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Demand of Fertilizer in Least Developed Countries (LDCs)

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Abstract

This study is attempt to examine the factors affecting demand of fertilizer in three selected least developed countries (LDCs); Myanmar, Lesotho and Tanzania by using Ordinary Least Square (OLS) method. The theory of demand function has been applied to the analysis and the model has been transformed to log form for estimation purposes. Several tests have been conducted to detect multicollinearity, autocorrelation and heteroscedasticity. The finding reveals that cereal yield is statistically significant for all countries while price is only statistically significant for Lesotho. It is expected more robust result could be evidenced using larger data set, adding more variables and using other proxies for the variables.

Key words: Fertilizer demand; LDCs; Ordinary Least Square (OLS); Multicollinearity; Autocorrelation and heteroscedasticity

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INTRODUCTION

The role of fertilizer cannot be denied in the agricultural production and development worldwide. Fertilizer demand is influenced by global circumstances which it depends on the self sufficiency of food and fertilizer in the country. Food production has to be increased in order to support rising in global population by 2050. Europe is the most developed organic fertilizer market and it has the largest production capacity. Products of various qualities and origins are sold for agriculture (30-40%), landscaping (30%), hobby garden (30%) and other areas (<10%). This mature European market is marked by demand for high quality. However, the quality criteria for such products vary in European countries concerning the amount, the requirements and the limited values for a certain number of ingredients. In many countries fertilization is insufficient to meet world demand which is remarkable increasing over the year particularly in developing economies (Figure 1). Surprisingly, fertilizer demand in least develop countries (LDCs) is very low as compared to other developed and developing countries.

Figure 2 shows the trend of total fertilizer consumption in the three selected LDCs from 1961 to 2001. Myanmar recorded the highest consumption and the agriculture is the most important economic sector in the country which contributes approximately 60 percent of their GDP.

In 21st century, climate change is emerging as one of the most challenging problem facing by the whole world. The issue of climate change will affect agriculture sector due to the global warming problems. The effects of high temperatures, changing patterns of precipitation and increased frequency of extreme weather such as drought and floods will decrease farm yields and increase production risk in many countries (IPCC, 2001). Thus, it contributes to the future uncertainty in the fertilizer consumption and affected the crop yields, farmers' income and price of the fertilizer itself.

Usually, farmers in LDCs are facing serious limitations for example poor output incentives and lack of agricultural knowledge. Weather shocks are common which give several bad impacts on crop yields and quality especially during the unprofitable year of rainfall. It also would reluctant the farmers to risk of consuming the fertilizer (Druilhe and Hurle, 2012). Morris et al. (2007) states that fertilizer demand in most LDCs always at the low rate. It is due to several factors such as high fertilizer price level, deficiency of information about the fertilizer cost, farmers' failure to increase the income and lack of knowledge on how to use fertilizer.

Definitely, it is important to estimate demand function and examine the association of fertilizer demand to its determinant. Therefore, the appropriate policy can be designed for the improvement and development of agricultural sector. The objective of the study is to analyse the relationship of fertilizer demand between its price and cereal yield in three selected LDCs which are Myanmar (East Asia), Lesotho and Tanzania (Sub Saharan Africa). A few studies have been done on the topic chosen in LDCs, thus this study will fulfil the gap in the literature.

