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Estimating The Supply Response to Price and Non-Pricing factors of Macadamia Nuts Farmers in Zimbabwe: The Case of Chipinge's Makandi Estates

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Abstract: **This research examines how the Zimbabwean Macadamia nuts farmer responds to changes in prices and non-price factors. The research utilized the Nerlovian Model (1958), a dynamic model that expresses current production output as a function of lagged variables of production output and other exogenous variables, which is an Autoregressive Distributed Lag (ARDL) Model. The natural logarithm (ln) of Yield per hectare depended on the ln of Yield lagged once, price, rainfall, fertilizer, chemical, fuel and labour, all lagged once. Time series monthly data (2009-2016) from Makandi Estates was analyzed. Results revealed an inelastic supply response both in short and long run. Such a weak supply response indicated that non-price factors were hindering the crop to swiftly respond to price changes.**

Keywords: **Macadamia Nuts Supply Response, Nerlovian Partial Adjustment Model, Autoregressive Distributed Lag Model (ARDL), Price Factor, Non-Price Factors.**

1. INTRODUCTION

The total supply response is the response of the total output to price and non-price factors (Rao, 1989). The concept of supply response in economic theory usually refers to output production in response to their prices and supply curves that are anticipated. Over the past years there has been a number of empirical studies on supply response and economic rationale of farmers in developed and developing agricultural economies. This research focuses on Macadamia nuts supply response to prices and non-prices factors in Zimbabwe. It is a case study of Makandi Estates, a Rift Valley Company.

Macadamia nuts belong to the nuts and dried fruits family. Price elasticity of supply (PES) is a useful concept that can be used as an aide for making short and long term capital decisions at Makandi Estates. In general, favorable Macadamia prices would encourage Makandi Estates to increase production. However, there is no firm evidence so far, which support this hypothesis. This research therefore is estimating the supply response of Makandi Estates to changes in Macadamia nut prices. Furthermore, past studies revealed weak supply response for agriculture in developing countries as non-price factors seem to dominate over price factors in farmers' decision making problems (Gulati and Kelly, 1999). One of the reasons for low response to prices in developing countries is limited access to technology and poor rainfall (Mythili, 2001). This makes it essential in this study to examine how farmers also react to non-price factors.

Schimmelpfennig et al (1996) analyzed South African supply response in agricultural production. The study applied time series techniques to explain production planning decisions of the two dominant crops in the summer-rainfall grain area, maize and sorghum. After establishing the time series properties of the variables, cointegration was determined and used as the theoretical foundation for an Error Correction Model (ECM). Maize area planted in the short run or the long run (or both), was found to depend on two sets of variables. One group changed the quantity or supply (area) of maize directly, likes own price, the prices of substitutes (like sorghum and sunflowers), and complementary intermediate input prices. The other variables changed the supply environment like, rainfall, farmer education, R&D and cooperative extension. Sorghum was found to be a secondary crop dominated by expected changes in the maize variables, and the area planted depends simply on intermediate input prices and rainfall over both the short and long run. These results further illustrate the dominance of maize and maize policies in production decisions in the summer-rainfall areas of South Africa.

Oyewumi et al (2011) studied the supply response of beef in South Africa using the Error Correction Model. The results of the study confirmed that beef producers in South Africa respond to economic, climatic, trade and demographic factors in the long run. In the short run, however, the study showed that cattle marketed for slaughtering were responsive to climatic factors (that is rainfall) and imports of beef. Animal demographics, producer price of yellow maize and the producer price of beef were found not to have a short run effect on cattle marketed for slaughtering.

Alemu et al (2003) investigated grain-supply response in Ethiopia using the Error Correction Model. From the study, it was found that planned supply of grain crops is positively affected by own price, negatively by prices of substitute crops and variously by structural breaks related to policy changes and the occurrence of natural calamities. The results found significant long run price elasticities for all crop types and insignificant short run price elasticities for all crops except for maize. Higher and significant long run price elasticities as compared to lower and insignificant short run price elasticities were attributed to various factors, namely structural constraints, the theory of supply and the conviction that farmers respond when they are certain that price changes are permanent. The study concluded that farmers do respond to incentive changes. Thus, attempts, which directly or indirectly tax agriculture with the belief that the sector is non-responsive to incentives, harm its growth and its contribution to growth in other sectors of the economy.

