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Variation in Livestock Product Price Volatility between Regions and Markets in Jambi Province, Indonesia

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Abstract This study conducts a quantitative examination of secondary data, specifically weekly prices of chicken, eggs, and beef across various regions (urban and rural) and market types (traditional and modern) in Jambi Province, Indonesia, spanning from 2018 to the conclusion of the COVID-19 pandemic in 2022. The data is sourced from the Center for Information on Strategic Food Prices. The objective of this study is to uncover the differences in price volatility and price behavior of livestock products based on whether they are in rural or urban areas or in traditional and modern markets. The unique aspect of this research is the examination of the contrast in price volatility and price behavior of livestock products during various stages of the COVID-19 pandemic (before, start, period, and end) in relation to rural or urban areas or traditional and modern markets. The findings of this study are anticipated to be beneficial for central and provincial government policymakers in formulating post-COVID-19 policies aimed at controlling inflation in livestock products. The research employs the coefficient of variation to analyze the price trends of livestock products and the ARCH/GARCH model to estimate volatility levels. The analysis includes several tests such as the unit root test, ARIMA test, ARCH-LM test, ARCH/GARCH model, Lagrange Multiplier test, Ljung Box test, and Jargue-Bera test. The findings reveal that price volatility of livestock products (chicken, eggs, and beef) is more pronounced in urban areas compared to rural areas, and in traditional markets compared to modern markets. The study concludes that there are distinct differences in the price volatility of livestock products across different regions and markets.

Keywords Volatility, Livestock Products, Urban, Rural

1. Introduction

Jambi Province is strategically significant as it directly faces the IMS-GT (Indonesia Malaysia Singapore Growth Triangle) economic growth area, with an economic structure dominated by sectors such as agriculture, plantation, livestock, forestry & fisheries (30.25%). It contributes 6.35% to the economy of the island of Sumatra, Indonesia. However, Jambi Province experienced the highest inflation rate in the country, at 8.55%. This was primarily due to inflation in livestock products such as chicken, eggs, and beef, which reached an annual rate of 11.47%, surpassing the maximum limit of 6%. Both urban and rural areas felt the inflationary pressure on livestock products. Changes in chicken prices, in particular, had a detrimental effect on inflation [1]. In India, food inflation was primarily driven by items like eggs, meat, fish, milk, cereals, and vegetables [2]. Inflation in agricultural prices posed a significant short-term threat [3]. The study of price variations in livestock products before, during, and after the COVID-19 pandemic across different regions (urban and rural) and market types (traditional and modern) was particularly fascinating. The objective of this study is to uncover the differences in price volatility and price behavior of livestock products based on whether they are in rural or urban areas or in traditional and modern markets.

Studies on volatility transmission were crucial as they shed light on the systematic variation in agricultural commodity prices [4]. Price volatility has been a long-standing area of interest for economists seeking to understand market dynamics [5].

High and unpredictable price changes lead to increased price volatility [6]. When price volatility is extremely high, product substitution occurs, while financial losses are incurred when price volatility is very low [7]. Low price volatility disrupts markets and poses risks to consumers and governments [8]. Swift government action is necessary to mitigate the adverse effects of livestock product price volatility on producers and traders. During the onset and throughout the COVID-19 pandemic, consumers faced more unstable and irregular prices for livestock products across different regions (urban and rural) and market types (traditional and modern).

Prices of livestock products fluctuated due to a variety of factors at the start and during the COVID-19 pandemic, including social distancing, reduced demand from the food service industry sector (Horeca: hotels, restaurants, catering), decreased production, supply chain disruption [9], trade barriers [10], fewer food options [11], short-term shortages [12], higher prices [13-14], panic buying and hoarding by consumers [15], and changes in shopping behavior and methods [16].

The COVID-19 pandemic had varying impacts on traditional and modern markets. Traditional markets were less feared by consumers due to the perceived lower risk of COVID-19 transmission. Conversely, modern markets, despite facing policies that restricted their operating hours, were able to maintain profitability during the pandemic. The pandemic also caused disruptions in the logistics system responsible for food supply in Indonesia, leading to significant price disparities among provinces, erratic and extreme price fluctuations, substantial reductions in production and consumption, a decrease in imported products, and widespread job losses. The supply chain system was impacted by blockages in the distribution system, resulting in production accumulation at the producer level and a drop in prices. Demand also fell as people had less disposable income [17].

The ability to predict price volatility is crucial for all stakeholders in the supply chain [18]. High prices of agricultural products pose challenges for consumers and food producers [19]. The volatility of agricultural product prices influences the decisions of consumers, traders, and producers [20]. The chicken market experiences lower price volatility due to its unique market structure with fewer producers. The market structure of each commodity plays a role in determining its price volatility. Commodities in robust markets with large producers (imperfect competitive markets like oligopoly and monopoly) exhibit lower price volatility. Conversely, commodities in weaker markets with smaller producers (perfectly competitive markets) display higher price volatility [21].

2. Materials and Methods

2.1. Research Methods

This study is a quantitative analysis of secondary data, specifically the average weekly prices of chicken, eggs, and beef, because complete daily average data was not available. The data was obtained from the Center for Information on Strategic Food Prices. The data spans from the previous year (2018) to the conclusion of the COVID-19 pandemic in 2022. The coefficient of variation is used to analyze the price trends of these livestock products, while the ARCH/GARCH model [22-24] is employed to estimate the volatility of these prices.

2.2. Data Analysis Stages

The initial step involves conducting a unit root test on the price data for eggs, chicken, and beef at the producer, wholesaler, and retailer levels using a stationarity test. Unit root testing is a crucial aspect of time series data modeling, as modeling with non-stationary data (data that has a unit root) can lead to incorrect interpretations. The Augmented Dickey-Fuller (ADF) test is utilized for unit root testing, where the ADF statistical value is compared with the Mackinnon critical value of 1% using the formula:

$$\Delta P_t = \propto_0 + \gamma P_{t-1} + \beta_i \sum_{j=1}^{m} \Delta P_{t-1} + \varepsilon_i$$

Ket:

ΔP_t	:	First different from P
α_0	:	Constant value
γP_{t-1}	:	Coefficient for lag P
β_i	:	Coefficient for difference lag P
ε	:	Error

Hypothesis:

H_0: $\gamma = 0$ (there is a unit root, it is not stationary)

H_1: $\gamma \neq 0$ (there is no unit root, stationary)

The ARIMA (Autoregressive Integrated Moving Average) test [25] is based on the smallest AIC (Akaike Information Criterion) and SC (Schwartz Criterion) values. The ARIMA model consists of AR, MA, ARMA, and ARIMA. The general form of an autoregressive model with order p (AR(p)) is:

$$Z_t = \emptyset_1 Z_{t-1} + \emptyset_2 Z_{t-2} + \cdots + \emptyset_p Z_{t-p} + \alpha_t$$

with $\emptyset_1$, $\emptyset_2$, …, $\emptyset_p$: autoregressive parameters, α_t: error value at time t.

