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Abstract. Shallot is one of the leading horticultural commodities from the seasonal vegetable group in Indonesia. Of all the total harvested area of the seasonal vegetable crops in Indonesia, the largest is used to produce shallots. The increase in demand for shallot because of population growth and increase in income, as well as the domestic production of shallot which cannot meet the high needs for shallot, results in imbalance condition in shallot market and thus push price up. The autoregressive model adapted from Nerlove partial adjustment model and multiple linear regression analysis with the estimation technique of Ordinary Least Square (OLS) were used to analyse the factors affecting the demand for shallot and estimate the demand elasticity to the price of shallot in North Sumatera. The results showed that the consumer price of shallot, the consumer price of garlic, and the population of North Sumatera have a positive effect on the demand for shallot, while the GDP per capita of North Sumatera and the demand for shallot in the previous period have a negative effect on the demand for shallot in North Sumatera. Demand elasticity of shallot in North Sumatera is inelastic, both in the short-run and the long-run.

1. Introduction

Seasonal vegetable crops are the plant aged less than one year which are the sources of vitamins, mineral salts, and others, consumed from plant part in the form of leaves, flowers, fruits, and tubers. Shallot is one of the leading horticultural commodities from the seasonal vegetable group in Indonesia. Of the 22 main seasonal vegetable species in Indonesia, shallot and red chili are the most fluctuating rapidly in prices and often soar very high. Shallots are used as cooking ingredients as well as traditional medicinal ingredients that cannot be substituted with other ingredients. Of all the total harvested area of the seasonal vegetable crops in Indonesia, the largest is used to produce shallots and chilies [1].

Population growth and increase in income have caused the demand for shallot to increase as well. The increase in demand for shallot, as well as the domestic production of shallot which cannot meet the high needs for shallot, results in imbalance condition in shallot market and thus push price up. The volume of imported shallot in North Sumatera tends to increase from year to year, while the cultivation area, production, and productivity of shallot in North Sumatera tend to decrease from year to year [2]. The overflow of imported shallot with low price and large tuber, as well as the implementation of cultivation method that has not met the standard operational procedure (SOP), are suspected to be the cause of decreased interest of farmers to cultivate shallot.

The slow increase in production, while the consumption keeps increasing as the result of increasing population and income, has made the availability of shallot for household and food industries often less than the necessity. Moreover, often the increase in demand for shallot contributes to more problems and push up the price. This condition drives the increase in shallot import demand. The existing government

policies focus only on import regulation. The government has to use the proper policy instruments based on the factors affecting shallot demand so that import can be controlled and domestic shallot production can be increased significantly so that the needs of society can be fulfilled continuously. For these reasons, this research aims to analyse the factors affecting the demand for shallot and estimate the demand elasticity to the price of shallot in North Sumatera.

2. Methods

This study was conducted in North Sumatera as it has a high contribution to the demand for shallot nationally. The data used were monthly time series for five years (2010-2014), which includes the data of shallot demand, shallot harvested area, shallot cultivation area, shallot price, garlic price, and TSP fertilizer price in North Sumatera. The data were obtained from the Department of Agriculture of North Sumatera and Central Bureau of Statistics of North Sumatera.

The autoregressive model was used because, in this research, the dependent variable was affected by the independent variable at time t, and also by the dependent variable itself at time t-1. It is because when planting seasonal plants, farmers do not react at the price of the commodity in the previous year, but more on the current expected price [3-4]. Therefore, Nerlove partial adjustment model that is a multiple linear regression equation was used. Data analysis was done using an econometric approach, which is the Ordinary Least Square (OLS) method.

