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RESEARCH ARTICLE

INFLUENCE OF EXPECTED FARM-GATE PRICE ON MAIZE PRODUCTION IN LUDEWA DISTRICT OF NJOMBE REGION, TANZANIA: ESTIMATION OF KOYCK LAG MODEL.

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Abstract

It is evident from theory that farmer responds to both price and non-price factors. Despite this fact, little has been documented concerning the influence of expected farm-gate price on maize production in Tanzania. Therefore, this paper intended to estimate the relationship between expected farm-gate price and land grown with maize in Ludewa District of Njombe Region, Tanzania using Koyck lag model. The results revealed that maize production is positively and significantly related to its own expected price. Other significant factors were land grown with maize in the previous year and household size. The study concluded that apart from technical issues, the efficient output market which reduces transaction costs is an important factor for crop production. Therefore, a policy that will lead to low transaction costs along output market channels which in turn improve farm-gate price and hence increased crop production is recommended.

Introduction:-

Background for Statement of Problem:-

Maize is the first crop in terms of caloric intake in Tanzania (Nazir, et al., 2010). According to Mboya et al. (2011), it leads in carbohydrates provision when compared to wheat and sorghum.

Furthermore, maize has high yield per unit compared to other crops and this rationalises its importance in the supply of food and in promoting food security in the country (FAO, 2008). Due to this fact, in Tanzania, the availability of maize has been equated to national food security, and lack of food has been equated to low supply of maize (Mwakalinga and Massawe, 2007). Maize influences food security via two different channels: one is through consumption, because it is an important component of the nation's caloric intake, and the other is, through production because it is an income-generating activity.

Despite the importance of availability of maize as far as food security is concerned, the production of maize in Tanzania is not up to its full potential. For example, maize productivity at national level averages at 1.6 metric tons per hectare against a potential of more than 5 metric tons per hectare (Mwakalinga and Massawe, 2007). In addition, Wolter (2008) indicated that only 11% of arable land in Tanzania is put under cultivation. All these show uncaptured potential for increasing maize supply.

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Several previous studies have studied the factors which determined maize production in Tanzania but most of them concentrated on technological and climatic factors. Although each study adds new knowledge, the explanation of output market as one of the factors of crop production is scant. This gap becomes the essence of the current study.

Production of Maize in Tanzania:-

Tanzania has largest planted area of maize in all Southern and East Africa (Wilson and Lewis, 2015). As indicated by African Agricultural Technology Foundation (AATF) and Commission for Science and Technology (COSTECH) (2010), in Tanzania maize is found almost everywhere in the country.

Despite of good conditions for maize farming, low average yield is evident in Tanzania (Wilson and Lewis, 2015). Among others, the factors for poor performance outlined by Kaliba et al. (2000), Cairns et al. (2013), and Homann-Kee et al. (2013) all cited in Suleiman and Rosentrater (2015) are; inadequate rainfall and harmful insects.

In particular, USAID (2012) cited in Wilson and Lewis (2015) revealed that Tanzania resorted to export ban policy to address food security concerns although it is evident that the policy is not an effective measure of ensuring food security. Instead, the export ban has adverse effect on producer prices and this is more prevalent in Southern Highlands of Tanzania (Zorya and Mahdi, 2009).

Generally, from explanation above it can be concluded that marketing aspect is equally important for increasing crop production. Thus, the focus of this study is to estimate the relationship between the expected maize farm-gate price and production response as little has been done on the theme.

Theoretical Framework:-

The theory on determinants of agricultural output is better presented through a production function or rather a supply response function. As proposed by Colman (1983) it is appropriate to employ the term production response when referring to production instead of supply response as the term supply is defined to mean technical concepts “change in supply” and “change in quantity supplied” as used in economics. Mythili (n.d) identified two existing approaches for undertaking analysis in production response which are; (i) Nerlovian expectation model, the approach accommodates both the analysis of speed and level of adjustment of actual acreage towards desired acreage and (ii) Supply function which is derived from the profit maximizing framework. The second approach was discouraged by Mythil as it is not easy to get input price information.