An empirical investigation on the supply of maize and tobacco for commercial agriculture in Zimbabwe was presented by Townsend et al (1997). The Error Correction Model, which employs the concept of co-integration to avoid spurious regressions, was used in the analysis. The factors affecting percentage area planted to maize were, expected real maize price, real price of tobacco, real price of fertilizer and government intervention. The factors affecting percentage area planted to tobacco were real price of tobacco, expected and real price of maize and institutional factors. The price elasticity of maize was 1.44 and 1.76 in the short and the long run respectively. For tobacco, these were 0.28 and 1.36 in the short and long run, respectively.

Olwande et al (2009) studied the supply responsiveness of maize farmers in Kenya. The results of the study showed that maize price support is an inadequate policy for expanding maize supply. Fertilizer use was found to be particularly important in the decisions on resource allocation in maize production. Of the fixed inputs, land area was found to be the most important factor contributing to the supply of maize. It is suggested that making fertilizer prices affordable to small holder farmers by making public investment in rural infrastructure and efficient port facilities, and promoting standards of commerce that provide the incentives for commercial agents to invest in.

Mythili, (2008) estimated supply response for major crops during pre-and post-reform periods in India using Nerlovian adjustment/adaptive expectation model. Estimation was based on dynamic panel data approach with pooled cross section time series data across states for India. The study found no significant difference in supply elasticities between pre-and post-reform periods for majority of crops. This study also indicated that farmers increasingly respond better through non-acreage inputs than shifting the acreage. This includes better technology, use of better quality of inputs and intensive cultivation.

Mesike et al (2010) applied the Vector Error Correction Model to measure the supply response of rubber farmers in Nigeria. Preliminary analysis suggested that estimations based on their levels might be spurious as the results indicated that all the variables in the model were not stationary at their levels. Further results indicated that producers’ prices and the structural break significantly affected the supply of rubber. Response of rubber farmers to price were low with an estimated elasticity of 0.373 in the short run and 0.204 in the long run due to price sustainability and the emergence of other supply determinants indicating significant production adjustments based on expected prices. Policy efforts in promoting sustainable marketing outlets and promoting high value and high quality products for export were suggested in understanding farmer’s responses to incentive changes.

Shoko (2014) carried out a research of estimating the supply response of maize in South Africa. A modified Nerlovian partial adjusted model was applied on historical time series data spanning from 1980 – 2012. The non-price factors considered in his study were rainfall, technology, and market policy. The results from his study indicated a short run elasticity of 0.49 and a long run of 0.65, signifying that maize farmers are less sensitive to price changes. The results confirm that non-price factors seem to have more effect on maize supply in South Africa. These findings coincide with those obtained in supply response studies for field crops conducted in other developing African countries. The study also showed that non-price factors such as, rainfall, technology and market policies have a positive impact on maize production.

2. METHODOLODY

Historical time series data for the period 2009 to 2016 was used in this study. The data include Macadamia nuts farm prices, Macadamia nuts yield, and non-price factors like rainfall and a bunch of input variables like fertilizer, chemicals, fuel and labor. The data used was obtained from Chipinge's Makandi Estates.

Literature has proved that the Nerlovian model is the most prominent and effective econometric model used to estimate agricultural supply response. The pioneering work of Nerlove (1958) on supply response enables one to determine short run and long run elasticities. It also gives the flexibility to introduce non-price shift variables in the model. The Norlovian Partial Adjustment Lagged model is considered appropriate for crop producers was applied by Rao (1989), Belete (1995), Leaver (2003), Wasim (2005), Mythili (2008), to measure the producers' behavior.

The basic form of the Nerlovian model for an annual crop consists of the following three equations.

$Q_t^D = a_0 + b_1 P_t^e + cX_t + V_t$ …… (1)

$P_t^e = P_{t-1}^e + \gamma(P_{t-1} - P_{t-1}^e)$ …… (2)

$(Q_t - Q_{t-1}) = \delta(Q_t^D - Q_{t-1})$ …… (3)

Where:

Q_t → actual output at time t Q_t^D → desired output at time t P_t → actual price at time t,

P_t^e → expected price at time t X_t → other observed, non-economic factors affecting supply at time t, and are labelled the expectation and adjustment coefficients respectively.