The general form of the moving average model of order q (MA (q)) is as follows:

$$Z_t = \alpha_t - \theta_1 \alpha_{t-1} - \theta_2 \alpha_{t-2} - \cdots - \theta_q \alpha_{t-q}$$

with θ_1, θ_2, …, θ_q: moving average parameters.

In general, the ARIMA model (p,d,q) is:

$$\emptyset(B)(1-B)^d Z_t = \theta_0 + \theta_q(B)\alpha_t \text{ with: } \emptyset_p(B) = (1 - \emptyset_1 B - \cdots - \emptyset_p B_p), \theta_q(B) = (1 - \theta_1 B - \cdots - \theta_q B_q)$$

d: order of differencing.

Lagrange Multiplier test is to detect the presence of an ARCH process. ARCH testing with Lagrange Multiplier is carried out by regressing the t-th residual square with the t-th residual square (t-q).

$$\varepsilon_t^2 = \alpha_0 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \cdots + \alpha_p \hat{\varepsilon}_{t-p}^2.$$

H_0: There is no ARCH process (homoscedasticity)

H_1: There is an ARCH (heteroscedasticity) process.

If the Lagrange Multiplier value is ≥ than the X^2 table value, it is rejected, and it can be concluded that the data has an ARCH-GARCH effect or is heteroscedastic.

Test the model ARCH/GARCH to overcome the residual volatility problem; a variant model approach is used using the ARCH and GARCH methods [26]. In general, the form of the ARCH (p) model is

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_p \varepsilon_{t-p}^2$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-1}^2$$

where $\alpha_0 > 0$, $\alpha_1, \alpha_2, \ldots, \alpha_p \geq 0$ with ε : residual.

The ARCH model was developed into a Generalized ARCH (GARCH) to overcome orders that are too large in the ARCH model. In the GARCH model, changes in the conditional variance are influenced by the previous random data and the variance of the previous random data. In general, the GARCH model (p,q):

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \cdots + \alpha_p \varepsilon_{t-p}^2 + \beta_1 \hat{\sigma}_{t-1}^2 + \cdots + \beta_p \hat{\sigma}_{t-p}^2,$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \sigma_{t-1}^2 + \sum_{j-1}^{q} \beta_j \hat{\sigma}_{t-j}^2,$$

where $\alpha_0 > 0$, $\alpha_1, \alpha_2, \ldots, \alpha_p \geq 0$, $\beta_0 > 0$, $\beta_1, \beta_2, \ldots, \beta_p \geq 0$ with ε: residual.

3. Results and Discussion

3.1. Variation in the Price Behavior of Livestock Products between Regions

In urban areas, the price behavior of chicken exhibited high instability throughout all phases of the COVID-19 pandemic, peaking at the start of the pandemic (15.14%). Conversely, beef and eggs demonstrated low stability throughout all phases, with the highest fluctuation for beef during the pandemic (4.68%) and for eggs at the end of the pandemic (8.33%). In rural areas, chicken prices were mostly unstable, except during the pandemic period, with the highest instability occurring before the pandemic (13.56%). Beef and egg prices in rural areas remained stable throughout all phases, with the highest fluctuation for beef during the pandemic (3.08%) and for eggs at the end of the pandemic (8.48%). Table 1 provides a comprehensive overview.

The prices of animal products across different regions varied throughout the COVID-19 period, ranging from highly unstable to relatively stable, with the latter being more prevalent. Urban chicken prices were highly unstable throughout the pandemic, while beef and egg prices remained relatively stable. According to Kang's study, the pandemic initially had a greater impact on urban food expenditure than rural food expenditure in countries like India (35.2% vs. 24.0%), Myanmar (30.8% vs. 8.5%), and Vietnam (31.0% vs. 2.3%) [27]. The pandemic disrupted urban food markets, particularly in India's largest cities, with smaller cities experiencing a greater impact and higher price increases than average [28]. Staple food prices in urban areas of Uganda significantly increased during the total lockdown due to COVID-19 compared to one week before or after the lockdown was partially lifted ($p < 0.05$) [29]. Changes in food consumption were observed in urban areas of Iran before and after the pandemic, such as a decrease in meat and milk consumption [30]. The price factor for livestock products in the Philippines is a factor in consumer acceptance of these products [31]. A negative significant relationship was revealed between domestic consumption of red meat and meat price index, with 1% increase in the meat price index leads to 2.0% decrease in the domestic consumption of red meat in Saudi Arabia [32].

Table 1. Variation in Price Behavior of Livestock Products in Urban and Rural Areas

Regions	Livestock Products	COVID-19 Pandemic Phases	Average (IDR/kg)	Standard Deviation (IDR)	Coefficient of Variation (%)	Price Behavior
Urban	Chicken	Before (2018-2019)	32,019	4,541	14.18	Unstable/highly fluctuating
		Start (2020)	28,524	4,317	15.14	Unstable/highly fluctuating
		Period (2021)	31,457	3,179	10.11	Unstable/highly fluctuating
		End (2022)	30,726	4,740	15.43	Unstable/highly fluctuating
	Beef	Before (2018-2019)	123,474	2,217	1.80	Stable/low fluctuation
		Start (2020)	121,154	2,184	1.80	Stable/low fluctuation
		Period (2021)	126,370	5,916	4.68	Stable/low fluctuation
		End (2022)	135,913	4,832	3.56	Stable/low fluctuation
	Eggs	Before (2018-2019)	20,865	1,130	5.41	Stable/low fluctuation
		Started (2020)	21,516	1,311	6.09	Stable/low fluctuation
		Period (2021)	21,871	1,173	5.37	Stable/low fluctuation
		End (2022)	24,677	2,057	8.33	Stable/low fluctuation
Rural	Chicken	Before (2018-2019)	33,879	4,594	13.56	Unstable/highly fluctuating
		Start (2020)	32,543	3,922	12.05	Unstable/highly fluctuating
		Period (2021)	34,531	2,720	7.88	Stable/low fluctuation
		End (2022)	34,291	3,586	10.46	Unstable/highly fluctuating
	Beef	Before (2018-2019)	121,995	3,123	2.56	Stable/low fluctuation
		Start (2020)	120,000	0.00	0.00	Stable/low fluctuation
		Period (2021)	123,558	2,816	2.28	Stable/low fluctuation
		End (2022)	132,764	4,093	3.08	Stable/low fluctuation
	eggs	Before (2018-2019)	20,881	1,012	4.85	Stable/low fluctuation
		Start (2020)	21,708	1,773	8.17	Stable/low fluctuation
		Period (2021)	22,073	1,302	5.90	Stable/low fluctuation
		End (2022)	24,849	2,107	8.48	Stable/low fluctuation

In rural areas, chicken prices typically exhibited high fluctuations, with the exception of the COVID-19 period when they were relatively stable. The greatest instability in chicken prices in rural areas occurred prior to the onset of COVID-19. Beef and egg prices in certain rural areas remained stable throughout all phases of the pandemic. The lockdown in India during the COVID-19 pandemic resulted in significant changes in food prices due to supply shortages in rural areas, leading to higher inflation in these areas [33].