As explained in Yu et al. (2010), a farmer responds to both price and non-price factors. On one hand, the relevant prices include expected output prices and expected prices of factor inputs. In addition, non-price factors that would bear influence on production responsiveness of farmers include level of technology, availability of factor inputs, and a myriad of exogenous factors. The production response function implies that apart from other factors, price of output is an important determinant of the output production.

Another model presented by Eriksson (1993) is the simple model named “neoclassical model of peasant behavior” developed by Lundahl and Ndulu (1987). According to this model the crop’s price is positively related to the amount produced. However, it is pointed out in the literature that production response is not only a function of price but also a number of other factors including; good transportation and communication systems, adequately and well established markets and manufacturing sectors, and serious administrative organs in both private and government sectors.

Methodology:-

Introduction:-

This section covers the explanation on the methodology adopted in this particular study. To elucidate, the section presented the explanation on; study area, sample size, analytical techniques, variables and model specifications.

Description of the study area:-

The study was conducted in Ludewa District of Njombe Region. Other districts in Njombe Region include: Njombe, Makete, and Wanging’ombe. Ludewa is bordered by Njombe District in the North and Ruvuma Region in the South and East and it covers a total of 6,325 Sq Km. It has 5 divisions, 25 wards, and 77 villages of which 8 were included in this study (Map 1). Ludewa District is generally endowed with a rich soil which is high in lixisols (lx) and low

Cation Exchange Capacity. This signifies it is potentiality in maize production. Ludewa District had a population of 133,218 in 2012. Ludewa lies between latitudes $10^{\circ}00'00''$ and longitudes $34^{\circ}45'00$.

