Analyzing long run equilibrium of broiler egg prices between wholesalers and retailers in Banda Aceh City using cointegration and Error Correction Model (ECM) approaches

Novrizal¹, Romano²*, A Nugroho² and S Kasimin²

¹Magister of Agribusiness, Universitas Syiah Kuala, Banda Aceh, Indonesia
²Department of Agribusiness, Universitas Syiah Kuala, Banda Aceh, Indonesia

*E-mail: romanos_agri@unsyiah.ac.id

Abstract. Broiler eggs are a strategic food commodity whose price stability needs to be maintained. During a period of 4 years, from 2016 to 2019, the City of Banda Aceh had no egg production, so eggs were supplied from outside the city, including North Sumatra, with the main distribution pattern involving wholesalers and retailers. This study aims to apply the cointegration test to figure out a long-term or stability relationship between the price of eggs at the wholesale trader level and the price of eggs at the retail trader level in Banda Aceh City. Monthly time series data were taken from January 2017 to December 2019. The analytical method used the Johansen Cointegration approach and the Error Correction Model (ECM), and data processing used Stata SE-64 software. The test results showed that there was a cointegration relationship between the price of eggs at the wholesaler level (HPG) and the price of eggs at the retailer level (HPE). This indicates that there is a long run equilibrium or price stability of eggs both at the wholesale trader level and at the retail trader level in Banda Aceh City.

1. Introduction

Eggs are food from poultry that are a great source of animal protein, easy to digest, and highly nutritious. The consumption level of eggs is greater than that of other livestock products as eggs are easy to obtain and the price is relatively cheap, making it affordable for people with low purchasing power [1]. Chicken eggs are one of the strategic food commodities in Indonesia that have been established by the government, and therefore, the stabilization of egg price is one of the government’s strategic policy agendas. Egg production in Aceh Province is still very low, especially in Banda Aceh City. The absence of egg production from 2016 to 2019 caused the city to supply eggs from outside. This can be seen from the increase in the entry of eggs of broilers to Banda Aceh City from 2016-2019. In 2016, the imported eggs to Banda Aceh reached 771,960 tons per year and continued to increase until 2019 amounting to 936,194.49 tons per year [2]. The survey results showed that 97.51% of eggs traded in Aceh Province came from North Sumatra Province, and the remaining 2.49% were obtained locally [3].

These data are in line with that from the Central Statistics Agency of the Republic of Indonesia, that apart from being an egg producer, Aceh gets most of the supply of eggs from North Sumatra Province. Based on the data of the production of eggs from the Ministry of Agriculture and the need for chicken eggs consumption of SUSENAS data in March 2018 with almost 9 eggs per month per capita, the consumption of chicken eggs that can be fulfilled from breeders in the province is only around 18 percent, and the rest is met by supplying from outside the province such as North Sumatra. The largest
percentage of purchases from producers and from outside the province is made by wholesalers, and then more than 60 percent of the supply is distributed to retailers [4]. The main distribution pattern of purebred chicken eggs in Banda Aceh City involves two trading activity actors: wholesalers and retailers.

The regulation of the Minister of Trade of the Republic of Indonesia Number 07 of 2020 concerning the reference price for purchases at the farm level and the reference price for sales at the consumer level aims to ensure the availability, stability and certainty of prices for several strategic staple commodities, one of which is the price of eggs. In light of these descriptions, this study aims to apply the cointegration test and the Error Correction Model (ECM) to identify whether or not there is a long run equilibrium or price stability of eggs at the wholesaler level and retailer level in Banda Aceh City.

2. Methods

This study obtained secondary data in the form of monthly time series data with a time period from January 2017 to December 2019 from the Aceh Food Service [5]. This study used two variables, namely the price of eggs at the wholesaler level and the price of eggs at the retailer level. The two variables were analyzed using the Johansen cointegration approach and the Error Correction Model (ECM) while data processing utilized the Stata SE-64 software. There are several steps applied in this analysis, as shown in the following:

2.1. Stationarity test

Time series data are generally stochastic or have a trend that is not stationary, meaning that they have a unit root. To be able to estimate a data usage model, the first step is to perform the stationarity test of the data, known as the unit root test [6].