The poultry sector was significantly impacted by the COVID-19 pandemic. In Bangladesh, chicken prices fluctuated before, during, and after the lockdown, showing an upward trend [34]. In China, chicken prices initially surged during the first wave of COVID-19 due to issues with the supply of day-old chickens (DOC), but prices fell once these issues were resolved [35]. The lockdown and the pandemic drastically reduced the production, distribution, and consumption of poultry products [36], with a 35% decrease in egg and chicken production in Bangladesh [37], and 32.5% of respondents indicating that their poultry farming was severely affected by COVID-19 [38]. The demand for chicken initially decreased as a result of the pandemic [39-41]. Following the onset of COVID-19, prices of poultry products at the farm, wholesale, and retail levels sharply declined in the first three months. However, chicken and egg prices subsequently increased by more than 40% and 30%, respectively [42], while the price gap for beef at the wholesale and retail levels widened [12]. In Italy, during the first wave of COVID-19, home consumption of eggs increased by about 45%, but prices also rose by 20% [43].

3.2. Variation in the Price Behavior of Livestock Products between Markets

The COVID-19 pandemic had varying impacts on traditional markets. Consumers were less apprehensive about visiting traditional markets due to the perceived lower risk of COVID-19 transmission. Chicken prices at traditional markets exhibited high instability, peaking at the end of the pandemic (19.58%). Conversely, beef and egg prices remained relatively stable at traditional markets, except for the end of the pandemic when they exhibited high instability. Notably, beef price volatility at traditional markets increased significantly from 1.87% at the start of the pandemic to 16.11% at the end. Similarly, egg price instability sharply increased from 4.82% at the start of the pandemic to 17.07% at the end.

The price behavior of chicken in modern markets varied considerably. It was highly unstable prior to the pandemic, stabilized at the start and during the pandemic, and then became highly unstable again at the end of the pandemic. Interestingly, the instability of chicken prices in modern markets at the end of the pandemic (19.72%) was higher than before the pandemic (12.53%). The price behavior of beef and eggs in modern markets was relatively stable, except for the end of the pandemic when they exhibited high instability. The instability of beef and egg prices in modern markets increased significantly from the start to the end of the pandemic. Table 2 provides a detailed overview.

Table 2. Variation in Price Behavior of Livestock Products in Traditional and Modern Markets

Market	Livestock Products	COVID-19 Pandemic Phases	Average (IDR/kg)	Standard Deviation (IDR)	Coefficient of Variation (%)	Price Behavior
Traditional	Chicken	Before (2018-2019)	33,051	4,474	13.54	Unstable/highly fluctuating
		Start (2020)	30,906	4,335	14.03	Unstable/highly fluctuating
		Period (2021)	33,056	2,719	8.22	Stable/low fluctuation
		End (2022)	31,974	6,259	19.58	Unstable/highly fluctuating
	Beef	Before (2018-2019)	122,649	2,296	1.87	Stable/low fluctuation
		Start (2020)	120,568	969	0.80	Stable/low fluctuation
		Period (2021)	124,770	3,889	3.12	Stable/low fluctuation
		End (2022)	121,011	19,491	1611	Unstable/highly fluctuating
	Eggs	Before (2018-2019)	20,897	1,006	4.82	Stable/low fluctuation
		Start (2020)	21,700	1,380	6.36	Stable/low fluctuation
		Period (2021)	22,000	1,215	5.52	Stable/low fluctuation
		End (2022)	21,186	3,616	17.07	Unstable/highly fluctuating
Modern	Chicken	Before (2018-2019)	38,472	4,822	12.53	Unstable/highly fluctuating
		Start (2020)	37,728	2,591	6.87	Stable/low fluctuation
		Period (2021)	43,764	1,310	2.99	Stable/low fluctuation
		End (2022)	39,602	7,811	19.72	Unstable/highly fluctuating
	Beef	Before (2018-2019)	112,878	7,353	6.51	Stable/low fluctuation
		Start (2020)	126,139	7,675	6.08	Stable/low fluctuation
		Period (2021)	150,326	9,035	6.01	Stable/low fluctuation
		End (2022)	127,350	28,312	22.23	Unstable/highly fluctuating
	Eggs	Before (2018-2019)	22,852	1,178	5.16	Stable/low fluctuation
		Start (2020)	22,875	1,416	6.19	Stable/low fluctuation
		Period (2021)	22,988	782	3.40	Stable/low fluctuation
		End (2022)	22,583	3,719	16.47	Unstable/highly fluctuating

This study identified variations in the prices of animal products. In traditional markets, chicken prices generally exhibited high fluctuations, except during the COVID-19 period when they were relatively stable. A sharp increase in instability was observed in egg prices at the onset of the pandemic. In modern markets, chicken prices varied significantly; they were highly unstable prior to the pandemic, stabilized at the start and during the pandemic, and then became highly unstable again at the end of the pandemic. Beef and egg prices in modern markets were generally stable, except for the end of the pandemic when they exhibited high instability. The instability of beef and egg prices in modern markets saw a significant increase from the start to the end of the pandemic.

The shift to working from home due to the COVID-19 pandemic led to an increase in food consumption and changed the frequency of visits to superstores [44]. Chicken products, which are typically purchased in supermarkets, saw a change in buying and consumption patterns due to the pandemic [45]. Egg prices at the consumer level increased as a result of COVID-19, but they remained more stable in the producer market than in the consumer market in Indonesia [46]. In China, traditional markets, which offer a wide network of food sources for fresh vegetables and meat in every community, were more popular than supermarkets for fresh food [47]. In Bangladesh, lockdown measures caused chicken prices to drop by about 44%, while meat and egg prices rose by 26% and 8%, respectively [48].