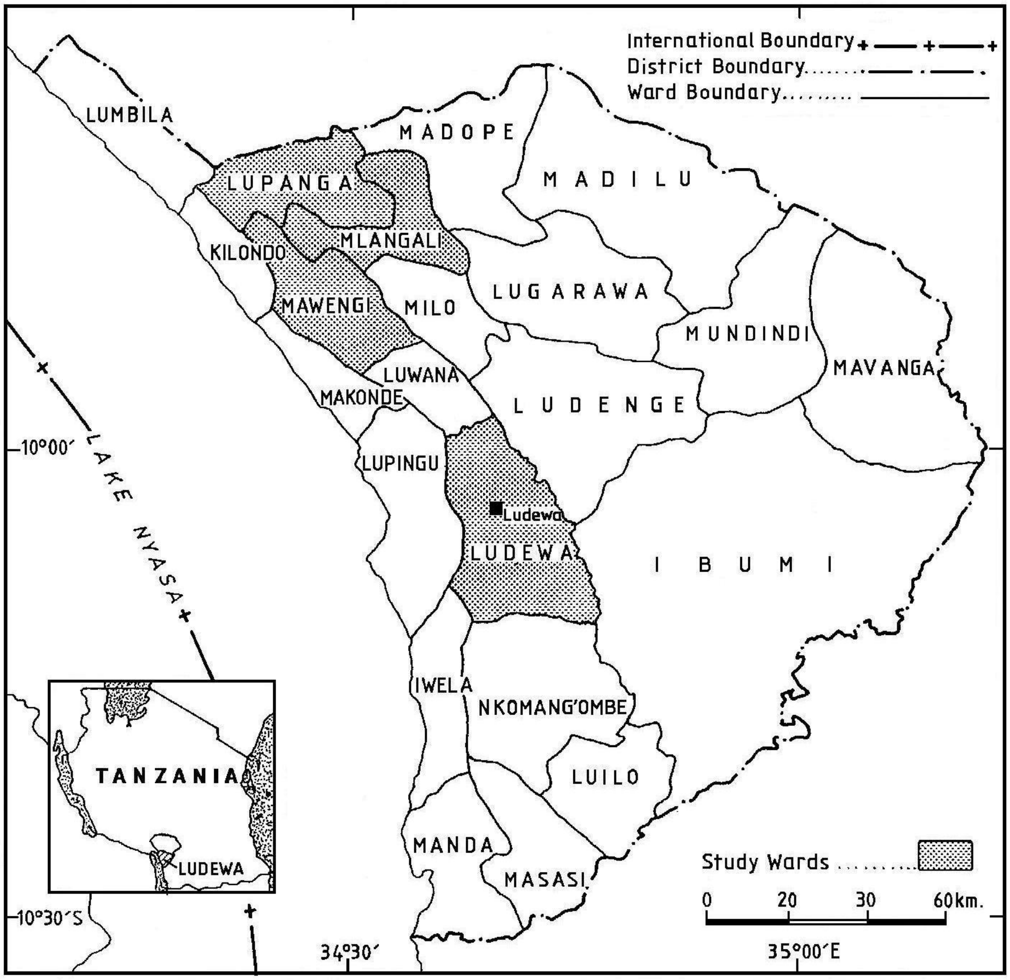

Figure 1:- Map of Ludewa District showing the study areas

Sample size:-
In deciding the sample size, an exploratory/pilot survey was conducted which established that farmers' households constitute approximately 85% of total households in the study area. The following formula adopted from Mwanje (2001), was then employed to calculate sample size:

$$n = \frac{Z^2(1-p)p}{e^2} = \frac{1.96^2(1-0.85)0.85}{0.05^2} \approx 196 \quad \text{......(1)}$$

where:
n = sample size;
Z = desired degree of confidence (i.e., 95% = 1.96);
p = estimate of percentage (i.e. 85%); and
e = desired level of sampling error (sampling error allowance).

However, due to the weakness of the formula above its outcome was more than doubled to obtain the bigger sample size that was used in this study (i.e., 427 households ≈ 19% of the farming households). Furthermore, the "Power Stata Analysis" conducted to confirm the power of sample size found it to be 0.89 which is highly recommended.

Analytical techniques, variables, and model specification:-

The model used to empirically investigate the effect of farm-gate price on maize production in the study area is based on a slightly different version of that used by Badmus and Ogumndele (2008), Dharmaratne and Hathurusinghe (1999), and also Weerahewa (2004):

$Q = f(P_0, T)$..(2)

where:

Q = quantity of agricultural crop produced;

P_o = price of the given crop at farm-gate; and

T = a state of technology used in production.

Badmus and Ogumndele (2008), Dharmaratne and Hathurusinghe (1999), and also Weerahewa (2004) put clear that, in theory, factors other than price and technology determine the production of agricultural crops. Employment of more or less resources, depending upon whether there was a price rise or decrease, ceteris paribus, would increase crop output; and, increase in agricultural output could also result from modification of scale or farm size, access to credit, market information, and price certainty. The model describes production response to a particular factor, other factors held constant. The model can be used to predict changes in quantity of agriculture products produced when prices change.

The production response function that includes a lagged level of output (Q_{t-1}), last season's price of the commodity (P_{o-1}), and acreage devoted to the commodity during the last season (A_{t-1}) is:

$Q_t = f(P_o, P_c, A_{t-1}, P_{o-1}, W, T, V, Q_{t-1})$..(3)

The function specified in (3) above is appropriate for estimating production responsiveness of arable crop defined as that crop that grows and is harvested within one calendar year. Such crops include maize, millet, sorghum, rice, wheat, cowpeas, soya beans, yams, sweet potatoes, cocoyam, cassava, vegetables, etc.

