Measuring the range of recommended monthly prices and quantities supplied of patchouli oil: a case of Gayo Lues patchouli

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Abstract. The drop of patchouli oil production in the beginning 2018 because many producers in Gayo Lues have switched to other commodities when range of the (monthly) prices were too often fluctuating below their expectations, lower than IDR. 500,000, due to increase in total quantities supplied during 2017. This research is aimed to develop a stability model in order to measure a recommended monthly range of stable prices offered by middlemen as local buyers and quantity supplied by producers. The model was developed based on the cobweb model theorem and by using statistical analysis of regression linear model to process prices and quantities supplied data of the oil at equilibrium points. The research result indicates that most producers sell their oils directly to middlemen. The middlemen adjusted prices monthly based on amount of actual quantity supplied. While on the producers’ side, it is assumed that their quantities supplied were influenced by their last observed prices. The result also shows that the model can be used to measure the range of optimum prices and monthly quantities supplied, which are between IDR 480,593 dan IDR 588,089 for the prices, and between 1,721.35 kg and 1,872.65 kg for the quantities supplied to the middlemen (samples) or between 3,431.95 kg and 3,733.61 kg for those to the local markets in Gayo Lues. These numbers can be used as reference data for managing the monthly quantities supplied e.g. by establishing community storage at producers level or finding new markets.

1. Introduction
The lack of Gayo Lues patchouli oil supply in the beginning of 2018, which is predicted to continue until 2019 has become a serious concern of the patchouli value chain actors in Gayo Lues, especially among the buyers. It is due to the fact that Gayo Lues patchouli oil is well-known as one of the best Sumatran patchouli oils in global market, which has superior quality in terms of patchouli alcohol (PA) value and aroma. Both of these characteristics are the main determinants of the oil quality, as raw
material for premium products (perfume and aromatherapy), as well as a mixture of other low quality patchouli oil in order to improve the Indonesian patchouli oil quality as a whole in the global market. One of the main causes of the oil scarcity was that the prices volatile (fluctuated) and fallen too often below their expectations, which ultimately causes producers to switch to other crops, especially to citronella plant.

The pricing problem for a business, especially for an agricultural business, is quite complex, and a less controlled factor than other factors: product, promotion, and distribution [1]. In a short term, producers have opportunities to set prices according to their respective business objectives, such as: for business continuity, maximizing sales or profits, etc. However, for a long term, the prices are typically determined by markets (supply and demand). After 2006, although changes (increases) in agricultural commodity prices was resulted from many factors occurred in parallel, (adverse) changes in supply-demand relations is still one of the most significant factors for the changes (growth) of agricultural commodity prices [2]. Furthermore, formation of agricultural product prices over time are influenced by a mixture of complex changes related to many factors [3]. Normally, the price is more affected by seasonal factors, low during harvest season, then rising gradually, and reaching its peak before next harvest season. However, some prices of agricultural commodities are much more influenced by cycle factors and fluctuating, because quantity supplied of most of the commodities are effected by their prices in the past. Therefore, the general trend is: amount of quantity supplied will rise when expected price applies in the hope that prices will stay high, which triggers prices falls in the next period due to increasing quantity supplied. Then the amount of productions will decline again due to the price falls, thereby reducing quantity supplied and triggering price rises in the next period. This cycle will repeat itself following the Cobweb Model Theorem proposed by Ezekiel [4].

The volatile price of patchouli oil in Indonesia has been going on for decades. The actors controlling the price, from the highest to the lowest control are: middlemen (local buyers) and exporters (buyers), distillers and collectors of patchouli leaves, and farmers [5]. The highest fluctuations in selling prices are at the producers level. Moreover, price fluctuations outside the tolerable limits greatly disrupted the production [6]. If the price falls, farmers are reluctant to grow their plants, which causes a shortage of quantity supplied and triggers price rises. Whereas, when the price is satisfactory, the farmers will eager to move back to their plantations [7]. However, if then the quantity supplied increases, the price will decline again. The fact that the magnitude of interplay between the price (P) and quantity supplied (Q), maintaining stability of these factors is very important, so that the value chain can be sustainable, and finally, it can help all of the value chain actors to manage their (production and marketing) plans.

