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# Price Volatility of Ornamental Plants in Batu Municipality

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## ABSTRACT

The imbalance between supply and demand of ornamental plants in the market cause fluctuations that lead to price volatility. This study aimed to analyze the price volatility of ornamental plants with high economic value, such as orchids, adenium, aglaonema, anthurium, and palm. This study also analyzed the long-term and short-term relationship between the production and prices of these ornamental plants. The data used were the productions and prices of orchid, adenium, aglaonema, anthurium, and palm at the producer level from 2012 to 2020 obtained from the Agriculture Office of Batu Municipality. Volatility analysis was carried out using the ARCH/GARCH method, the long-term relationship was analyzed using the Johansen cointegration test, and the short-term relationship was carried out using the Error Correction model. The results of volatility analysis showed that all the ornamental plants studied had low price volatility. In addition, the productions and prices of the ornamental plants were cointegrated in the long run, but only the orchid had a short-term relationship with an adjustment period of 2.6 months.

**Keywords:** ARCH/GARCH; cointegration; ECM; ornamental plants; price volatility

## INTRODUCTION

Macroeconomically, the horticulture subsector ranks fourth in contributing to Indonesia's agricultural sector's Gross Domestic Product (GDP). According to BPS-Statistics Indonesia (2020), the GDP value of the horticulture subsector was IDR 33.7 trillion in the fourth quarter of 2019. This value increased in the second quarter of 2020 to IDR 42.9 trillion, with a growth rate of 21.75%. Java Island has a total agricultural sector's Gross Regional Product (GRDP) of 35.20%, the second largest of 34 provinces in Indonesia. The largest contributor to the GRDP of the agricultural sector on the island of Java is East Java. The horticulture sub-sector is in the fourth position with a contribution of 14.97% in 2015 and has decreased to 13.67% in 2019. Due to the increase in the contribution value of the horticulture sub-sector, it is necessary to increase the horticulture production balanced with the amount of demand.

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Nowadays, ornamental plant agribusiness in Indonesia is relatively developing. Ornamental plants are horticultural sub-sector plants with aesthetic value in form, crown, leaves, color, scent, and flowers. The development of ornamental plant agribusiness is marked by the increasing production trends in ornamental plant cultivation (González-Gómez and Marrero, 2009). This development is inseparable from the demands of the beauty of the environment, people's lifestyles, the development of the agro-tourism sector, hotels, housing, offices, and increased community income. The increasingly varied use of ornamental plants, accompanied by increasing demand, has become a business opportunity and stimulus for producers to develop ornamental plant businesses.

Batu Municipality is one of the suitable ornamental plant business areas. In East Java, Batu Municipality is known as a center for ornamental plant production (Manurung, 2011). There are 22 types of ornamental plants cultivated in Batu Municipality, such as roses, chrysanthemums, orchids, flower anthurium, aglaonema, anthurium, adenium, palm, and so on. These ornamental plants are generally used to redecorate both indoor and outdoor environments. Orchids, adenium, aglaonema, anthurium, and palm are high economic value ornamental plants. These five types of ornamental plants are the top ten highest productions in Batu Municipality (Badan Pusat Statistik Kota Batu, 2020). This implies that ornamental plant farmers in Batu Municipality have developed their businesses. On the producer side, these types of ornamental plants were prospective businesses when coupled with an increase in demand in quantity and quality. The increase in demand for ornamental plants usually occurs during particular events such as religious events, decorations, weddings, birth, deaths, and trends (Suminah et al., 2021).

One of the important concerns in floriculture agribusiness is the distribution or marketing patterns that impact the farmers. This problem is critical because it involves the sustainability of the farm business (Suminah et al., 2021). Distribution problems are closely related to the inefficiency of marketing chain from producers to consumers, which involves marketing actors. The price indicator can evaluate the problems in the efficiency of the marketing chain. Price is an important indicator in measuring marketing efficiency because it can show the market information that is publicly available (Assaf et al., 2021).

Price fluctuations characterize an inefficient marketing system. Price fluctuations in horticultural commodities will be more detrimental to farmers. This condition is caused by the farmers' inability to manage their time to sell their products for more profit (Khan et al., 2022). Price fluctuations cause uncertainty in farming revenue and indicate instability of market equilibrium. Besanko and Braeutigam (2014) explain that market equilibrium occurs when the amount offered is the same as the amount demanded. There is a difference between the actual conditions in the field and the theory statement. The actual conditions in the field often indicate instability in the supply and demand for ornamental plants.

Disturbances in the demand and supply transmit into price variability and cause price fluctuations. Based on data from the Agriculture Office of Batu Municipality, the production of ornamental plants in Batu Municipality tends to be unstable. The increase and decrease in production cannot be separated from the agro-climate condition, cultivation technology, and harvest area. Meanwhile, the demand for ornamental plants is difficult to predict because it is only based on demands for hobbies and decorations (Suminah et al., 2021). This condition causes the demand for ornamental plants to differ from food. The increase in demand for ornamental plants can occur in line with the rise in the tourism sector, public appreciation of freshness and beauty, flower arrangement services, decoration services, and others (Manurung, 2011). In contrast, the decrease in demand for ornamental plants can be caused by producers' inability to maintain the continuity of qualified plant supplies.