Therefore, the crop production response function for this study derived from equation (3) reads as:

$Q_t = f(Q_{t-1}, X_1, X_2, X_3, X_4, X_5, X_6)$...(4)

where:

Q_t = quantity of maize produced in year 2009/2010 (in 100kgs bag);

Q_{t-1} = quantity of maize produced in the year 2008/2009 (in 100kgs bag);

X_1 = age of head of household (in years);

X_2 = number of visits done by extension officers;

X_3 = expected farm-gate price (in TZS);

X_4 = Household size;

X_5 = number of years head of household spent in school.

This specification guided the thinking in designing research for empirical analysis of an arable crop production function. However, other scholars have used land cultivated instead of crop output because farmers have no control on crop output due to factors like rainfall and temperature but they have more control on size of land put in production. Therefore, in this study land farmer cultivated was used as a dependent variable instead of output. For example, Coyle (1993) cited in Haile et al. (2013) and Chaudhary (2000) informs that, it is important to model crop production in terms of acreage response rather than output since planted area is not influenced by the conditions after planting (e.g. weather, pest) as output does.

So, equation (4) is re-written as;

$A_t = f(A_{t-1}, X_1, X_2, X_3, X_4, X_5, X_6)$...(5)

where A_t is size of land grown with maize in year 2010/2011 (in acres), A_{t-1} is size of land grown with maize in year 2009/2010 (in acres), and other variables are as already defined.

As stated earlier, expectation models like Nerlovian expectation model (distributed lag model) are used to estimate farmers' production response function. The Distributed lag model assumed that the area farmers desire to cultivate is a function of the expected price and some other important variables (Chaudhary, 2000). Furthermore, the Nerlovian expectations model (i.e. distributed lag model) assumed that the current value of the dependent variable depends on the weighted sum of present and past values of the independent plus error term. The distributed lag model reads as;

$y_t = y_t(P_t, P_{t-n})$...(6)
$Y_t = \propto + \beta_0 P_t + \beta_1 P_{t-1} + \beta_2 P_{t-2} + \dots + u_t$...(7)

Equation (7) is distributed lag model. However, distributed lag model suffer from various econometrics problems. For example, Erdal et al. (2009) highlighted problems associated with distributed lag model as; first, lack of pre-information in the model about how long the lag period will be, second, the loss of observations occurred in lag value set (decreases degree of freedom), and, third, variables decided as defining variables are in a multiple linear relationships as a result of the fact that lag values of price variable were used in the model (multicolinearity problem).

Altogether, Haile et al. (2013) informs that there is no literature that provides evidence on superior price expectation model to be used for estimation of agricultural production response. According to Erdal (2009), Koyck lag model (a reduced model from distributed lag model) developed by Koyck in 1954 addresses the limitations of distributed lag model. The Koyck model developed based on the assumption that lags in independent variable affect the dependent variable to some extent and the weight of these lags decrease geometrically.

So, derivation of Koyck lag model is based on the assumption that;
$\beta_i = \lambda^i \beta_0$, i = 1,2,3...(8)
where $0 < \lambda < 1$

Substituting (8) into (7),
$Y_t = \propto + \beta_0 P_t + \lambda\beta_0 P_{t-1} + \lambda^2\beta_0 P_{t-2} + \dots + u_t$...(9)

Lagging by one period
$Y_{t-1} = \propto + \beta_0 P_{t-1} + \lambda\beta_0 P_{t-2} + \dots + u_{t-1}$...(10)

Multiplying equation (10) by λ
$\lambda Y_{t-1} = \lambda \propto + \lambda\beta_0 P_{t-1} + \lambda^2\beta_0 P_{t-2} + \dots + \lambda u_{t-1}$...(11)

Subtracting (11) from (9)
$Y_t - \lambda Y_{t-1} = \propto + \beta_0 P_t + \lambda\beta_0 P_{t-1} + \lambda^2\beta_0 P_{t-2} + \cdots - \lambda \propto - \lambda\beta_0 P_{t-1} - \lambda^2\beta_0 P_{t-2} - \cdots + u_t - \lambda u_{t-1}$...(12)
$Y_t - \lambda Y_{t-1} = \propto - \lambda \propto + \beta_0 P_t + u_t - \lambda u_{t-1}$...(13)
$Y_t = \propto (1 - \lambda) + \beta_0 P_t + \lambda Y_{t-1} + \nu_t$...(14)
Equation (14) is called the KOYCK LAG MODEL which is the transformation of distributed lag model (7) to eliminate P_s to solve the problem of multicollinearity.

