

Article history:

Submitted: July 30th, 2022

Revised : November 28th, 2022

November 8th, 2022

Accepted : December 1st, 2022

Jamhari^{1,*}, Muh Amat Nasir¹, Agus Dwi Nugroho^{1,2}, Ismiasih³, Hitoshi Yonekura⁴

¹ Department of Agricultural Socio-economics, Faculty of Agriculture, Universitas Gadjah Mada, Indonesia

² Doctoral School of Economic and Regional Sciences, Hungarian University of Agriculture and Life Sciences, Godollo, Hungary

³ Department of Agribusiness, Faculty of Agriculture, Institut Pertanian Stiper, Yogyakarta, Indonesia

⁴ Graduate School of Agricultural Science, Faculty of Agriculture, Tohoku University, Sendai, Japan

*) Correspondence email: jamhari@ugm.ac.id

Does the Sleman Chili Auction Market Affect the Local, Regional and National Market Prices in Indonesia?

DOI: <https://doi.org/10.18196/agraris.v8i2.15654>

ABSTRACT

Promoting the horticultural auction market as an alternative outlet is becoming more popular. The horticultural auction market has some benefits, such as reducing price volatility and controlling inflation. This research used a case study in Sleman Regency, which established a horticultural auction market to manage volatile chili prices. The daily price data with ECM-GARCH analysis was used to investigate market integration between the Sleman chili auction market and other markets. The result showed that the Sleman auction market had a beneficial impact on the price decline in the local markets. This impact indicated that the auction market controls inflation at the regional level. However, only 5% to 13% of daily variations of the long-term equilibrium of the auction market to other markets were adjusted. There was information efficiency of the chili prices in Indonesia based on the GARCH model. This study proves that auction markets promote control of macro inflation. This study was the first to manage horticultural product price risk from a chili auction market perspective. Moreover, the model applied in this study expands the ECM-GARCH model to improve the validity of an ECM's significance tests and the efficiency of standard ECM parameter estimation.

Keywords: Auction market; Chili; ECM; GARCH; Market integration

INTRODUCTION

Low and stable inflation is one of the requirements for a country to experience sustained economic growth. Therefore, several studies investigate the dynamics and factors of inflation in several countries (Abbas & Lan, 2020; Bhattacharya & Jain, 2020; Bhattacharya, Jain, & Singh, 2019; Iddrisu & Alagidede, 2020). There is a lag between changes in supply and demand for food commodities resulting in domestic food commodity prices fluctuating. In addition, due to the low elasticity of most food commodities, even slight changes in demand can result in significant price changes (Sasmal, 2015). Food prices also affect consumer preferences (Widodo, Rusimah, & Choirunisa, 2018). In recent years, rising food commodity inflation has been the primary concern for several countries. For example, in Indonesia, food

commodities were the second-largest contributor to inflation in 2020, reaching 0.91% or increasing 0.05% from the previous year (BPS-Statistics Indonesia, 2021b). Food commodity inflation increase poverty and food insecurity in low-income households. This is due to food represents for a sizable portion of low-income households' overall expenses (Ngarava, 2021).

The risk of price volatility in food commodities has become an important issue and the main focus of various studies (Bohl & Sulewski, 2019; Bórawski, Bełdycka-Borawska, & Dunn, 2018; T. T. Sun, Su, Mirza, & Umar, 2021; Y. Sun, Mirza, Qadeer, & Hsueh, 2021). One of the food commodities with very high price volatility in Indonesia is chili (Mariyono & Sumarno, 2015; Muflikh, Smith, Brown, & Abdul Aziz, 2021). Food inflation has a terrible impact on the decline in welfare, especially for the poor (Sekhar, Roy, & Bhatt, 2018). Product and market characteristics strongly influence chili price fluctuation (Mariyono, 2017; Nuvaisyah, Nhita, & Saepudin, 2019). Therefore, the government has designated chili as a staple item by the Presidential Decree No. 71 of 2015 to manage its availability, supply, and stabilize prices. As a perishable commodity, chili is considered vulnerable to high transaction and storage costs, implying that when there is a decrease in supply. Hence, prices increase and the government cannot stabilize them effectively because of a lack of chili reserves (Muflikh et al., 2021).