The volatile price of the oil have caused the displacement of main production centers of Indonesian patchouli oil several times, from Sumatra, to Java, then to Celebes (Sulawesi). The positive thing since the transfer of the center to Sulawesi is that patchouli oil price volatile (fluctuations) are slightly reduced [8]. But this is allegedly due to massive intervention from a world class volatile oil company since 2013 [9], leading to reduced numbers of local exporters, better control at the level of oil collection, and lack of price speculation. However, there is no guarantee that this situation can last forever. Unfortunately, the fact that average quality of the Sulawesi patchouli oils is far inferior to that of Sumatran patchouli oils, including to the Gayo Lues patchouli oil, is another problem should be considered to maintain the competitiveness of Indonesian patchouli oil in global market. Furthermore, there were some efforts to increase the Gayo Lues patchouli oil production and quality by some NGOs and local government [10]. However, there was no research has been done to manage excess quantity supplied and price volatility in the area yet, and middlemen (local buyers) have the highest control of local patchouli oil price.

2. Materials and Methods
2.1. Data collection
The study was conducted in the beginning of 2018, located in Tripe Jaya and Terangun Districts, Gayo Lues Regency, where patchouli oil business has been developed for decades and development of
the business has received many supports from various parties. The research was began by recognizing marketing direction of the patchouli oil, and identifying local value chain actors (farmers, distillers, and middlemen) as the main sources of data collection. The data from the actors were collected using focus group discussions (FGDs) and in-depth interviews with the actors. About 10 FGDs were done with 2 – 8 participants of farmers, which some of them were also distillers. The interviews were done with two (2) medium scale local middlemen and 4 (four) big scale local middlemen.

The study was conducted to develop a patchouli oil stability model, which shows a recommended ranges of stable prices and quantities supplied of the patchouli oil. The model was developed following the cobweb model theorem and by using linear regression equation models. Primary data collected were the monthly quantities supplied and prices of patchouli oil on October 2015 - December 2017 at the middlemen level. However, the main data used were the data based on transactions at the middlemen level in 2016, when the prices still got good responses from producers as shown by the growth of total amount of quantity supplied in 2017, before the decline of quantity supplied drastically in the beginning of 2018. The price data from October to December 2015 were included as additional data in the calculation, which affects quantities supplied in the beginning of 2016.

2.2. Analysis of patchouli oil price formation and stability mechanisms

The steps to analyze the patchouli oil price formation and stability mechanisms in the patchouli value chain are as follows:

1) Identifying mechanism of the price formation, including market direction, and who determines the price and amount of quantity supplied.
2) Development of patchouli oil price stability model based on observations of existing price fluctuations and patchouli oil supply. The steps are as follows:
   a) Formulating relationship of $P_t$ and $P_{t+1}$ at the equilibrium points, when the supply was absorbed by the local market (clearing). The relationship of $P_t$ and $P_{t+1}$ is used to show how the price changes phenomenon over time, in order to determine level of price stability.
   b) Determining stability constraints values (lower and upper) of $P_t$ and $Q_t$ of a stable price system
   c) Collecting monthly data of patchouli oil prices and quantities supplied: the data showing prices ($P_t$) and quantities supplied ($Q_t$) changes per month ($t$).
   d) Formulating equation of quantity supplied: the equation showing a relation of actual quantity supplied ($Q_t$) and price of patchouli oil in previous period ($P_{t-1}$).
   e) Formulating equation of quantity demanded: the equation showing a relation of actual quantity demanded ($Q'_t$) and actual patchouli oil price ($P_t$).
   f) Formulating relationship of $P_t$ and $P_{t+1}$ at the equilibrium points, when the supply was absorbed by local market (market clearing). The relationship of $P_t$ and $P_{t+1}$ is used to show how the price changes over time, in order to determine limits of price stability.
   g) Determining recommended limit values (lower and upper) of monthly actual prices actual quantity demanded/ supplied of the patchouli oil in a stable price system.

