The stochastic disturbance term is ε_{2t}.

Johansen cointegration testing uses two statistics, the trace statistic and the maximum eigenvalue. The testing procedure compares the calculated statistic with the critical value. The trace statistic or maximum eigenvalue exceeds the critical value, indicating a cointegration relationship. After the Johansen cointegration test confirmed a long-term relationship among the variables, the vector error correction model (VECM) can be used to identify that relationship (Johansen, 1988). In general, the VECM model can be written as follows.

$$\Delta R_t = \gamma_1 + \sum_{i=1}^{k} \alpha_{wi}\Delta W_{t-1} + \sum_{j=1}^{l} \alpha_{rj}\Delta R_{t-j} + \beta Z_{t-1} + \varepsilon_{t1} \quad \text{(Formula 9)}$$

ΔR_t denotes the first difference of the dependent variable R_t, capturing short-run adjustments. The constant term γ_1 represents the intercept, while α_{wi} and α_{rj} are coefficients that measure the short-run effects of lagged changes in W_t and R_t, respectively. The term Z_{t-1} is the error correction component, and its coefficient β indicates the speed at which deviations from the long-run equilibrium are corrected. The disturbance term ε_{t1} represents the stochastic error.

The error correction model (ECM) is widely used in econometric studies because it explains short-term dynamics between variables and shows the speed of adjustment toward long-term equilibrium (Granger, 1969). The final analysis in the present study was the impulse response function (IRF) and variance decomposition, which measure the response of variables to shocks and assess the contribution of other variables to the variation of a variable in the system (Pang et al., 2023). The accuracy of the poultry product price forecasting models was evaluated using the root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), and Theil's inequality coefficient.

Data analysis

In the first stage, the data was analyzed using descriptive statistics, including the mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera, and probability values. In the second stage, a stationarity test was conducted using the ADF method by comparing the ADF statistic value to the MacKinnon critical value at the 1% significance level. After that, the optimal lag length in the VAR model was determined based on the AIC, SC, HQ, LR, and FPE. Long-term market integration was analyzed using a cointegration test, where the null hypothesis (H_0) was rejected if the trace statistic surpassed the critical value, indicating the existence of cointegration. If no cointegration was found among variables, the VARD (VAR in difference) model was applied; otherwise, the VECM was employed. In the fifth stage, the existence of a significant causal relationship was tested using the pairwise Granger causality test at a 5% significance level based on the F-statistic ($p \leq 0.05$). The sixth stage involved estimating the VAR/VECM model using coefficients, standard errors, t-statistics, F-statistics, Akaike AIC, and Schwarz SC values. Then the IRF was analyzed, which illustrated the response of one variable to a shock in another variable over time using coefficients and standard errors. The eighth stage involved variance decomposition analysis, which provided information on the proportion of the movement in a variable explained by shocks to itself and to other variables in both the current and future periods. The final stage involved forecasting, which was achieved by projecting the current and future values of all variables using historical data. Forecast accuracy was evaluated using the RMSE, MAE, MAPE, mean squared error (MSE), and Theil's inequality coefficient.

RESULTS AND DISCUSSION

On average, the chicken meat price at the producer level was 1.13 USD/kg, which was below the reference price of 1.27-1.39 USD/kg. At the retail level, the average price was 1.95 USD/kg, also below the reference price of 2.23 USD/kg. Both prices remained below the sales reference prices set by the National Food Agency of the Republic of Indonesia Regulation Number 5 in 2022, except for the maximum prices of chicken meat at the producer and retail levels (1.42 USD/kg and 2.54 USD/kg), which were higher than the established reference prices (1.27-1.39 USD/kg and 2.23 USD/kg). Likewise, the average egg prices at the producer and retail levels were 0.95 USD/kg and 1.43 USD/kg, respectively (Table 1), which were below the reference prices, except that the maximum price of eggs at the retail level exceeded the reference price. For the producer level, it was 1.33-1.45 USD/kg, and for the retail level, it was 1.64 USD/kg. Currently, no reference price exists for selling chicken meat and eggs at the wholesale level. This fact forces the Indonesian Government, particularly the National Food Agency, to establish reference prices at the wholesale level, particularly for poultry products. On average, chicken meat and egg prices at the producer and retail levels were lower than the reference prices set in the National Food Agency Regulation No. 5 in 2022, reflecting an overall stable market condition and suggesting that the government's price stabilization policy remained effective during the study period. The stable market condition indicated that supply and demand for these products were generally well-balanced, and that producers were able to maintain production levels sufficient to meet market needs without causing significant price surges. However, the occurrence of maximum prices for chicken meat at both the producer and retail levels, as well as for eggs at the retail level, exceeding the reference prices, revealed the presence of temporary market pressures. These pressures align with the findings of Selmi et al. (2023), who identify key drivers such as seasonal demand increases during religious holidays, rising feed costs, and disruptions in distribution channels, all of which can limit supply and elevate prices. Such dynamics highlighted the sensitivity of poultry and egg markets to short-term shocks, emphasizing the importance of continuous monitoring and adaptive policy responses to maintain price stability and protect both producers and consumers.

Table 1. Chicken meat and egg prices at producer, wholesale, and retail levels from January 2020 to July 2023 in Jambi Province, Indonesia

Descriptive statistics (USD/kg)	Chicken Meat			Egg		
	Producer	Wholesaler	Retail	Producer	Wholesaler	Retail
Mean	1.13	1.53	1.95	0.95	1.27	1.43
Median	1.15	1.52	1.95	0.95	1.26	1.38
Maximum	1.42	2.13	2.54	0.98	1.57	1.76
Minimum	0.72	1.06	1.30	0.88	0.99	1.13
Standard deviation	0.19	0.19	0.24	0.13	0.14	0.16
Skewness	-0.38	0.25	0.23	-3.38	0.17	0.39
Kurtosis	2.32	2.71	3.04	19.99	2.27	2.99
Jarque-Bera	8.09	2.10	1.66	25.90	5.05	12.60
Probability	0.02	0.35	0.43	0.00	0.08	0.00

Chicken meat prices indicated low variability, with standard deviations of 0.19 USD/kg at both the producer and wholesaler levels and 0.24 USD/kg at the retail level. Similarly, egg prices exhibited low fluctuations, with standard deviations of 0.13 USD/kg, 0.14 USD/kg, and 0.16 USD/kg at the producer, wholesaler, and retail levels, respectively. The skewness values of chicken meat prices were -0.38, 0.25, and 0.23 at the producer, wholesaler, and retail levels, respectively, indicating near-symmetrical distributions. In contrast, egg prices demonstrated skewness values of -3.38, 0.17, and 0.39, reflecting a strong left skew at the producer level and slight right skewness at the wholesale and retail levels.

The kurtosis values of chicken meat prices were 2.32, 2.71, and 3.04 at the producer, wholesaler, and retail levels, respectively, indicating distributions close to normal. In contrast, egg prices indicated kurtosis values of 19.99, 2.27, and 2.99, suggesting extreme price fluctuations at the producer level and more stable distributions at the wholesale and retail levels.