This data stationarity test can be done using Augmented Dickey-Fuller (ADF) at the same degree (level or different) to obtain stationary data. The ADF test uses the following equation [7]:

$$\Delta P_t = a_0 + \gamma P_{t-1} + \sum_{i=1}^{j} a_1 \Delta P_{t-i+1} + \varepsilon_t$$

(1)

$\Delta P_t$ in equation (1) is the first difference variable tested ($Y_t - Y_{t-1}$), whereas $t$ is the time period, $j$ is the length of the lag used, and $\varepsilon$ is the error term. The statistical hypothesis tested is $H_0: \gamma = 0$ which means that if the time series data contain the unit root, the data are not stationary. If $H_1: \gamma \neq 0$, this means the data are stationary. If the data are not stationary, a differentiation process will be carried out from the first-difference level to the next level, until the data are stationary at the same level. The resulting output is in the form of statistical values and critical values of 1%, 5% and 10%. The formula used to find statistical values is shown below:

$$t = \frac{\gamma - \gamma H_0}{S\gamma}$$

(2)

If the t-statistical value is greater than t-critical, the decision is to reject $H_0$, and if the t-statistical value is smaller than t-critical, then $H_0$ cannot be rejected and this shows that the data are not stationary. The data that are not stationary must be differentiated to achieve the stationarity requirements.

2.2. Cointegration test

The cointegration test aims to see whether or not there is a long-term relationship between the variables used in the model. The cointegration test is carried out if the data concerned are not stationary at the same level. A variable is said to be cointegrated or has a long-term relationship if a variable that is stationary at the same degree moves with the same wavelength. This study used the Johansen cointegration test with the help of the stata application. One of the cointegration test methods is the one
developed by Johansen (1995), the Johansen Cointegration test [8]. To identify a long-term relationship, this method utilized the trace test (TS) with the equation as follows:

\[
\lambda_{\text{trace}} = T \sum_{i=k+1}^{n} (1 - \lambda_i)
\]

(3)

Where:
- \( k = 0, 1, \ldots, n-1 \)
- \( T \) = number of observations used
- \( \lambda_i \) = estimated value of the order of the eigenvalue of the matrix \( \Pi \)
- \( r \) = the number of vectors of cointegration vectors in the null hypothesis

The hypothesis used in the trace test (TS) is:
- \( H_0: r \leq 0 \) = There is no cointegration relationship
- \( H_0: r \leq 1 \) = There is at most one cointegrated equation
- \( H_0: r \leq n-1 \) = There are at most n-1 cointegrated equations

If the statistical test is greater than the critical value in the Johansen table, \( H_0 \) is rejected, indicating that there is a cointegration relationship.

2.3. Causality test

The causality test intends to ascertain the direction of the cause-and-effect relationship between the variables being tested. This study used the Engle-Granger causality test because it could be used on cointegrated variables. The standard Granger causality test has a weakness in which autocorrelation often occurs. According to Engle and Granger [9], if the two variables are proven to be integrated in the cointegration test in the previous stage, it is necessary to know the relationship between these variables and the causality test. The equation model used for the Granger causality test can be written as follows. The relationship between the price of eggs at the wholesaler level (PG) and the price of eggs at the retailer level (PE).

\[
\Delta P_G = a_0 + \sum_{i=1}^{n} \beta_{PG} \Delta P_G_{t-1} + \sum_{i=1}^{n} \beta_{PE} \Delta P_E_{t-1} + \pi_1 \text{ect}_{t-1} + \varepsilon_t
\]

(4)

\[
\Delta P_E = a_0 + \sum_{i=1}^{n} \beta_{PE} \Delta P_E_{t-1} + \sum_{i=1}^{n} \beta_{PG} \Delta P_G_{t-1} + \pi_1 \text{ect}_{t-1} + \varepsilon_t
\]