3. Results and Discussion
3.1. Mechanism of patchouli oil price formation

The prices of patchouli oil at the producers level are influenced by demands of buyers (exporter/ dealer/main trader), which is realized in the form of patchouli oil prices informed to middlemen (local buyers). Prices offered by the buyers are then translated into prices at various levels of local value chain actors/groups: price at (offered by) middlemen level, prices at (offered to) distiller level, and price at (offered to) farmer level. It is important to note that, at the research site, most farmers do a sharing system with distillers for the outcome (patchouli oil), and they sell their own patchouli oil directly to middlemen. Therefore, the patchouli oil producers are a combination of farmers and
distillers, and the middlemen are actually the very dominant local price regulators of the patchouli oil (oligopoly market).

Based on aforementioned mechanism, assuming that other factors being equal (ceteris paribus), each actor will supply their oil in a certain quantity, following their last observed price. For producers, their quantities supplied are heavily influenced by prices in previous periods. For an example (see also Figure 1), if the past price is relatively high (P2), then quantity supplied will tend to rise (Q2) because they increased their productions. The increase in quantity supplied lead to price falls (P1) over the next period. The price falls cause quantity supplied drops (Q1) because they decrease their productions. The drop in quantity supplied will cause price rises over the next period (P2), and so on. This phenomenon is so called dynamic stable price cycle phenomenon. In the case of patchouli business, the past period (P(t-1)) is about 4 months, optimal time of patchouli plant before first harvest [11]. While the actual price set by middlemen (as local buyers) adjusted to their demand, or their quantity demanded (Q′) depends on the actual price (P).

![Figure 1. Dynamic stable price cycle phenomenon (linear)](image)

The dynamic stable price cycle phenomenon as shown in Fig. 1 can be explained mathematically as follows:

1. Actual quantity supplied (Q′) is influenced by price in the past period (P(t-1)), so that the quantity supplied will change following the equation: 
   \[Q'_t = f_1(P_{t-1})\]  
   Where, Q′ is quantity supplied in actual period (t); P is price per unit in past period (t-1).

2. Actual quantity demanded in period t (Q″) is the consequence of price in actual period (P), although it is actually reaction of middlemen by setting the price based on amount of quantity supplied. Absorption of the supplied will follow the equation below: 
   \[Q''_t = f_2(P_t)\]  
   Where, Q″ is quantity demanded in actual period (t); P is price per unit in actual period (t)

3. At equilibrium point, the supplies are fully absorbed by the market (market clearing) in period t, when 
   \[Q'_t = Q''_t\]  or  \[f_2(P_t) = f_1(P_{t-1})\]

4. The relationship between P_t dan P_{t-1} can be formulated as follows: 
   \[P_t = f_1(P_{t-1})\]

Where, P_t is price per unit in actual period (t); P_{t-1} is price per unit in past period (t-1)

3.2. Development of the price stability model

The price fluctuations from January 2016 to December 2017 are as shown in Fig. 2. In 2016 (month 1 – 12). Total amount of patchouli oil managed by the middlemen was about 20,835 kg out of total 41,540 kg quantity supplied in Gayo Lues [12]. In 2017 (month 13 – 24), total amount of patchouli oil managed by the middlemen was increased to about 22,545 kg. However, as aforementioned reason, the measurements was based on data of price and quantity supplied of patchouli oil from October 2015 to December 2016 (see also Table 1).

Table 1 shows that in 2016, despite the fluctuations in price and the prices tend to decrease but the monthly prices were still ≥ IDR 500,000/kg, minimum expectation price of the producers. Moreover, at the middlemen level, the quantities supplied (from producers) per month were between 1,490 – 1,890 kg, with total quantity supplied of 20,835 kg. In 2017, the price was expected to rebound (increase) to be above IDR 500,000/kg. However, due to the increase of quantity supplied to a total
amount of 22,545 kg, the price in 2017 (on average) became lower than that in 2016 and continues to fall to be less than IDR 500,000/kg.