The Jarque-Bera values for chicken meat prices were 8.09, 2.10, and 1.66 at the producer, wholesaler, and retail levels, respectively, indicating near-normal distributions except for a slight deviation at the producer level. In contrast, egg prices recorded values of 25.90, 5.05, and 12.60, showing stronger deviations from normality, particularly at the producer level.

Based on the unit root test results for poultry products, the chicken meat price data at the producer, wholesale, and retail levels were found to be stationary at their level form. Meanwhile, egg price data at the wholesale and retail levels were stationary at the first difference, except at the producer level, which remained stationary at the level. The optimal lag length for the chicken price VAR model was 2, indicating that prices at the producer, wholesale, and retail levels were interdependent and influenced by prices from the previous two weeks. In contrast, the optimal lag length for the egg price VAR model was 6, suggesting a more prolonged dynamics where prices at all three levels influence each other relative to prices from the previous six weeks. Meanwhile, egg price data at the wholesale and retail levels were stationary at the first difference, except at the producer level, which was stationary at the level. The cointegration test for chicken prices at the producer, wholesale, and retail levels revealed significant results ($p \leq 0.05$) for both the trace statistic (63.41872 > 24.27596) and the Max-Eigen statistic (34.74923 > 17.79730), indicating the existence of a long-run cointegration relationship among these market levels. Similarly, the cointegration test for egg prices at the producer, wholesale, and retail levels indicated significant trace (81.91906 > 24.27596) and Max-Eigen statistics (48.02391 >17.79730) with $p \leq 0.05$, confirming the presence of a long-term equilibrium relationship among the respective price series. These findings indicated a long-term cointegration relationship among egg prices at the producer, wholesale, and retail levels, suggesting that price movements across market levels are interconnected over time. This result is consistent with those of Putri et al. (2022), who also reported strong long-run price linkages within the poultry market chain.

The cointegration of poultry product prices at the producer, wholesale, and retail levels indicated that, in the long term, the market was integrated. However, in the short term, integration might not exist. Therefore, further analysis using the VECM was required to examine short-term integration of the poultry market at the producer, wholesale, and retail levels. Table 2 shows a significant error correction parameter, indicating a mechanism for adjusting chicken prices from the short term to the long term, with a value of -0.282 at the producer level.

Table 2. Vector error correction model estimation results for chicken meat prices in producer, wholesale, and retail levels from January 2020 to July 2023 in Jambi Province, Indonesia

Error correction	D (Producer)			D (Wholesale)			D (Retail)		
		SE	T-statistics		SE	T-statistics		SE	T-statistics
CointEq1	-0.282192*	(0.04562)	[-6.18535]	0.010537	(0.04025)	[0.26177]	0.056695	(0.07224)	[0.78477]
D Producer (-1)	-0.034416	(0.06703)	[-0.51346]	-0.057798	(0.05914)	[-0.97732]	-0.211041	(0.10614)	[-1.98836]
D Producer (-2)	-0.002550	(0.06683)	[-0.03815]	-0.012834	(0.05897)	[-0.21763]	-0.119525	(0.10583)	[-1.12939]
D Wholesale (-1)	-0.127694	(0.10966)	[-1.16449]	-0.580782*	(0.09675)	[-6.00273]	-0.311502	(0.17364)	[-1.79392]
D Wholesale (-2)	0.067912	(0.08399)	[0.80854]	-0.120925	(0.07411)	[-1.63172]	0.080368	(0.13300)	[0.60426]
D Retail (-1)	-0.021631	(0.06525)	[-0.33152]	0.745166*	(0.05757)	[12.9437]	0.317191*	(0.10332)	[3.06995]
D Retail (-2)	-0.043127	(0.08355)	[-0.51615]	0.215082*	(0.07372)	[2.91746]	-0.141069	(0.13231)	[-1.06620]
C	-3.742058	(112,557)	[-0.03325]	-8.657082	(99.3115)	[-0.08717]	26.63930	(178,235)	[0.14946]

SE: Standard errors, C: The constant term (intercept), which represents the average weekly change in the price at that market level when all other explanatory variables in the equation are zero, D: The first difference, which denotes the weekly change in price. *Indicates significance difference in a column ($p \leq 0.05$).

The present findings suggested that price shocks at the wholesale level were temporary. The market adjusts after a large price fluctuation the next week, offsetting approximately 58% of the prior week's changes. This VAR analysis revealed that a 1 USD/kg increase in the retail price predicted a further 0.32 USD/kg increase the following week. Retail prices exhibited a short-term corrective response by decreasing 0.21 USD/kg for every 1 USD/kg increase in the prior week's wholesale price, and the markets were tightly integrated, with a 1 USD/kg change in retail price associated with a 0.75 USD/kg change in wholesale price the following week. The cointegration test results indicated that the CointEq1 variable in D (Producer) was statistically significant ($p \leq 0.05$), suggesting the presence of an error correction mechanism at the producer level that drives adjustment toward long-run equilibrium at a speed of 28.2% per period. The D (Wholesale) was significant ($p \leq 0.05$) for D Wholesale (-1), D Retail (-1) and D Retail (-2), while the D (Retail) was significant ($p \leq 0.05$) only for D Retail (-1), suggesting the long-run equilibrium was maintained primarily through adjustments in producer prices, not wholesale or retail prices. The estimated constant (C) in the producer price equation was not statistically significant (t-stat: -0.033), indicating that there was no consistent drift or average change in the producer price regardless of the other variables.

The cointegration test results (Table 3) revealed that CointEq1 in D (Wholesale, 2) and D (Retail, 2) were significant ($p \leq 0.05$), indicating the presence of an error-correction mechanism at the wholesale and retail levels, the D (Producer) was significant ($p \leq 0.05$) for D Producer (-4), while the D (Retail) was significant ($p \leq 0.05$) for D Wholesale (-1, 2), D Wholesale (-2, 2), D Wholesale (-3, 2) and D Wholesale (-5, 2). The estimated constant (C) in the producer price equation was statistically insignificant (t-stat: 0.734) and could not be interpreted as a meaningful economic adjustment.

The subsequent analysis employed a VECM to investigate short-term dynamics in the egg market. The current results indicated a complex adjustment process. The error-correction mechanism exhibited that deviations from the long-run equilibrium were corrected at a rate of 17.3% per period at the retail level. However, the positive and significant coefficient for the wholesale level (14.8%) indicated a destabilizing effect, as disequilibrium caused wholesale prices to move further from their equilibrium. This finding indicated that the primary adjustment effort was placed on the retail sector, while wholesale prices exhibited potentially volatile patterns. Short-term dynamics revealed significant self-correcting behavior and cross-market influences ($p \leq 0.05$). At the producer level, a 1.00 USD/kg increase in price four weeks prior was associated with a 0.44 USD/kg decrease in the current price, indicating strong negative feedback. Furthermore, retail prices were highly sensitive to the past wholesale price accelerations. For instance, a 1 USD/kg acceleration in wholesale price growth one week prior was associated with a 1.03 USD/kg decrease in the current retail price, with this influence persisting over several weeks (coefficients of -0.91, -0.72, -0.48, and -0.42 for lags two through five).