The shallot demand model was modified from the Nerlove model which was used by [5] for their research. The shallot demand model in this research is systematically written on the following equations.

$$Q_{d*t} = f\,(P_t, PP_t, JP_t, Y_t) \tag{1}$$

$$ln\,Q_{d*t} = b_0 + b_1\,ln\,P_t + b_2\,ln\,PP_t + b_3\,ln\,JP_t + b_4\,ln\,Y_t \tag{2}$$

$$ln\,Q_{dt} = \delta\,ln\,Q_{d*t} + (1-\delta)\,ln\,Q_{dt-1} \tag{3}$$

Accordingly:

$$ln\,Q_{dt} = \delta\,(b_0 + b_1\,ln\,P_t + b_2\,ln\,PP_t + b_3\,ln\,JP_t + b_4\,ln\,Y_t) + (1-\delta)\,ln\,Q_{dt-1} \tag{4}$$

$$ln\,Q_{dt} = \delta b_0 + \delta b_1\,ln\,P_t + \delta b_2\,ln\,PP_t + \delta b_3\,ln\,JP_t + \delta b_4\,ln\,Y_t + (1-\delta)\,ln\,Q_{dt-1} \tag{5}$$

$$a_0 = \delta b_0\;;\; a_1 = \delta b_1\;;\; a_2 = \delta b_2\;;\; a_3 = \delta b_3\;;\; a_4 = \delta b_4\;;\; a_5 = 1-\delta \tag{6}$$

$$ln\,Q_{dt} = a_0 + a_1\,ln\,P_t + a_2\,ln\,PP_t + a_3\,ln\,JP_t + a_4\,ln\,Y_t + a_5\,ln\,Q_{dt-1} \tag{7}$$

$$\delta = 1 - a_5\;;\; b_0 = {}^{a_0}/_{\delta}\;;\; b_1 = {}^{a_1}/_{\delta}\;;\; b_2 = {}^{a_2}/_{\delta}\;;\; b_3 = {}^{a_3}/_{\delta}\;;\; b_4 = {}^{a_4}/_{\delta} \tag{8}$$

where:

Q_{d*t}	= Expected demand for shallot at period t (ton)
Q_{dt}	= Demand for shallot at period t (ton)
P_t	= Consumer price of shallot at period t (IDR/Kg)
PP_t	= Consumer price of garlic at period t (IDR/Kg)
JP_t	= Population of North Sumatera (people)

Y_t = GDP per capita of North Sumatera (IDR)
Q_{dt-1} = Demand for shallot in the previous period (ton)
a_0 = Intercept coefficient/constant
$a_1, \ldots, a_5$ = Regression coefficient/parameter

Stationarity and cointegration tests were conducted before model estimation to see whether there was a trend element on the data or not so that the obtained regression model has a strong capability to predict and avoid a spurious regression [6]. The stationarity test used the *Phillips-Perron Fisher Unit Root Test* while the cointegration test used the *Engle-Granger* (EG) method. *Engle-Granger* (EG) cointegration test was conducted to find out how the independent variables affect the dependent variable in the long-run. In econometrics, cointegrated variables are said to have a long-run relationship [7-8].

After the estimation result was obtained, several tests were conducted, which are linearity test using *Ramsey RESET Test*, autocorrelation test using *Durbin-Watson Test*, heteroscedasticity test using *Breusch-Pagan-Godfrey and Glejser Test*, and multicollinearity test by seeing Variance Inflation Factors (VIF) value. Hereafter, statistical tests were conducted, including *F-test*, *t-Test*, and the coefficient of determination (R^2).

Demand elasticity was used to measure the responsiveness of the quantity of demanded shallot on the change of shallot price itself. The existence of lag and the use of time series data have caused the demand elasticity of shallot on the short-run and the long-run can be counted. By using equation (6), the demand elasticity to the price of shallot can be formulated as follows.

$$E_{SR} = a_1 \tag{9}$$

$$E_{LR} = b_1 = {}^{a_1}/_{\delta} = {}^{E_{SR}}/_{\delta} = {}^{E_{SR}}/_{1-a_5} \tag{10}$$

where:
E_{SR} = Short-run elasticity
E_{LR} = Long-run elasticity
a_1 = Regression coefficient of variable *Consumer price of shallot*
a_5 = Regression coefficient of variable *Demand for shallot in the previous period*
δ = Partial adjustment coefficient, where $0 < \delta < 1$

3. Results and discussion

3.1. Stationarity test

The result of the stationary test showed that all variables, which are the variables of demand for shallot (Q_{dt}), consumer price of shallot (P_t), consumer price of garlic (PP_t), population of North Sumatera (JP_t), GDP per capita of North Sumatera (Y_t), and demand for shallot in the previous period (Q_{dt-1}), were stationary at *second difference*.