V_t → Error term, capturing all other factors that has not been included in the model.

Q_{t-1} → is actual output in period t-1 $(Q_t - Q_{t-1})$ → is actual change in output,

$(Q_t^D - Q_{t-1})$ → is desired change in output, δ → is adjustment coefficient, and $0 < \delta < 1$

Nerlove (1958) adjustment model postulates that the desired output Q_t^D is a function of expected normal priceP_t^e, while the actual output Q_t adjusts to the desired output Q_t^D with some lag. Equation (1) is a behavioral relationship, stating that the desired output Q_t^D of a product depends upon the relative prices P_t^e in the preceding year. According to Seay et al (2004), equation (3) states that the current output Q_t will move only partially from the previous position to the target level Q_t^D. The amount of the adjustment of farmers to various factors between time t and t-1 is equal to $\delta(Q_t^D - Q_{t-1})$.

δ measures the speed of adjustment and assumes values from 0 to 1. It is interpreted as the coefficient of adjustment which characterizes the fact that there are limitations to the rate of adjustment of Q_t due to economic and non-economic factors like technological constrains, weather variability, prices and various inflexibilities. Relations with equation (1) and (3) give the reduced form which eliminates the unobserved variable by an observed variable Q. By eliminating these variables, the estimating or the reduced form Nerlovian equation is achieved. Following is the substitution:

Substituting the value of P_t^e and Q_t^D from equation (2) and (3), in equation (1), we obtain:

$$\delta^{-1}Q_t - \delta^{-1}Q_{t-1} + Q_{t-1} = a + bP_{t-1}^e + b\gamma P_{t-1} - b\gamma P_{t-1}^e + cX_t + V_t$$

By making Q_t the subject of formula we obtain:

$$Q_t = a\delta + b\delta P_{t-1}^e - b\delta\gamma P_{t-1}^e + b\delta\gamma P_{t-1} + c\delta X_t + Q_{t-1} - \delta Q_{t-1} + \delta V_t$$

By simplification equation (1) becomes:

$$Q_t = b_0 + b_1 P_{t-1} + b_2 Q_{t-1} + b_3 X_t + U_t \ldots\ldots. (4)$$

Equation (4) is the reduced form equation of the Norlovian Model.

Where; b_0 → is a $a\delta$, b_1 → is a $b\delta\gamma$, → is a $(1-\delta)+(1-\gamma)$, b_3 → is a $c\delta$

U_t → δV_t Which is the disturbance term capturing all other factors that has not been included in the model.

The reduced form would basically remain the same if we include more independent variables than the ones included in equation (4).

COMPUTING ELASTICITIES:

In this study the short and long run price elasticities are computed using the relationships drawn from the Norlovian Model.

The short run supply elasticity is calculated as follows;

$$\varepsilon = b_1 \frac{\bar{P}}{\bar{Q}}$$

Where: b_1 → is the slope.

$\bar{P}$ and $\bar{Q}$ → are the historical mean of prices and output, respectively.

The long run supply elasticities will be obtained by diving the corresponding short run elasticities with the coefficient of adjustment δ.

ESTIMATING THE MACADAMIA NUTS SUPPLY RESPONSE:

The model used for this study is based on economic theory and previous work done in the field of supply response for field crops and other agricultural products such as beef. However, it is not always possible to estimate a model suggested by theory, because it is not always possible to include all the variables initiated by theory due to the non-availability of data and quantification problems. The supply model used in this particular study is based on supply models for field crops used by Belete (1995), Leaver (2003) and Mythili (2008). The models used by these research studies were used as a framework for constructing a macadamias supply model for this study.

Ordinary Least Squares (OLS) technique was used to estimate the parameters of the models. The estimation of the Nerlovian model may result in residuals that violate the assumption of normality of the error terms (Leaver, 2003). To ensure normality of the residuals, the estimating equations used in this study were expressed in logarithmic form. The transformation is acceptable because it ensures that the errors are both homoscedastic and normally distributed (Maddala, 2001). An additional benefit of using the logarithmic form is that the coefficient of the price variable can be directly deduced as the short run supply elasticity.