The observed destabilizing wholesale adjustment and the multi-week lagged effects aligned with findings of Penone and Trestini (2022) that futures markets can influence agricultural prices and exhibit complex temporal dynamics. The segmentation and incompleteness of price adjustments align with the patterns observed in the study conducted by Noda and Kyo (2023) in meat markets. Most importantly, the evidence of a malfunctioning error correction mechanism at the wholesale level strongly supported the theory that market power can distort and weaken price transmission (Deb et al., 2022), preventing the market from efficiently self-correcting. The Granger causality test revealed distinct market structures for chicken meat and eggs (Table 4). In the chicken meat market, the relationship was hierarchical, with both wholesale and retail prices unidirectionally influencing producer prices ($p \leq 0.05$), indicating that downstream market levels determine producer prices. Furthermore, a strong bidirectional relationship existed between wholesale and retail prices ($p \leq 0.05$), confirming their tight mutual adjustment. In contrast, the egg market exhibited a different dynamic. Retail prices unidirectionally influence wholesale prices ($p \leq 0.05$). However, producer prices were independent, showing no significant relationship with either wholesale or retail prices ($p > 0.05$). This suggested a disconnect in which consumer price signals did not fully transmit back to egg producers.

This evidence of asymmetric price transmission, where producer prices did not respond to market signals, was consistent with findings of Seok et al. (2018) and Deb et al. (2022) that retailers and wholesalers can use market power to influence pricing dynamics. Following the onset of COVID-19, prices for poultry products fell sharply across farm, wholesale, and retail markets for the first three months, subsequently rising by roughly 40% for chicken meat and over 30% for eggs (Amin et al., 2023). The supply chain was disrupted because the distribution system was blocked, causing production to accumulate at the producer level and prices to fall. At the same time, demand also declined due to reduced purchasing power during COVID-19 (Surni et al., 2020).

The IRF analysis revealed a distinct hierarchical, lagged structure in the price transmission of chicken meat in Jambi, Indonesia, quantifying how shocks propagate across market levels (Table 5). A shock originating at the retail level, indicative of a change in demand, is the most potent driver of the system. The shock elicited an immediate and substantial response across all levels, with prices increasing by 1,692.28 at retail ($p \leq 0.05$), 1,496.88 at wholesale ($p \leq 0.05$), and a significant 438.32 at the producer level ($p \leq 0.05$) within the first period. This final figure was 4.7 times higher than the producer's response to a wholesale shock, showing that consumer signals reach farmers much more effectively than intermediary ones. In contrast, a shock at the producer level, indicating a cost push, resulted in a delayed pass-through. This shock at the producer level caused a large initial increase in its own price (1,507.27), but its effect on downstream markets only peaked after a considerable delay, reaching a maximum of 766.91 at wholesale and 745.64 at retail in the fifth period. Meanwhile, a wholesale price shock indicated strong, immediate integration with the retail sector, eliciting a 1,299.61 response. Still, the effect had a weak, short-lived effect on producers, turning negative after the third period. This evidence collectively painted a picture of a retail-driven market in which downstream demand shocks prompt rapid upstream adjustments, whereas upstream cost shocks were absorbed and transmitted to consumers only after a considerable delay, with the wholesale level acting as a primary link to retailers but a weak link to producers.

Table 3. Vector error correction model estimation results for egg prices in producer, wholesale, and retail levels from January 2020 to July 2023 in Jambi Province, Indonesia

Error correction	D (Producer)			D (Wholesale, 2)			D (Retail, 2)		
		SE	T-statistics		SE	T-statistics		SE	T-statistics
CointEq1	-0.009614	(0.00834)	[-1.15222]	-0.014805*	(0.00529)	[2.79813]	-0.017291*	(0.00498)	[-3.46913]
D Producer (-1)	0.028346	(0.07988)	[0.35488]	0.099750	(0.05065)	[0.01969]	-0.249165	(0.47715)	[-0.52220]
D Producer (-2)	0.008928	(0.07992)	[0.11172]	-0.520516	(0.50679)	[-1.02708]	-0.183504	(0.47740)	[-0.38439]
D Producer (-3)	-0.022331	(0.07067)	[-0.31602]	-0.977809*	(0.44812)	[-2.18202]	-0.672969	(0.42213)	[-1.59423]
D Producer (-4)	-0.441462*	(0.07082)	[-6.23315]	0.249017	(0.44914)	[0.55444]	0.113150	(0.42308)	[0.26744]
D Producer (-5)	0.015876	(0.07899)	[0.20098]	-0.027545	(0.50092)	[-0.05499]	-0.183812	(0.47187)	[-0.38954]
D Producer (-6)	0.009995	(0.07808)	[0.12800]	-0.533817	(0.49517)	[-1.07804]	-0.132049	(0.46645)	[-0.28309]
D Wholesale (-1, 2)	-0.069795	(0.05266)	[-1.32531]	-0.101628	(0.33396)	[-0.30431]	-1.033752*	(0.31459)	[-3.28604]
D Wholesale (-2, 2)	-0.036093	(0.04777)	[-0.75564]	-0.218612	(0.30290)	[-0.72172]	-0.917867*	(0.28533)	[-3.21682]
D Wholesale (-3, 2)	-0.028129	(0.04067)	[-0.69164]	-0.277792	(0.25791)	[-1.07710]	-0.718272*	(0.24295)	[-2.95650]
D Wholesale (-4, 2)	-0.027741	(0.03218)	[-0.86196]	-0.125102	(0.20409)	[-0.61297]	-0.483273*	(0.19225)	[-2.51373]
D Wholesale (-5, 2)	0.002045	(0.02361)	[0.08663]	-0.017076	(0.14969)	[-0.11407]	-0.419705*	(0.14101)	[-2.97639]
D Wholesale (-6, 2)	0.000200	(0.01503)	[0.01330]	0.064975	(0.09532)	[0.68166]	-0.055314	(0.08979)	[-0.61604]
D Retail (-1, 2)	0.081356	(0.05691)	[1.42962]	-0.379166	(0.36088)	[-1.05067]	0.642659	(0.33995)	[1.89047]
D Retail (-2, 2)	0.049314	(0.05176)	[0.95278]	-0.236109	(0.32822)	[-0.71935]	0.509019	(0.30918)	[1.64633]
D Retail (-3, 2)	0.032501	(0.04442)	[0.73169]	-0.105462	(0.28168)	[-0.37440]	0.362593	(0.26534)	[1.36650]
D Retail (-4, 2)	0.044726	(0.03531)	[1.26682]	0.035969	(0.22389)	[0.16065]	0.317596	(0.21090)	[1.50588]
D Retail (-5, 2)	0.020112	(0.02671)	[0.75284]	-0.108482	(0.16941)	[-0.64035]	0.159474	(0.15958)	[0.99931]
D Retail (-6, 2)	0.013248	(0.01817)	[0.72893]	-0.171677	(0.11525)	[-1.48954]	-0.121483	(0.10857)	[-1.11894]
C	6.765237	(9.21229)	[0.73437]	5.722529	(58.4196)	[0.09796]	10.98379	(55.0309)	[0.19959]