However, the opposite condition occurs during the harvest season between February and April. On the production side, increased chili harvests result in more supply and market availability and finally raise the chili price. On the demand side, chili consumption is known to be fairly constant throughout the year, implying that price fluctuations are influenced by supply. In addition, chili supply and price fluctuations can be influenced by unorganized and complicated value chains (Muflikh et al., 2021). The dominance of value chain middlemen drives up prices (Ranjan, 2017). The middlemen caused a gap between red chili price at the farmer level and final consumer increased by around 30.93% in 2019 (BPS-Statistics Indonesia, 2020). So, a better understanding of these conditions is essential for designing policy mechanisms and effectively targeting intervention programs.

One of the initiatives to solve the price gap is establishing an auction market to reorganize the value chains (Feenstra & Hardesty, 2016; Johnson, Fraser, & Hawkins, 2016; Muflikh et al., 2021; Reid, Simmonds, & Newbold, 2019). The auction market is advantageous for farmers because it gets them closer to the market and increases their opportunity of engaging in commercial farming (Mariyono, 2018). It will always set a price less than the retail market price, implying that the auction price will positively impact the market price. As auction volume rises, a large quantity of low-price chili enters the market and lowers the total price of the chili market (J. Li, Liu, & Song, 2020). Therefore, spatial chili price trends in regional markets can be considered an essential indicator of overall market performance. Despite their ability to provide several benefits, not all Indonesian auction markets operate at their optimal performance (Mishra & Kumar, 2011). This is due to the auction market's challenges, which include low-quality human resources, limited capital, a lack of infrastructure, and rivalry from other market participants (Nugroho, Prasada, & Rosyid, 2021).

The Sleman chili auction market is one of the well-perform markets in Indonesia (Dewi, Nugroho, & Jamhari, 2021). This auction market was established in October 2017 to shorten the supply chain and reduce the price volatility of chili (Hansen & Stowe, 2018; Kibler & Thompson, 2020; Marks & Welsch, 2015; Marshall et al., 2021). Miyashita (2014) concludes that the auction market is beneficial for streamlining trade in perishable goods. Further, the existence of the Sleman chili auction market significantly impacts the selling price of chili farmers. Nugroho et al. (2021) stated that farmers who sell chilies through the Sleman chili auction market could expect a twofold price increase compared to those who do not. Despite its positive results, no study has been conducted to demonstrate the economic interactions between this auction market and other local, regional, and national markets.

This research focuses on integrating chili pricing across areas that considerably contribute to the development of good marketing management. Furthermore, this study advances market integration theory, especially concerning the agricultural auction market. The authors use the chili price from 2018 to 2020 to empirically assess the short- and long-term impact of the Sleman chili auction market on each market. Most studies on price transmission between agricultural commodity markets have focused on grain markets (Zakari, Ying, & Song, 2014).

This research applied an ECM-GARCH model, which is a combination of the error correction model (ECM) and the generalized autoregressive conditionally heteroskedasticity (GARCH). The ECM-GARCH model was used due to some previous studies on price integration between agricultural markets only used the ECM model (Akhter, 2017; Arnade, Cooke, & Gale, 2017; Baquedano & Liefert, 2014; Ganneval, 2016; Zakari et al., 2014). Meanwhile, John (2014) performed a vector autoregressive and Jiang & Wang (2013) used co-integration tests to estimate the co-integration relationship between international rice markets. According to Nair (2021) ECM-GARCH can be used to test price transmission between markets. Moreover, the model proposed for this study extends the ECM-GARCH model to obtain ECM parameter estimators in the presence of conditional heteroskedasticity. As a result, applying the ECM-GARCH model improves the validity of an ECM's significance tests and the efficiency of standard ECM parameter estimation (W. K. Li, Shiqing, & Wong, 2001; Sin, 2006).

RESEARCH METHOD

Research context and case selection

The research focuses on the Sleman chili auction market as one of Indonesia's largest horticultural auction markets. This auction market is located in Sleman Regency, Special Region of Yogyakarta Province (Indonesian: Daerah Istimewa (D.I.) Yogyakarta) (Figure 1). During the last three years, this province has been one of Indonesia's largest red chili producers, with the second largest farmer's terms of trade in Java's horticultural crops sector (BPS-Statistics Indonesia, 2021a). Farmer's terms of trade in the Special Region of Yogyakarta have a surplus value, which indicates that the growth in farmers' income is greater than the

increase in their expenditure. Therefore, the study aims to maximize the impact of red chili auction price variation on price formation in the local, regional and national markets. The study determined Pakem and Gamping market as the local market. Pakem market was chosen since it represents Sleman's central production, and Gamping market was chosen due to its role as the wholesale horticultural market in Sleman. Meanwhile, the Beringharjo market was designated the regional market, and the Kramat Jati Central Market was designated the national market. Those markets were considered due to the Indonesian Central Bank's continuous monitoring to ensure price control.