The price of ornamental plants in Batu Municipality from 2012 to 2020 tends to be unstable, according to the Batu Municipality Agriculture Office. The unstable condition of ornamental plant prices can be seen in Figures 1a to j. The instability of ornamental plant prices impacts price volatility and causes higher uncertainty prices in the future. Farmers also face a risk of uncertain income in the short and long term (Jin et al., 2021).

The ornamental plants' price fluctuation effect farmers' business. Producers make a higher profit when prices increase. Meanwhile, when prices decrease, producers take a lower profit or even a loss. Considering the ornamental plant farming is a profit-oriented business (González-Gómez and Marrero, 2009), it is important to investigate the price volatility of ornamental plants for price certainty.

Based on previous research, the fundamental difference with this research is the object under study. Previous research on the price volatility of agricultural commodities was primarily aimed at analyzing price fluctuations for food crops (Taghizadeh-Hesary et al., 2019), vegetables (Muflikh et al., 2021), and meat (Hui-shang et al., 2021). This study enriches the knowledge of the price behavior of the ornamental plant. Ornamental plants have various types and features (Zheng et al., 2021) whose demand characteristics differ from groceries and depend on consumers' likelihood which causes price fluctuation. Based on this research, it can be seen how much price volatility of ornamental plants is widely circulated in the market. So, it can be a signal for producers to pay more attention to the availability of plants, referring to the trend of ornamental plants.

The aims of this study were (1) to analyze producers' price volatility of the ornamental plants, (2) to analyze both the long-term and short-term relationship between the price and production of ornamental plants in Batu Municipality.

## RESEARCH METHOD

The location was determined to Batu Municipality as a city with high levels of ornamental plant production based on Central Bureau of Statistics in 2019. Batu Municipality is one of the cities in East Java, known as one of the centers of horticulture, especially ornamental plants (Manurung, 2011; Puspitasari et al., 2019; Agustina et al., 2019). This research was conducted from April to May 2021. The data covered quarterly production and farm gate price of orchid, adenium, aglaonema, anthurium, and palm in Batu Municipality from 2012 to 2020.

An ARCH-GARCH model was applied to analyze price volatility with the Eviews 11 due to heteroscedasticity in the data. The Johansen cointegration test was used to analyze the long-term relationship between price and production of ornamental plants. Meanwhile, the short-term relationship between price and ornamental plant production was analyzed using the Error Correction Model (ECM) test method.

**Price Volatility Analysis**

Before analyzing price volatility using the ARGH/GARCH method, several steps must be taken. The steps were stationarity test, ARIMA model selection, Heteroskedasticity test, and ARCH effect, then ARCH/GARCH Modeling.

*Stationarity Test*

Gujarati (2011) explains that stationarity must be considered using time series data. The results of the stationarity test on the variable producer prices for all ornamental plants were stationary with different test levels using an intercept without a trend or with a trend. Price data for orchid, adenium, anthurium, and palm have been stationary at the first difference level, and aglaonema price data were stationary at the second difference level. The stationarity test was carried out at the level of difference because the data was not stationary at the level. Time series data that are not stationary at the level must be stationary through differencing (Moledina et al., 2003). The t-statistic value of each ornamental plant price was greater than the critical value, which was at the 5% significance level in absolute terms or stationery at the 95% confidence level.

*ARIMA Model Selection*

The ARIMA model was chosen due to the data was stationary after the differencing process. Selection of the best ARIMA model was based on the F-Statistic probability value, which was significant or close to zero, and the smallest Akaike Info Criterion (AIC) and Schwarz Criterion (SC) values. The ARIMA order was determined based on the collerogram (ACF and PACF patterns) to determine the AR and MA order. The best ARIMA model was ARIMA (3,1,1) for orchid, ARIMA (3,1,3) for adenium, and ARIMA (1,2,1) for aglaonema, which was significant at 95%. There was also the best ARIMA model, namely ARIMA (0,1,2) of anthurium at 90% significance level and ARIMA (0,1,3) of palm at 85%significancy level. Volatility analysis is applied ARIMA model if the model is indeed good to use. The value of volatility is known through the sum of the AR and MA coefficients (Piot-Lepetit and M'Barek, 2011). The ARIMA equation was formed like Equation 1.

$$Yt = \mu + \Sigma_{pi}=0\ \varphi_i Y_t - i + \Sigma_{qj}=0\ \theta_{j\varepsilon t} - j + \varepsilon_t \qquad (1)$$

Where $\mu$ was mean, q was lagged error terms, p was lagged dependent variables, $\varphi$ and $\theta$ were coefficients of AR and MA, $\varepsilon_j$ was residual random with constant variants (white noise), and $_{t-i,\ t-j}$ was lag of a certain period.

*Heteroskedasticity Test and ARCH Effect*

The white heteroscedasticity test was implied to examine the constant variance of data (Wooldridge, 2013). The heteroscedasticity test results of the ARIMA model of all ornamental plants showed a probability value of 0.0000. It means the ARIMA model of all plants rejected the H0 and showed a non-constant variant.