To analyze the supply response of macadamias, the yield response function is applied. The OLS method is applied to calculate the supply parameters of the function. Choi and Helmberger (1993), Mushtaq and Dawson (2002), Hertel and Keeney (2008) used yield response function in order to assess the farmers' response to price and non-price factors. Diagnostic tests are performed to validate quality of the supply model. The short and long run supply elasticities are determined after the diagnostic tests. To estimate the impact of price and non-price factors on changes in macadamias output this study uses yield response function. The area and yield response estimating equations were simplified from the Nerlovian Partial Adjustment model in section 3.2. The following sub-sections are explaining the variables used in the supply response model.

Output/ Dependent Variables:

Mshomba (1989) explained the three choices for measuring output which are: the planting area or hectares under cultivation, production or yield per unit area and total production in terms of weight or tonnage produced. This study uses yield as an output variable because macadamia trees may have the same planted area, yet increasing its output per hector over time. This is based on the notion that farmers respond to price incentives partly through intensive application of other inputs given the same area, which is reflected in yield Mythili (2008). (Singh, 1998) also believed that the farmers could keep area constant and increase output by varying yield level. This is advocated by many researchers such as Choi and Helmberger (1993), Mushtaq and Dawson (2002), Hertel and Keeney (2008).The coefficients of variables for the yield response function are directly interpreted as the short run supply elasticity. The long run elasticities are obtained by dividing short run elasticities by the coefficient of the lagged output variables.

Yield Response Function:

Yield was used as the dependent variable in the yield response function. This may be justified by the fact that farmers may display response by adopting better technology of production with no change in area or by adopting intensive cultivation by using more or better quality of inputs. This will change the output without changing the area, something that is hidden in when using planted area and production weight (tonnes). A lag variable of macadamia nuts yield was included as an independent variable in the yield response equation leading to an autoregressive distributed lag model (ARDL).

An ARDL was used in this study. The ARDL is a dynamic model, stating that yield is a function of own yield, lagged price, and some exogenous variables. A model is described as dynamic if the time path of the dependent variable is explained by its previous values (Gujarati, 1995). Using the ARDL as the basic frame for analysis, the yield response relationship in the study was estimated with the following equation:

$$\ln Yield_t = \varphi_0 + \varphi_1 \ln Price_{t-1} + \varphi_2 \ln Yield_{t-1} + \varphi_3 \ln Rain_{t-1} + \varphi_4 \ln Fert_{t-1} + \varphi_5 \ln Chem_{t-1} + \varphi_6 \ln Fuel_{t-1} + \varphi_7 \ln Labor_{t-1} + U_t$$

Where:

$\ln Yield_t$ → natural logarithm of the macadamia nuts yield. [$yield = tonnes \div hectors$],

$\ln Price_{t-1}$ → natural logarithm of the macadamia nuts price at time *t*-1 (USD per ton),

$\ln Yield_{t-1}$ → natural logarithm of the macadamia nuts yield at time *t*-1,

$\ln Rain_{t-1}$ → natural logarithm of the total monthly average rainfall at time *t-1*(mm),

$\ln Fert_{t-1}$ → natural logarithm of the total monthly fertilizer cost at time *t-1*,

$\ln Chem_{t-1}$ → natural logarithm of the total monthly chemicals cost at time *t-1*,

$\ln Fuel_{t-1}$ → natural logarithm of the total monthly fuel cost at time *t-1*,

$\ln Labor_{t-1}$ → natural logarithm of the total monthly labor cost at time *t-1*,

U_t→ the random distance term capturing all other variables that are not included in this model (assumed to be white noise).

φ_i → are the coefficients to be estimated ($i = 0,1,2,3,4$).

Non-Price Factors considered in this study are broadly categorized as weather and time trend variables.

Other variables, the costs of acquiring inputs - fertilizers, chemicals, fuel, and labor have been incorporated in the macadamia nuts supply function. These have a direct impact on the yield of macadamia nuts at Makandi Estates. Nerlove (1958) suggests that the inclusion of inputs to the supply response function will result in a more complete model.