3.2. Cointegration test

Cointegration test demonstrated that all variables used in each regression model in this study were cointegrated, or that the independent variables in the model had a long-run relationship with its dependent variable. Equation estimation could be continued without worrying that it would result in a spurious regression.

3.3. Estimation result of the demand function of shallot in North Sumatera

Table 1 shows the estimation result of the demand function of shallot in North Sumatera. The coefficient of determination (*R-Squared*) of 0.446721 shows that 44.6721% variations of the dependent variable,

which is the demand for shallot, is explained by the variations of the independent variable, which is the consumer price of shallot, consumer price of garlic, population of North Sumatera, GDP per capita of North Sumatera, and demand for shallot in the previous period. Meanwhile, the remaining 55.3279% is explained by the variations of other variables that are not included in the model.

Table 1. Estimation result of the demand function of shallot in North Sumatera

No.	Notation	Variables	Coefficient	Probability
1	D (ln P_t, 2)	Consumer price of shallot	0.115653	0.6630
2	D (ln PP_t, 2)	Consumer price of garlic	0.039393	0.9198
3	D (ln JP_t, 2)	Population of North Sumatera	2075.618	0.8494
4	D (ln Y_t, 2)	GDP per capita of North Sumatera	-13.89886	0.7375
5	D (ln Q_{dt-1}, 2)	Demand for shallot in the previous period	-0.568173	0.0000
6	D (ln P_t, 2)^2	Consumer price of shallot - squared	0.354111	0.1106
7	D (ln PP_t, 2)^2	Consumer price of garlic - squared	-0.120603	0.7706
8	D (ln JP_t, 2)^2	Population of North Sumatera - squared	-4751853	0.9624
9	D (ln Y_t, 2)^2	GDP per capita of North Sumatera - squared	-292.2987	0.9305
10	D (ln Q_{dt-1}, 2)^2	Demand for shallot in the previous period - squared	0.213365	0.0007
	a_0	Constant	-0.143482	0.1246
	R^2 *(R-squared)*	Coefficient of determination	0.446721	-
	Prob(F-statistic)	F-Test	3.794812	0.000849

The demand function of shallot in North Sumatera in the form of a quadratic equation can be written as the following equation.

$$D(ln\,Q_{dt}, 2) = -0.143482 + 0.115653\,D(ln\,P_t, 2) + 0.039393\,D(ln\,PP_t, 2) + 2075.618\,D(ln\,JP_t, 2) - 13.89886\,D(ln\,Y_t, 2) - 0.568173\,D(ln\,Q_{dt-1}, 2) + 0.354111\,D(ln\,P_t, 2)^2 - 0.120603\,D(ln\,PP_t, 2)^2 - 4751853\,D(ln\,JP_t, 2)^2 - 292.2987\,D(ln\,Y_t, 2)^2 + 0.213365\,D(ln\,Q_{dt-1}, 2)^2 \quad (11)$$

The probability value of F-statistic of 0.000849 (< α 5% or 0.05) shows that the independent variables included in the model, which are the consumer price of shallot, consumer price of garlic, population of North Sumatera, GDP per capita of North Sumatera, and demand for shallot in the previous period, simultaneously have a significant effect on the dependent variable that is the demand for shallot at α = 5%.

The probability value of t-statistic of the independent variable which is the demand for shallot in the previous period (Q_{dt-1}) is less than 0.05 or 0.10. It shows that the demand for shallot in the previous period partially has a significant effect on the dependent variable that is the demand for shallot. Meanwhile, the probability values of t-statistic of the consumer price of shallot (P_t), the consumer price of garlic (PP_t), the population of North Sumatera (JP_t), and the GDP per capita of North Sumatera (Y_t) are more than 0.05 or 0.10. It shows that the consumer price of shallot, the consumer price of garlic, the population of North Sumatera, and the GDP per capita of North Sumatera partially have no significant effect on the demand for shallot.