Meanwhile, the ARCH effect test was used to determine whether the ARIMA model can be continued to the ARCH/GARCH analysis or not. The ARCH effect test was done by looking at the kurtosis value in the data. Orchid price data had a kurtosis value of 1.869792, and palm had a kurtosis value of 1.918247. Meanwhile, the value of kurtosis adenium was 14.52981, aglaonema was 3.097657, and anthurium was 14.65109. It means the price data for adenium, aglaonema, and anthurium had an ARCH effect. On the other hand, the price data for orchids and palms did not have an ARCH effect, so it was enough to analyze the volatility using the ARIMA model. Data with a kurtosis value of more than 3 indicates the data is heteroscedastic and has an ARCH effect, so ARCH/GARCH modeling can be done (Puspitasari et al., 2019).

*ARCH/GARCH Modeling*

The selection of the ARCH/GARCH model was based on the smallest AIC and SC values, and the coefficient was not more than 1. The smallest AIC and SC value is a criterion commonly used to determine the best model and widely used in the literature (Lin, 2018). The ARCH and GARCH equations in this study were showed in Equation 2 until 6:

$$\sigma^2 PO_t = \alpha_0 + \alpha_1 \varepsilon^2 PO_{t-1} + \beta_1 \sigma^2 PO_{t-1} + \varepsilon_t \quad (2)$$
$$\sigma^2 PA_t = \alpha_0 + \alpha_1 \varepsilon^2 PA_{t-1} + \beta_1 \sigma^2 PA_{t-1} + \varepsilon_t \quad (3)$$
$$\sigma^2 PG_t = \alpha_0 + \alpha_1 \varepsilon^2 PG_{t-1} + \beta_1 \sigma^2 PG_{t-1} + \varepsilon_t \quad (4)$$
$$\sigma^2 PN_t = \alpha_0 + \alpha_1 \varepsilon^2 PN_{t-1} + \beta_1 \sigma^2 PN_{t-1} + \varepsilon_t \quad (5)$$
$$\sigma^2 PP_t = \alpha_0 + \alpha_1 \varepsilon^2 PP_{t-1} + \beta_1 \sigma^2 PP_{t-1} + \varepsilon_t \quad (6)$$

$\sigma^2$ was a variation of residuals at the t-period and $\sigma^2_{t-1}$ for residuals from the previous period, $\alpha_0$ was constant, $\varepsilon^2_{t-1}$ was the volatility of the previous period (t-1), $\alpha_1$ and $\beta_1$ were estimated parameters. $PO_{t-1}$, $PA_{t-1}$, $PG_{t-1}$, $PN_{t-1}$, and $PP_{t-1}$ were producer prices in the previous period for orchid (IDR/stalk), adenium (IDR/pot), aglaonema (IDR/pot), anthurium (IDR/pot), and palm (IDR/tree). The last, $\varepsilon t$ was a stochastic factor.

In this study, the best ARCH/GARCH model for adenium was GARCH (1,1), for aglaonema was ARCH (1,0), and GARCH (0,1) for anthurium. Piot-Lepetit and M'Barek (2011) explains that the value of volatility can be known through the sum of the ARCH ($\alpha$) and GARCH ($\beta$) coefficients. If $\alpha+\beta < 1$, it means that the price had low volatility. If $\alpha+\beta = 1$, then it was classified as high volatility. While the result of $\alpha+\beta > 1$, the price was indicated to have extremely high volatility.

**Cointegration Analysis**

The Johansen cointegration test analysis is a strong procedure in the case of heteroscedasticity (Kühl, 2010). On the other hand, this test was also applied considering using time-series data in this study. The Johansen cointegration test uses the Maximum Likelihood (ML) method. The ML parameter estimation method is a consistent, symmetrically distributed, and unbiased median (Cheung and Lai, 1993). The steps taken in the Johansen cointegration test were stationarity test, determination of optimal lag length, and cointegration test.

*Stationarity Test*

Generally, the Johansen cointegration test was carried out on non-stationary time-series data. The data on prices for all ornamental plants were stationary at different levels. Similar to the price data, the production variables were stationary at the first difference level using an intercept both without or within a trend. In absolute terms, the t-statistic value of each ornamental plant production was greater than the critical value at the 5% significance level.

*Determination of Optimal Lag Length*

Determining the optimal lag length is very important in cointegration tests. The optimal lag length (neither too long nor too short) allows us to retain sufficient and relevant information (Kacou et al., 2022). The optimal lag length was determined based on the smallest AIC and SC values and the largest Likelihood Ratio (LR) value indicated by a sign (*) in Eviews.

TABLE 1. OPTIMAL LAG LENGTH OF ORNAMENTAL PLANT PRICES AND PRODUCTIONS DATA

| Price and Production Data | AIC | SC | LR | Optimal Lag |
|---|---|---|---|---|
| Orchid | 45.27332 | 45.95076 | 12.48137 | 3 |
| Adenium | 37.22442 | 38.51115 | 10.85141 | 5 |
| Aglaonema | 42.47844 | 43.34943 | 10.95761 | 4 |
| Anthurium | 42.18463 | 42.47259 | 22.35792 | 1 |
| Palm | 38.89486 | 40.54006 | 10.48536 | 8 |

Table 1 shows differences in the optimal lag length of each ornamental plant data. It meant that production and price data from orchid, adenium, aglaonema, anthurium, and palm had different degrees of freedom and lags.