3.3. Variability in the Volatility of Livestock Products

The study identified different ARIMA models for livestock product prices in traditional markets, as shown in Table 3. Chicken prices adhered to the ARIMA (1,0,1) model, beef prices followed the ARIMA (1,1,1) model, and egg prices conformed to the ARIMA (12,0,6) model, all of which had significant probabilities. Similarly, in modern markets, various ARIMA models were observed for livestock product prices, with chicken prices following the ARIMA (9,1,9) model, and both beef and egg prices following the ARIMA (0,1,1) model. These models also exhibited significant probabilities. The ARCH heteroskedasticity test results in the ARIMA model for livestock product prices in traditional markets indicated no significant heteroskedasticity or ARCH effect for chicken and beef, suggesting that the ARIMA model can accurately predict future prices for these products.

Table 3. ARIMA Model Results and Heteroskedasticity Test for Livestock Products in Traditional and Modern Markets

Livestock Products	**ARIMA Model Test**						**ARIMA's Heteroskedasticity Test Model**			
	ARIMA Models	**AIC**	**S.C**	**R-Squared**	**Adjusted R-Square**	**Prob***	**F-statistics**	**Prob. F(1.235)**	**Obs*R-squared**	**Prob. Chi-Square(1)**
Traditional Market										
Chicken	ARIMA(1,0,1)	18.2865	18.3447	0.7132	0.7095	0.0000	0.0185	0.8919	0.0187	0.8913
Beef	ARIMA(1,1,1)	18.2833	18.3417	0.2446	0.2349	0.0000	0.3453	0.5573	0.3477	0.5554
Eggs	ARIMA(12,1,6)	15.3322	15.4051	0.2331	0.2199	0.0000	5.0114	0.0261	4.9486	0.0261**
Modern Market										
Chicken	ARIMA(9,1,9)	17.5576	17.6451	0.2937	0.2785	0.0000	7.2903	0.0074	7.1311	0.0076**
Beef	ARIMA(0,1,1)	18.3056	18.3494	0.2974	0.2915	0.0000	0.0048	0.9448	0.0048	0.9445
Eggs	ARIMA(0,1,1)	14.9317	14.9754	0.2179	0.2112	0.0000	0.1592	0.6902	0.1605	0.6887

* Significant

**There is Heteroskedasticity

Table 4. ARCH/GARCH Model Results for Livestock Products in Traditional and Modern Markets

Livestock Products	ARCH/GARCH Model Test						Heteroscedasticity testARCH LM			
	ARCH / GARCH Models	Variables	coefficient	Std. Error	Z-statistics	Prob.	F-statistics	Prob. F(1.235)	Obs*R-squared	Prob. Chi-Square (1)
Traditional Market										
Chicken	GARCH (1,1)	AR(1)	0.6504	0.0589	11.0404	0.0000	0.2380	0.2406	0.6255	0.6237
		MA(1)	0.5708	0.0675	8.4610	0.0000				
Beef	GARCH (1,1)	AR(1)	0.0792	0.0097	8.1369	0.0000	0.0312	0.0314	0.8600	0.8593
		MA(1)	-0.4676	0.0625	-7.4842	0.0000				
Eggs	GARCH (1,1)	AR(12)	-0.1491	0.0628	-2.3747	0.0176	0.1571	0.1584	0.6922	0.6906
		MA(1)	0.4096	0.0909	4.5077	0.0000				
		MA(6)	-0.1126	0.0467	-2.4120	0.0159				
Modern Market										
Chicken	ARCH (1,0)	AR(2)	-0.1589	0.0622	-2.5557	0.0106	0.2064	0.2080	0.6500	0.6483
		AR(9)	-0.4288	0.0657	-6.5231	0.0000				
		MA(1)	0.5530	0.1024	5.3981	0.0000				
		MA(9)	0.1889	0.0745	2.5366	0.0112				
Beef	GARCH (1,1)	MA(1)	0.7512	0.0342	21.9559	0.0000	0.0123	0.0124	0.9118	0.9113
Eggs	GARCH (1,1)	MA(1)	0.5728	0.0883	6.4857	0.0000	0.5539	0.5574	0.4574	0.4553

The study also presented the results of the ARCH/GARCH model analysis for livestock products in traditional markets, as outlined in Table 4. Chicken and beef prices followed a GARCH model (1,1) with AR(1) and MA(1), while egg prices followed a GARCH model (1,1) with AR(12) and MA(1) MA(6), all with a probability value of 0.000. In modern markets, beef and eggs followed a GARCH model (1,1), while chicken adhered to an ARCH model (1,0). Beef and eggs had a GARCH model (1,1) with MA(1) and a probability value of 0.000, while chicken had an ARCH model (1,0) with AR(2) AR(9), and MA(1) MA(9) and a probability value of 0.000. Table 4 provides further details.

The product price forecasting models in traditional markets met the criteria of RMSE, MAE, MAPE, Theil Inequality Coefficient, Theil U2 Coefficient, and Symmetric MAPE, indicating that the GARCH (1,1) model can effectively forecast the prices of livestock products in traditional markets. The MAPE values for chicken (5.317100), beef (0.764376), and eggs (1.536121) are below 10%, which means the GARCH(1,1) model works very well.

The MAPE value is smallest compared to RMSE for chicken (2208,859), beef (2201,836), eggs (516,244), and MAE for chicken (1720,2019), beef (981,219), and eggs (339,199), so the forecasting results are very significant and have a very small error.

Similarly, in modern markets, the price forecasting models for livestock products such as beef, chicken, and eggs also met the criteria of RMSE, MAE, MAPE, Theil Inequality Coefficient, Theil U2 Coefficient, and Symmetric MAPE. These results suggest that the GARCH (1,1) and ARCH(1,0) models can accurately forecast the prices of livestock products in the modern market. The MAPE values for chicken (2.004336), beef (0.726457), and eggs (0.993014) are below 10%, which means the GARCH(1,1) model works very well. The MAPE value is smallest compared to RMSE for chicken (1482.450), beef (2285.911) eggs (417.223), and MAE for chicken (798.848), beef (918.544), eggs (233.708), so the forecasting results are very significant and have errors which is very small. Table 5 provides additional details.