SE: Standard errors, C: The constant term (intercept), which represents the average weekly change in the price when all other explanatory variables are zero, D: The first difference, which denotes the the simple weekly change for producer and for wholesale and retail prices, it denotes the appropriate differenced series used to achieve stationarity. * Indicates significant differences in a column ($p \leq 0.05$)

Table 4. Granger causality test results for poultry product prices in producer, wholesale, and retail levels from January 2020 to July 2023 in Jambi Province, Indonesia

Chicken Meat	F-Statistics	Probability value	Egg	F-Statistics	Prob.
Wholesale - Producer	20.6705*	8.E-09	Wholesale ------> Producer	2.00268	0.0680
Producer - Wholesaler	1.36264	0.2586	Producer ------> Wholesaler	0.34233	0.9135
Retail - Producer	20.1798*	1.E-08	Retail ------> Producer	1.99925	0.0685
Producer - Retail	0.17566	0.8391	Producer ------> Retail	0.45678	0.8394
Retail - Wholesale	109.725*	8.E-32	Retail ------> Wholesale	10.3460*	1.E-09
Wholesale - Retail	5.62176*	0.0043	Wholesale ------> Retail	0.81481	0.5598

F-Statistics: * Indicates significant differences in a row ($p \leq 0.05$).

Table 5. The impulse response function of chicken's meat price from January 2020 to July 2023 in Jambi Province, Indonesia

Period	Response of producer			Response of wholesaler			Response of retail		
	Producer	Wholesaler	Retail	Producer	Wholesaler	Retail	Producer	Wholesaler	Retail
1	1507.271*	-	-	92.13679	1253.131*	-	438.3294	1496.885	1692.289*
	(78.5719)	-	-	(92.5068)	(65.3240)	-	(168.119)	(147.150)	(88.2166)
2	1077.787*	215.3716	236.4793	292.3961	1481.956*	1299.610	244.9584	1283.554	2041.168*
	(128.389)	(105.271)	(109.811)	(173.847)	(150.166)	(113.419)	(248.063)	(227.936)	(197.687)
3	764.9420*	531.4367	414.0491	76.81566	1032.163*	1196.625	-32.82334	876.8867	1256.646*
	(120.200)	(125.627)	(131.720)	(194.434)	(192.291)	(179.052)	(229.289)	(248.494)	(243.946)
4	556.8817*	731.8545	656.1556	-59.28651	730.4505*	714.0961	-96.41490	711.7966	763.9416*
	(133.380)	(146.717)	(144.777)	(171.387)	(196.227)	(201.167)	(200.870)	(241.415)	(254.725)
5	374.1701*	766.9092	745.6371	-72.86634	585.5645*	502.4680	-90.83263	583.4699	588.1081*
	(147.176)	(163.717)	(154.639)	(157.955)	(192.878)	(197.290)	(189.396)	(235.115)	(235.304)
6	228.5340	718.9354	700.9001	-71.50221	449.6264*	405.5632	-95.88382	427.8945	440.7079*
	(151.881)	(171.023)	(161.645)	(149.322)	(182.638)	(179.213)	(176.770)	(214.094)	(208.018)
7	127.5990	640.0202	613.9962	-76.45083	317.0927	294.8205	-97.80534	292.4627	290.7657
	(149.780)	(174.310)	(165.348)	(137.651)	(166.174)	(158.824)	(158.983)	(193.355)	(182.849)
8	60.08912	545.5968	519.3146	-74.32502	214.5404	192.8388	-88.04149	193.7833	180.6274
	(143.892)	(173.421)	(164.473)	(121.207)	(151.878)	(142.693)	(135.651)	(177.128)	(165.920)
9	15.39921	446.2916	422.6194	-64.97440	140.8141	121.3887	-73.70023	121.5938	108.5903
	(135.094)	(168.012)	(158.814)	(101.561)	(139.474)	(130.334)	(110.472)	(162.175)	(151.402)
10	-12.28219	352.3430	330.8200	-53.99870	86.62581	72.70204	-59.83145	68.39915	58.66981
	(123.528)	(159.443)	(150.040)	(81.7453)	(127.424)	(118.700)	(86.7678)	(147.418)	(137.331)

Standard errors are presented in parentheses. * Indicates significant differences ($p \leq 0.05$).

The IRF for egg prices revealed a market with weak integration and significant volatility, particularly in response to wholesale shocks (Table 6). A shock at the producer level had a positive but gradually decaying effect on its own price, decreasing from 116.56 to 13.6 and remaining significant ($p \leq 0.05$) from period 1 to 4. In contrast, its impact on wholesale and retail prices was minimal and statistically insignificant across all 10 periods ($p > 0.05$). A shock at the wholesale level exerted a positive and significant effect ($p \leq 0.05$) on its own price (720.73) and a strong negative effect on producer prices (-63.44), which further intensified to -105.37 by period 4. This indicates that cost pressures at the wholesale level are transmitted upstream to producers, resulting in sustained price suppression. Meanwhile, a shock at the retail level had a positive effect (577.43) on its own price and was significant ($p \leq 0.05$) in periods 1, 2, 4, 7, and 9. Finally, a shock at the retail level also exerted an immediate negative influence on producer prices (-83.63) and created fluctuating, often negative, responses in wholesale prices. The most striking feature was the consistent negative response of producer prices to both wholesale and retail shocks, demonstrating that producers experienced market disruptions more. Additionally, the retail market exhibited wide and unpredictable fluctuations, failing to settle into a stable equilibrium within the observed timeframe.

The variance decomposition analysis indicated which shocks at the producer, wholesale, and retail levels contributed to fluctuations in poultry prices (chicken meat and eggs). In the first period, 100% of the variation was caused by shocks at the producer level. This self-influence gradually decreases over time, falling to 44.60% by the tenth period. Concurrently, the influence of shocks from the wholesale level increased to 29.47%, and from the retail level to 25.93% (Table 7). Initially, wholesale price variance was entirely (99.46%) explained by its own shocks, with only 0.54% from the producer level. Over time, the contribution of wholesale price shocks declined to 58.45%, while shocks originating from the retail level became a major factor, accounting for 40.27% of the variation by the tenth period. The influence from the producer level remains small, increasing slightly to 1.27%. The retail level was influenced by all three levels from the start. In the first period, 54.07% of its variation was due to its own shocks, 42.30% from wholesale shocks, and 3.63% from producer shocks. This dynamic stabilizes, with retail's own shocks becoming the dominant factor (61.65%), followed by wholesale shocks (36.43%), while producer-level influence remained minimal (1.91%).