*Cointegration test*

Johansen's cointegration test assumed that there was no interception and trend in the trend deterministic assumption test. This assumption is based on the AIC and SC values indicated by the sign (*) in the Eviews. The cointegration analysis between production data and ornamental plant prices was determined based on the trace statistic and maximum eigenvalue. The addition of the maximum eigenvalue can be used as a correction for the estimated number of parameters (Mandala and Kim, 1999) because, in many cases, the use of trace statistics tends always to indicate cointegration, so it must be confirmed using maximum eigenvalue (Onatski and Wang, 2019). If the value of the trace statistic and maximum eigenvalue is less than the critical value with a probability value above 5%, there is no cointegration between the two variables. Meanwhile, suppose the value of the trace statistic and maximum eigenvalue is greater than the critical value with a probability value of less than 5%. In that case, two variables were cointegrated.

### Error Correction Model Analysis

The ECM test was carried out since two time series variables had a long-term relationship or were cointegrated. According to Gujarati (2011), two time series variables with a long-term equilibrium might also have a short-term equilibrium. The ECM equation was formulated in Equation 7.

$$\Delta Y_t = \alpha + b_0 X_t + b_1 EC_{t-1} + \varepsilon_t \quad (7)$$

$Y_t$ and $X_t$ were, respectively the price and production of ornamental plants at the t-period, $\alpha$ was constant, $b_0$ and $b_1$ were estimated parameters, $EC_{t-1}$ was error correction term, and $\varepsilon_t$ was stochastic factor.

The ECM model was considered valid if the probability of $EC_{t-1}$ was less than the 5% significance level. That was, the production variable and the price of ornamental plants have a short-term balance. In order to achieve a short-term balance in the market, it takes time to adjust (Poplavskaya et al., 2021). The adjustment time can be determined by dividing one year by the $EC_{t-1}$ coefficient, which will later be obtained when the adjustment period is in months.

## RESULT AND DISCUSSIONS

### Trend of Productions and Prices of Ornamental Plants in Batu Municipality

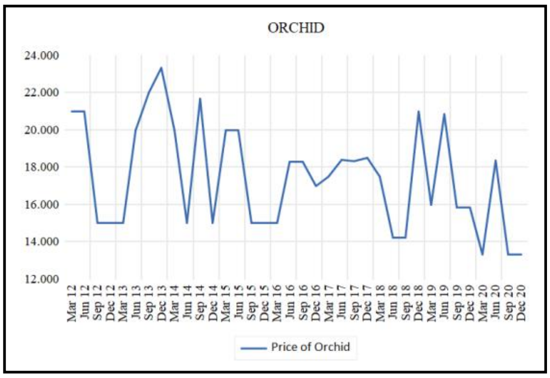
Orchid production from 2012 to 2020 fluctuated but was generally increasing, as shown in Figure 1a. The lowest orchid production occurred in the 4th quarter of 2014, which was 420,910 stalks. Meanwhile, based on Figure 1b, the price of orchids fluctuated. The lowest price was IDR 23,333, and the highest was IDR 13,300 per stalk. The average orchid price was IDR 17,475 per stalk. Fluctuations in agricultural product prices were caused by the output that depends on natural and human factors, land, time lags in using inputs, and market structure (Xie and Wang, 2017).

The adenium production seems to fluctuate with a downward trend, as shown in Figure 1c. The largest production occurred in the 3rd quarter of 2013, coming to 4,435 pots and the lowest production occurred in the 3rd quarter of 2016, where no adenium was produced. In Figure 1d, the highest price of adenium occurred in the 3rd quarter of 2020. This increasing price is related to lockdown and quarantine policy to suppress the spread of COVID-19; thus, a trend of ornamental plant cultivation emerged in the community. The trend increased the demand for ornamental plants, but farmers' production, especially adenium, did not respond positively to it. The imbalance between supply and demand was caused by a decrease in the quarterly production of adenium to 352 pots in the second quarter of 2020 compared to the previous year. When the production does not respond to an increase in demand, the prices will increase (Deng et al., 2021).

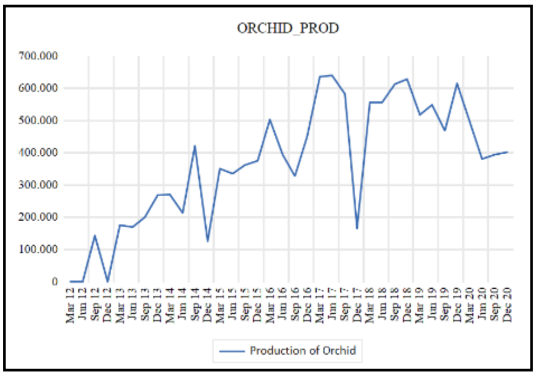
The production of aglaonema fluctuated from 27,000 pots to approximately 57,000 pots, as shown in Figure 1e. A significant increase in production occurred in the 1st quarter of 2015, which was also the highest production. During the last nine years, aglaonema production has decreased at a negative rate of -3.33 percent per quarter. Meanwhile, Figure 1f shows that the price of aglaonema has fluctuated with an increasing trend. The highest price is IDR 91,700 per pot, which occurred in the second quarter of 2020. This phenomenon of price increases was inseparable from the growing interest in cultivating ornamental plants during the COVID-19 pandemic.