(5)

Where:
- \( P_G_t \) = Price of eggs at the wholesaler level in the t-period (IDR/Crate)
- \( P_G_{t-1} \) = Price of eggs at the wholesaler level in the previous period (IDR/Crate)
- \( P_E_t \) = Price of eggs at retailer level in period t (IDR/Crate)
- \( P_E_{t-1} \) = Price of eggs at retailer level in the previous period (IDR/Crate)
- \( a_0, \beta_{PG}, \beta_{PE} \) = Coefficient
- \( \text{ect} \) = Error Correction Term

The causality test model produces two possible relationships that can occur between variables: a two-way or one-way long-term causality relationship. This test is done by comparing the probability value with the real level used. The Granger causality test can be seen from the real levels of 1\%, 5\% and 10\%. If the probability value is smaller than the real level used, \( H_0 \) is rejected, indicating there is no causality between the variable pairs, whereas if the probability value is greater, \( H_0 \) is accepted, inferring the causality between the variable pairs.
2.4. Error correction model (ECM) test

The existence of cointegration in a variable means that the variable has a long-term relationship. However, if there is a long-term balance, there is a possibility that in the short term it will not strike a balance. An adjustment is needed if there is a difference between what is desired and what truly happens. Error Correction Model (ECM) is a model that can include these adjustments to correct short-term imbalances towards long-term equilibrium [10].

The ECM model of the relationship between the price of eggs at the wholesaler level (PG) and the price of eggs at the retailer level (PE) is as follows [11]:

\[
\Delta PG_t = a_PG \beta_{PG} PG_{t-1} + \sum_{i=1}^{p-1} r_{PG} \Delta PG_{t-1} + v_{PG} + \epsilon_t
\]

\[
\Delta PE_t = a_{PE} \beta_{PE} PE_{t-1} + \sum_{i=1}^{p-1} r_{PE} \Delta PE_{t-1} + v_{PE} + \epsilon_t
\]

Where:

- \( PG_t \) = Price of eggs at the wholesaler level in the t-period (IDR/Crate)
- \( PG_{t-1} \) = Price of eggs at the wholesaler level in the previous period (IDR/Crate)
- \( PE_t \) = Price of eggs at retailer level in period t (IDR/Crate)
- \( PE_{t-1} \) = Price of eggs at retailer level in the previous period (IDR/Crate)
- \( a, \beta, r, v \) = Coefficient
- \( \epsilon \) = Equation error
- \( t \) = Trend time

3. Result and discussions

3.1. Characteristics of marketing of broiler eggs in Banda Aceh City

The marketing pattern for eggs in the city of Banda Aceh does not originate from the producers, but from outside Aceh Province. Nine percent of eggs circulating in Banda Aceh City come from the supply of local layer hens while 91% are from North Sumatra. The distributors (wholesalers) market chicken eggs to retailers located in Lambaro, Neusu, Keutapang, Aceh, Peunayong, Ulhekareng and Lamnyong markets. In addition, they also market the eggs to the sub-district market in Aceh Besar (Greater Aceh) District situated near the city of Banda Aceh. A small portion of the eggs are sold to martabak (Acehnese egg pancake) food stalls and cake and pastry businesses. The supply chain and distribution of eggs in Banda Aceh City is shown in Figure 1 [12].
3.2. The development of chicken egg prices in Banda Aceh City

This study focused on two variables, the price of eggs at the wholesale trader level (PG) and the price of eggs at the retailer level (PE). The development of the monthly prices of eggs in the city of Banda Aceh at the wholesale trader level and at the retail trader level during the 2017-2019 period showed the same pattern or movement, suggesting that if the wholesale price is high, then the price at retail traders will also be high. Conversely, if the price at retailers is low, the price at wholesalers will also be low. The development of the monthly prices of eggs in Banda Aceh City at the wholesaler and retailer level can be seen in Figure 2.