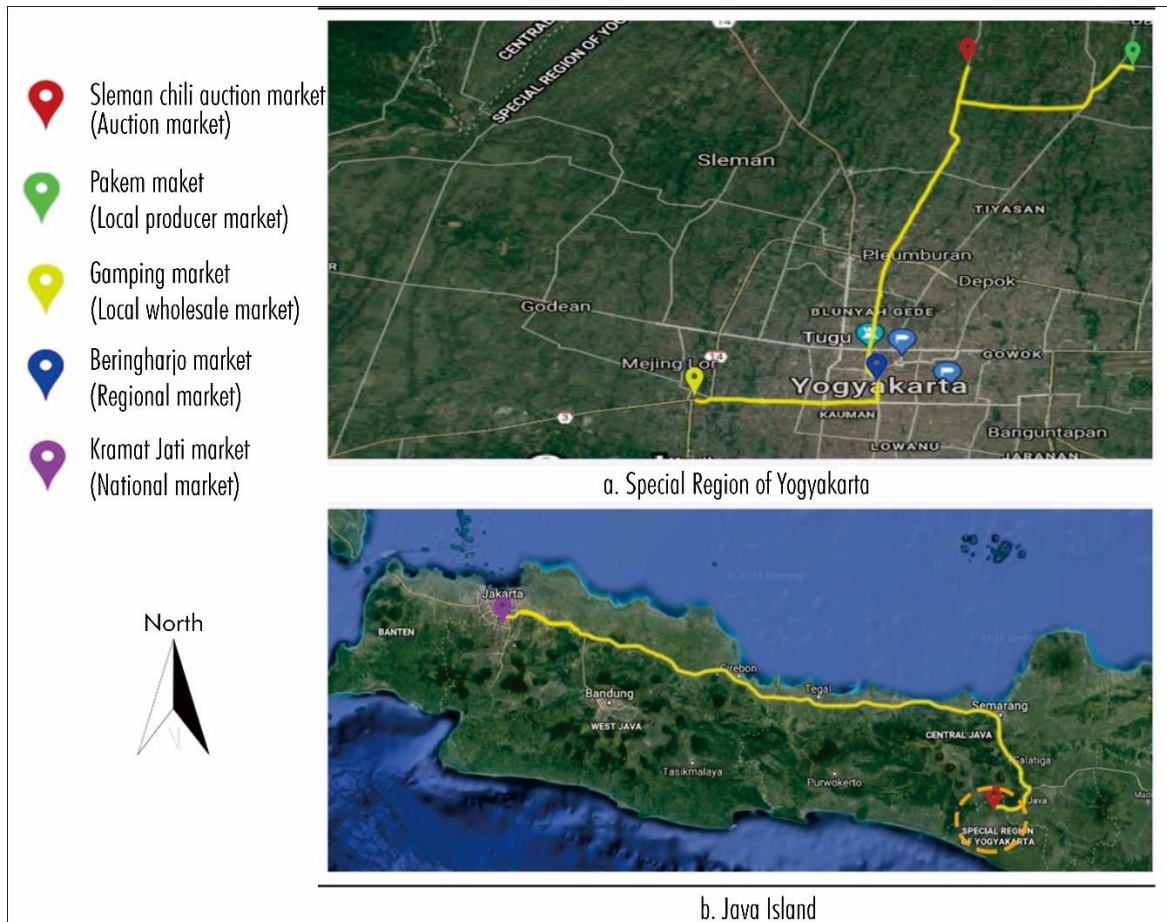


FIGURE 1. MAP OF SLEMAN CHILI AUCTION, LOCAL PRODUCER, LOCAL WHOLESALE, REGIONAL, AND NATIONAL MARKETS

Data collection

This research used daily red chili prices data from the auction, local, regional, and national markets from 1st March 2018 to 30th December 2020 (1,036 data). Data from the auction market manager had to be manually gathered due to it was not provided in a machine-readable format. Price information for local, regional, and national markets has been collected from the National Strategic Food Price Information Centre of the Bank of Indonesia (available at <https://hargapangan.id/>) in machine-readable form. Retail pricing data was used to examine price transmission from the customer's perspective. On the other hand, there are weaknesses in using retail price data because these prices are not inflation-adjusted and are higher than wholesale prices (Akhter, 2017).