Anthurium production seemed to fluctuate with an increasing trend, as shown in Figure 1g. Meanwhile, the lowest production occurred in the 2nd quarter of 2012, with only 760 pots. Based on Figure 1h, the price of an anthurium is around IDR 80,000. The high increase in price reached almost IDR 200,000 per pot in the 3rd quarter of 2020. The rise in demand for anthurium in 2020 during the COVID-19 pandemic was not responded to positively by the production. In the 3rd quarter of 2020, anthurium production was 12,545 pots, 3,250 pots smaller than the previous period. It means the increase in production has not met market demand. Therefore, there was the highest price increase, which was IDR 183,350 per pot.

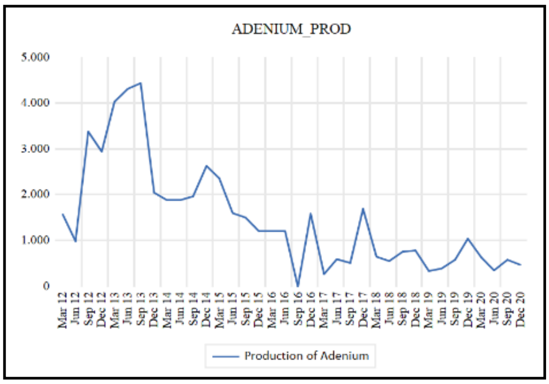
Figure 1i showed that the highest palm production occurred in the 4th quarter of 2013, which produced come to 47,450 palm trees with a productivity of 1.44%. However, in the next quarter, palm production tends to decline. In the 1st quarter of 2014, only 3,660 palms were produced, with a productivity of 1.09%. This condition reflects that the decline in palm production is not only caused by a decrease in the harvested area but also by productivity. The palm prices from 2012 to 2020 fluctuated but tend to be higher, as shown in Figure 1j. Since the 1st quarter of 2012 to the 1st quarter of 2017, the price of palm has fluctuated, under IDR 80,000 per tree. However, from the third quarter of 2018 to 2020, the price of palm reached IDR 110,000 per tree.



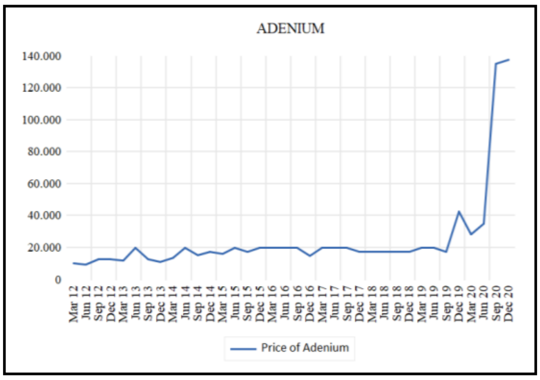

(a)




(b)




(c)




(d)