![Figure 2. Prices of Gayo Lues patchouli oil](image)

**Table 1. Price and quantity supplied of Gayo Lues patchouli oil (Oct. 2015 – Dec. 2016).**

| Month | 10 | 11 | 12 |
|-------|----|----|----|
| Q.S (kg) | 1,917 | 1,826 | 1,627 |
| Price (,000 IDR/kg) | 560 | 560 | 570 |

Furthermore, how the cycle phenomenon shown in Figure 1, as well as the common form of equations above can be used to find stability values of patchouli oil price and quantity supplied. Therefore, from equations (3) and (4) and at the equilibrium points, we can formulate a general form of relationship between Pt and Pt-1 as follows:

\[ P_t = f_t(P_{t-1}) = A \cdot P_{t-1} + B \]

Where, \( P_t \): price in period t (actual); \( P_{t-1} \): price in period t-1 (3 - 4 months before first harvest); A: amplitude coefficient of patchouli oil price changes; and B: Constants value

The equation (5) has several possibilities of the actual patchouli price changes as follows:

1. Constant price system, when price is constant: \( P_t = P_{t-1} \) (Figure 3). If \( P_t = A \cdot P_{t-1} + B \), and \( P_t = P_{t-1} \), then: \( A = 1 - B / P_{t-1} \). It is well known that agricultural commodity prices are never constant (fix), because the productions are heavily affected by various factors, especially natural condition (i.e. climatic fluctuation) [13].

![Figure 3. Constant price system](image)
2) Unstable price system, when price fluctuations deviate and tend to decrease (divergent fluctuation) at \( A < 1 \) (Fig. 4); or increase continuously at \( A > 1 - B/P_{t, t} \) and \( P_t > P_{t, t} \) (Fig. 5). Unstable price system occurs when a market failure because markets are unable to bring about a stable equilibrium [14] [15].

![Figure 4. Unstable price system (diverged)](image)

![Figure 5. Unstable price system (rises continuously)](image)

3) Dynamic stable price system, when prices fluctuate constantly at \( A = 1 \) (Fig. 6). Minimum value of \( P_t \) is \(-P_{t, t} + B\) and maximum value of \( P_t \) is \( P_{t, t} \). This condition is a perfect continuous fluctuation which has been described by Ezekiel (1938) that market must dynamically go towards stable equilibrium point each time quantity and price move away from the point.

4) Stable price system, when price fluctuations tend to be converging (convergent fluctuation) at \(-1 < A < 1 - B/P_{t, t} \), or the prices are at \(-P_{t, t} + B < P_t < P_{t, t} \) (Fig. 7).

![Figure 6. Dynamic stable price system](image)

![Figure 7. Stable price system (converged)](image)

From the various possibilities above (Fig. 3 – 7), the stable price system (Fig. 7) is used to determine the range of stable prices, when price fluctuations over time reduce due to the changes of quantity demanded/ supplied. To get a stable price cycle (Fig. 7), as aforementioned, we need to limit the values of \( A \) between the two, so that: \(-1 < A < 1 - B/P_{t, t} \) or lower limit and upper limit values of \( P_t^{\text{stability}} \) are: \(-P_{t, t} + B < P_t^{\text{stability}} < P_{t, t} \), where \(-P_{t, t} + B \) is \( P_t^{\text{lower stability}} \) and \( P_{t, t} \) is \( P_t^{\text{upper stability}} \). From the both values of \( P_t^{\text{stabilities}} \), then we can be calculate limits of stable price and quantities supplied. Thus, determination of the stable ranges based on data at Table 1 is carried out by using statistical analysis of regression linear model and assuming that quantity supplied and quantity demanded is linearly following the equations below:

1) Actual quantity supplied: \( Q_t = f_t(P_{t, t}) = \bar{Q} + b.P_{t, t} \) for \( b > 0 \)

2) Actual quantity supplied: \( Q_t = f_t(P_{t, t}) = 1044.92 \times 0.00118 \) \( P_{t, t} \); with the value of \( \bar{Q} = 1044.92 \) and value of \( b = 0.00118 \). The statistical analysis and results of relationship between actual quantity supplied and past price are as presented in Tables 2, 3, 4, and 5. Past price has positive impact on the growth of actual quantity supplied. However, the \( p \)-value (Sig.) = 0.377 tells us that this coefficient is not significantly influence on actual quantity supplied. Past price also only explain 9.2% of the variance in the quantity supplied by the producers in Gayo Lues.

### Table 2. Descriptive Statistics

|                      | Mean  | Std. Deviation | N  |
|----------------------|-------|----------------|----|
| Actual quantity supplied | 1736.2500 | 119.17758      | 12 |
| Past price            | 587500.0000 | 30785.17943    | 12 |
Table 3. Model Summary

| Model | R  | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|----|----------|-------------------|---------------------------|
| 1     | .304<sup>a</sup> | .092     | .002              | 119.08006                 |

a. Predictors: (Constant), Past price

Table 4. Anova

| Model | Sum of Squares | df | Mean Square | F    | Sig. |
|-------|----------------|----|-------------|------|------|
| 1     | Regression     | 1  | 14435.641   | 1.018| .337<sup>b</sup> |
|       | Residual       | 10 | 14180.061   |      |      |
| Total | 156236.250     | 11 |             |      |      |

a. Dependent Variable: Actual quantity supplied
b. Predictors: (Constant), Past price

c. Predictors: (Constant), Actual price

Table 5. Regression Coefficients

| Model | Unstandardized Coefficients | Standardized Coefficients | t     | Sig. |
|-------|-----------------------------|---------------------------|-------|------|
|       | B                           | Std. Error                | Beta  |      |
| 1     | (Constant)                  | 1044.916                  | 686.048| 1.523| .159 |
|       | Past price                  | .001                      | .001  | .304 | 1.009| .337 |

a. Dependent Variable: Actual quantity supplied
2) Actual quantity demanded: \( Q'_d = f_2(P_t) = \bar{Q}^d - a.P_t \), for \( a > 0 \) \( (7) \)

Actual quantity demanded: \( Q'_d = f_2(P_t) = 2549.076 - 0.00141.P_t \); with the value of \( \bar{Q}^d = 2549.08 \) and value of \( a = 0.00141 \). The statistical analysis and results of relationship between actual quantity demanded and actual price are as presented in Tables 6, 7, 8 and 9. Actual price is negatively adjusted to actual quantity demanded. The \( p \)-value (Sig.) = 0.86 tells us that the model significant at 10% level of significance or actual price is significantly adjusted to actual quantity demanded. Furthermore, actual price explain 26.7% of the variance in the quantity demanded by the middlemen in Gayo Lues.

Table 6. Descriptive Statistics

|                   | Mean   | Std. Deviation | N  |
|-------------------|--------|----------------|----|
| Actual quantity demanded | 1736.2500 | 119.17758 | 12 |
| Actual price      | 577500.0000 | 43719.14496 | 12 |

Table 7. Model Summary

| Model | R  | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|----|----------|-------------------|---------------------------|
| 1     | .516<sup>a</sup> | .267     | .193              | 107.04442                 |

a. Predictors: (Constant), Actual price
Table 8. Anova

| Model        | Sum of Squares | df | Mean Square | F     | Sig. |
|--------------|----------------|----|-------------|-------|------|
| 1 Regression | 41651.180      | 1  | 41651.180   | 3.635 | .086 |
| Residual     | 114585.070     | 10 | 11458.507   |       |      |
| Total        | 156236.250     | 11 |             |       |      |

a. Dependent Variable: Actual quantity demanded
b. Predictors: (Constant), Actual price