The consumer price of shallot has a coefficient value of 0.115653. It shows that the consumer price of shallot has a positive effect on the demand for shallot in North Sumatera. It means that if there is an increase in the consumer price of 1%, the shallot demand will increase by 0.115653%, and vice versa, if there is a decrease in the consumer price of 1%, the shallot demand will decrease by 0.115653%. It is

because the consumption of shallot and the price of shallot in North Sumatera tends to increase from year to year.

The consumer price of garlic has a coefficient value of 0.039393. It shows that the consumer price of garlic has a positive effect on the demand for shallot in North Sumatra. It means that if there is an increase in the consumer price of garlic of 1%, then the shallot demand will increase by 0.039393%, and vice versa, if there is a decrease in the consumer price of garlic of 1%, then the shallot demand will decrease by 0.039393%. It is because garlic is also used as a natural food flavouring.

The population of North Sumatera has a coefficient value of 2075.618. It shows that the population of North Sumatera has a positive effect on the demand for shallot in North Sumatera. It means that if there is an increase in of 1% population of North Sumatera, then the shallot demand will increase by 2075.618%, and vice versa, if there is a decrease of 1% population of North Sumatera, then the shallot demand will decrease by 2075.618%.

The GDP per capita of North Sumatera has a coefficient value of -13.89886. It shows that the GDP per capita of North Sumatera has a negative effect on the demand for shallot in North Sumatera. It means that if there is an increase of 1% GDP per capita of North Sumatera, then the shallot demand will decrease by 13.89886%, and vice versa, if there is a decrease of 1% GDP per capita of North Sumatera, then the shallot demand will increase by 13.89886%.

Population and GDP per capita are related to the amount of demand. If the other variables are assumed to be constant (ceteris paribus), the increase in the population and GDP per capita will increase the amount of consumption. If the population and GDP per capita increase so that the demand for shallot will be higher as well.

The demand for shallot in the previous period has a coefficient value of -0.568173 and is significant at $\alpha = 5\%$. It shows that the demand for shallot in the previous period has a negative effect on the demand for shallot in North Sumatera. It means if there is an increase of 1% in demand for shallot in the previous period, then the demand for shallot will decrease by 0.568173%, and vice versa, if there is a decrease of 1% in demand for shallot in the previous period, then the demand for shallot will increase by 0.568173%. It also means that the demand for shallot is lower than the demand for shallot in the previous period.

3.4. Short-run and long-run demand elasticity of shallot in North Sumatera

Table 2 shows the estimation result of the short-run and the long-run demand elasticity of shallot in North Sumatera as follow.

Table 2. Short-run and long-run demand elasticity of shallot in North Sumatera

Notation	Variable	a_1	a_5	E_{SR}	$\delta = 1 - a_5$	E_{SR}/δ
D (ln P_t, 2)	Consumer price of shallot	0.1157	-0.5682	0.1157	1.5682	0.0738

The value of shallot demand elasticity to price in North Sumatra is inelastic both in the short-run and the long-run. The value of shallot demand elasticity to price in the short-run is 0.1157 and in the long-run is 0.0738. It means, if there is an increase or decrease in shallot price by 1% it will cause an increase or decrease in shallot demand of 0.1157% in the short-run, and an increase or decrease in shallot demand of 0.0738% in the long-run.

4. Conclusions

The consumer price of shallot, the consumer price of garlic, and the population of North Sumatera have a positive effect on the demand for shallot, while the GDP per capita of North Sumatera and the demand for shallot in the previous period have a negative effect on the demand for shallot in North Sumatera. Demand elasticity of shallot in North Sumatera is inelastic, both in the short-run and the long-run. The elasticity value of shallot demand to shallot price is 0.1157 in the short-run and 0.0738 in the long-run.

Because the results showed that the demand for shallot is inelastic to price in the short-run and the long-run, it is necessary to do further research at the farm level to find the cause of this inelasticity.

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Acknowledgments

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 22nd May 2017.