Testing for Unit Root Non-Stationarity:

In order to compute supply elasticities, relevant tests are done beforehand to avoid spurious regression results and unstable models. The time series data of the selected variables first have to be tested for unit roots. The Augmented Dickey Fuller (ADF) test was performed on each of the logarithmic series of Macadamia Nuts Prices (MP), Macadamia Nuts Yield (MY), Rainfall (Rn), Fertilizer (Fe), Chemicals (Ch), Fuel (Fu), and Labor (La) to formally ascertain whether they contained a unit root or not.

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Seven autoregressive forms of models were set up, each for the four respective data series of MP, MY, MA, Rn, Fe, Ch, Fu, La in the manner demonstrated below:

$$\Delta \ln MP_t = \varphi_1 + \phi MP_{t-1} + \sum_{i-1}^{p} \propto_i \Delta MP_{t-i} + U_t$$

$$\Delta \ln MY_t = \varphi_1 + \phi MY_{t-1} + \sum_{i-1}^{p} \propto_i \Delta MY_{t-i} + U_t$$

$$\Delta \ln Rn_t = \varphi_1 + \phi Rn_{t-1} + \sum_{i-1}^{p} \propto_i \Delta Rn_{t-i} + U_t$$

$$\Delta \ln Fe_t = \varphi_1 + \phi Fe_{t-1} + \sum_{i-1}^{p} \propto_i \Delta Fe_{t-i} + U_t$$

$$\Delta \ln Ch_t = \varphi_1 + \phi Ch_{t-1} + \sum_{i-1}^{p} \propto_i \Delta Ch_{t-i} + U_t$$

$$\Delta \ln Fu_t = \varphi_1 + \phi Fu_{t-1} + \sum_{i-1}^{p} \propto_i \Delta Fu_{t-i} + U_t$$

$$\Delta \ln La_t = \varphi_1 + \phi La_{t-1} + \sum_{i-1}^{p} \propto_i \Delta La_{t-i} + U_t$$

Where:

$\ln MY_t$ → natural logarithm of macadamia nuts yield series to be tested,

$\ln MY_{t-1}$ → natural logarithm of macadamia nuts yield series lagged by 1 period.

$\sum_{i-1}^{p} \propto_i \Delta MY_{t-i} + U_t$ → the 1st, 2nd, . . ., pth lagged 1st differenced values of $\ln MY$,

$\ln MP_t$ → natural logarithm of macadamia nuts price series to be tested,

$\ln MP_{t-1}$ → natural logarithm of macadamia nuts price series lagged by 1 period.

$\sum_{i-1}^{p} \propto_i \Delta MP_{t-i} + U_t$ → the 1st, 2nd, . . ., pth lagged 1st differenced values of $\ln MP$,

$\ln Rn_t$ → natural logarithm of macadamia nuts rainfall series to be tested,

$\ln Rn_{t-1}$ → natural logarithm of macadamia nuts rainfall series lagged by 1 period.

$\sum_{i-1}^{p} \propto_i \Delta Rn_{t-i} + U_t$ → the 1st, 2nd, . . ., pth lagged 1st differenced values of $\ln Rn$,

$\ln Fe_t$ → natural logarithm of macadamia nuts fertilizer series to be tested,

$\ln Fe_{t-1}$ → natural logarithm of macadamia nuts fertilizer series lagged by 1 period.

$\sum_{i-1}^{p} \propto_i \Delta Fe_{t-i} + U_t$ → the 1st, 2nd, . . ., pth lagged 1st differenced values of $\ln Fe$,

$\ln Ch_t$ → natural logarithm of macadamia nuts chemicals series to be tested,

$\ln Ch_{t-1}$ → natural logarithm of macadamia nuts chemicals series lagged by 1 period.

$\sum_{i-1}^{p} \propto_i \Delta Ch_{t-i} + U_t$ → the 1st, 2nd, . . ., pth lagged 1st differenced values of $\ln Ch$,

$\ln Fu_t$ → natural logarithm of macadamia nuts rainfall series to be tested,

$\ln Fu_{t-1}$ → natural logarithm of macadamia nuts rainfall series lagged by 1 period.