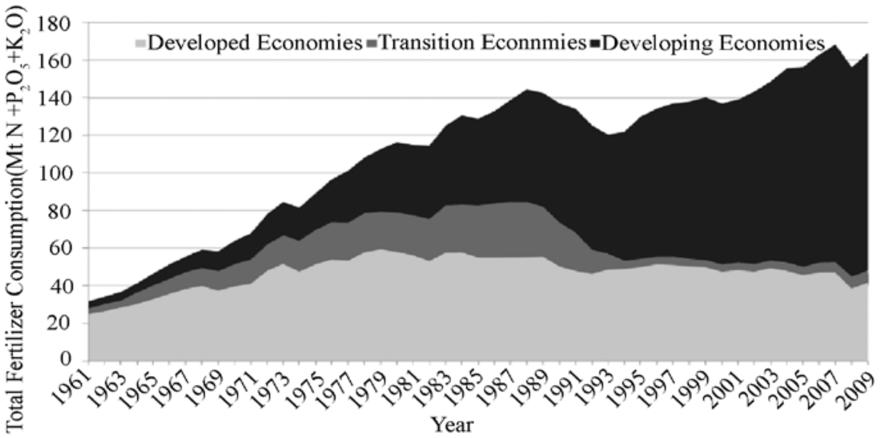


Figure 1
World Fertilizer Consumption From 1961-2009
Source: Food Agriculture Organization of United Nations (FOA)

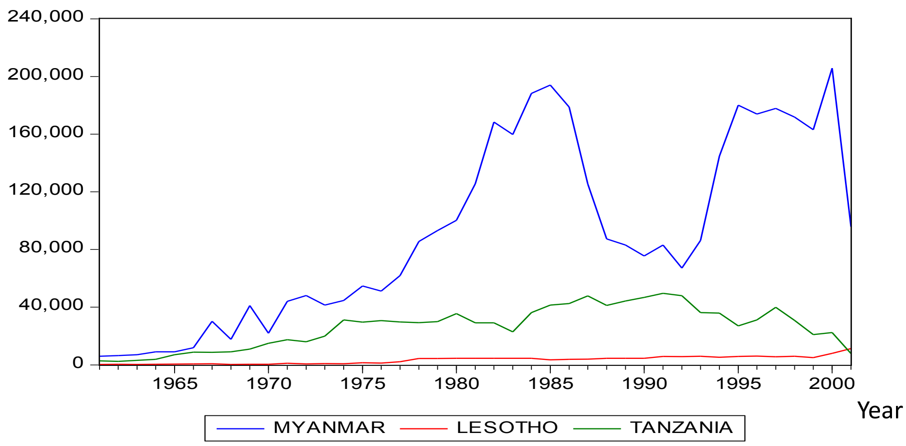


Figure 2
Total Fertilizer Consumption in Myanmar, Lesotho and Tanzania (in metric ton)
Source: Econ Stats (2012)

1. LITERATURE REVIEW

Many previous empirical on the association of fertilizer demand and its determinants have been discussed in developed countries (Carman, 1979; Hayami, 1964), and developing countries (Leonard, 1969; Hsu, 1972; Sidhu and Baanante, 1979; Pitt, 1983; Quddus et al., 2008). While, only a few studies have been done on LDCs (Chembezi, 1990). Carman (1979) states that development of fertilizer demand in West United States is due to significant increases in agricultural production. The expected crop and land price increase has increased the volume of each nutrient sold per acre. In Pakistan, Quddus (2008) determines demand for nitrogen and phosphorous are price inelastic while potash fertilizer is price elastic. According to the study in Japan, almost 100 percent of the variations in fertilizer input per unit of cultivated land are described by technical improvement in fertilizer industry which lowered the fertilizer price relative to the farms products price (Hayami, 1964). Jayne et al. (2003) state that price reductions would increase farmers' effective demand for fertilizer.

Among these studies, it can be classified into three following groups:

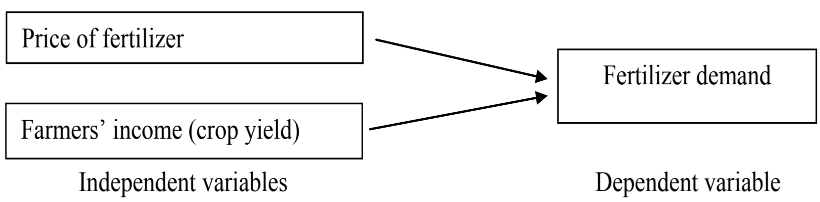
(a) Specific country studies (Hsu, 1972; Quddus et al., 2008)
(b) country-state level studies (Leonard, 1969; Carman, 1979; Leonard, 1969; Sidhu and Baanante, 1979) and
(c) country-farm level studies (Hayami, 1964; Pitt, 1983).