At the producer level, the standard error of chicken meat prices increased gradually from 0.091 USD/kg in the first period to 0.193 USD/kg in the tenth period, indicating a moderate increase in forecast uncertainty as the prediction horizon extended. Similarly, the standard error values at the wholesale level increased from 0.076 USD/kg to 0.196 USD/kg, and at the retail level from 0.139 USD/kg to 0.242 USD/kg (Table 7). Such progressive increases in standard error are typical in variance decomposition analysis, as forecast errors tend to accumulate over longer horizons. Overall, the relatively low standard error magnitudes across all market levels suggested that the model produced stable and reliable estimates of chicken meat price dynamics at the producer, wholesale, and retail levels.

Table 6. Impulse response function results of egg prices from January 2020 to July 2023 in Jambi Province, Indonesia

Period	Response of producer			Response of wholesaler			Response of retail		
	Producer	Wholesaler	Retail	Producer	Wholesaler	Retail	Producer	Wholesaler	Retail
1	116.5565*	-	-	-63.44108	720.7286*	-	-83.62848	342.8415	577.4281*
	(6.16020)	-	-	(53.9740)	(38.0917)	-	(50.3873)	(46.8084)	(30.5180)
2	109.1291*	2.126972	9.382338	-14.61331	69.10047	334.4932	-53.16382	131.3594	130.1406*
	(10.8666)	(9.17199)	(8.70667)	(62.4544)	(62.1328)	(56.7804)	(55.1416)	(54.4209)	(50.9352)
3	96.67954*	17.29681	-5.009949	-55.75431	-33.75448	83.06692	-17.81089	13.05960	-54.60292
	(13.3822)	(12.4178)	(11.9700)	(59.7262)	(62.4713)	(59.1944)	(52.1349)	(54.5712)	(52.1004)
4	83.30814*	14.93264	-5.627737	-105.3729	-46.96195	-52.55257	-68.68930	12.16472	-115.8414*
	(15.1199)	(14.6132)	(13.9485)	(59.0117)	(62.4504)	(59.3263)	(52.5935)	(55.1844)	(52.2412)
5	19.56857	16.43882	8.863565	-10.80488	104.1179	-76.53270	-20.76690	60.73543	-55.37512
	(15.9150)	(16.0600)	(14.9513)	(59.4433)	(62.9056)	(59.5409)	(52.4106)	(55.0019)	(52.4912)
6	12.64758	27.98823	-0.572234	-9.460613	17.21420	-97.21674	4.731710	-61.82128	-48.59772
	(15.9341)	(16.1069)	(14.5544)	(58.6101)	(62.8600)	(59.1538)	(51.3345)	(54.5580)	(51.8344)
7	6.624650	17.20979	10.43083	11.00733	-94.34024	-95.85121	9.744696	45.56801	-198.3516*
	(15.6581)	(15.3800)	(14.3471)	(46.3593)	(59.6550)	(59.4779)	(43.5274)	(52.2972)	(53.0655)
8	0.848460	17.50656	4.550301	18.10395	-11.19106	-94.24168	35.24793	-22.00622	18.09749
	(15.5662)	(12.9231)	(11.3497)	(44.2605)	(40.6764)	(46.8414)	(43.7882)	(35.7454)	(43.0518)
9	18.24547	9.021906	0.288201	-6.980016	-3.334132	57.82960	2.462929	-23.10982	90.04003*
	(15.5770)	(10.3384)	(8.99511)	(40.3891)	(33.6756)	(40.5545)	(39.7226)	(30.5635)	(39.3580)
10	13.62375	0.985953	1.909630	6.540386	-4.929292	56.22133	-11.24682	-40.14171	53.58497
	(15.5158)	(8.23325)	(7.33287)	(36.0771)	(31.0867)	(38.1191)	(36.6791)	(28.2672)	(36.7495)

Standard errors are presented in parentheses. * Indicates significant differences ($p \leq 0.05$).

Table 7. The variance decompositions of chicken meat prices from January 2020 to July 2023 in Jambi Province, Indonesia

Period	Variance decomposition of the producer				Variance decomposition of wholesale				Variance decomposition of retail			
	Producer	Wholesaler	Retail	SE	Producer	Wholesaler	Retail	SE	Producer	Wholesaler	Retail	SE
1	100.00	-	-	0.091	0.54	99.46	-	0.076	3.63	42.30	54.07	0.139
2	97.11	1.31	1.58	0.114	1.69	67.87	30.43	0.143	2.26	34.81	62.93	0.203
3	87.84	7.19	4.97	0.130	1.24	60.00	38.76	0.172	1.87	34.45	63.68	0.223
4	73.98	14.77	11.24	0.147	1.14	58.96	39.90	0.183	1.80	35.32	62.88	0.232
5	62.63	20.36	17.01	0.162	1.12	58.85	40.03	0.189	1.77	35.94	62.29	0.237
6	55.16	24.03	20.81	0.174	1.13	58.68	40.19	0.192	1.78	36.22	61.99	0.240
7	50.42	26.44	23.14	0.182	1.17	58.56	40.28	0.194	1.82	36.35	61.82	0.242
8	47.45	27.97	24.58	0.187	1.21	58.50	40.29	0.195	1.86	36.41	61.73	0.242
9	45.65	28.91	25.44	0.191	1.24	58.47	40.28	0.195	1.89	36.43	61.68	0.242
10	44.60	29.47	25.93	0.193	1.27	58.45	40.27	0.196	1.91	36.43	61.65	0.242

SE: Standard error

Producer prices primarily caused the fluctuations and shocks. This effect began at 100% in the first period and remained very high, decreasing only slightly to 94.24% by the tenth period. Shocks from the wholesale level had a minor influence (4.98%), while retail-level shocks were negligible (0.78%). In the second to tenth periods, the impact of shocks to producer egg prices decreased from 99.64% to 94.24%, while the impacts of shocks to wholesale prices and retail prices were 4.98% and 0.78%, respectively. The wholesale level was primarily influenced by its own shocks, which accounted for 99.23% of the initial variation. Over time, this self-influence declined to 75.20%, while shocks from the retail level became significant ($p \leq 0.05$), explaining 22.16% of the variation by the tenth period. The influence of producer prices remains small, increasing to 2.63%. The retail level was dominated by its own shocks from the outset (72.81%), with shocks from the wholesale level explaining most of the remaining variation (25.67%). The influence from the producer level was minimal, starting at 1.53% and increasing slightly to 2.86% by the tenth period (Table 8).

Fluctuations in retail prices were moderately affected by shocks originating from the wholesale market. The contribution of wholesale price shocks accounted for 25.67% in the first period, increased slightly to 27.23% in the second period (Table 8), and then remained relatively stable at around 25-26% throughout the subsequent periods. This pattern suggested that wholesale prices play a consistent and moderate role in shaping retail price variability over the forecast horizon. In comparison, producer-level shocks contributed only about 2-3%, whereas the largest portion of retail price fluctuations (approximately 71-73%) was attributed to shocks within the retail market itself, highlighting the dominance of internal market dynamics at the retail level.