Estimation model:-
The KOYCK LAG MODEL used in this study is modified by replacing output variable with land variable due to the reason stated earlier and to include other relevant variables. Also, as suggested by Erdal (2009), price of the harvesting period prior the planting period can be used as a proxy for expected harvest crop prices. In this modified model, the price of maize in 2009/2010 season was used as a proxy for expected price of the planted maize in the year 2010/2011.

Therefore, the modified Koyck lag model estimated in STATA reads as;
lmlandsize2010= $\propto (1 - \lambda) + \lambda$mlandsize2009 + β_1Agehead + $\beta_2$novists + $\beta_3$mprice + $\beta_4$hhsize + β_5Edu + ε_t...(15)

Definition of variables:-
mlandsize2009 = one lag period land grown with maize in acre. Negative sign is expected.
Agehead = age of household head in years. Positive sign is expected.

novists = number of visits done by extension officers per season. Positive sign is expected.
mprice = expected farm-gate price in TZS per 100kg bag. The positive sign is expected.

hhsize = numbers of people in the household. Positive sign is expected.
Edu = number of years household head spent in school. Positive sign is expected
λ = weght
$\propto$ = constant term,
$\beta_1, \beta_2, \beta_3, .., \beta_5$ = parameters to be estimated.
v_t = random error term.

Results and Discussions:-

Introduction:-

The purpose of this paper is to measure the effect of expected farm-gate price on maize production response. The null hypothesis to be tested is "*expected farm-gate price does not influence maize production response*". Prior to estimation of the Koyck lag model (15), descriptive analysis of some factors expected to influence maize production response was undertaken. The factors include: land size grown with maize in 2010/2011 (dependent variable) and expected farm-gate prices.

The descriptive statistics indicate that the maximum land size grown with maize in the study area in 2010/2011 was 25 acres and mean land size grown with maize was 2.4 acres. Also, the mean expected farm-gate price was TZS 12,222 per 100ks bag which is relatively lower as compared with the prices in the urban markets which averaged at TZS 39,796.

Determinants of maize production response:-

The modified Koyck lag model (15) was estimated in order to estimate the relationship between expected farm-gate price and size of land grown with maize in the current year/season. In this study, size of land grown with maize has been used as a proxy for production. The F – statistic suggested that the Koyck lag model estimated was statistically significant at 1% level. The adjusted R-square suggests that the explanatory variables in the equation explained about 71.7% of the variations observed in the dependent variable (current size of land grown with maize) (Table 1).

Table 1:- Koyck lag model Results

Variable	Coefficient	Standard Error	t-value	Probability
Constant	-0.581	0.123	-4.710	0.000
mlandsize2009	0.217	0.008	27.570	0.000***
Agehead	0.001	0.001	0.99	0.322
Mprice	0.000012	6.61e-06	1.82	0.069*
hhsize	0.043	0.008	5.260	0.000***
Edu	0.005	0.007	0.760	0.446
R square = 0.721, Adjusted R square = 0.7165, F =176.19 (0.000)				

***** significant at 1%, ** significant at 5%,** * significant at 10%
Dependent variable: Land grown with maize in 2010/2011 season
Source: Field survey data (2011) and own computations

Size of land grown with maize in previous season (mlandsize2009):-

The results showed that size of land grown with maize in previous season is positively and statistically significant (at 1%) related to size of land grown with maize in current season. The findings of the study suggest that an increase in land grown with maize by 1 acre would increase next season's land put under maize production by 0.22%. The positive sign was not expected because the expectation was that high production in 2009/2010 would lead to low price, and vice versa, such that farmers would be demotivated to produce more in the next season (2010/2011). The unexpected positive sign as it may be, would, attribute to low production in 2009/2010 that caused increase in maize price, hence to motivate farmers to expand land for maize production in season 2010/2011 (cobweb theorem).