The model identifies many similarities and differences in these studies. Mostly, the dependent variable been specified as total fertilizer use or fertilizer nutrient. For instance, Carman (1979) employs pounds of plant nutrient sold per acre of harvested cropland, and Hsu (1972) examines kilograms of nitrogen, phosphorus and potash element used per hectare but Leonard (1969) considers fertilizer sales as the dependent variable measurement. Quddus (2008) Carman (1979) and Leonard (1969) estimate demand function for time series data using the same dependent variables which consist of price of fertilizer and farmers' income. Many proxies are used for instance Quddus (2008) measures ratio price of fertilizer index to 5 major price of crops index, Carman (1979) uses nutrient price index divided by the wholesale price index and Leonard (1969) selects real price of fertilizer at farm level calculated based on actual price deflated by an agricultural income index. Meanwhile, in terms of farm income, Quddus (2008) and Carman (1979) use crop income for lagged of one year while Leonard (1969) employ index of agricultural income founded on average net income for four major crops.

2. THEORETICAL FRAMEWORK

The study of fertilizer demand can be estimated based on different framework. Sidhu and Baanante (1979) illustrated the fertilizer demand estimated based on the Cobb-Douglas profit function formulation and production function for explanatory variables of labor, fertilizer, irrigation water, land, capital, and education. However, Pitt (1983) expressed the association of fertilizer demand by using the meta-production function approach who proposed changes in fertilizer price to encourage farmers to shift to seed varieties of fertilizer intensiveness to maximize earnings with respect to a meta-production function.

This study applies the use of theory of input demand that derives the fertilizer demand function. Economic theory mentions that the quantity of fertiliser consumption influenced by fertilizer and related inputs price, productivity of fertilizer and related inputs (Carman, 1979). It is crucial to select appropriate factors and relevant variable in the estimation of the model. Carman (1979) hypothesized that increase fertilizer price will affect restricted supplies and future demand while the lagged crop income variable appears reasonable variable particularly for nitrogen fertilizer. Therefore, the study estimates the demand of fertilizer associates with its price and farmers' income (based on crop yield).



Hypothesis is a fact whose fact has not yet been established. This hypothesis is divided into two types of hypotheses which are null hypothesis (H0) and alternate hypotheses (Ha). The null hypotheses states that there is no significant relationship between fertilizer demand and both independent variable which are price and cereal yield. The alternate hypotheses states that there is significant relationship between fertilizer demand and both independent variable which are price and cereal yield.

3..METHODOLOGY

The empirical analysis incorporates a time series data set from 1961 to 2001 for three selected LDCs; Myanmar, Lesotho and Tanzania and consisting of 1 dependent variable as well as 2 independent variables. This period is mainly chosen because of the data availability. The model is derived into log model as a result can be used to determine the elasticity of each variable (Mohd Hafiz and Mohd Fauzi, 2010). The log model has been familiar and widely used in agricultural studies due to straight forwardness in estimating fertilizer demand (Leonard, 1969). The fertilizer demand model applied a log transformation that can be written in linear logarithmic form as Equation 4.1 below:

$$\text{In } Q_t = \alpha - \beta_1(\text{In } REALP_t) + \beta_2(\text{In } CY_t) + u_t \quad \text{Equation 4.1}$$

Where the sub index t is time trend and ln is natural logarithms (log10). According to general theory of demand, parameter β1 is expected to be a negative sign given the law of demand which suggests the inverse relationship between the Qt and REALPt. Meanwhile, the parameter β2 is expected to be a positive sign since the law of demand proposes direct relationship between Qt and CYt (Table 1).