Data analysis

The empirical results in this study begin with two preliminary statistical tests, namely the unit root and the co-integration tests. This study used the Augmented Dickey-Fuller Test (ADF) technique to conduct the unit root test (Fuller, 1976). The next step applied the Johansen co-integration test to investigate whether there is a dynamic long-term relationship among the variables (Johansen & Juselius, 1990). However, the error correction model (ECM) was applied to discover variables' short- and long-term dynamic relationships (Brooks, 2008). The ECM is a model that uses a compound of first difference and lagged values on co-integrated variables to determine the long-term relationship and short-term dynamics between variables. The ECM was applied due to it was appropriate to examine the change of one variable concerning the change of another variable (Engle & Granger, 1987):

$$\Delta y_t = \alpha + (y_{t-1} \beta_1 * x_{t-1}) * \beta_2 + \gamma * \Delta x_t + e_t \quad (1)$$

where α was the constant, β_1 displayed the long-term of the adjustment parameter, β_2 presented the speed of adjustment back to equilibrium, and γ showed the short-term impact.

In this paper, the ECM was formulated as follows:

$$\Delta Markets_t = \alpha + (Markets_{t-1} \beta_1 * Auction_{t-1}) * \beta_2 + \gamma * \Delta Auction_t + e_t \quad (2)$$

where $Markets_t$ as the dependent variable represents chili prices (IDR per kg) at the local markets, represented by Pakem market and Gamping market; regional market represented by Beringharjo market; and national market by Kramat Jati Central Market. The independent variable was chili price (IDR per kg) at the Sleman chili auction market.

Furthermore, the GARCH model was employed to discover the existence of chili price volatility in local, regional, and national markets due to the Sleman chili auction market (Bollerslev, 1986). The occurrence of volatility was known as a response to shocks. According to (Brooks, 2008), the general mathematics of GARCH (p, q) model was:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i u_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 \quad (3)$$

where σ_t^2 was the conditional variance model, α_0 was known as a constant, $(\alpha_i u_{t-i}^2)$ presented the information about volatility during the previous period, and $(\beta_j \sigma_{t-j}^2)$ showed the fitted variance from the model during the previous period.

There were several formulated hypotheses in this research: First, the market integration between two markets inside the province was more integrated than in two provinces. Second, two markets within the province adjust their prices more quickly (or fix them) than markets outside the province. The hypothesis was at least one long-term relationship (co-integration) between all three prices simultaneously.

RESULTS AND DISCUSSION

The Sleman chili auction market: an overview

There are several chili auction markets in Indonesia. One of the chili auction markets is the Sleman chili auction market, located in Sleman, Special Region of Yogyakarta. It was

established in 2017 and served as a physical gathering place for fresh chili products from different agricultural regions in Sleman to be auctioned to the highest bidder. Through a better and more transparent trading system that benefits all parties, the Sleman chili auction market can accommodate the various interests of chili agribusiness actors. The real benefit of an auction market is that farmers have certainty of selling prices and bidders can more easily obtain high-quality chilies. Furthermore, the auction market plays a role in transferring ownership of chili from farmers to wholesalers, distributors, or retailers (Tourte & Gaskell, 2004).

Since its establishment, the Sleman chili auction market has been essential in selling fresh chilies in Sleman Regency (Dewi et al., 2021). Farmers, managers, and bidders usually follow the auction process. Sleman Regency's chili farmers dominated the farmers who took part in the chili auction. There is no restriction on who can engage in the auction market as a bidder. Before the auction begins, the farmer brings the chili to the auction location. Next, the manager does the weighing, sorting, grading, and then re-weighing. Based on the auction market policy, generally, all products brought by farmers with the best quality will be sold on that day.

The auction market charges sellers (farmers) to cover the auction's operating costs (Bergefur, 2011). For example, in the Sleman chili auction market, the auction's operating costs were determined based on the selling price on that day. Generally, farmers' auction operational costs range between IDR100 to IDR1,000 per kilogram. The agreement's results on the auction's operating costs were divided into two, for the auction manager and strengthening farmer associations. After the auction process was complete, the next stage was packaging and shipping to the destination area, with shipping costs paid by the bidder. Meanwhile, the auction winner will not receive the product before payment (C.-H. Sun, 2010).