Figure 2 displays that the price development of purebred chicken eggs at the level of wholesalers and retailers relatively fluctuated with an increasing trend in 2019. In May 2019, there was an increase in price which was in line with the increase in demand during HBKN (Religious and National Holidays), where prices at the wholesale level rose from 34,000 IDR/crate to 38,000 IDR/crate, while the price at the retail level rose to 40,000 IDR/crate from 37,000 IDR/crate. This trend conformed to the
Development of national chicken egg prices, in which in May 2019, the price of broiler eggs also experienced inflation of 2.67% (mtm), higher than the previous month's inflation of 2.20% (mtm). The pattern of higher prices for eggs in this month followed the rise in demand during HBKN. Based on this development, the price of eggs for broilers has now reached 23,950 IDR/kg, higher than the reference price (Figure 3) [13].

![Figure 3. Inflation of broiler eggs.](image)

3.3. Data stationarity test results
In general, secondary data used in research tend to have a trend that will lead to non-stationary data, causing spurious regression. Therefore, this study employed the Augmented Dickey Fuller data stationarity test (ADF Test) to ensure the consistency of data movement. The data stationarity test was carried out on the variable price of eggs at the wholesaler level (HPG) and that at the retailer level (HPE). The test results are shown in Table 1.

| Table 1. Data stationarity test results on the price of broiler eggs at the wholesaler level (HPG) and the price of broiler eggs at the retail trader level (HPE). |
|-----------------|-----------------|-----------------|-----------------|
| Variable        | Level ADF Test  | Differentiation ADF Test | Information ADF Test |
| HPG             | -1.037          | -6.172***        | stationary in Order I |
| HPE             | -1.105          | -6.077***        | stationary in Order I |
| Critical Value  | 1%              | 5%              | 10%              |

The results of the data stationarity test showed that the variable price of eggs at wholesalers (HPG) was not stationary at the same level (zero order), as indicated by the statistical value on the ADF test of -1.037, which was greater than 1% critical value of -3.682. Thus, it was necessary to perform the differentiation process level I (order I) that showed a statistical value of -6,172, smaller than 1% critical value (-3.689). In this case, it can be concluded that the price variable for broiler eggs at wholesalers is stationary in order I. In addition, at the retail traders (PE), the price was not stationary at the same level (zero order) as shown in the statistical value on the ADF test of -1.105, which was greater than 1% critical value (-3.682). Therefore, the differentiation process level I (Order I) was conducted and
revealed the statistical value of -6.077 which was less than 1% critical value (-3.689). Thus, it can be inferred that the variable eggs of broilers at retail traders are stationary in order I.

Based on the results of the stationarity test, the two variables have time series data that are stationary. If the data are stationary, a further test, the Johansen cointegration test, can be carried out.

3.4. Johansen cointegration test

The cointegration test is performed because all variables are integrated or stationary in the same order. Variables can be said to have a long-run relationship (long-run equilibrium) when the variables are cointegrated. The cointegration test used in this study was the Johansen Cointegration Test, whose results are described in Table 2.

**Table 2.** Results of the Johansen Cointegration Test on the price of broiler eggs at the wholesaler level (HPG) and the price of broiler eggs at the retail trader level (HPE).

| Rank | Eigenvalue | Trace Statistic | 5% Critical Value |
|------|------------|-----------------|-------------------|
| r = 0 | 0.82453 | 73.5399 | 15.41 |
| r = 1 | 0.38627 | 16.1105 | 3.76 |

As seen in the table above, the results of the Johansen method cointegration test on the price of eggs at the wholesaler level (HPG) and the price of eggs at the retailer level (HPE) indicated the decision to reject Ho, which means that there is cointegration at the 95% confidence level. The test obtained the trace statistic value of 73.5399, greater than the critical value of 15.41. Thus, the null hypothesis, which stated that there was no cointegration, was rejected, whereas the alternative hypothesis stating that there was cointegration was accepted. This finding suggests that the prices at the wholesaler level and at the retailer level have a cointegration relationship. It can be concluded that the prices of eggs at the wholesale trader level and at the retail trader level in Banda Aceh City have a relationship of stability or equilibrium and similar movements in the long term. In other words, if prices in one market are cointegrated with prices in other markets, the prices tend to move towards long-term equilibrium.