Table 5. Evaluation Results of Livestock Product Price Forecasting Models in Traditional and Modern Markets

Livestock Products	Model	RMSE	MAE	MAPE	Theil Inequality Coefficient	Theil U2 Coefficient	Symmetric MAPE
Traditional Market							
Chicken	ARIMA (1,0,1)	2208.859	1720.201	5.317100	0.033534	0.855629	5.290245
Beef	ARIMA (1,1,1)	2201.836	981.219	0.764376	0.008872	0.980036	0.773200
Eggs	GARCH (1,1)	516.244	339.199	1.536121	0.011827	0.879388	1.541824
Modern Market							
Chicken	ARCH (1,0,1)	1482,450	798.848	2.004336	0.018162	0.852983	2.012974
Beef	ARIMA (1,1,1)	2285.911	918.544	0.726457	0.008655	0.863862	0.727309
Eggs	ARIMA (0,1,1)	417.223	233.708	0.993014	0.009002	0.876289	0.992591

This study revealed that the prices of animal products in traditional markets exhibited significant heteroskedasticity or ARCH effect in the ARIMA model, with the exception of eggs, indicating that the ARIMA model was not suitable for forecasting future egg prices and necessitating the use of the ARCH/GARCH model. Conversely, in the modern market, the ARIMA model was effective for forecasting future prices for beef and eggs, as the ARCH heteroscedasticity test on the ARIMA model was not significant. However, for chicken prices, the ARIMA model was not suitable, and the ARCH/GARCH model was required. The study also found that the GARCH (1,1) model eliminated heteroskedasticity or ARCH effect for all animal products in traditional markets, suggesting that the GARCH (1,1) model is suitable for forecasting future prices of animal products (chicken, beef, and eggs) in traditional markets. Similarly, in the modern market, the GARCH (1,1) model eliminated heteroskedasticity or ARCH effect for beef and eggs, and the ARCH (1,0) model did so for chicken. These results suggest that in the modern market, the ARCH (1,0) model is suitable for forecasting chicken prices, while the GARCH (1,1) model is suitable for beef and eggs. Agbo's research results indicate that ARIMA (1,1,1), ARIMA (2,1,2), ARIMA (1,1,0), ARIMA (1,1,2), ARIMA (0,1,0), and ARIMA (1,1,1) model was the best model for assessing price volatility and GARCH (1,1) was a better model for forecasting prices [49].

Chicken prices fluctuated the most at the start of COVID-19 in all areas (urban and rural) and markets (traditional and modern), with urban areas (0.8105) recording the highest value, followed by rural areas (0.6078), traditional markets (0.6241), and modern markets (0.2551). Conversely, beef prices fluctuated the most during COVID-19 in all areas and markets, with urban areas (0.3284) recording the highest value, followed by traditional markets (0.1909) and modern markets (0.1685). Egg prices fluctuated the most during COVID-19 in urban areas (0.2807) and traditional markets (0.2289), during the early COVID-19 period in modern markets (0.1821), and during the end of COVID-19 period in rural areas (0.2923). Table 6 provides further details.

This study discovered that the prices of animal products such as beef, chicken, and eggs exhibited variations in volatility across different regions and markets. Urban areas experienced higher price volatility for animal products compared to rural areas. Chicken prices saw the greatest volatility at the onset of COVID-19 across all regions and markets. Beef prices experienced the most volatility during the pandemic in urban areas and in both market types.

The post-COVID-19 government policy involves several key strategies. Firstly, it aims to optimize the central and provincial inflation control teams to enhance synergy and innovation in controlling food inflation. This is achieved through market intervention to reduce fluctuations in livestock product prices and by strengthening regional food reserves, including regulation distribution. Secondly, the policy focuses on enhancing livestock facilities and infrastructure to boost livestock productivity. Thirdly, it involves integrating provincial livestock product stock and balance sheet data to fortify cooperation between provinces. Fourthly, the policy aims to strengthen infrastructure and supply chains to facilitate the distribution of livestock products. To stabilize livestock product prices, the Indonesian government can implement control measures such as improving transportation infrastructure to minimize price gaps between regions, enhancing fast and up-to-date market information systems, and enforcing the law of one price for livestock products across regions [50].

Table 6. Variation in Volatility of Livestock Products between Regions and Markets

Livestock Products	COVID-19 Pandemic Phases	Regions		Market	
		Urban	Rural	Traditional	Modern
Chicken	Before (2018-2019)	0.6993	0.6482	0.5717	0.4043
	Start (2020)	0.8105	0.6078	0.6241	0.2551
	Period (2021)	0.5905	0.4531	0.4049	0.0733
	End (2022)	0.7203	0.4679	0.5402	0.3030
Beef	Before (2018-2019)	0.1269	0.1565	0.1287	0.1220
	Start (2020)	0.1519	0.0063	0.0637	0.1292
	Period (2021)	0.3284	0.1259	0.1909	0.1685
	End (2022)	0.1435	0.1345	0.1400	0.1266
Eggs	Before (2018-2019)	0.1541	0.1772	0.1297	0.1088
	Start (2020)	0.2055	0.2562	0.1748	0.1821
	Period (2021)	0.2807	0.2063	0.2289	0.1190
	End (2022)	0.2556	0.2923	0.2156	0.1522

Egg prices saw the most volatility during the pandemic in urban areas and traditional markets and at the start of the pandemic in modern markets. According to Lagat's research, food prices fluctuated more in rural and urban markets [51]. Egg prices changed more during the pandemic period (0.26) than before it (0.14) [52]. Chicken prices in rural areas of Indonesia experienced low and rapid changes [53]. Egg prices at the producer and consumer levels were stable before the pandemic. Still, they became unstable at the consumer level during the pandemic, while they were expected to be unstable at the producer level in Indonesia [54]. Changes in egg prices are important as they can help understand the patterns and causes of price fluctuations, enabling the government and producers to plan for potential changes and ensure food security at all times [55]. Bozma's research showed that COVID-19 significantly affected beef price changes at the 1% level in Turkey [56].

Proposed strategies to reduce business losses due to price changes include improving market information systems, enhancing the transparency and reliability of information in domestic and international markets, and improving institutional skills to maintain stable food prices. The policies of the Indonesian government, in the form of the Presidential Regulation of the Republic of Indonesia Number 59 of 2020 and Regulation of the Minister of Trade of the Republic of Indonesia Number 07 of 2020 through price ceilings and price floors, have not been effective in stabilizing beef prices. Therefore, it is time for the Indonesian government to enforce the Law of One Price for beef across regions [50].

4. Conclusions

The price behavior of livestock products across different regions (urban and rural) and market types (traditional and modern) exhibited variations during the COVID-19 period (before, start, period, and end), ranging from high instability to low stability, with the latter being more prevalent. There was also a variation in price volatility for livestock products such as beef, chicken, and eggs across different regions and markets in Jambi Province. Urban areas experienced higher price volatility for livestock products compared to rural areas, and traditional markets exhibited higher price volatility for livestock products compared to modern markets. The price forecasting model for livestock products, including beef, chicken, and eggs, met the criteria of RMSE, MAE, MAPE, Theil Inequality Coefficient, Theil U2 Coefficient, and Symmetric MAPE. Therefore, it can be concluded that the price forecasting model for livestock products in traditional and modern markets in Jambi Province, using the GARCH (1,1) and ARCH (1,0) models, demonstrated excellent performance.