Integration of the Sleman auction market with other markets

The line chart of all the price series can be applied to recognize price movements and the presence of price trends (Akhter, 2017). Figure 2 shows all price series fluctuations and upward trends from June to August 2019 and January to March 2020. The series can be attributed to non-stationary properties due to the increasing trend. The primary trigger of price volatility for chili in Indonesia was production disruption. In the rainy season (October – November), several agricultural areas frequently encounter very high rainfall intensity, which causes many chilies plants to lead a failure. This condition implied a reduction in supply, so chili prices tend to increase in Indonesia at the end and beginning of the year.

During the research period, chili prices in the national market central market had a higher trend than in other markets. The trend might be attributed to differences in market structures between national market and other markets. The national market (Kramat Jati central market) is located in DKI Jakarta, one of Indonesia's megacities with a population of over 10 million, and it serves as a barometer of the country's horticulture market (Saragih, Bahagia, Suprayogi, & Syabri, 2019). The massive population in DKI Jakarta helps to explain the strong demand for foods like chili. The national market highly depends on chili-producing

areas to meet the demand. Unfortunately, the national market cannot meet the demand effectively and efficiently, one of which is caused by the transportation issue of traffic congestion (Saragih, Bahagia, Suprayogi, & Syabri, 2015).

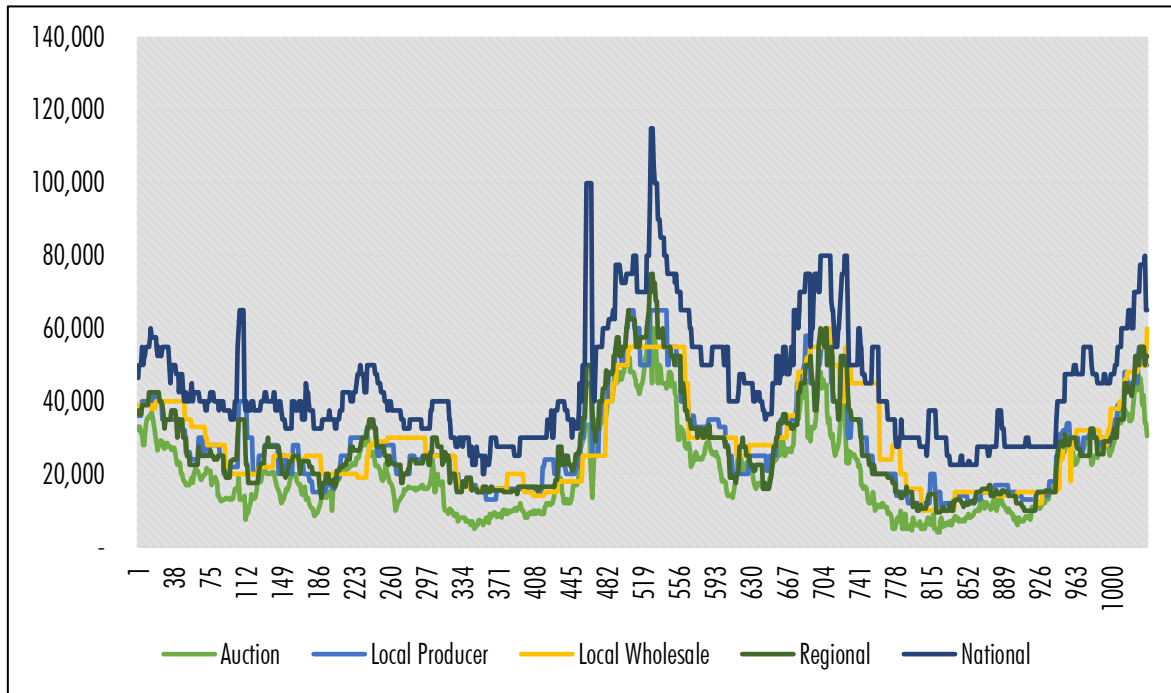


FIGURE 2. TRENDS OF CHILI PRICES FROM MARCH 2018 TO DECEMBER 2020 (IDR/KG) IN SLEMAN CHILI AUCTION, LOCAL PRODUCER, LOCAL WHOLESALE, REGIONAL, AND NATIONAL MARKETS

