The supply elasticity for North Sumatera shallot in short and long-run

T C Pane and T Supriana*
Faculty of Agriculture, Universitas Sumatera Utara, Medan, Sumatera Utara, Indonesia.

E-mail: *tavi@usu.ac.id or tasyacpane@usu.ac.id

Abstract. Shallot is one of the horticultural commodities, which its instability can cause inflation. Government policies often pay more attention to reducing prices to prevent inflation, so that the consumers' welfare finally increases, while producers' welfare is still less accommodated by the policies. North Sumatera is one of the major shallot producing provinces in Indonesia, and it includes in the recommended areas for expanding shallot cultivation areas. This study analysed the factors affecting the supply of North Sumatera shallot and estimated its elasticity to the price in order to help formulating agricultural policies relating to the stabilization of the North Sumatera shallot supply. To estimate it, the Nerlove partial adjustment model, the autoregressive model, was analysed by multiple linear regression with the Ordinary Least Square (OLS) estimation technique. The results showed that the North Sumatera shallot supply was positively affected by the shallot harvest area, the shallot cultivation area, the garlic producer price, and the TSP fertilizer price. In addition, it was also negatively affected by the shallot producer price and the North Sumatera shallot supply in the previous period. In both the short and long-run, North Sumatera shallot supply is inelastic to the price.

1. Introduction

For the people of Indonesia, shallot becomes one of the crucial horticulture commodities. Shallot is a spice that cannot be substituted with other herbs due to its function as a spice in cooking and an ingredient of traditional Indonesian medicines. If it is cultivated intensively, shallot farming can be a major source of income for farmers and provides employment, so that it contributes quite high to the development of the regional economy [1]. Because of its irreplaceability by other spices, with the assumption that demand will always grow along with the increase of population, then instability in the supply of shallot can stimulate an increase in the price of shallot, which finally causes inflation.

In order not to cause unrest in Indonesian society, which is almost entirely consumers of shallot, the government often issues policies that are more aimed at reducing the price of shallot to avoid inflation. A reduction in the price of shallot can provide a surplus for consumers of shallot, so that their welfare increases [2,3]. Meanwhile, the impact of these policies on the welfare of shallot producers is often overlooked. In fact, the stability of supply is highly dependent on the welfare of producers. If shallot farming is considered to be capable of developing the welfare of farmers, then the farmers will be motivated to produce more shallot. However, if it is less promising to prosper, then the farmers will certainly be reluctant to produce shallot, and instead they plant other crops considered as more prospective.
Shallot can be produced in almost all regions of Indonesia. North Sumatera is a province of the main producer and largest consumers of shallot in Indonesia [1], so it is included in the list of recommended areas for the development of shallot farming in 2005-2025. In North Sumatera, the main centres of shallot are located in areas around Lake Toba [4], so it is recommended that shallot farming is developed in the districts of North Tapanuli, Toba Samosir, and Padang Sidempuan [1].

In an effort to formulate policies related to the efforts to develop and maintain the stability of shallot supply without ignoring the welfare of producers and consumers, this study aimed to analyse the factors that influence the supply of North Sumatera shallot and estimate the short-run and long-run supply elasticity of North Sumatera shallot towards North Sumatera shallot price at producer level.

2. Methods
In accordance with the purpose of the study, which examined the elasticity of North Sumatera shallot supply, the study area was determined intentionally (Purposive Method) in the districts around Lake Toba, where the centres of shallot production in North Sumatera were located, namely Simalungun, Samosir, North Tapanuli, Dairi, Toba Samosir, and Karo [4,5]. Secondary data in the form of monthly time series data from January 2010 - December 2014 was collected from the Department of Agriculture, the Central Bureau of Statistics (BPS-Statistics), and related agencies in the study area. The research data included shallot supply data, shallot harvest area, shallot cultivation area, shallot price, garlic price, and TSP fertilizer price in North Sumatera.