At the producer level, the standard error of egg prices indicated a slight increase from 0.007 USD/kg in the first period to 0.013 USD/kg in the tenth period, reflecting minimal forecast uncertainty over the estimation horizon. Similarly, the standard error at the wholesale level increased modestly from 0.044 USD/kg to 0.052 USD/kg, while at the retail level, the standard error increased from 0.041 USD/kg to 0.046 USD/kg. Such minor and gradual increases in standard error values were characteristic of variance decomposition analysis, as forecast errors naturally accumulate over extended horizons. Overall, the consistently low standard error values across all market levels indicated that the model provided robust, stable, and reliable estimates of egg price dynamics at the producer, wholesale, and retail levels.

The present findings are consistent with those of Tomycho et al. (2023), who examined price transmission in the Indonesian egg market using cointegration and VECM analysis. Tomycho et al. (2023) found that market integration between areas with oversupply and areas of shortage existed before the COVID-19 pandemic but declined significantly during it. The variance decomposition results indicated that own-price effects for chicken parts, legs, breasts, and wings account for more than 80% of the variation after nine months. In contrast, for whole chickens, the decomposition became nearly evenly distributed between whole chicken and breast prices after approximately seven months (McKenzie et al., 2009). The results of the forecast error variance decomposition indicated that the broiler's own price consistently served as the primary determinant of price variability across all subperiods (Duangnate et al., 2025). In the Danish markets, shocks in the chicken market exhibited both own-market and cross-market effects that manifest quickly and intensely (Andersen et al., 2007). The present results are in line with the findings of Dietrich et al. (2021), who indicated that the effects of increasing food prices seemed to be caused by interconnected markets that relied more on trade with other markets in low- and middle-income countries, such as Indonesia. In a well-functioning market, competition ensures that the impact of a shock on the price of a product in one location spreads to other locations, allowing producers and consumers to take advantage of opportunities (Iregui and Otero, 2017).

This finding in Jambi Province was in line with the study conducted by Setiadi (2022), which revealed a positive correlation between chicken egg prices in Kendal Regency and Semarang City, Indonesia. Overall, egg prices across Semarang City, Kendal Regency, and Semarang Regency in Central Java Province exhibited a symmetric relationship. In traditional markets in Jambi Province, chicken meat prices tended to experience substantial fluctuations, whereas in modern markets, chicken meat prices indicated considerable variation. In contrast, egg prices in modern markets were generally more stable, although price instability demonstrated a noticeable increase. In urban areas in Jambi Province, Indonesia, chicken meat prices exhibited pronounced volatility, while egg prices maintained relatively low levels of fluctuation (Firmansyah and Harahap, 2024). The present results were not consistent with the findings of Firmansyah and Harahap (2024), who reported that chicken meat prices in urban markets were volatile, whereas egg prices remained relatively stable. Additionally, Liu and Tang (2023) examined poultry market integration in China, finding that it was stronger in major production provinces but weaker in main consumption provinces.

Market integration and the application of poultry price forecasting at the producer, wholesale, and retail levels play a crucial role in stabilizing prices by reducing market imperfections, such as monopoly and monopsony practices, while also improving efficiency. The comparison of forecasting methods uses MAPE to identify the most accurate forecasting model (Sukiyono et al., 2021). Table 9 provides the assessment outcomes of the poultry price forecasting models for the producer, wholesale, and retail market levels. The present findings indicated that the forecasting models performed too optimally across all three market levels.

Table 8. The variance decompositions of egg prices from January 2020 to July 2023 in Jambi Province, Indonesia

Period	Variance decomposition of the producer				Variance decomposition of D(Wholesale)				Variance decomposition of D (Retail)			
	Producer	D (Wholesale)	D (Retail)	SE	Producer	D (Wholesale)	D (Retail)	SE	Producer	D (Wholesale)	D (Retail)	SE
1	100.00	-	-	0.007	0.77	99.23	-	0.044	1.53	25.67	72.81	0.041
2	99.64	0.02	0.34	0.010	0.66	81.86	17.47	0.048	1.98	27.23	70.78	0.043
3	98.82	0.86	0.32	0.011	1.13	80.64	18.23	0.049	2.03	27.08	70.89	0.043
4	98.42	1.24	0.34	0.012	2.76	79.03	18.21	0.050	2.87	26.15	70.98	0.044
5	97.64	1.84	0.52	0.013	2.71	78.67	18.62	0.050	2.92	26.49	70.59	0.044
6	95.91	3.58	0.51	0.013	2.69	77.60	19.71	0.050	2.89	26.90	70.21	0.044
7	95.04	4.21	0.75	0.013	2.64	76.86	20.50	0.051	2.69	25.31	71.99	0.046
8	94.35	4.86	0.79	0.013	2.65	75.89	21.46	0.051	2.90	25.31	71.79	0.046
9	94.22	4.99	0.78	0.013	2.64	75.53	21.82	0.052	2.86	25.02	72.12	0.046
10	94.24	4.98	0.78	0.013	2.63	75.20	22.16	0.052	2.86	25.10	72.04	0.046

SE: Standard error, D: The first difference price series at the wholesale and retail levels.

Table 9. The forecasting models for poultry product price from January 2020 to July 2023 in Jambi Province, Indonesia

Poultry products	Market levels	Root mean square errors	Mean absolute errors	Mean absolute percentage error	Theil inequality coefficient
Chickens' meat	Producer	1232.381	954.6619	3.829234	0.024290
	Wholesaler	1478.322	971.9190	5.437471	0.039325
	Retail	2257.241	1719.889	5.310742	0.034835
Egg	Producer	684.0396	500.9430	2.432937	0.016141
	Wholesaler	110.1971	46.64723	0.298112	0.003500
	Retail	639.8025	454.8876	1.951737	0.013442

For chicken meat, the MAPE model performed best at the producer level (3.82%), with slightly higher errors at the wholesale (5.43%) and retail levels (5.31%). For eggs, the MAPE forecasts were more accurate overall, particularly at the wholesale level (0.29%), followed by the retail (1.95%) and producer levels (2.43%). The Theil inequality coefficients, all below 0.04, indicated excellent predictive accuracy and confirmed that the models effectively captured short-term price movements across poultry markets in Jambi Province, Indonesia.

CONCLUSION

On average, chicken prices at both the producer and retail levels remained below their normal levels, not reaching the target sales prices. Similarly, average egg prices at the producer and retail levels were below normal. There was a long-term cointegration relationship among chicken and egg prices across producer, wholesale, and retail markets in Jambi Province, Indonesia. Prices of chicken and eggs at all market levels affect one another not only in the current period but also with respect to prices observed two and six weeks prior. Wholesale and retail chicken prices influence producer prices, retail prices affect wholesale prices, and wholesale prices influence retail prices. Wholesale egg prices influence producer prices, retail prices influence producer prices, and retail egg prices influence wholesale prices. The vector error correction model used to forecast chicken and egg prices at the producer, wholesale, and retail levels in Jambi Province, Indonesia, demonstrated outstanding predictive performance. There was no reference price for chicken and eggs at the wholesale level; this has led the government of Indonesia, specifically the National Food Agency and the Ministry of Trade, to establish reference prices at the wholesale level, especially for poultry products (chicken and eggs), to prevent large price fluctuations. Future studies are recommended to analyze market integration across different market levels (producer, wholesale, and retail) for chicken meat and eggs in Indonesia, encompassing both producing and consuming provinces, such as West Java, Central Java, and East Java, and consuming provinces (Jakarta and Banten) in Indonesia.