Table 9. Regression Coefficients

| Model         | Unstandardized Coefficients | Standardized Coefficients | t   | Sig. |
|---------------|-----------------------------|---------------------------|-----|------|
| (Constant)    | 2549.076                    | 0.001                      | 5.963 | .000 |
| Actual price  | -.001                       | .001                      | -.516 | -1.907 | .086 |

a. Dependent Variable: Actual quantity demanded

3) At equilibrium point (market clearing): \( Q_t^d = Q_t^s \iff \bar{Q}_t^d = \bar{Q}_t^s + b.P_{t-1} \) (8) Therefore, \( Q_t^d = Q_t^s \iff 2549.076 - 0.00141 P_t = 1044.916 + 0.00118 P_{t-1} \).

4) Relationship between actual price (\( P_t \)) and past period price (\( P_{t-1} \)). The equation (8) can be also written as: \( a.P_t + b.P_{t-1} = \bar{Q}_t^d - \bar{Q}_t^s \iff P_t = -\frac{b}{a} P_{t-1} + \frac{\bar{Q}_t^d - \bar{Q}_t^s}{a} \) (9)

If \( A = -\frac{b}{a} \), and \( B = \frac{\bar{Q}_t^d - \bar{Q}_t^s}{a} \), then: \( P_t = A.P_{t-1} + B \) (10)

Where the amplitude value is \( A = -\frac{b}{a} = \frac{0.00118}{0.00086} = -0.8361 \); and constant value is \( B = \frac{\bar{Q}_t^d - \bar{Q}_t^s}{a} = \frac{2549.076 - 1044.916}{0.00086} = 1,068,681.75 \), thus: \( P_t = -0.8361 P_{t-1} + 1,068,681.75 \).

5) Range of stable prices, the prices (\( P_t \)) between the \( P_t \) lower stability dan \( P_t \) upper stability, is obtained when: \( -1 < A < 1/B.P_{t-1} \) or when: \(-P_{t-1} + B < P_t < P_{t-1} \) (11)

Where \( P_{t-1} \) value can be obtained from: \( P_{t-1} = \frac{\sum_{i=1}^{n_i} Q_{t-1}^s}{\sum_{i=1}^{n_i} Q_{t-1}^d} \) (12)

The calculation results are \(-P_{t-1} + B = 480,593 \) and \( P_{t-1} = 588,089 \), thus the range of recommended stable prices are between IDR 480,593 dan IDR 588,089.

6) Finally, the equilibrium quantity of stable price can be measured as follows:
- \( Q_t^s \) stability maximum = \( \bar{Q}_t^d - a.P_t \) lower stability = 2549.076 - 0.00141 \( P_t \) lower stability (13)
- \( Q_t^s \) stability minimum = \( \bar{Q}_t^d - a.P_t \) upper stability = 2549.076 - 0.00141 \( P_t \) upper stability (14)

Thus, the result is that the range of recommended stable monthly quantities supplied from the producers to the four middlemen are between 1,721.35 kg (\( Q_t^s \) stability maximum) and 1,872.65 kg (\( Q_t^s \) stability minimum).

4. Conclusions

The equation \( Q_t^s = 2549.076 - 0.00141 P_t \), can be used to estimate total amount of the oil should be supplied monthly by the producers to the middlemen or local markets in Gayo Lues at 90% level of confidence, where standard deviation of the actual total amount is 34.40 and that of the predicted total amount is 17.76. However, to achieve market stability, recommended monthly quantities supplied from the producers to the four middlemen (samples) are between 1,721.35 kg and 1,872.65 kg with prices of between IDR 480,593 - IDR 588,089. Since the four middlemen managed approximately 50.16% of total patchouli oil in Gayo Lues, total amount of the oil should be supplied monthly by the
producers to local markets in Gayo Lues at the range of recommended stable prices (IDR 480,593 - IDR 588,089) are between 3,431.95 kg and 3,733.61 kg.

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