Seasonal crop farmers will usually cultivate a crop commodity based on the expectation of the current commodity price, and not based on the commodity price in the previous period [6-10]. For this reason, the North Sumatera shallot supply model was an autoregressive model adapted from the Nerlove Partial Adjustment Model. In the autoregressive model, the dependent variable was affected by the independent variable at the period, and also by the dependent variable itself in the previous period. Ordinary Least Square (OLS) method was used to estimate the model, which is classified as a multiple linear regression equation. The following equation shows the shallot supply model estimated in this study.

\[ Q_{st} = f \left( LP_t, LT_t, Pf_t, Pf p_t, Pf x_t \right) \]  
\[ \ln Q_{st} = b_0 + b_1 \ln LP_t + b_2 \ln LT_t + b_3 \ln Pf_t + b_4 \ln Pf p_t + b_5 \ln Pf x_t \]  
\[ \ln Q_{st} = \delta \ln Q_{st+1} + (1 - \delta) \ln Q_{st-1} \]

accordingly:

\[ \ln Q_{st} = \delta b_0 + \delta b_1 \ln LP_t + \delta b_2 \ln LT_t + \delta b_3 \ln Pf_t + \delta b_4 \ln Pf p_t + \delta b_5 \ln Pf x_t + (1 - \delta) \ln Q_{st-1} \]  
\[ a_0 = \delta b_0 ; a_1 = \delta b_1 ; a_2 = \delta b_2 ; a_3 = \delta b_3 ; a_4 = \delta b_4 ; a_5 = \delta b_5 ; a_6 = 1 - \delta \]

\[ \ln Q_{st} = a_0 + a_1 \ln LP_t + a_2 \ln LT_t + a_3 \ln Pf_t + a_4 \ln Pf p_t + a_5 \ln Pf x_t + a_6 \ln Q_{st-1} \]

\[ \delta = 1 - a_6 ; b_0 = a_0/\delta ; b_1 = a_1/\delta ; b_2 = a_2/\delta ; b_3 = a_3/\delta ; b_4 = a_4/\delta ; b_5 = a_5/\delta \]
In which:

\( Q_{sr}^* \) = Expected North Sumatera shallot supply at period \( t \) (ton)

\( Q_{sr} \) = North Sumatera shallot supply at period \( t \) (ton)

\( LP_t \) = Shallot harvest area at period \( t \) (ha)

\( LT_t \) = Shallot cultivation area at period \( t \) (ha)

\( Pf_t \) = Shallot producer price at period \( t \) (IDR/Kg)

\( Pfp_t \) = Garlic producer price at period \( t \) (IDR/Kg)

\( Pfxt \) = TSP fertilizer price at period \( t \) (IDR/Kg)

\( Q_{sr-1} \) = North Sumatera shallot supply in the previous period (ton)

\( a_0 \) = Intercept coefficient/constant

\( a_1, \ldots, a_6 \) = Regression coefficient/parameter

In order to estimate the autoregressive model, stationary and cointegration tests needed to be done. Stationarity and cointegration tests on time series data were very important, so that estimation results could be generalized to predict other periods and predict relationships in the long-run. Regression models using non-stationary data could lead to spurious regression because a strong trend in the time series variables, and non-cointegrated time series variables had no effect in the long-run [11]. The Phillips-Perron Fisher Unit Root Test was used to test data stationarity, and the Engle-Granger (EG) method was used to test the cointegration between variables. With the cointegration test, it could be seen the long-run influence of independent variables on the dependent variable [12-14].

OLS assumptions testings were conducted on the North Sumatera shallot supply regression model. The Ramsey RESET test was utilized to test the linearity assumption of the model, the Breusch-Pagan-Godfrey test and the Glejser test were applied to test the assumption of autocorrelation in the model, and the Variance Inflation Factors (VIF) value was used to test the multicollinearity assumption in the model. After fulfilling all these assumptions, the F test, the t test, and the determination coefficient \( (R^2) \) could be tested and interpreted. The hypotheses tested were:

H0: The independent variables have an insignificant effect on the dependent variable.

H1: The independent variables have a significant effect on the dependent variable.

The test criteria were at 95% confidence level (\( \alpha \) 5%), with the conditions:

If the probability value \( \leq \alpha \) 5% or 0.05, H0 is rejected and H1 is accepted.

If the probability value \( > \alpha \) 5% or 0.05, H0 is accepted and H1 is rejected.

How responsive the change in the amount of shallot supply due to changes in the price of shallot at the farm level could be seen through the elasticity of the supply. With the cointegration test, the elasticity of the shallot supply to the producer price of the shallot could be estimated, both in the short and long-run. The elasticity of North Sumatera shallot supply to the producer price of North Sumatera shallot could be calculated based on the formula in Equation (6) and Equation (8).

\[
E_{SR} = a_3
\]  
\[
E_{LR} = b_3 = \frac{a_3}{\delta} = \frac{E_{SR}}{\delta} = \frac{E_{SR}}{1-a_6}
\]

3. Results and discussion

3.1. Stationarity and cointegration test

Data stationarity test results showed that all data variables that would be estimated, namely North Sumatera shallot supply at period \( t \) (\( Q_{sr} \)), shallot harvest area at period \( t \) (\( LP_t \)), shallot cultivation area at period \( t \) (\( LT_t \)), shallot producer price at period \( t \) (\( Pf_t \)), garlic producer price at period \( t \) (\( Pfp_t \)), TSP fertilizer price at period \( t \) (\( Pfxt \)), and North Sumatera shallot supply in the previous period (\( Q_{sr-1} \)), have
been stationary at first difference. It means that the regression using the data of these variables on the first difference will avoid spurious regression.