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Availability of data and materials

The datasets generated or analyzed in the present study can be obtained from the corresponding author upon reasonable request

Authors' contributions

Firmansyah contributed to the conceptualization, methodology, and formal analysis. Fachroerrozi Hoesni assisted in drafting the manuscript. Afriani Harahap carried out the data analysis and interpretation. Lailal Gusri was involved in the investigation and project administration. All authors have read and approved the final edition of the manuscript.

Competing interests

The authors declare that there are no conflicts of interest.

Ethical considerations

Ethical considerations, including plagiarism, consent for publication, research misconduct, data fabrication or falsification, duplicate publication or submission, and redundancy, have been reviewed and confirmed by all authors. Additionally, the authors have not assisted artificial intelligence during the conduct of the present study and preparing the manuscript.

REFERENCES

Amin MdR, Alam GMM, Parvin MstT, and Acharjee DC (2023). Impact of COVID-19 on the poultry market in Bangladesh. Heliyon, 9(2): e13443. DOI: https://www.doi.org/10.1016/j.heliyon.2023.e13443

Andersen L, Babula RA, Hartmann H, and Rasmussen MM (2007). A time series analysis of Danish markets for pork, chicken, and beef. Acta Agriculturae Scandinavica, Section C — Food Economics, 4(2): 103-118. DOI: https://www.doi.org/10.1080/16507540701439787

Ankamah-Yeboah I and Bronnmann J (2018). Market integration in the crustacean market: Evidence from Germany. Marine Policy, 87: 72-77. DOI: https://www.doi.org/10.1016/j.marpol.2017.10.012

Bakucs Z, Fałkowski J, and Fertő I (2013). Does market structure influence price transmission in the agro-food sector? A meta-analysis perspective. Journal of Agricultural Economics, 65(1): 1-25. DOI: https://www.doi.org/10.1111/1477-9552.12042

Chapot L, Hibbard R, Ariyanto KB, Maulana KY, Yusuf H, Febriyani W, Cameron A, Paul M, Vergne T, and Faverjon C (2024). Needs and capabilities for improving poultry production and health management in Indonesia. PLoS ONE, 19(8): e0308379. DOI: https://www.doi.org/10.1371/journal.pone.0308379

Deb P, Dey MM, and Surathkal P (2022). Price transmission and market integration of Bangladesh fish markets. Aquaculture, 560: 738592. DOI: https://www.doi.org/10.1016/j.aquaculture.2022.738592

Dickey DA and Fuller WA (1981). Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49(4): 1057-1072. DOI: https://www.doi.org/10.2307/1912517

Dietrich S, Giuffrida V, Martorano B, and Schmerzeck G (2021). COVID-19 policy responses, mobility, and food prices. American Journal of Agricultural Economics, 104(2): 569-588. DOI: https://www.doi.org/10.1111/ajae.12278

Duangnate K, Mjelde JW, and Anderson DP (2025). Evolving price dynamics in the broiler cut industry: Distinct roles of white and dark meat cuts. Journal of Agricultural and Applied Economics, 57(2): 259-275. DOI: https://www.doi.org/10.1017/aae.2025.4

Evalia NA, Harianto, Nurmalina R, and Hakim DB (2022). Price transmission between input and output markets: The COVID-19 effect on laying hens' industry in Indonesia. Jurnal Manajemen & Agribisnis, 19(3): 418-427. DOI: http://www.doi.org/10.17358/jma.19.3.418

Fernández-Polanco J and Llorente I (2019). Price transmission and market integration: Vertical and horizontal price linkages for gilthead seabream (*Sparus aurata*) in the Spanish market. Aquaculture, 506: 470-474. DOI: https://www.doi.org/10.1016/j.aquaculture.2019.03.052

Fitriani A, Daryanto HK, Nurmalina R, and Susilowati SH (2014). Impact on increasing concentration in Indonesian broiler industry. International Journal of Poultry Science, 13(4): 191-197. DOI: https://www.doi.org/10.3923/ijps.2014.191.197

Firmansyah and Harahap A (2024). Variation in livestock product price volatility between regions and markets in Jambi Province, Indonesia. Universal Journal of Agricultural Research, 12(1): 108-120. DOI: https://www.doi.org/10.13189/ujar.2024.120111

Granger CWJ (1969). Investigating causal relation by econometric and cross-sectional method. Econometrica, 37(3): 424-438. DOI: https://www.doi.org/10.2307/1912791

Hassouneh I, Radwan A, Serra T, and Gil JM (2012). Food scare crises and developing countries: The impact of avian influenza on vertical price transmission in the Egyptian poultry sector. Food Policy, 37(3): 264-274. DOI: https://www.doi.org/10.1016/j.foodpol.2012.02.012

Hoshino E, Schrobback P, Pascoe S, and Curtotti R (2021). Market integration between the major domestic fish markets in Australia. Fisheries Research, 243: 106085. DOI: https://www.doi.org/10.1016/j.fishres.2021.106085

Hou S and Song L (2021). Market integration and regional green total factor productivity: Evidence from China's province-level data. Sustainability, 13(2): 472. DOI: https://www.doi.org/10.3390/su13020472

Iregui AM and Otero J (2017). Testing for Spatial market integration: Evidence for Colombia using a pairwise approach. Agricultural Economics, 48(6): 743-753. DOI: https://www.doi.org/10.1111/agec.12371

Johansen S (1988). Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2-3): 231-254. DOI: https://www.doi.org/10.1016/0165-1889(88)90041-3

Jojo J, Harianto H, Nurmalina R, and Hakim DB (2021). Price transmission in the broiler chicken sector in Indonesia: An asymmetric NARDL approach. Journal of the Austrian Society of Agricultural Economics, 17(2): 293-302. Available at: https://www.sagepublisher.com/article/price-transmission-in-the-broiler-chicken-sector-in-indonesia-an-asymmetric-nardl-approach

Karim S, Ali A, Nadeem N, Ghafoor A, and Imran MA (2017). Market integration and price transmission in poultry products markets of Punjab, Pakistan. Journal of Marketing and Consumer Research, 32: 37-43. https://www.iiste.org/Journals/index.php/JMCR/article/view/35591/36608

Kumar R, Manocha K, and Ortega J (2022). On the integration of shapley–scarf markets. Journal of Mathematical Economics, 100: 102637. DOI: https://www.doi.org/10.1016/j.jmateco.2022.102637

Lence SH, Moschini GC, and Santeramo FG (2017). Threshold cointegration and spatial price transmission when expectations matter. Agricultural Economics, 49(1): 25-39. DOI: https://www.doi.org/10.1111/agec.12393