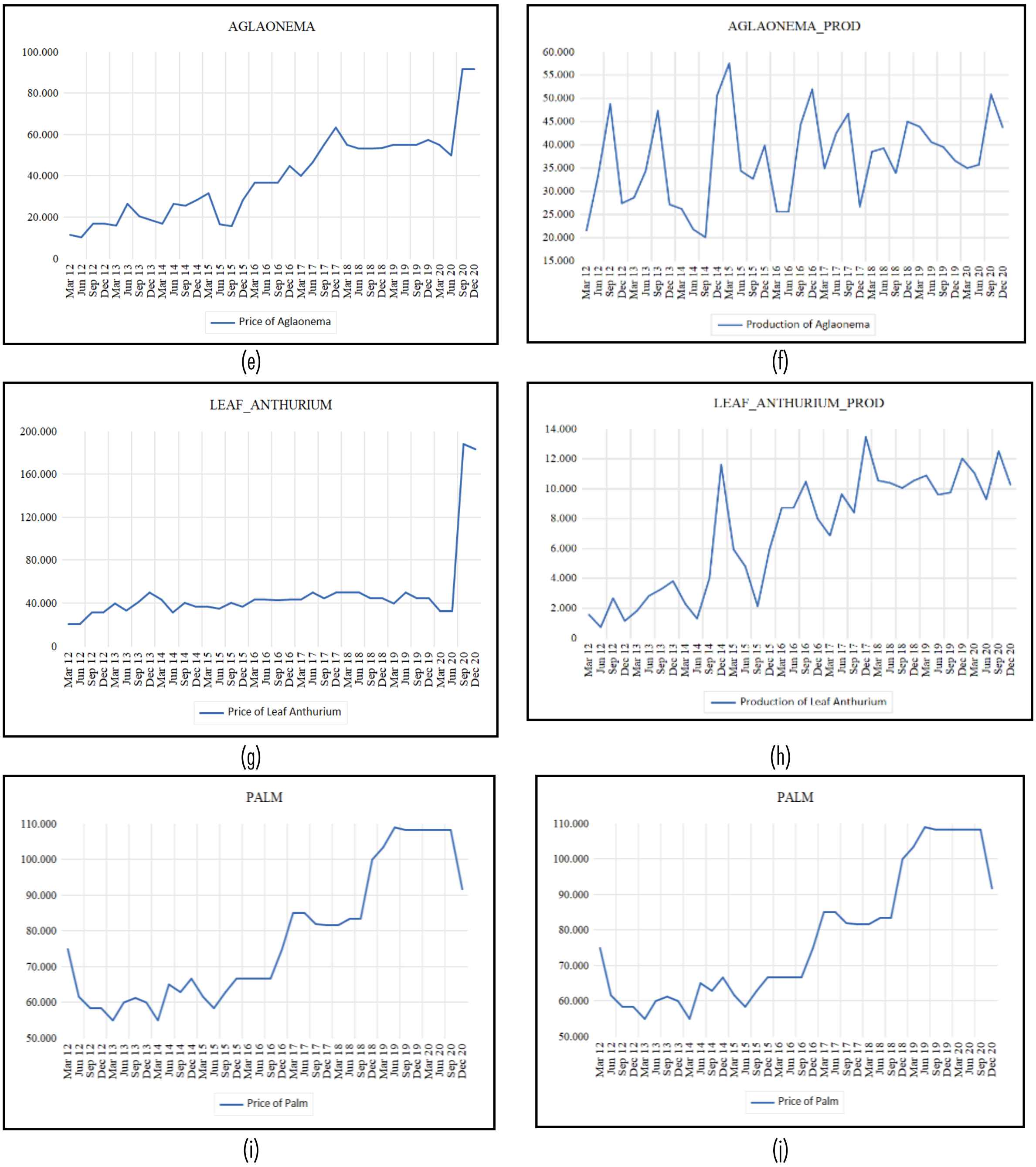



FIGURE 1. TREND OF PRODUCTION AND PRICE FOR (A) AND (B) ORCHID, (C) AND (D) ADENIUM, (E) AND (F) AGLAONEMA, (G) AND (H) ANTHURIUM, (I) AND (J) PALM

## Ornamental Plant Price Volatility Analysis

The analysis of price volatility of all ornamental plants at the farm gate in Batu Municipality is shown in Table 2. The ARIMA equation of the orchid price data showed that the AR and MA coefficients sum was -1.311958. The value was less than 1, which was included in the low volatility category. The probability value of AR showed that the previous price influences orchid prices within the 90% significance level. Palm price volatility was relatively low, as indicated by the MA coefficient was less than 1 (-0.139455) with a probability value of

0.6811. Palm price volatility was not influenced by the residual value of the previous data within the 95% confidence level.

TABLE 2. THE EQUATION OF PRICE VOLATILITY OF ORNAMENTAL PLANTS IN BATU MUNICIPALITY

| Variable | Equation | Volatility Value ($\alpha + \beta$) |
|---|---|---|
| Price of Orchid | $Yt = \mu + \Sigma^{p}_{i=0}\phi iY_{t-i} + \Sigma^{q}_{j=0}\theta_j\varepsilon_{t-j} + \varepsilon t$<br>(-0.311958) (-1.000000)<br>(0.0674) (0.9998) | -1.311958 |
| Price of Adenium | $\sigma^2PA_t = \alpha_0 + \alpha 1\varepsilon^2PA_{t-1} + \beta 1\sigma^2PAt\text{-}1 + \varepsilon_t$<br>(0.150000) (0.600000)<br>(0.8357) (0.3976) | 0.750000 |
| Price of Aglaonema | $\sigma^2PG_t = \alpha_0 + \alpha 1\varepsilon^2PG_{t-1} + \varepsilon_t$<br>(0.171429)<br>(0.6473) | 0.171429 |
| Price of Anthurium | $\sigma^2PN_t = \alpha_0 + \beta 1\sigma^2PN_{t-1} + \varepsilon_t$<br>(0.171429)<br>(0.9269) | 0.171429 |
| Price of Palm | $Yt = \mu + \Sigma^{q}_{j=0}\theta_j\varepsilon_{t-j} + \varepsilon_t$<br>(-0.139455)<br>(0.6811) | -0.139455 |

The volatility of the adenium price was also low, indicated by the sum of the ARCH and GARCH coefficients of 0.75000. The probability value of ARCH was 0.8537, and GARCH was 0.3976. Adenium price volatility was not influenced by the previous price variance and the previous residual variance within the 95% confidence level. The GARCH model shows price volatility that depends on the previous residual and the previous volatility (Berger et al., 2021). It means that the current price increase was not influenced by the price variation of the last quarter.

Meanwhile, based on the ARCH coefficient of the aglaonema, the price of 0.171429 was classified as low volatility. The ARCH probability value of 0.6473 indicates that the volatility of the aglaonema price was not influenced by the previous price variation within the 95% significance level. Similar to other plants, the price volatility of anthurium was also relatively low, with an ARCH coefficient of 0.17129. The probability value of the ARCH coefficient was 0.9269, meaning that the previous residual variance did not influence the volatility of anthurium prices within the 95% significance level.