Meanwhile, the chili price at Sleman chili auction market was lower than the local, regional, and national markets. The acts of Sleman chili auction market as the physical gathering point of fresh chili commodities at the farm level, especially for those located far from the auction market, had affected this price. The rationalization of auction chili gathering points is essential in several ways. Fewer auction chili gathering points imply that chili was distributed farther before being auctioned. After the chilies are collected, the managers will deliver chilies to the auction location. The auction market is expected to become an essential mechanism to streamline the supply chain to reduce retail pricing potentially (Mason & Villalobos, 2015).

TABLE 1. AUGMENTED DICKY-FULLER TEST

Markets	Levels		First differences	
	Lag length	t-value	Lag length	t-value
Auction	0	-0.18	0	-32.17***
Local producer	0	0.04	0	-31.66***
Local wholesale	0	0.16	0	-34.43***
Regional	0	0.05	0	-30.46***
National	0	0.06	0	-30.14***

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively

The stationary test was conducted due to the all-price series having an upward trend (Table 1). The test results showed that the unit root null hypothesis could not be rejected at level but at first differences. A co-integration analysis can be performed since the result indicated that all the price series were stationary at first differences. The Johansen and Juselius maximum-likelihood multivariate co-integration approach will be used to investigate co-integrating vectors among the chili prices.

Table 2 represents the results of the Johansen and Juselius multivariate co-integration VAR (1). The trace and maximum eigenvalue tests identify two co-integrating vectors, indicating that the prices had a long-term co-integration relationship. The trace and maximum eigenvalue statistics were more significant than the critical value (5%). It indicated that all local, regional, and national retail markets were integrated with the Sleman auction market.

TABLE 2. JOHANSEN CO-INTEGRATION TEST

Market	Trace		Maximum Eigenvalue	
	Null	Statistic	Null	Statistic
Local producer– Auction	$r = 0$	140.17**	$r = 0$	133.03**
	$r \leq 1$	7.14**	$r = 1$	7.14**
Local wholesale– Auction	$r = 0$	70.90**	$r = 0$	65.55**
	$r \leq 1$	5.35**	$r = 1$	5.35**
Regional – Auction	$r = 0$	141.76**	$r = 0$	133.79**
	$r \leq 1$	7.97**	$r = 1$	7.97**
National – Auction	$r = 0$	110.55**	$r = 0$	101.28**
	$r \leq 1$	9.27**	$r = 1$	9.27**
5% Critical Value	$r = 0$	15.49	$r = 0$	14.26
	$r \leq 1$	3.84	$r = 1$	3.84

Note: ** indicates significance at 5% level; lag length is set by minimizing Schwarz Bayesian Information Criteria (SBIC); for all series lag length has resulted 1

The pairwise ECM (1) framework was employed to determine the price series' long-term and short-term co-integrating relationships. Before testing the ECM, the EC residual serial correlation Lagrange Multiplier (LM) test was used to assess autocorrelation between residuals. The results (Table 3) showed that the null hypothesis of no serial correlation at lag 1 was accepted at a 1% significance level in most of the paired markets except national – auction market. However, the national – auction market at lag 2 indicates no autocorrelation at a 5% significance level.

The ECM estimates for each retail market paired with the auction market showed that the coefficients on the long-term equilibrium were statistically significant at the 1% significance level in all markets. In the long term, all market pairs had the positive sign of price flexibility, conforming that retail prices would increase when auction prices rise and conversely. The long-term coefficient ranges from 0.57 to 0.84, indicating that about 57% to 84% of price changes were transmitted efficiently from the auction market to the retail market. These results showed that the auction market was spatially linked with retail markets long-term, indicating that all markets were in the same economic market. Furthermore, based on the ECM estimation results, the price relationship between the auction and retail markets

reduces as distance increases. Thus, this condition can consider the distance between markets as a factor affecting market integration (Roman & Kroupová, 2022).