Liu T and Tang S (2023). Research on the impact of emergencies on the poultry market integration in China. China Agricultural Economic Review, 15(1): 197-213. DOI: https://www.doi.org/10.1108/CAER-10-2020-0237

Loy JP, Holm T, Steinhagen C, and Glauben T (2014). Cost pass-through in differentiated product markets: A disaggregated study for milk and butter. European Review of Agricultural Economics, 42(3): 441-471. DOI: https://www.doi.org/10.1093/erae/jbu031

MacDonald JM and Key N (2015). Market power in poultry production contracting? Evidence from a farm survey. Journal of Agricultural and Applied Economics, 44(4): 477-490. DOI: https://www.doi.org/10.1017/S1074070800024056

McKenzie AM, Goodwin HL, and Carreira RI (2009). Alternative model selection using forecast error variance decompositions in wholesale chicken markets. Journal of Agricultural and Applied Economics, 41(1): 227-240. DOI: https://www.doi.org/10.1017/S1074070800002650

Mohapatra S and Singh J (2021). Co-integration of major vegetable markets in Punjab, India. Economic Affairs, 66(2): 181-187. DOI: https://www.doi.org/10.46852/0424-2513.2.2021.1

Noda H and Kyo K (2023). Dynamic relationships among changes in prices of beef, pork, and chicken in Japan: A Bayesian approach. Journal of Agriculture and Food Research, 11(4): 100464. DOI: https://www.doi.org/10.1016/j.jafr.2022.100464

Nugroho AD (2021). Agricultural market information in developing countries: A literature review. Agricultural Economics, 67(11): 468-477. DOI: https://www.doi.org/10.17221/129/2021-AGRICECON

Pan FH and Li CX (2019). Evolution of agricultural spatial market integration: Evidence from the hog market in China. Journal of Agricultural and Applied Economics, 51(3): 349-367. DOI: https://www.doi.org/10.1017/aae.2019.7

Pang J, Yin J, Lu G, and Li S (2023). Supply and demand changes, pig epidemic shocks, and pork price fluctuations: An empirical study based on an SVAR model. Sustainability, 15(17): 13130. DOI: https://www.doi.org/10.3390/su151713130

Peltzman S (2000). Prices rise faster than they fall. Journal of Political Economy, 108(3): 466-502. DOI: https://www.doi.org/10.1086/262126

Penone C and Trestini S (2022). Testing for asymmetric cointegration of Italian agricultural commodities prices: Evidence from the futures-spot market relationship. Agricultural Economics, 68(2): 50-58. DOI: https://www.doi.org/10.17221/226/2021-AGRICECON

Popat M, Griffith G, Mounter S, and Cacho O (2022). Infrastructure investments, regional trade agreements and agricultural market integration in Mozambique. Food Security, 14: 9-22. https://www.doi.org/10.1007/s12571-021-01207-2

Pozo CF, Bachmeier LJ, and Schroeder TC(2021). Are there price asymmetries in the US beef market?. Journal of Commodity Markets, 21: 100127. DOI: https://www.doi.org/10.1016/j.jcomm.2020.100127

Pukthuanthong K and Roll R (2009). Global market integration: An alternative measure and its application. Journal of Financial Economics, 94(2): 214-232. DOI: https://www.doi.org/10.1016/j.jfineco.2008.12.004

Putri MA, Yelfiarita, Afrizal R, and Arnayulis (2022). Analysis of price variations and integration of broiler chicken eggs market in West Sumatra. Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis, 21(1): 31-44. DOI: https://www.doi.org/10.31186/jagrisep.21.1.31-44

Richards TJ, G´omez MI, and Lee J (2014). Pass-through and consumer search: An empirical analysis. American Journal of Agricultural Economics, 96(4): 1049-1069. DOI: https://www.doi.org/10.1093/ajae/aau009

Roman M (2020). Spatial integration of the milk market in Poland. Sustainability, 12(4): 1471. DOI: https://www.doi.org/10.3390/su12041471

Selmi, Putra A, Khairunnisa NP, and Asriani PS (2023). Fluctuations and movement patterns of race chicken egg prices in Bengkulu Province. Jurnal Sain Peternakan Indonesia, 18(1): 57-63. DOI: https://www.doi.org/10.31186/jspi.id.18.1.57-63

Seok JH, Kim G, Reed MR, and Kim SE (2018). The impact of avian influenza on the Korean egg market: Who benefits?. Journal of Policy Modeling, 40(1): 151-165. DOI: https://www.doi.org/10.1016/j.jpolmod.2017.11.003

Setiadi A, Santoso SI, and Sumalde Z (2022). Egg market integration and financial feasibility laying hens farmer in Central Java, Indonesia. SOCA, 16(2): 144-154. DOI: https://www.doi.org/10.24843/SOCA.2022.v16.i02.p02

Suganda A, Fahmid IM, Baba S, and Salman D (2024). Fluctuations and disparity in broiler and carcass price before during and after Covid-19 pandemic in Indonesia, Heliyon, 10(8): e29073. DOI: https://www.doi.org/10.1016/j.heliyon.2024.e29073

Sukiyono K, Arianti NN, Sumantri B, Romdhon MM, Suryanty M, and Adiprasetyo T (2021). A model selection for price forecasting of crude palm oil and fresh fruit bunch price forecasting. Iraqi Journal of Agricultural Sciences, 52(2): 479-490. DOI: https://www.doi.org/10.36103/ijas.v52i2.1312

Sumiati, Fadilah R, Darmawan A, and Nadia R (2025). Challenges and constraints to the sustainability of poultry farming in Indonesia. Animal Bioscience, 38(4): 802-817. DOI: https://www.doi.org/10.5713/ab.24.0678

Surathkal P and Chung C (2017). Retail price responses to changes in wholesale prices in the US beef industry: Differences among quality grades and primal cuts. Applied Economics, 49(54): 5512-5522. DOI: https://www.doi.org/10.1080/00036846.2017.1311003

Surni, Nendissa DR, Wahib MA, Astuti MH, Arimbawa P, Miar, Kapa MMJ, and Elbaar EV (2021). Socio-economic impact of the Covid-19 pandemic: Empirical study on the supply of chicken meat in Indonesia. AIMS Agriculture and Food, 6(1): 65-81. DOI: https://www.doi.org/10.3934/agrfood.2021005

Tomycho O, Nendissa DR, and Chamdra S (2023). Transmission of broiler egg prices between surplus and deficit areas: Exploring the dynamics. Eurasia: Economics & Business, 4(70): 9-16. Available at: http://econeurasia.com/issue-2023-04/article_02.pdf

von Cramon-Taubadel S (2017). The analysis of market integration and price transmission – results and implications in an African context. Agricultural Economics Research, Policy and Practice in Southern Africa, 5(2): 83-96. DOI: https://www.doi.org/10.1080/03031853.2017.1295655

Zamani O, Bittmann T, and Loy JP (2021). The role of temperature for seasonal market integration: A case study of poultry in Iran. Australian Journal of Agricultural and Resource Economics, 66(1): 187-215. DOI: https://www.doi.org/10.1111/1467-8489.12443