Cointegration test results of the variables that would be estimated show that all independent variables in the regression model have been cointegrated with the dependent variable. It means that there is a long-run effect of the independent variable on the dependent variable, so the regression results can be used to predict both the short-run and long-run effects.

3.2. Estimation result of the supply function for North Sumatera shallot

Table 1 illustrated the estimated results of the supply function for North Sumatera shallot. The coefficient of determination (R²) in Table 1 was 0.561056. It means that the variation of the dependent variables, namely the shallot harvest area, shallot cultivation area, shallot producer price, garlic producer price, TSP fertilizer price, and North Sumatera shallot supply in the previous period, have been able to explain the variation of the dependent variable, namely the North Sumatera shallot supply variable, amounting to 56.1056%. Meanwhile, the remaining 43.8944% is explained by variations of other variables not included in the regression model.

| No. | Notation         | Variables                          | Coefficient | Probability |
|-----|------------------|------------------------------------|-------------|-------------|
| 1   | D (ln LP)        | Shallot harvest area               | 0.950279    | 0.0000      |
| 2   | D (ln LT)        | Shallot cultivation area           | 0.161714    | 0.0454      |
| 3   | D (ln Pf)        | Shallot producer price             | -0.227402   | 0.4155      |
| 4   | D (ln PfP)       | Garlic producer price              | 0.162999    | 0.4337      |
| 5   | D (ln PfT)       | TSP fertilizer price               | 1.428438    | 0.2451      |
| 6   | D (ln Qst,1)     | North Sumatera shallot supply in the previous period | -0.126974   | 0.1856      |
|     | \( a_0 \)        | Constant                           | -0.003057   | 0.9119      |
|     | \( R^2 \)        | Coefficient of determination       | 0.561056    | -           |
|     | Prob(F-statistic)| F Test                             | 11.07771    | 0.000000    |

The supply function for North Sumatera shallot in the form of linear equation is written in the Equation (11).

\[
D(ln Q_{st}) = -0.003057 + 0.950279 D(ln LP_t) + 0.161714 D(ln LT_t) - 0.227402 D(ln Pf_t) + 0.162999 D(ln PfP_t) + 1.428438 D(ln PfT_t) - 0.126974 D(ln Q_{st-1})
\]  

The test of independent variables influences simultaneously through the F Test in Table 1 showed an F-statistic value of 11.07771, with a probability value of 0.000000 (\( \alpha < 5\% \) or 0.05), so that \( H_0 \) was rejected and \( H_1 \) was accepted. It means, simultaneously, independent variables, namely the shallot harvest area, shallot cultivation area, shallot producer price, garlic producer price, TSP fertilizer price, and North Sumatera shallot supply in the previous period significantly influence the dependent variable North Sumatera shallot supply at \( \alpha 5\% \).

The test of the independent variables influences partially through the t test in Table 1 demonstrated the regression coefficient value of the independent variable shallot harvest area was 0.950279, with a probability value of 0.0000 (\( \alpha < 5\% \) or 0.05), so that \( H_0 \) was rejected and \( H_1 \) was accepted. It means, partially, the independent variable shallot harvest area has a positive effect on the dependent variable North Sumatera shallot supply, and the effect is significant at \( \alpha 5\% \). The regression coefficient of 0.950279 means that North Sumatera shallot supply will increase by 0.950279% with each increase in
shallot harvest area of 1%. On the other hand, North Sumatera shallot supply will also decrease by 0.950279% along with a decrease in shallot harvest area of 1%.

The regression coefficient value for the shallot cultivation area was 0.161714, with a probability value of 0.0454 (α < 5% or 0.05), so H₀ was rejected and H₁ was accepted. It means, partially, the independent variable shallot cultivation area has a positive effect on the dependent variable North Sumatera shallot supply and the effect is significant at α 5%. The regression coefficient of 0.161714 means that North Sumatera shallot supply will increase by 0.161714% along with the increase in shallot cultivation area by 1%. On the other hand, North Sumatera shallot supply will decrease by 0.161714% every 1% decrease in shallot cultivation area.

