Production and prices forecasting analysis of red chili (Capsicum annuum L.) in North Sumatera in 2028

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Abstract. This study aims to find out the most compatible method specification used to forecast the production and prices of red chili and to analyse the results of the production and prices forecasting of red chili in North Sumatera in 2028. The analytical methods used are the linear trend analysis, quadratic trend analysis, and exponential trend analysis where the three method specifications will be tested with MSE and MAPE to see which one is the most compatible. The results indicated that quadratic trend analysis is the most compatible one and that both the production and the prices forecasting are having a negative trend. The decreasing of production is caused by the decreasing of red chili’s planting area while the decreasing of prices is caused by the decreasing of demand for red chili.

1. Introduction
The development of horticulture subsector is not only focusing on increasing the production, but also related to important issues in a wider perspective. Some of horticultural commodities, like chili and shallot, are contributing significantly to inflation. Therefore, those strategic commodities need attention from the government in order to attain price stability by increasing the production and improving the quality of product [1].

Table 1. The demand of red chili in North Sumatera

| Year | Demand |
|------|--------|
| 2006 | 49,800 |
| 2007 | 49,800 |
| 2008 | 52,302 |
| 2009 | 54,936 |
| 2010 | 47,827 |
| 2011 | 78,932 |
| 2012 | 78,932 |
| 2013 | 83,256 |
| 2014 | 85,155 |
| 2015 | 95,892 |
| 2016 | 95,892 |
| 2017 | 32,437 |

Source: Food Security Agency of North Sumatera, 2018
According to the Food Security Agency of North Sumatera, there has been no report regarding import activity for red chili from outside the country which means the supply still meet the demand. The demand for red chili in North Sumatera fluctuated but tend to increase for the past twelve years. With the population keep increasing, it will affect the demand for red chili and eventually affect the prices too. Therefore, this research is conducted to see if the production and prices of red chili in North Sumatera for the next ten years will still able to meet the needs and be used as the reference to make plans and decisions for future policies.

2. Research methods

2.1 Method specifications for forecasting the production and the prices of red chili

Three method specifications will be used to forecast the production and the prices of red chili. The specifications used are as follow:

2.1.1 Linear trend.

\[ Y_t = a + bt + et, \quad t = 1,2,3,\ldots \]  

Information:
- \( Y_t \): Production and prices at the t-th year
- \( a \): Intercept coefficient
- \( b \): Regression coefficient of \( t \)
- \( t \): Time (notated in numbers)
- \( e_t \): Other determining factors (\( e_t = 0 \))

2.1.2 Quadratic trend.

\[ Y_t = a + bt + ct^2 + et, \quad t = 1,2,3,\ldots \]  

Information:
- \( Y_t \): Production and prices at the t-th year
- \( a \): Intercept coefficient
- \( b \): Regression coefficient of \( t \)
- \( c \): Regression coefficient of \( t^2 \)
- \( t \): Time (notated in numbers)
- \( e_t \): Other determining factors (\( e_t = 0 \))

2.1.3 Exponential trend.

\[ \log(Y_t) = a + bt + et, \quad t = 1,2,3,\ldots \]  

Information:
- \( Y_t \): Production and prices at the t-th year
- \( a \): Intercept coefficient
- \( b \): Regression coefficient of \( t \)
- \( t \): Time (notated in numbers)
- \( e_t \): Other determining factors (\( e_t = 0 \))

The formula will later be changed back with antilog as follows:

\[ \hat{Y} = ab^t \]
Information:
Ŷ = Production and prices forecasting
a = Intercept coefficient
b = Average increase in Ŷ per time unit
t = Time (notated in numbers)

2.2 Methods for Compatibility Test
To see which method is the most compatible one, several test will be used including:

2.2.1 MSE (Mean Squared Error).

\[ \text{MSE} = \left( \frac{1}{n} \sum_{i=1}^{n} e_i \right)^2 = \text{mean}(e_i^2) \]  

(5)

The formula used to find \( e_i \) is as follows:

\[ e_i = (y_i - f_i^n) \]  

(6)

Information:
n = Data amount
e = error
i = Year
\( y_i \) = Measured value in the field at i-th time
\( f_i \) = Forecasted value at i-th time

The method specification with the lowest MSE value will be the most compatible specification used to forecast the production and the prices of red chili in the future time.

2.2.2 MAPE (Mean Absolute Percentage Error).

\[ \text{MAPE} = \frac{1}{n} \sum_{i=1}^{n} 100 \cdot |p_i| \]  

(7)

The formula used to find \( p_i \) is as follows:

\[ |p_i| = \frac{|e_i|}{y_i} \]  

(8)

Information:
n = Data amount
|\( e_i |\) = Absolute error value at i-th time
i = Year
\( y_i \) = Measured value at i-th time
|\( p_i |\) = Absolute error value per measured value at i-th time

The criteria for MAPE values are; very accurate if \(<10\%\), accurate if 10-20\%, accurate enough if 20-50\%, less accurate if \( >50\% \) [2].
3. Results and discussion

3.1 Compatibility Test for the Forecasting Method specifications

The results are attained by regressing the data of red chili’s production and prices from 2005 – 2017 to a linear trend, quadratic trend, and exponential trend respectively. Then, each of the specification is tested by calculating their MSE value and MAPE value.