Table 1
Variable (Sign, Description and Expected Sign)

Sign	Description	Expected sign
Q_t	Quantity of fertilizer consumption in metric ton which is the quantity of plant nutrients per unit of arable land.	-
a	Constant term.	-
$REALP_t$	Real price is world price index for fertilizer.	Negative (-)
CY_t	Cereal yield is proxy of farmers' income. It measured as kilograms per hectare of harvested land including wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat and mixed grains.	Positive (+)
u_t	Random error term	-

The study employed Ordinary Least Square (OLS) method. The model of analysis will examine the simultaneous effects of fertilizer price and cereal yield on the fertilizer demand. Then, autocorrelation is detected by Durbin-Watson d test and Serial Correlation LM Test. Moreover, Breusch-Pagan-Godfrey Test is done to ensure that homoscedasticity assumption is not violated. The HAC (Newey-West) Test is applied as remedial measures of both autocorrelation and heteroscedasticity situations to correct OLS standard error unlike the White Test which was designed for heteroscedasticity only (Gujarati and Porter, 2009). Correlation matrix is used to ensure there is no multicollinearity among the independent variables. Jarque-Bera Normality test to show the residuals are normally distributed. Ramsey RESET Test is applied to prove the stability of the model.

4. RESULT AND DISCUSSION

4.1 Fertilizer Demand in Myanmar

Table 2 below illustrates the estimated coefficients for fertilizer demand equations for Myanmar. Not all the results are satisfied as referring to the economic theory and statistical viewpoint. Cereal yield (CY) is statistically significant at 99% level of confidence and the sign on the coefficient is positive which follows the hypothesis. It implies that 1% increase in CY would result in 3.18% increase in fertilizer demand (Qf). The price of fertilizer (REALP) is statistically insignificant and the coefficient is not as hypothesized. The coefficient of determination (adjusted R2) indicates that 74% of the variation in fertilizer demand has been defined by price of fertilizer and cereal yield keeping other factor constant. The coefficient of determination (adjusted R2) measures how well the sample regression line fits the data. The closer is the adjusted R2 to 1 shows the fit of the model and it is a better measure than R2 (Gujarati and Porter, 2009).

The intercept is significant at 99% level of confidence which implies output level when the value of all independent variables is zero. From the Correlation matrix, it shows that there is no multicollinearity since |r -0.38, -0.38| < 0.8. According to Jarque-Bera Normality Test, the model is normally distributed since null hypothesis is not rejected which skewness and excess kurtosis is zero. It is found from the Durbin-Watson table for 41 observations and two explanatory variables that the critical d values are dL = 1.391 and dU = 1.600 at the 5% level.

Since the Durbin-Watson d of 0.41 lies below dL, therefore reject null hypothesis which means that there is positive first order autocorrelation. Serial Correlation LM test shows that the value of observed R-squared and prob. Chi-Square(4) are 23.15616 and 0.0001 respectively. Thus, the p-value of 0.0001 < 0.001 is statistically significant at 99% level of confidence and the null hypothesis is rejected. It means that at least one ρ is statistically significant different from zero. According to Breusch-Pagan-Godfrey (BPG) Test, the observed chi-square value of 13.96622, since the p-value of 0.0009 < 0.01, thus it is significant at 99% level of confidence. Means that there is no heteroscedasticity then the null hypothesis is rejected. The HAC (Newey-West) Test is applied as remedial measures of both autocorrelation and heteroscedasticity situations to correct OLS standard error.

Table 2
Regression Coefficients and Related Statistics for Fertilizer Demand in Myanmar

Explanatory variables	Elasticities	Standard errors	t-statistics	Prob.
Intercept	-14.05609	3.261839	(-4.309252)	0.0001
lnREALP	0.124556	0.307951	(0.404468)	0.6881
lnCY	3.182229	0.322652	(9.862743)	0.0000
Adjusted R^2	0.743900			
d^b	0.410518			

The dependent variable is ln Qf where quantity of fertilizer consumption in metric ton.
db is Durbin-Watson statistic. The critical value at 5% significance level is: dL = 1.391, dU = 1.600 (41 observations and 2 explanatory variables).