Harvest area and cultivation area have a big influence on the supply of shallot. If the other independent variables are assumed to be constant (ceteris paribus), then the addition of harvest area and cultivation area can increase the amount of shallot production, so that the supply of shallot also increases. Therefore, one of the efforts that can be done to gain the supply of shallot is to increase cultivation area. The addition of cultivation area is expected to increase the harvest area and increase the production of shallot, so that the supply also develops.

The value of the shallot producer price regression coefficient was -0.227402, with a probability value of 0.4155 (α > 5% or 0.05), so H₀ was accepted and H₁ was rejected. It means, partially, the independent variable garlic producer price has a negative effect on the dependent variable North Sumatera shallot supply, but the effect is so small so that it is insignificant at α 5%. The regression coefficient of -0.227402 means that North Sumatera shallot supply will decrease by 0.162999% along with the increase in shallot producer price of 1%. On the other hand, North Sumatera shallot supply will also increase by 0.162999% along with every 1% decrease in shallot producer price. It can occur because the price of shallot tends to increase, while the supply of shallot tends to decrease from year to year.

The regression coefficient value of the independent variable producer price was 0.162999, with a probability value of 0.4337 (α > 5% or 0.05), so H₀ was accepted and H₁ was rejected. It means, partially, the independent variable garlic producer price has a positive effect on the dependent variable North Sumatera shallot supply, but the effect is so small so that it is insignificant at α 5%. The regression coefficient of 0.162999 means that North Sumatera shallot supply will increase by 0.162999% along with an increase in garlic producer price of 1%. On the other hand, North Sumatera shallot supply will also decrease by 0.162999% along with 1% decrease in garlic producer price. It can occur because garlic is also used as a spice in cooking and ingredients for traditional Indonesian medicines, so that when the price of garlic rises due to its rising demand, then farmers will expect demand and the price of shallot also rise.

The regression coefficient value of TSP fertilizer price was 1.428438, with a probability value of 0.2451 (α > 5% or 0.05), so H₀ was accepted and H₁ was rejected. It means, partially, the independent variable TSP fertilizer price has a positive effect on the dependent variable North Sumatera shallot supply, but the effect is so small so that it is insignificant at α 5%. The regression coefficient of 1.428438 means that North Sumatera shallot supply will increase by 1.428438% along with an increase in TSP fertilizer price of 1%. On the other hand, North Sumatera shallot supply will also increase by 1.428438% along with an increase in shallot producer price of 1%. It can occur because farmers are not too concerned about the input price in producing shallot.

The regression coefficient value of the independent variable North Sumatera shallot supply in the previous period was -0.126974, with a probability value of 0.1856 (α > 5% or 0.05), so that H₀ was accepted and H₁ was rejected. It means, partially, the independent variable North Sumatera shallot supply in the previous period has a negative effect on the dependent variable North Sumatera shallot supply, but the effect is so small so that it is insignificant at α 5%. The regression coefficient of -0.126974 means that North Sumatera shallot supply will decrease by 0.126974% along with an increase in North Sumatera shallot supply in the previous period of 1%. On the other hand, North Sumatera shallot supply will increase by 0.126974% along with 1% decrease in North Sumatera
shallot supply in the previous period. It also means that when compared with North Sumatera shallot supply in the previous period, North Sumatera shallot supply is lower 0.126974%.

3.3. Supply elasticity for North Sumatera shallot in short-run and long-run
Table 2 showed the supply elasticity for North Sumatera shallot in short and long-run. The elasticity value of the North Sumatera shallot supply towards producer price in the short-run in Table 2 was -0.2274. It means that the supply of shallot in North Sumatera is inelastic towards producer price in the short-run. The elasticity value of the North Sumatera shallot supply towards price in the long-run in Table 2 was -0.2018. It means that the supply of shallot in North Sumatera is inelastic to price in the long-run. A negative elasticity value means that if there is an increase in producer price of shallot by 1%, there will be a decrease in supply of North Sumatera shallot by 0.2274% in the short-run, and 0.2018% in the long-run, and vice versa, if there is a decrease in producer price of shallot by 1%, then there will be an increase in North Sumatera shallot supply by 0.2274% in the short-run, and 0.2018% in the long-run.

| Notation | Variable | \( a_3 \) | \( a_6 \) | \( E_{SR} \) | \( \delta = 1 - a_6 \) | \( E_{SR} / \delta \) |
|----------|----------|---------|---------|-----------|-----------------|------------------|
| D (ln \( P_f \)) Shallot producer price | -0.2274 | -0.1270 | -0.2274 | 1.1270 | -0.2018 |