The low volatility of ornamental plant prices indicates that the price increases and decreases were insignificant in the producer market. The price volatility of all ornamental plants was low because these plants were included in the top ten ornamental plants with high production in Batu Municipality. Therefore, its existence was available throughout the year, although production tends to fluctuate. However, the production of these ornamental plants may also not meet the community's demands. The rise in ornamental plant demand is difficult to quantify and predict accurately because it is only based on hobby and room decoration. On the other hand, the low price volatility of all ornamental plants is also caused that ornamental plants are not the primary necessity, such as food. Therefore, there is no significant shock in supply and demand, although demand is difficult to predict. Low price volatility is also related to ornamental plants, which are heterogeneous commodities. It means various types and choices of ornamental plants can be cultivated in various landscapes (Taib et al., 2019). Therefore, the demand for ornamental plants relies not only on a type of plant.

The low Price volatility is included in transitory volatility. Transitory volatility is caused by market uncertainty, such as market shocks from both the supply and demand sides and expectations (Živkov et al., 2020). Low volatility indicates that price volatility occurs relatively quickly (Maguire et al., 2017). In this study, from 2012 to 2020, the prices of all ornamental plants fluctuated. On average, a significant price increase occurred in 2020 due to the COVID-19 pandemic, which hit almost all countries, including Indonesia. Since 29 February 2020, the Indonesian government has implemented the Large-Scale Social Restrictions (PSBB) policy. The policies restricted people's mobility and transportation, locked all schools, universities, and offices (especially for non-essential services), and forbade public meetings (Anugerah et al., 2021). This policy is intended to restrict people's activities outside to suppress the spread of the COVID-19. So, most of the community's activities, including schooling and work, were carried out at home. Then, the trend of ornamental plant cultivation emerged in the community. This activity is intended to fill the free time at home to stay productive. Therefore, the demand for ornamental plants increased.

In Batu Municipality, the low volatility of ornamental plant prices at the producer level is caused by producers cannot directly respond to the price. This is due to the existence of middlemen between producers and consumers. Even though Batu Municipality is one of the cultivation and shopping centers for ornamental plants especially in East Java, the business is inefficient due to marketing actors blocking the market (Suminah et al., 2021). Producers cannot directly get the price information, which causes producers to be disconnected from the market. When prices rise, the information not immediately and perfectly received by producers, but when the price decreases, the information will be quickly and completely received. This condition reflects the information asymmetry caused by parties manipulating information related to prices in the marketing chain (Raungpaka and Savetpanuvong, 2017).

The low-price volatility of all ornamental plants aligns with research by Bohl and Sulewski (2019) and Hau et al. (2020). The low-price volatility at the producer level is related to the producer's position in the ornamental plants market, which acts as a price taker. Therefore, producers typically receive low prices and do not benefit greatly when prices rise. The existence of price volatility makes poor producers unable to reduce the risk of falling prices and unable to take profits when prices rise (Assouto et al., 2020).

The position of producers as price takers makes producers unable to control prices (Vadlamannati and de Soysa, 2020). Producers must accept the set price in the market mechanism, and it will affect the producers' revenue on their sales or service. Therefore, producer revenues are likely to decline when the prices of ornamental plants decrease, and contrariwise. Meanwhile, the categorization of price volatility of ornamental plants can be used by producers to increase their farming. Therefore, information about price changes of ornamental plants in Batu Municipality is needed, especially when the price increase. It will support the producer to get higher profit by expanding their production. One of the causes of limited information on market prices of ornamental plants in Batu Municipality is still no information system that provides information about prices. Information related to price changes is beneficial for producers (Greenlaw and Taylor, 2017) and is a horticulture agribusiness development strategy, especially in determining marketing strategies (Muflikh et al., 2021). The price volatility of all ornamental plants is low but differs between each ornamental plant. Adenium volatility value is closer to 1, which was higher than others. High volatility indicates that price volatility arises over a more extended period (Ligot et al., 2021); that is called permanent volatility (Ahmed et al., 2012). Therefore, the price fluctuations in the future must be monitored.

**Cointegration Analysis**

Johansen's cointegration test results based on trace statistical values can be seen in Table 3. The production and price data of all ornamental plants in this research were more than the critical values. In addition, the probability value of each of these types of plants was less than the 5% significance level.

TABLE 3. COINTEGRATION TEST BASED ON TRACE TEST

| Price and Production Data | Trace Statistics | Critical Value | Probability |
|---|---|---|---|
| Orchid | 36.52491 | 12.32090 | 0.0000 |
| Adenium | 40.63686 | 12.32090 | 0.0000 |
| Aglaonema | 18.94827 | 12.32090 | 0.0034 |
| Anthurium | 31.05909 | 12.32090 | 0.0000 |
| Palm | 28.95083 | 12.32090 | 0.0000 |

Meanwhile, the cointegration test results based on the maximum eigenvalue can be seen in Table 4. The production and price of all data were above the critical value with a probability value of less than the 5% significance level.