Table 3 indicates the result on the fertilizer demand equation after standard error has been corrected. The probability value of F-statistic of 0.0000 < 0.01 is statistically significant at 99% level of confidence demonstrates the whole model is correct. The p-value of 0.0000 < 0.05, shows that CY is statistically significant. It indicates 1% increase in CY would increase Qf by 3.18%. Thus, fertilizer is luxury or superior good in Myanmar since the income elasticity of 3.18 is greater than 1 (Vengedasalam and Madhavan, 2010). REALP is statistically insignificant since the p-value of 0.7241 > 0.05 significant level. The result is similar as study done by Leonard (1969). The adjusted R2 indicates that 74% of the variation in explanatory variables influencing fertilizer demand and the remaining is captured by the error term. According to Ramsey RESET Test, the p-value of 0.0478 < 0.05, null hypothesis is rejected, thus the model is not correctly specified. The reason is due to the autocorrelation and heteroscedasticity exist in the model.

Table 3
Regression Coefficients and Related Statistics for Fertilizer Demand in Myanmar after HAC (Newey West) **Test**

Explanatory variables	Elasticities	Standard errors	t-statistics	Prob.
Intercept	-14.05609	4.731453	(-2.970776)	0.0051
lnREALP	0.124556	0.350266	(0.355605)	0.7241
lnCY	3.182229	0.55916	(5.839855)	0.0000
Adjusted R^2	0.743900			
d^b	0.410518			
Prob(F-statistic)	0.0000			

The dependent variable is ln Qf where quantity of fertilizer consumption in metric ton.
db is Durbin-Watson statistic. The critical value at 5% significance level is: dL = 1.391 , dU = 1.600 (41 observations and 2 explanatory variables).

4.2 Fertilizer Demand in Lesotho

Table 4 illustrates the estimated coefficients for fertilizer demand equations for Lesotho. All the results are fulfilled the economic theory and statistical viewpoint. Both of the explanatory variables CY and REALP is statistically significant at 95% level of confidence but not at 99% level of confidence. The sign on the coefficient is positive and negative for the CY and REALP respectively as the hypothesized. It implies 1% increase in CY would result in 1.40% increase in Qf. While, 1% increase in REALP would result in 1.26% decreases in fertilizer demand. The coefficient of determination (adjusted R2) indicates that the variables included explain 18% of the variation in fertilizer demand has been defined by price of fertilizer and cereal yield keeping other factor constant.

The intercept is not statistically significant. From the Correlation matrix, it shows that there is no multicollinearity since |r 0.11, 0.11| < 0.8. According to Jarque-Bera Normality Test, the model is normally distributed and null hypothesis is not rejected which skewness and excess kurtosis is zero. It is found from the Durbin-Watson table for 41 observations and two explanatory variable that the critical d values are dL = 1.391 and dU = 1.600 at the 5% level. Since the Durbin-Watson d of 0.28 lies below dL, therefore reject null hypothesis which means there is positive first order autocorrelation.

The Serial Correlation LM Test shows that the value of observed R-squared and prob. Chi-Square are 28.87196 and 0.0000 respectively. Thus, the p-value of 0.0000 < 0.001 is statistically significant at 99% level of confidence and the null hypothesis is rejected. It means that at least one ρ is statistically significant different from zero. The HAC (Newey-West) Test is applied as remedial measures of autocorrelation. According to Breusch-Pagan-Godfrey (BPG) Test, the observed chi-square value of 3.592508 is insignificant since the p-value of 0.1659 > 0.05, thus the null hypothesis of no heteroscedasticity is not rejected. In other words, there is homoscedasticity.