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$\sum_{i-1}^{p} \propto_i \Delta Fu_{t-i} + U_t$ → the 1st, 2nd, . . ., pth lagged 1st differenced values of $\ln Fu$,

$\ln La_t$ → natural logarithm of macadamia nuts rainfall series to be tested,

$\ln La_{t-1}$ → Natural logarithm of macadamia nuts rainfall series lagged by 1 period.

$\sum_{i-1}^{p} \propto_i \Delta La_{t-i} + U_t$ → the 1st, 2nd. . . pth lagged 1st differenced values of $\ln La$,

$\varphi_1, \emptyset, \propto$ → coefficients,

U_t → a stochastic non-auto correlated error term with zero mean and a constant variance.In each of the cases above, the null hypothesisH_0: ø = 0 (unit root) was tested with the alternative hypothesis specified as H_1: ø < 0 (time series is stationary). The decision rule that guided the test required that the null hypothesis be rejected only if the Augmented Dickey Fuller test statistic < MacKinnon critical values. Rejecting H_0 would imply that the process that generates MP series of data is time invariant (that is MP is stationary), otherwise the series would be non-stationary raising the need to difference the data to get rid of the unit root.

Table 1

Test	Method
Heteroskedasticity	White Test
Serial Correlation	Breush - Godfrey Test
Auto-Correlation	Lagrange Multiplier Test (h-statistic)
Stability	Ramsey Resert Test
Normality	Jarque - Bera Test

3. RESULTS AND INTERPRETATION

Descriptive Statistics

Table 2 shows the statistical properties of the data used in the Macadamia nuts supply function.

Table 2: Statistical Properties of the Original Data

Variable	Mean	StdDev	Min	Max
Yield	1.8008971	1.2817512	0.377542	4.452196
Price	2540.619	841.84486	1008.628	4383.4333
Rainfall	74.863133	69.885804	0	248
Fert	12155.319	14686.824	-14764.291	61942.25
Chem	1041.5299	710.08573	-223.55386	3083.64
Fuel	6046.3552	3231.4527	-1523.531	12044.299
Labor	12181.914	2580.6588	5859.1372	18250.529

The mean, standard deviation, maximum and minimum of the variables of the model are presented for the specified time frame. On average, 1.8 tonnes per hectare of macadamia nuts are produced monthly with an average standard deviation of 1.28 tonnes per hectare. The average farm price of macadamia nuts is $2,540.62 per tonne with a standard deviation of $841.84 per tonne. The average monthly rainfall is 74 mm with a standard deviation of 69 mm per year. Statistical properties of the variables of the macadamia nuts supply model. The transformation of data into logarithmic form ensures that the errors are normally distributed.

Table 3: Statistical Properties of the Natural Logarithm of the Original Data

Variable	Mean	StdDev	Min	Max
Yield	0.3310651	0.7385624	-0.9740735	1.4933975
Price	7.7743414	0.3861625	6.9163463	8.3855876
Rainfall	3.5641854	1.5704236	0	5.5134287
Fert	7.5217542	3.724638	0	11.033958
Chem	6.5135543	1.3794786	0	8.033866
Fuel	8.3011263	1.7040458	0	9.3963467
Labor	9.383807	0.2254715	8.6757576	9.8119493