Table 2. The linear trend, quadratic trend, and exponential trend formulas for production and prices of red chili in North Sumatera

|                | Production                                  | Prices                                      |
|----------------|---------------------------------------------|---------------------------------------------|
| Linear Trend   | \( Y = 148019.4615 + 5940.423077t \)       | \( Y = 21565.2 + 1214.97t \)               |
| Quadratic Trend| \( Y = 164870 + 5940.423t - 1203.68t^2 \) | \( Y = 23276.82 + 1214.97 - 122.259t^2 \) |
| Exponential Trend| \( Y = 174.0897(1.019338)^t \)          | \( Y = 74.91(1.0263)^t \)                |

Table 3. The MSE value and MAPE value for each of the production Forecasting Method

|                | MSE           | MAPE         |
|----------------|---------------|--------------|
| Linear Trend   | 550,471,391   | 12.4044%     |
| Quadratic Trend| 327,350,725.6 | 10.4562%     |
| Exponential    | 22,902,090,458 | 99.8775%    |

According to the results of MSE value and MAPE value for each of the production forecasting method, the quadratic trend has the lowest MSE value at 327,350,725.6 and MAPE value at 10.4562% which means it’s included in the accurate criteria. Therefore, quadratic trend is the most compatible method specification to forecast the production of red chili in North Sumatera.

Table 4. The MSE value and MAPE value for each of the prices Forecasting Method specification

|                | MSE           | MAPE         |
|----------------|---------------|--------------|
| Linear Trend   | 14,736,989.8  | 15.3503%     |
| Quadratic Trend| 12,435,113.1  | 14.9107%     |
| Exponential    | 497,155,031   | 99.6293%     |

According to the results of MSE value and MAPE value for each of the prices forecasting method specification, the quadratic trend again has the lowest MSE value at 12,435,113.1 and MAPE value at 14.9107% which means it’s included in the accurate criteria much like the method specification for the production forecasting. Therefore, quadratic trend is the most compatible method specification to forecast the prices of red chili in North Sumatera.

3.2 Forecasting analysis of production and prices of red chili

After attaining the most compatible method specification to forecast the production and the prices of red chili, the forecast value of production and prices of red chili from 2019-2028 can be attained. The results are attained by using the quadratic trend formula and changing the \( t \) with predetermined number notation for each year.
The results show that the production of red chili in North Sumatera keep decreasing each year which means it’s having a negative trend. The graphic of the forecasted value of red chili’s production can be seen at Figure 1.

### Table 5. The results of production forecasting of red chili

| Year | t (notated in numbers) | Forecasted Value of Red Chili’s Production |
|------|------------------------|------------------------------------------|
| 2019 | 8                      | 135358.8                                  |
| 2020 | 9                      | 120836.6                                  |
| 2021 | 10                     | 103907.1                                  |
| 2022 | 11                     | 84570.27                                  |
| 2023 | 12                     | 62826.06                                  |
| 2024 | 13                     | 38674.48                                  |
| 2025 | 14                     | 12115.54                                  |
| 2026 | 15                     | -16850.8                                  |
| 2027 | 16                     | -48224.4                                  |
| 2028 | 17                     | -82005.4                                  |

**Figure 1.** The forecasted value of red chili’s production chart

**Figure 2.** The forecasted value of red chili’s planting area chart

Assuming that the cause of the decreasing in red chili’s production is the decreasing of red chili’s planting area, the results show that after forecasting the red chili’s planting area from 2019-2028 it has proven that the assumption is correct. Using the same method of forecasting as the red chili’s production, the results can be seen at Figure 2.

As seen on the figure planting area of red chili in North Sumatera is also keep decreasing each year. There is a correlation between the production and the production factors (input) and the most important factors are land, capital, labour, and management aspect [3].

The results show that the prices of red chili in North Sumatera keep decreasing each year which means it’s having a negative trend. The graphic of the forecasted value of red chili’s prices can be seen at Figure 3.

Assuming that the cause of decreasing in red chili’s prices is the decreasing of red chili’s demand, the results show that after forecasting the red chili’s demand from 2019-2028 it has proven that the assumption is correct. Using the same method of forecasting as the red chili’s prices, the results can be seen at Figure 4.
Table 6. The results of prices forecasting of red chili

| Year | t (notated in numbers) | Forecasted Value of Red Chili’s Prices |
|------|------------------------|---------------------------------------|
| 2019 | 8                      | 25172                                 |
| 2020 | 9                      | 24308.57                              |
| 2021 | 10                     | 23200.62                              |
| 2022 | 11                     | 21848.15                              |
| 2023 | 12                     | 20251.16                              |
| 2024 | 13                     | 18409.66                              |
| 2025 | 14                     | 16323.64                              |
| 2026 | 15                     | 13993.1                               |
| 2027 | 16                     | 11418.04                              |
| 2028 | 17                     | 8598.459                              |

As seen on the chart above, the demand for red chili in North Sumatera is also keep decreasing each year. The price mechanism is a process that works based on pull force between consumers and producers in the market. At one time, the price might increase because the consumers’ pull force is strengthened. On the contrary, the price might decrease if the pull force is weakened [4].

4. Conclusions

The most compatible method specification to forecast the production of red chili in North Sumatera is quadratic trend with MSE value at 327.350.725,6 and MAPE value at 10.4562% and the most compatible method specification to forecast the prices of red chili in North Sumatera is quadratic trend with MSE value at 12.435.113,1 and MAPE value at 14.9107%. The forecasting results show that both the production and the prices of red chili in North Sumatera are having a negative trend for the next ten years.

References

[1] Badan Pusat Statistik [Central Bureau of Statistics] 2019 Statistik Tanaman Hortikultura 2017 [Horticultural Plant Statistic 2017] (Medan, Indonesia: Badan Pusat Statistik [Central Bureau of Statistics])

[2] Amalia S N 2016 Peramalan singular spectrum analysis dengan missing data [Singular spectrum analysis with missing data]
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