Table 4
Regression Coefficients and Related Statistics for Fertilizer Demand in Lesotho

Explanatory variables	Elasticities	Standard errors	t-statistics	Prob.
Intercept	3.901866	4.304164	(0.906533)	0.3704
lnREALP	-1.264708	0.530866	(-2.382347)	0.0223
lnCY	1.404730	0.577155	(2.433886)	0.0197
Adjusted R^2	0.175209			
d^b	0.278700			

The dependent variable is ln Qf where quantity of fertilizer consumption in metric ton
db is Durbin-Watson statistic. The critical value at 5% significance level is: dL = 1.391, du = 1.600 (41 observations and 2 explanatory variables).

Table 5 indicates the result on the fertilizer demand equation after standard error has been corrected. The probability value of F-statistic of 0.009711 < 0.01 is statistically significant at 99% level of confidence illustrates the whole model is correct. Both CY and REALP are statistically significant at 95% level of confidence and have the expected relationship. This result is supported by Carman (1979).

As a result, both of explanatory variables influence Qf. It implies 1% increase in CY would increase Qf by 1.40% and 1% increase in REALP would decrease Qf by 1.26%. It shows that demand of fertilizer is price inelastic since the estimated elasticity of demand is less than 1 (McConnell and Brue, 2008). It is a luxury good in Lesotho since the income elasticity of demand is greater than 1. The adjusted R2 indicates that 0.18% of the variation in explanatory variables influences fertilizer demand and the remaining is captured by the error term. According to Ramsey RESET Test, the p-value of 0.2552 > 0.05, null hypothesis is not rejected, thus the model is correctly specified.

Table 5
Regression Coefficients and Related Statistics for Fertilizer Demand in Lesotho After HAC (Newey-West Test)

Explanatory variables	Elasticities	Standard errors	t-statistics	Prob.
Intercept	3.901866	5.621624	0.694082	0.4919
lnREALP	-1.264708	0.614291	-2.058808	0.0464
lnCY	1.404730	0.609218	2.305792	0.0267
Adjusted R^2	0.175209			
d^b	0.278700			
Prob(F-statistic)	0.009711			

The dependent variable is ln Qf where quantity of fertilizer consumption in metric ton
db is Durbin-Watson statistic. The critical value at 5% significance level is: dL = 1.391 , du = 1.600 (41 observations and 2 explanatory variables).

4.3 Fertilizer Demand in Tanzania

Table 6 illustrates the estimated coefficients for fertilizer demand equations for Tanzania. Not all the results are acceptable to the economic theory and statistical viewpoint. Cereal yield (CY) is statistically significant at 99% level of confidence and the sign on the coefficient is positive that follows the hypothesis. It implies 1% increase in CY would result in 1.28% increase in fertilizer demand. The REALP is not statistically significant but the coefficient is not parallel to the economic theory.

The coefficient of determination (adjusted R2) indicates that the variables included explain 21% of the variation in fertilizer demand has been defined by price of fertilizer and cereal yield, holding other factors constant. A reasonably low R2 in the equation proves the existence of autocorrelation which no longer efficient (Carman, 1979). The intercept is not statistically significant. From the Correlation Matrix, it shows that there is no correlation between explanatory variables since |r -0.21, -0.21| < 0.8. According to Jarque-Bera Normality Test, the p-value of 0.0019 < 0.05 shows the model is not normally distributed since null hypothesis is rejected. It is found from the Durbin-Watson table for 41 observations and two explanatory variable that the critical d values are dL = 1.391 and du = 1.600 at the 5% level. Since the Durbin-Watson d of 0.36 lies below dL, therefore reject null hypothesis which means there is positive first order autocorrelation.

The Serial Correlation LM Test shows that the value of observed R-squared and prob. Chi-Square(4) are 24.6927 and 0.0001 respectively. Thus, the p-value of 0.0000 < 0.001 is statistically significant at 99% level of confidence and the null hypothesis is rejected. It means that at least one ρ is statistically significantly different from zero. The HAC (Newey-West) Test can be applied as remedial measures of autocorrelation. According to Breusch-Pagan-Godfrey (BPG) Test, the observed chi-square value of 2.8393 is not significant since the p-value of 0.2418 > 0.05, therefore the null hypothesis of no heteroscedasticity is not rejected. In other words, it is homoscedasticity.