TABLE 4. COINTEGRATION TEST BASED ON MAXIMUM EIGENVALUE

| Price and Production Data | Max-Eigen Statistic | Critical Value | Probability |
|---|---|---|---|
| Orchid | 22.79659 | 11.22480 | 0.0003 |
| Adenium | 30.57413 | 11.22480 | 0.0000 |
| Aglaonema | 16.58880 | 11.22480 | 0.0052 |
| Anthurium | 24.00652 | 11.22480 | 0.0000 |
| Palm | 26.73062 | 11.22480 | 0.0001 |

Based on the trace statistic in Table 3 and the maximum eigenvalue in Table 4, the production and price of all ornamental plants were cointegrated or had a long-term balance. This long-term relationship indicates that the production will affect the price of these ornamental plants. Therefore, in the long run, the production and price of ornamental plants will go hand in hand. However, the long-term relationship's direction has not yet been known, considering that in the cointegration test, all cointegrated variables are considered endogenous variables.

**Error Correction Model Analysis**

The results of the ECM test can be seen in Table 5. This table shows that only the ECt-1 coefficient from the production and price data of orchids had a probability of less than 5%. It means that only the production and price of orchids had a relationship in the short term.

TABLE 5. ECM TEST FOR ORNAMENTAL PLANTS IN BATU MUNICIPALITY

| Price and Production Data | Variable | Coefficient | Probability |
|---|---|---|---|
| | $X_t$ | 0.004555 | 0.2926 |
| Orchid | $EC_{t-1}$ | -0.389955 | 0.0308 |
| | C | -263.6226 | 0.6515 |
| Equation | $\Delta Y_t = -263.6226 + 0.004555X_t - 0.38955EC_{t-1} + \varepsilon_t$ | | |
| | $X_t$ | 1.495730 | 0.6978 |
| Adenium | $EC_{t-1}$ | 0.020976 | 0.8945 |
| | C | 3739.355 | 0.2407 |
| Equation | $\Delta Y_t = 3739.355 + 1.495730X_t + 0.020976EC_{t-1} + \varepsilon_t$ | | |
| | $X_t$ | 0.215615 | 0.0987 |
| Aglaonema | $EC_{t-1}$ | -0.034364 | 0.6966 |
| | C | 2103.421 | 0.1705 |
| Equation | $\Delta Y_t = 2103.421 + 0.215615X_t - 0.034364EC_{t-1} + \varepsilon_t$ | | |
| | $X_t$ | 2.545652 | 0.1664 |
| Anthurium | $EC_{t-1}$ | -0.191589 | 0.3161 |
| | C | 3331.644 | 0.4705 |
| Equation | $\Delta Y_t = 3331.644 + 2.545652X_t - 0.191589EC_{t-1} + \varepsilon_t$ | | |
| | $X_t$ | 0.094705 | 0.2218 |
| Palm | $EC_{t-1}$ | 0.184929 | 0.3317 |
| | C | 796.1095 | 0.4090 |
| Equation | $\Delta Y_t = 796.1095 + 0.094705X_t + 0.1849295EC_{t-1} + \varepsilon_t$ | | |

Statistically, the orchid's ECt-1 coefficient value of -0.389955 deserves to be negative. The value of the ECt-1 coefficient also shows that the adjustment time needed to achieve short-term equilibrium was 2.6 months (1/0.389955). Conditions in the field indicate that orchid plants can generally be harvested between 2-3 months from mature plants. Therefore, if there is a change in orchid production in the short term, it will be transmitted to the price of orchids within 2.6 months.

Based on Table 5, the coefficient of Xt for orchids was 0.004555 with a probability of 0.2926. If the production of orchids increases by 1%, the price will also increase by IDR 0.004555. This short-term relationship was directly proportional to the value of the Xt coefficient, which was positive with a significant level of 80%. Therefore, when production increases, prices will rise. In other words, the increase in production was a positive response shown by producers responding to increased demand for orchids in the community. Production that cannot keep up with demand will cause an increase in prices (Rotta, 2021). Orchid is one of the ornamental plants that has become a civilization for modern society. The lifestyle of people who use flowers to convey messages increases the demand for orchids, as does the number of important events such as weddings, Eid, Christmas, New Year's, and birthdays (Al-Sagheer, 2021). In addition, the rise in orchid demand equates to the increased demand for bouquets, congratulations, and table flower arrangements for hotels, restaurants, offices, and banks.

Meanwhile, the Xt coefficient of adenium, aglaonema, anthurium, and palm also shows a positive sign. It means that if there is an increase in supply, the price will also increase. However, when viewed from the probability value, the production and price of adenium, aglaonema, anthurium , and palm had a probability value of more than the 5% significance level. That means the two variables in the plant did not have a short-term relationship. Subsequently, the changes in the supply of these ornamental plants will not change the price significantly.

## CONCLUSION

The price volatility of all ornamental plants in Batu Municipality was low. The low volatility of these ornamental plant prices was due to ornamental plants are not a primary necessity. Therefore, there was no significant shock in supply and demand, although the demand was difficult to predict. Meanwhile, the results of the cointegration analysis showed that the production and price of all ornamental plants were cointegrated in the long term. However, only the production and price of orchids had a short-term relationship with an adjustment time of 2.6 months.

Based on this research, suggestions regarding the price volatility of ornamental plants in Batu Municipality are given to several stakeholders. The ministry of agriculture, the province and district offices of agriculture, and the statistics office are suggested to facilitate the producers an information systems of the ornamental plants market, especially prices. Further research is recommended to conduct additional tests that support cointegration tests. The test such as causality tests, to determine the direction of relationship between all cointegrated variables.

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