Furthermore, since it is known in Koyck lag model that $0<\lambda<1$ and $\beta_k = \lambda^k\beta_o$, using the results obtained above the distributed lag model can be derived from Koyck lag model as follows.
$\beta_0 = \lambda^0\beta^0 = (0.2161746)^0(0.000012) = 0.000012$
$\beta_1 = \lambda^1\beta^0 = (0.2161746)^1(0.000012) = 0.000002594$
$\beta_2 = \lambda^2\beta^0 = (0.2161746)^2(0.000012) = 0.00000056$

$\propto_0 = \lambda/(1-\lambda) = (0.2161746)/1-0.2161746 = 0.2757943$
The resulting equation from the values obtained above which is distributed lag model is:

$$lmlandsize2010 = 0.276 + 0.000012mlandsize2009 + 0.0000026mprice_{t-1} + 0.00000056mprice_{t-2}$$

This derived distributed lag model implies that lag maize prices have a decreasing influence on current land allocated to maize production.

Age of head of household (Agehead):-
Results show that age of the household head is positively associated with land allocated to maize production. The positive sign suggests that an increase in household head's age by 1 unit (year) above the mean is likely to increase land grown with maize by 0.0012%**.** However, unlike other studies, this study did not find age to be a significant determinant of maize production. For example, findings obtained in previous studies, like Nyambose and Jumbe (2013) found age of farmers to be very important in technology adoptability and hence, increasing productivity of crops in Malawi. According to them, farmer's age can increase or decrease the probability of adopting the technology and therefore it can carry either sign.

Expected price (Mprice):-
Results indicated that expected farm-gate price was positively associated with the size of land grown with maize in the current year/season, and it was significant at 5% (Table 1). The result suggests that if farmers expected high price they would significantly increase production of maize by allocating more land to maize production, and vice versa. Increase in expected farm-gate price by 1 unit would lead to 0.000012% increase in acres allocated to maize production. Thus, expected farm-gate price is an important factor for increased maize production. The result is consistent with Mose *et al.* (2007) who found high maize price to be significant determinant of aggregate maize supply in Kenya.

Household size (hhsize):-
The result shows that household size is positively and statistically significant (at 1%) determinant of land allocated to maize production. This suggests that an increase in household size by 1 member above mean will result in 0.043% increase in acres grown with maize. This is the reality on the ground as in the study area household depends on family labour in agricultural activities, and this also signifies that households produce maize mainly for subsistence needs. The result is consistent with the findings by Simonyan *et al.* (2011) that showed that household size is a significant positive determinant of agricultural production in Nigeria.

Number of years household head spent in school (Edu):-
As expected, education of household head has a positive sign. However, it was statistically insignificant determinant of size of land grown with maize. Result suggests that a 1 year increase in the number of effective years of schooling above the average would increase output of maize produced by 0.01%. Therefore, although not so important, educating household heads is likely to increase maize production and hence food security. Contrary to this finding, study by Ebojei *et al.* (2012) found education of the farmer to be an important determinant of technological adoption and use of extension services that increased crop output in Nigeria.

Conclusions and Recommendations:-
In conclusion, from the whole model estimated, among others, the targeted null hypothesis that "*expected farm-gate price does not influence maize production response"* is ***rejected*** and concluded that the maize production response is influenced significantly by expected farm-gate price. This study recommends policies that will facilitate the improvements of rural roads and other marketing infrastructure hence reducing transaction costs and therefore increased farm-gate price.

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