3.5. Causality test results

As shown in Table 3, the HPG variable showed that the β value at PG\textsubscript{t−1} was 0.065 significant at \(\alpha = 10\%\), and the β value at PE\textsubscript{t−1} was 0.060 significant at \(\alpha = 10\%\). This infers that the price of eggs at the wholesaler level can affect the price of eggs at the retailer level. Furthermore, the HPE variable showed that the β value in PG\textsubscript{t−1} was 0.070 significant at \(\alpha = 10\%\) and the β value on PE\textsubscript{t−1} was 0.092 significant at \(\alpha = 10\%\). This suggests that the variable price of chicken eggs at the retailer level can influence the price of eggs at the wholesaler level. Therefore, in the cointegration equation the HPG and HPE variables have a two-way relationship, indicating that the two variables affect each other [14]. The two-way relationship in this equation signifies that if the price of eggs at the wholesale trader level rises, the price of eggs at the retail trader level also increases and vice versa.

**Table 3.** The Granger Method Causality Test results on the price of broiler eggs at the wholesaler level (HPG) and the price of broiler eggs at the retail trader level (HPE).

| Parameter | Wholesale price (HPG) | Retail Price (HPE) | Causality Result |
|-----------|------------------------|--------------------|-----------------|
| Relationship (β) | | | Two-way relationship (HPG \(\leftrightarrow\) HPE) |
| PG Price t-1 | 0.065* | 0.070* |
| PE Price t-1 | 0.060* | 0.092* |
3.6. Error Correction Models (ECM) test

The results of the previous cointegration test revealed a cointegration relationship between the price of eggs at the wholesale trader level and the price of eggs at the retail trader level in Banda Aceh City. Afterwards, the co-integrated variables were tested further using the ECM test. In the ECM model, the short-term imbalance would be corrected by incorporating adjustments for the short-term imbalance correction towards the long-term equilibrium. The VECM estimates on the price of eggs in Banda Aceh are provided in Table 4.

Table 4. VECM Estimates of the price of broiler eggs at the wholesaler level (HPG) and the price of broiler eggs at the retailer level (HPE) in Banda Aceh City.

| Estimated Parameters | Price of broiler eggs at the wholesaler level (HPG) | Price of broiler eggs at the retailer level (HPE) |
|----------------------|----------------------------------------------------|--------------------------------------------------|
| Long Run Equilibrium | 1                                                  | -0.9027877                                      |
| (β)                  |                                                    |                                                  |
| Adjustment Speed (α) | -1.104056                                          | 1.483266                                         |
| Short Term Relationship (Γ) |                                                    |                                                  |
| HPG t-1              | 0.0249401                                          | -.7008762                                       |
| HPE t-1              | -0.420087                                          | 0.2275034                                       |

Table 4 describes that the equation indicated that the cointegration equation model was good. A good cointegration equation is expressed as an indication of a long run equilibrium between the price of eggs at the wholesaler level and the price of eggs at the retailer level. The equation also implies that when the prediction of the correlation equation is positive, the wholesaler price is above the equilibrium line due to positive HPG coefficient. In the short term, a negative value (-1.104) infers that when the average price of eggs at the wholesaler level is too high, it will quickly drop at the retailer level. In this equation, an estimate of the adjustment speed (α) on the HPE is 1.483, suggesting that when the wholesaler price is above the equilibrium, the retailer price will adjust accordingly to the equilibrium with an adjustment speed of 1.483.

4. Conclusion

This study concludes that there is a cointegration relationship between the price of eggs at the wholesaler level (HPG) and the price of eggs at the retailer level (HPE). This signifies a long run equilibrium or price stability of eggs at the wholesale trader level and the retail trader level in Banda Aceh City.

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