The post-COVID-19 government policy involves several key strategies. Firstly, it aims to optimize the central and provincial inflation control teams to enhance synergy and innovation in controlling food inflation. This is achieved through market intervention to reduce fluctuations in livestock product prices and by strengthening regional food reserves, including regulation distribution. Secondly, the policy focuses on enhancing livestock facilities and infrastructure to boost livestock productivity. Thirdly, it involves integrating provincial livestock product stock and balance sheet data to fortify cooperation between provinces. Fourthly, the policy aims to strengthen infrastructure and supply chains to facilitate the distribution of livestock products. To stabilize livestock product prices, the Indonesian government can implement control measures such as improving transportation infrastructure to minimize price gaps between regions, enhancing fast and up-to-date market information systems, and enforcing the law of one price for livestock products across regions.

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REFERENCES

[1] A. N. Tenriawaru, A. R. Al Tawaha, R. Rukka, M. Ridwan, N. V. Chan, and S. H. Syam. Vector autoregressive (VAR) method in analyzing the effect of inflation on food price volatility (FPV) in Palopo City, Indonesia. Internal Journal of Professional Bussiness Review, vol. 8, no. 5, pp. 1-20, 2023. https://doi.org/10.26668/businessreview/2023.v8i5.1872

[2] C. S. C. Sekhar, D. Roy. and Y. Bhatt. Food inflation and volatility in India: trends and determinants. Indian Economic Review, vol. 53, pp. 65–69, 2018. https://doi.org/10.1007/s41775-018-0017-z

[3] S. Guerrero, G. Hernández-del-Valle, and M. Juárez-Torres. Using a functional approach to test trending volatility in Mexican and international agricultural product prices. Agricultural Economics. vol. 48, pp. 1–11, 2016. https://doi.org/10.1111/agec.12290

[4] H. An, F. Qiu, J. Rude. Volatility spillovers between food and fuel markets: Do administrative regulations affect the transmission? Economic Modelling vol. 102, 105552, 2021. https://doi.org/10.1016/j.econmod.2021.105552

[5] T. Tanaka and J. Guo. International price volatility transmission and structural change: a market connectivity analysis in the beef sector. Humanities & Social Sciences Communications, vol. 7, no. 166, pp. 1-13, 2020. https://doi.org/10.1057/s41599-020-00657-x

[6] D. Boughton, K. Mahrt, J. Goeb, I. Lambrecht, D. Headey, H. Akeshima, B. Minten, I. Masias, S. Goudet, C. Ragasa, M. K. Maredia, and X. Diao. Impacts of COVID-19 on agricultural production and food systems in late transforming Southeast Asia: The case of Myanmar. Agricultural Systems, Vo. 188, 103026, pp. 1-9, 2021. https://doi.org/10.1016/j.agsy.2020.103026

[7] A.N. Rezitis, and G. Kastner. On the joint volatility dynamics in international dairy commodity markets. Australian Journal of Agricultural and Resource Economics, vol. 65, pp. 704–728, 2021. https://doi.org/10.1111/1467-8489.12433

[8] K. N. Pavithra, G. M. Gaddi, and Pooja. Price volatility and transmission: A case study of paddy and red gram markets in Karnataka. Economic Affairs, vol. 67, no. 02, pp. 143-152, 2022. https://doi.org/10.46852/0424-2513.2.2022.23

[9] K. Mahajan, and S. Tomar. COVID-19 and supply chain disruption: evidence from food markets in India. American Journal of Agricultural Economics, vol. 103, no. 1, pp. 35–52, 2021. https://doi.org/10.1111/ajae.12158

[10] W. A. Kerr. The COVID-19 pandemic and agriculture: short-and long-run implications for international trade relations. Canadian Journal of Agricultural Economics, vol. 68, no. 2, pp. 225–229, 2020. https://doi.org/10.1111/cjag.12230

[11] S. Devereux, C. Béné, and J. Hoddinott. Conceptualizing COVID-19's impacts on household food security. Food Security, vol. 12, pp. 769–772, 2020. https://doi.org/10.1007/s12571-020-01085-0

[12] J. E. Hobbs, The COVID-19 pandemic and meat supply chains. Meat Science. vol. 181, 108459. pp. 1-6, 2021. https://doi.org/10.1016/j.meatsci.2021.108459

[13] J. Rude. COVID-19 and the Canadian cattle/beef sector: some preliminary analysis. Canadian Journal of Agricultural Economics, vol. 68, no. 2, pp. 207–213, 2020. https://doi.org/10.1111/cjag.12228

[14] J. Ruan, Q. Cai, and S. Jin. Impact of COVID-19 and nationwide lockdowns on vegetable prices: evidence from wholesale markets in China. American Journal of Agricultural Economics, vol. 103, no. 5. pp. 1574–1594, 2021. https://doi.org/10.1111/ajae.12211

[15] B. Ellison, B. McFadden, B. J. Rickard, N. L. W. Wilson. Examining food purchase behavior and food values during the COVID-19 pandemic. Applied Economic Perspectives and Policy, vol. 43, no. 1, pp. 58-72, 2020. https://doi.org/10.1002/aepp.13118

[16] C. Bir, D. Peel, R. Holcomb, K. Raper, and J.J. Jones. The impact of COVID-19 on meat processing and the renewed interest in local processing capabilities. Western Economics Forum, vol. 19, no. 1, pp. 9–20, 2021. https://dx.doi.org/10.22004/ag.econ.311303

[17] Surni, D. R. Nendissa, M. A. Wahib, M. H. Astuti, P. Arimbawa, Miar, M. M. J. Kapa, and E. F. Elbaar. Socio-economic impact of the COVID-19 pandemic: Empirical study on the supply of chicken meat in Indonesia. AIMS Agriculture and Food vol. 6, no. 1, pp. 65–81, 2020. https://doi:10.3934/agrfood.2021005

[18] D. Rakshit, R.K. Paul, and S. Panwar. (2021) Asymmetric price volatility of onion in India. Indian Journal of Agricultural Economics, vol. 76, no. 2, pp. 245-260, 2021. https://isaeindia.org/wp-content/uploads/2021/07/03-Ranjit-Kumar-Paul.pdf