North Sumatera shallot supply elasticity in the short and long-run is inelastic to the price, which means that the percentage change in the supply of North Sumatera shallot is smaller than the percentage change in producer price. It happens because, in the short-run, the price predicted by farmers during cultivation is often different from the price that is ultimately obtained during the harvest season. When harvest time comes and the price of shallot is high, it cannot be immediately followed by a change in the supply of shallot. In the short-run, farmers cannot directly change and adjust their production factors. Changes and adjustments to their production factors can only be done by farmers in the long-run. However, the elasticity of shallot supply in the long-run is inelastic to price because the price of shallot is the price created by the market (traders and buyers), so farmers cannot control the price regardless of the amount of shallot they produce.

4. Conclusions
The North Sumatera shallot supply is positively affected by the shallot harvest area, the shallot cultivation area, the garlic producer price, and the TSP fertilizer price, and it is also negatively affected by the shallot producer price and the North Sumatera shallot supply in the previous period. Supply elasticity for North Sumatera shallot in the short-run was -0.2274 and in the long-run was -0.2018. In both the short and long-run, North Sumatera shallot supply is inelastic to the price.

References
[1] Suryana A, Suyamto, Nugraha US, Adiyoga W, Basuki RS, Setiawati W, et al 2005 Prospek dan Arah Pengembangan Agribisnis Bawang Merah [Prospects and Directions for Shallot Agribusiness Development] (Jakarta, Indonesia: Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian [Agricultural Research and Development Agency, Ministry of Agriculture]) Available from: http://www.litbang.pertanian.go.id/special/komoditas/b3bawang
[2] Suranovic SM 2007 International Trade: Theory and Policy Available from: http://internationalacon.com/Trade/tradehome.php
[3] Pane TC, Supriana T, Khaliqi M 2019 Short-run and long-run demand elasticity of shallot in North Sumatera Province IOP Conf Ser Earth Environ Sci 260(1) 012005
[4] Pane TC, Supriana T 2019 The supply chain of North Sumatera shallot International Conference on Agriculture, Environment, and Food Security (AEFS) 2019 (Medan, Indonesia) Accepted
[5] Badan Pusat Statistik Provinsi Sumatera Utara [BPS-Statistics of Sumatera Utara Province] 2014 Sumatera Utara dalam Angka 2014 [Sumatera Utara in Figures 2014] (Medan, Indonesia: Badan Pusat Statistik Provinsi Sumatera Utara [BPS-Statistics of Sumatera Utara Province])

[6] Nerlove M 1956 Estimates of the Elasticities of Supply of Selected Agricultural Commodities J Farm Econ 38(2) pp 496–509

[7] Nerlove M 1958 The dynamics of supply; estimation of farmer’s response to price (Baltimore: The John Hopkins Press)

[8] Nerlove M, Addison W 1958 Statistical Estimation of Long-Run Elasticities of Supply and Demand J Farm Econ 40(4) pp 861–80

[9] Nerlove M 1958 Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations J Farm Econ 40(2) pp 301–11

[10] Braulke M 1982 A note on the Nerlove model of agricultural supply response Int Econ Rev 23(1) pp 241–4 (Philadelphia)

[11] Gujarati DN 2004 Basic Econometrics Fourth Edi (New York: The McGraw Hill Companies)

[12] Ajija SR, Sari DW, Setianto RH, Primanti MR 2011 Cara Cerdas Menguasai Eviews [A Smart Way to Learn Eviews] (Jakarta, Indonesia: Salemba Empat)

[13] Ghozali I, Ratmono D 2013 Analisis Multivariat dan Ekonometrika. Teori, Konsep, dan Aplikasi dengan EViews 8 [Multivariate and Econometric Analysis. Theories, Concepts, and Applications with EViews 8] (Semarang, Indonesia: Badan Penerbit Universitas Diponegoro)

[14] Ghozali I 2016 Aplikasi Analisis Multivariat dengan Program IBM SPSS 23 [Multivariate Analysis Application with the IBM SPSS 23 Program] (Semarang, Indonesia: Badan Penerbit Universitas Diponegoro)

Acknowledgements
The research was funded by Universitas Sumatera Utara through the Non PNBP Fund Fiscal Year 2017 based on the Implementation Contract of Universitas Sumatera Utara TALENTA Research Fiscal Year 2017 between the Rector and the Chairman of Universitas Sumatera Utara Research Institute Number: 5338/UN5.1.R/PPM/2017 dated May 22nd 2017.