Table 6
Regression Coefficients and Related Statistics for Fertilizer Demand in Tanzania

Explanatory variables	Elasticities	Standard errors	t-statistics	Prob.
Intercept	2.255848	3.553198	(0.634878)	0.5293
lnREALP	-0.281735	0.396791	(-0.710034)	0.4820
lnCY	1.281763	0.392778	(3.263329)	0.0023
Adjusted R^2	0.211361			
d^b	0.363401			

The dependent variable is ln Qf where quantity of fertilizer consumption in metric ton
db is Durbin-Watson statistic. The critical value at 5% significance level is: dL = 1.391, du = 1.600 (41 observations and 2 explanatory variables).

Table 7 indicates the result on the fertilizer demand equation after standard error has been corrected. The probability value of F-statistic of 0.0041 < 0.01 is statistically significant at 99% level of confidence clarifies the whole model is correct. The p-value of 0.0146 < 0.05, shows that CY is statistically significant. It implies 1% increase in CY would increase Qf by 1.28%. Thus, it found that the fertilizer is luxury good in Tanzania. However, REALP is statistically insignificant since the p-value of 0.6253 > 0.05 of significant level. As a result, only CY influences the Qf. High price of fertilizer caused low fertilizer consumption in agricultural productivity.

Further, low rate of Tanzania per capita income for about USD297 in 1998 would not afford farmers' to purchase fertilizer for agricultural farm which considered as luxury good. The average of fertilizer consumption was only 8 kilograms per hectare of cultivated land in Sub-Saharan Africa which much lower than in developing countries (Morris et al. 2007). Therefore, price cannot be factor and associated to the fertilizer demand. The adjusted R2 indicates that only 0.21 of the variation in explanatory variables influencing fertilizer demand and the remaining is captured by the error term. According to Ramsey RESET Test, the p-value of 0.0888 > 0.05, null hypothesis is not rejected, thus the model is correctly specified.

Table 7
Regression Coefficients and Related Statistics for Fertilizer Demand in Tanzania After HAC (Newey West) **Test**

Explanatory variables	Elasticities	Standard errors	t-statistics	Prob.
Intercept	2.255848	3.651464	(0.617793)	0.5404
lnREALP	-0.281735	0.572167	(-0.492401)	0.6253
lnCY	1.281763	0.500740	(2.559740)	0.0146
Adjusted R^2	0.211361			
d^b	0.363401			
Prob(F-statistic)	0.004144			

The dependent variable is ln Of where quantity of fertilizer consumption in metric ton
db is Durbin-Watson statistic. The critical value at 5% significance level is: dL = 1.391 , dU = 1.600 (41 observations and 2 explanatory variables)

CONCLUSION

The estimated demand of fertilizer equations result that only cereal yield is the determining factor of fertilizer demand for all countries; Myanmar, Lesotho and Tanzania. All the cereal yield coefficients are statistically significant and the sign are consistent with the economic theory. The estimated coefficient indicates that fertilizer is considered as luxury or superior good in all countries. However, price of fertilizer only affects demand of fertilizer in Lesotho and has followed the expected negative sign. The elasticity shows that fertilizer is price inelastic. For adjusted R2 comparison, Myanmar obtains the highest R2 value of 0.73 followed by Tanzania and Lesotho which approximately 0.21 and 0.18. The relatively lower R2 shows the evidence of autocorrelation and exclusion of other important variables that influencing demand of fertilizer. It can be concluded that the whole model for Myanmar, Lesotho and Tanzania are not BLUE; best linear and unbiased estimator.

POSSIBLE EXTENSIONS AND LIMITATIONS

The selected variables and small data set are not strong enough to explain the demand of fertilizer. Not all the variables used are significant except for Lesotho. In future, it is expected more robust result could be evidenced using larger data set and adding more variables or using other proxies of demand for fertilizer. The other variables might be an economic indicator for example GDP, unemployment rate and many other factors.

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