[19] P. Bórawski, A. Perkowska, M. Guth, A. Parzonko, T. Rokicki, and J. W. Dunn. Price volatility of milk and dairy products in Poland after accession to the UE. Agricultural Economics-Czech, vol. 67, no. 3, pp. 111–119, 2021. https://doi.org/10.17221/459/2020-AGRICECON

[20] P. Bórawski, M. Guth, W. Truszkowski, D. Zuzek, A. Bełdycka-Bórawska, B. Mickiewicz, E. J. Szymańska, J. K. Harper, and J. W. Dunn. 2020. Milk price changes in Poland in the context of the common agricultural policy. Agricultural Economics-Czech, vol. 66, no. 1, pp. 19-26, 2020. https://doi.org/10.17221/178/2019-AGRICECON

[21] B. Fakari, M. M. F. Aliabadi, H. Mahmoudi, and M. Kojori. (2016). Volatility spillover and price shocks in Iran's meat market. Custos e @gronegócio *on line*, vol. 12, no. 2, pp. 84-98, 2016. http://www.custoseagronegocioonline.com.br

/numero2v12/OK%204%20volatility%20english.pdf

[22] M. Akay. Red meat price volatility and its relationship with crude oil and exchange rates in Turkey with the approach of GARCH (p, q) model. Yuzuncu Yil University Journal of Agricultural Sciences, vol. 31, no. 4. pp. 915-927, 2021. https://doi.org/10.29133/yyutbd.984277

[23] M. B. Abdallah, M. F. Farkas, and Z. Lakner. Analysis of meat price volatility and volatility spillovers in Finland. Agricultural Economics, vol. 66, no. 2, pp. 84–91, 2020. https://doi.org/10.17221/158/2019-AGRICECON.

[24] I. O. Fasanya, and T. F. Odudu. Modeling return and volatility spillovers among food prices in Nigeria. Journal of Agriculture and Food Research, vol. 2, 100029, 2020. https://doi.org/10.1016/j.jafr.2020.100029

[25] F. Capitanio, G. Rivieccio, and F. Adinolfi. Food price volatility and asymmetries in rural areas of South Mediterranean Countries: A copula-based GARCH model. International Journal of Environmental Research and Public Health, vol. 17, 5855, pp. 1-24, 2020. https://doi.org/10.3390/ijerph17165855

[26] R. Abaidoo, and E. K. Agyapong. Commodity price volatility, inflation uncertainty and political stability. International Review of Economics, vol. 69, pp. 351–381, 2022. https://doi.org/10.1007/s12232-022-00395-3

[27] Y. Kang, A. Baidya, A. Aaron, J. Wang, C. Chan, and Erica Wetzler. Differences in the early impact of COVID-19 on food security and livelihoods in rural and urban areas in the Asia Pacific Region. Global Food Security, vol. 31, 100580, pp. 1-12, 2021. https://doi.org/10.1016/j.gfs.2021.100580

[28] S. Narayanan, and S. Saha. Urban food markets and the COVID-19 lockdown in India. Global Food Security, vol. 29, 100515, pp. 1-11, 2021. https://doi.org/10.1016/j.gfs.2021.100515

[29] E. Buzigi, and S. Onakuse. Food price volatility and socio‑economic inequalities in poor food consumption status during coronavirus disease‑2019 lockdown among slum and non‑slum households in urban Nansana municipality, Uganda. Nutrition Journal, vol. 22, no. 4, pp. 1-13, 2023. https://doi.org/10.1186/s12937-023-00836-x

[30] M. Hajipoor, P. Rahbarinejad, K. Irankhah and S. R. Sobhani. Comparing food consumption during the COVID‑19 pandemic: analysis of household income and expenditure survey data in Iran. Journal of Health, Population and Nutrition, vol. 42, no. 43, pp. 1-13, 2023. https://doi.org/10.1186/s41043-023-00385-3

[31] M. B. Cayaban and M. T. S. Alvarez. Consumers' Acceptance of Isabela State University-Science and Technology (S&T) Based Chevon Products in Baguio City: Market Opportunities and Potential. Universal Journal of Agricultural Research, vol. 10, no. 2, pp. 99-107, 2022. https://doi.org/10.13189/ujar.2022.100201

[32] F. M. Alsarawi, A. A. Elbushra and I. F. Abdalla. Nexus of Macroeconomic Indicators and Meat Consumption in Saudi Arabia: An ARDL Approach. Universal Journal of Agricultural Research, vol. 10, no. 3, pp. 240-248, 2022. https://doi.org/10.13189/ujar.2022.100306

[33] A. G. A. Cariappa, K. K. Acharya, C. A. Adhav, R. Sendhil, P. Ramasundaram. COVID-19 induced lockdown effects on agricultural commodity prices and consumer behavior in India – Implications for food loss and waste management. Socio-Economic Planning Sciences, vol. 82, 101160, pp. 1-23, 2022. https://doi.org/10.1016/j.seps.2021.101160

[34] A. A. Sattar, R. Mahmud, Md. A. S. Mohsin, N. N. Chisty, Md. H. Uddin, N. Irin, T. Barnett, G. Fournie, E. Houghton and Md. A. Hoque. COVID-19 impact on poultry production and distribution networks in Bangladesh. Frontiers in Sustainable Food Systems, vol. 5, 714649. pp. 1-12, 2021. https://doi.org/10.3389/fsufs.2021.714649

[35] P. Fang, B. Belton, X. Zhang, and H. E. Win. Impacts of COVID-19 on Myanmar's chicken and egg sector, with implications for the sustainable development goals. Agricultural Systems, vol. 190, 103094, pp. 1-8, 2021. https://doi.org/10.1016/j.agsy.2021.103094

[36] P. Mishra, A. Golaviya, K. Panchal, A. Hinsu, K. Yadav, G. Fournié, T. Barnett, P. Koringa, H. U. I. Paleja, and R. Dasgupta. Exploring the impact of COVID-19 and the associated lockdown on the production, distribution, and consumption of poultry products in Gujarat, India: a qualitative study. Poultry, vol. 2, pp. 395–410, 2023. https://doi.org/10.3390/poultry2030029

[37] Md. T Rahman, Md. S. Islam, A. A. Shehata, S. Basiouni, H. M. Hafez, E. I. Azhar, A. F. Khafaga, F. Bovera, and Y. A. Attia.. Influence of COVID-19 on the sustainability of livestock performance and welfare on a global scale. Tropical Animal Health and Production, vol. 54, no. 309. pp. 1-10, 2022. https://doi.org/10.1007/s11250-022-03256-x