TABLE 3. THE ERROR CORRECTION MODEL TEST

Markets pair	α	β_1	β_2	γ	LM test
Local producer – Auction	0.0003	0.75***	-0.13***	-0.04*	6.34***
Local wholesale – Auction	0.0004	0.84***	-0.05***	-0.03*	3.84***
Regional – Auction	0.0003	0.79***	-0.13***	0.04	1.11***
National – Auction	0.0002	0.57***	-0.12***	0.01	17.24

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively; LM = Lagrange-Multiplier; lag length is set by minimizing Schwarz Bayesian Information Criteria (SBIC): for all series lag length has resulted 1

The national market has a considerable distance from the Sleman auction market compared to the local and regional markets. However, national market receives around 57% of the price changes in the auction market. The degree of separate market integration can be characterized by analyzing the product flow between different markets (Hamulczuk, 2020). The auction market and national market’s trade volume were increasing yearly. This was understandable, provided DKI Jakarta was one of the Special Region of Yogyakarta province's most important trading partners. The Special Region of Yogyakarta province sold around 40.37% of its chili production to DKI Jakarta in 2019, an increase of approximately 11.06% over the previous year (BPS-Statistics Indonesia, 2020).

The acceleration of adjustment coefficients in market pairs was statistically significant at a 1% significance level. The estimated correction parameters range from 0.05 to 0.13 among the different market pairs, indicating that 5% to 13% of any divergence from long-term equilibrium was adjusted daily. At the local market, the results showed a difference in the rate of price adjustment between the local producer and local wholesale markets. This implied that the spatial efficiency of the auction market at the local level could change depending on the distance between marketplaces (see Figure 1). Thus, the local producer market's adjustment speed was much faster than in local wholesale market. Meanwhile, the regional and national markets results indicated that the price adjustment of the regional market and the national market was worth higher than local wholesale market. This implied that regional and national markets had a greater intensity of auction chili trading due to those markets having a higher chili demand than local markets.

Furthermore, short-term price transmission analysis revealed that the auction market was not uniformly integrated. In the short term, only local markets were integrated with the auction market. This might be due to some bidders being local traders who already had a trading network at the regency. That implied the chili price changes in the auction market were transmitted effectively only to a limited market. The short-term coefficients of the local producer market (0.04) and the local wholesale market (0.03) were statistically significant at the conventional level of 10%. The results also showed a negative sign of the short-term coefficient, indicating that price declines in the local market outnumber price rises in the auction market. *Ceteris paribus*, inter-region traders will respond to increased auction chili

prices by supplying chilies to Sleman Regency. It had implications for increasing the supply of chilies, thereby reducing the local retail market price and vice versa.

Meanwhile, the auction price of chili had no influence on price behavior in regional and national markets in the short term, possibly due to the limited volume of auction chili supplied compared to those market demands. This might explain why Kulon Progo Regency dominates the supply of chili in the regional market as the largest chili surplus-producing region in the Special Region of Yogyakarta province (Susanawati, Akhmedi, Fauzan, & Rozaki, 2021). The result may also reflect that the Sleman chili auction market was small, so it cannot affect prices at the regional and national levels, implying that price changes in both markets may be influenced by price changes in other markets.

TABLE 4. THE GENERALIZED AUTOREGRESSIVE CONDITIONAL HETEROSKEDASTICITY TEST

Parameter	Local producer	Local wholesale	Regional	National
<i>Mean equation</i>				
Constant	3.259	4.155	2.580	5.441
Auction(-1)	0.706***	0.617***	0.771***	0.529***
<i>Variance equation</i>				
Constant	0.003	0.002	0.004	0.002
ARCH(1)	0.960***	1.031***	0.719***	0.678***
GARCH(-1)	0.076**	0.022	0.210***	0.252***
R ²	0.831***	0.668***	0.848***	0.774***

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 4 presents the results of the GARCH (1, 1) model, which showed the reliance of local, regional, and national markets on the Sleman chili auction market. This study estimated and compared the chili prices volatility from the auction market to other markets, thereby assessing the auction price efficiency. The auction price behavior was statistically significant at the 1% significance level in conditional mean equations. Furthermore, previous auction price movements impact present price changes in local, regional, and national markets. This indicated that the auction price could predict future prices in those markets, indicating the existence of information efficiency in Indonesian chili pricing.