[38] M. M. Meher, M. Afrin, Md. T. Islam, and M. A. Zinnah. Poultry farming and farmers' perception towards the farming condition during the COVID-19 pandemic in Bangladesh. Journal of Agriculture and Food Research vol. 6, 100239. pp. 1-8, 2021. https://doi.org/10.1016/j.jafr.2021.100239

[39] S. Kumar, V. Maheshwari, J. Prabhu, M. Prasanna, P. Jayalakshmi, P. Suganya, A. M. M. B. Benjula, and R. Jothikumar. The social, economic impact of the COVID-19 outbreak in India. International Journal of Pervasive Computing and Communications, vol. 16, no. 4, pp. 309-319, 2020. https://doi.org/10.1108/IJPCC-06-2020-0053

[40] E. B. Nchanji, C. K. Lutomia, R. Chirwa, N. Templer, J. C. Rubyogo, P. Onyango. Immediate impacts of COVID-19 pandemic on bean value chain in selected countries in sub-Saharan Africa. Agricultural Systems, vol. 188, 103034, pp. 1-13, 2021. https://doi.org/10.1016/j.agsy.2020.103034

[41] K. Nikolopoulos, S. Punia, A. Schäfers, C. Tsinopoulos, and C. Vasilakis. Forecasting and planning during a pandemic: COVID-19 growth rates, supply chain disruptions, and governmental decisions. European Journal of Operational Research, Vol. 290, pp. 99–115, 2021. https://doi.org/10.1016/j.ejor.2020.08.001

[42] Md. R. Amin, G.M. M. Alam, Mst. T. Parvin, and D. C. Acharjee. Impact of COVID-19 on poultry market in Bangladesh. Heliyon, vol. 9, e13443, 2023. https://doi.org/10.1016/j.heliyon.2023.e13443

[43] B. Coluccia, G. P. Agnusdei, P. P. Miglietta, and F. D. Leo. Effects of COVID-19 on the Italian agri-food supply and value chains. Food Control, vol. 123, 107839. pp. 1-12, 2021. https://doi.org/10.1016/j.foodcont.2020.107839

[44] S. Bakalis, V. P. Valdramidisc, D. Argyropoulosd, L.

Ahrnee, J. Chenf, P. J. Culleng, E. Cumminsd, A. K. Dattah, C. Emmanouilidisi, T. Fosterj, P. J. Fryerb, O. Gousetia, A. Hospidok, K. Knoerzerl, A. LeBailm, A. G. Marangonin, P. Raof, O. K. Schlütero, P. Taoukisp, E. Xanthakisq, and J. F. M. V. Impe. How COVID-19 changed our food systems and food security paradigms. Current Research in Food Science, vol. 3, no. 11, pp. 166–172, 2020. https://doi:10.1016/j.crfs.2020.05.003

[45] M. Ijaz, M. K. Yar, I. H. Badar, S. Ali, Md S. Islam, M. H. Jaspal, Z. Hayat, A. Sardar, S. Ullah, and D. Guevara-Ruiz. Meat production and supply chain under COVID-19 scenario: current trends and future prospects. Frontiers in Veterinary Science, vol. 8, 660736, pp. 1-8, 2021. https://doi.org/10.3389/fvets.2021.660736

[46] N. A. Evalia, Harianto, R. Nurmalina, and D. B. Hakim. Price transmission between input and output markets: the COVID-19 effect on laying hens' industry in Indonesia. Jurnal Manajemen & Agribisnis, vol. 19, no. 3. pp. 418-427, 2022. http://dx.doi.org/10.17358/jma.19.3.418

[47] Y. Yuan, Z. Si, T. Zhong, X. Huang, and J. Crush. Revisiting China's supermarket revolution: Complementarity and co-evolution between traditional and modern food outlets. World Development, vol. 147, 105631, pp. 1-12, 2021. https://doi.org/10.1016/j.worlddev.2021.105631

[48] Md. K. Haque, Md. R. U. Zaman, Md. A. Rahman, Md. Y. Hossain, T. I. Shurid, T. A. Rimi, H. Arby, and Md. G. Rabbany. A review on impacts of COVID-19 on global agricultural system and Scope for Bangladesh after pandemic. Environmental Science and Pollution Research, vol. 29, pp. 54060–54071, 2022. https://doi.org/10.1007/s11356-022-21016-0

[49] H. M. S. Agbo, Forecasting agricultural price volatility of some export crops in Egypt using ARIMA/GARCH model. Review of Economics and Political Science, vol 8, no. 2, pp. 123-133, 2023. https://doi.org/10.1108/REPS-06-2022-0035

[50] Firmansyah, P. Maruli, and A. Harahap. Analysis of beef market integration between consumer and producer regions in Indonesia. Open Agriculture, vol. 8, 20220221, 2023. https://doi.org/10.1515/opag-2022-0221.

[51] K. A. Lagat. Asymmetric price volatility transmission in remote food markets: Does it matter for domestic stabilization policies? World Food Policy, vol. 6, no. 2, pp. 157–175, 2020. https://doi.org/10.1002/wfp2.12020

[52] N. Küçük, F. Urak, G. Bozma, and A. Bilgiç. The Long-term volatility spillovers between egg and feed wheat prices during the COVID-19 pandemic in Turkey. Türk Tarım ve Doğa Bilimleri Dergisi, vol. 9, no. 3, pp. 741–753. 2022. https://doi.org/10.30910/turkjans.1128935

[53] H. Subagja, and D. Nikmah. Analysis of influencing factors and volatility of broiler meat prices in Pasuruan Regency, East Java Province. Bulletin Animal Science, vol. 44, no. 4, pp. 240-244, 2020. https://doi.org/10.21059/buletinpeternak.v44i4.34379

[54] P. F. Girsang, H. Toiba, and Syafrial, Egg chicken race price volatility in Indonesia before and during the COVID-19 pandemic. Agricultural Socio-Economics Journal, vol. 23, no. 1. pp. 25-31. 2023, http://dx.doi.org/10.21776/ub.agrise.2023.023.1.4

[55] Y. Liu, S. Liu, D. Ye, H. Tang, and F. Wang. Dynamic impact of negative public sentiment on agricultural product prices during COVID-19. Journal of Retailing and Consumer Services, vol. 64, 102790, pp. 1-16, 2022. https://doi.org/10.1016/j.jretconser.2021.102790

[56] G. Bozma, F., A. Bilgic, and W. J. Florkowski. The volatility of beef and lamb prices in Tu¨rkiye: The role of COVID–19, livestock imports, and energy prices. PLoS ONE, vol. 18, no. 3, e0282611, 2023. https://doi.org/10.1371/journal.pone.0282611