In the conditional variance equation, ARCH coefficients were used to discover the price dependence, and GARCH coefficients were employed to measure the sensitivity of every market to its past volatility. The results showed that the estimated ARCH coefficients in all markets were statistically significant at the 1% significance level. The ARCH coefficients showed that unexpected shocks in the past generated changes in the current conditional volatility of chili prices. Meanwhile, the result showed that the estimated GARCH coefficients were statistically significant, except in the local wholesale market. According to the GARCH coefficients, the national market was the most volatile. Price fluctuation in the national central market might be caused by the chili supply that was strongly reliant on other regions. Furthermore, there might be complexity in the chili supply chain to national market, which involves many actors. The national market also had a substantial volume of chili demand. As

a result, a chili supply shock will significantly impact national market pricing behavior (Susanawati et al., 2021).

The local market was the lowest volatile. It maybe was causes of its location, which was close to the chili surplus-producing region, so it has an adequate volume of chili supply. The most reliable reason for this finding was that not all chili produced in the Sleman Regency got auctioned off. In reality, farmers who live further away from the auction market will directly sell their products to local middlemen. Furthermore, local middlemen will distribute chili to the nearest retail market. It will potentially become another main variable in the local market's pricing behavior.

Moreover, the empirical evidence indicated that the ARCH coefficients were more significant than the GARCH coefficients in all markets, implying that the changes in past shocks highly affect conditional volatility. The past shocks were dominant in forecasting future chili price volatility in those markets. Furthermore, the ARCH coefficients presented a significant positive sign in each market. Thus, in case the great shocks of both signs will raise volatility. Meanwhile, the sum of the ARCH and GARCH coefficients was worth at least one, which means that volatility persists in local, regional, and national markets. This finding suggested that the chili price fluctuated in each region. Chili production in Indonesia was affected by climate and plant damage caused by pests and diseases, making policy initiatives such as chili supply stabilization may be difficult to evaluate. The research discovered the efficiency of information in chili pricing, which includes the Sleman chili auction market. As a result, market integration increases when a new auction opens in another producer area since direct sales prices become more comparable to auction sales prices.

CONCLUSION

This study was conducted using the ECM-GARCH to estimate the price relationship between the Sleman chili auction market with local, regional, and national markets. The results indicated a long-term relationship in which the auction market influenced the price development in the local, regional, and national markets. The speed of adjustment to the long-term equilibrium varies from 5% to 13%. The adjustment rates revealed the most significant integration between the Sleman chili auction market with local and regional markets. Meanwhile, the price adjustment at the national level indicated that the national market was more desirable than the local wholesale market. This implied that the national had a greater intensity of chili trading than the local market due to higher demand. Furthermore, this study also showed that the Sleman chili auction market was statistically significant in influencing the price change in local producer and local wholesale markets in the short term. Meanwhile, the GARCH model captured the effects of volatility from the Sleman chili auction markets to local, regional, and national markets.

Due to the results, it can be concluded that the Sleman chili auction market was connected to the local market in the short and long terms. The result confirmed that the existence of the Sleman chili auction market had the potential to control inflation in Sleman. The government should increase the number of chili gathering points to foster the business

development of the Sleman chili auction market. In addition, some efforts were required to increase the number of bidders, especially from outside the region, so the Sleman chili auction market's marketing network may develop. Increased auction participation was required to ensure stock and supply chain stability in the Sleman auction market and to play a larger role in regulating chili price volatility at the regional and national levels. In addition, digitizing price and stock information were beneficial for making predictions of chili prices in the future.

This study also revealed that the ECM-GARCH combination effectively determines price integration between markets; hence the authors recommend using both models for a similar study. As researchers, the authors recognize the limitations of this study. First, this study cannot assure the future recurrence of currently controlling chili price relations. Additional uncertainties overflow: climate changes, farming models, new players in the supply chain, price integration among other markets, also other economic disturbances, including the consequences of COVID-19, expose new uncertainties in the markets. Second, the study considers the price data of only five markets in Java, Indonesia, for ECM-GARCH analysis. Further study should include other agricultural markets from different regions in the sample and examine price transmission and volatility by multiple breaks to gain the robustness of price forecasts.

Authors' contribution: *Jamhari*: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Writing - original draft, Writing - review & editing; *Muh Amat Nasir*: Conceptualization, Data curation, Visualization, Writing - original draft, Writing - review & editing; *Agus Dwi Nugroho*: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Supervision; *Ismiasih*: Conceptualization, Writing - original draft, Writing - review & editing; *Hitoshi Yonekura*: Conceptualization, Writing - original draft, Writing - review & editing.

Conflict of interest: the authors declare no conflict of interest

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