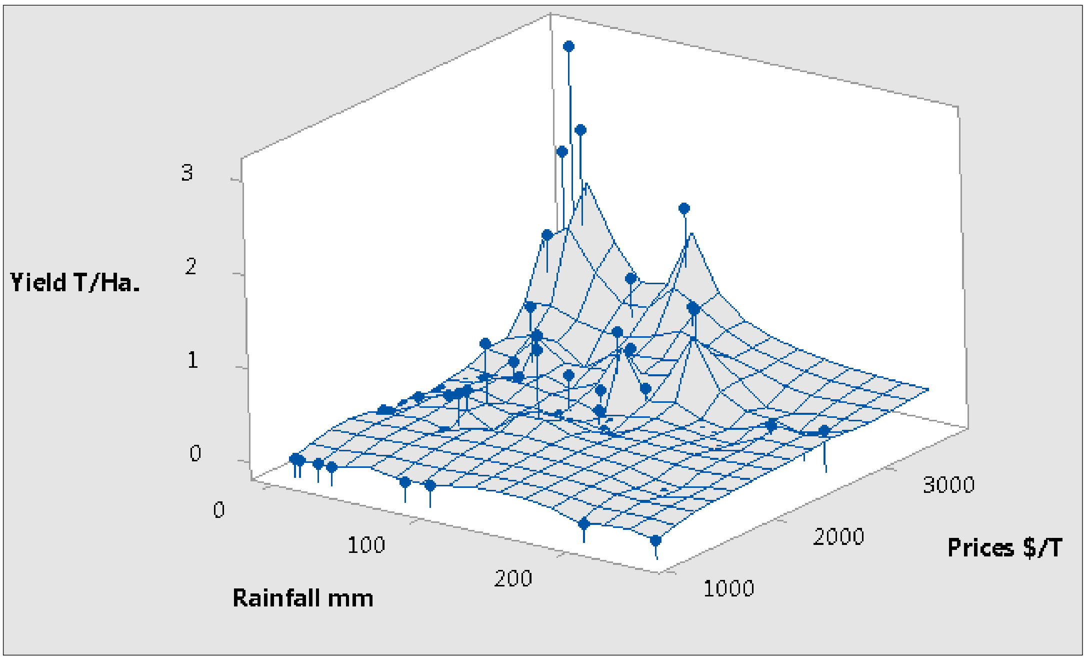

Figure 4: Yield-Prices-Rainfall Relationship

Relationship between Yield, Prices and Rainfall:

Figure 4 shows the relationship between Yield (tonnes per hectare), Prices ($ per tonnes) and Rainfall (mm). Prices and Rainfall are factors that a farmer cannot control. Whatever change that occurs in these variables, the farmer will respond in some way.

Generally if macadamia nuts prices go up and there is sufficient rainfall, the farmer would find it economically logical to produce more. Alternatively, if prices go down the farmer will find no incentive to respond positively even if rainfall pattern is favorable. On the other hand, if prices are favorable but rainfall is poor, the macadamia nuts plantation will experience a poor harvest, hence we interpret this as low supply response. Therefore, it may be concluded that Yield depends heavily on price and partially on rainfall, hence the price variable is expected to be more significant than other non-price variables.

Macadamia Nuts Farm Prices:

Figure 5 shows the month-on-month macadamia nuts price changes starting from $2,465.60 in 2009 to $3,550 in 2016. The aggregate trend may be interpreted as a rising macadamia nuts price over time.

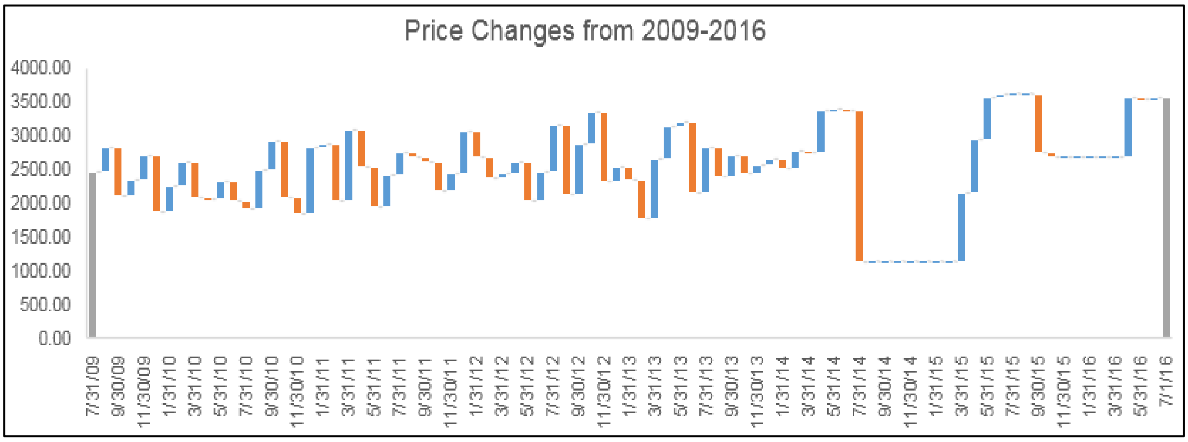

Figure 5: Change in Macadamia Nuts Farm Prices

Rainfall Variability:

Rainfall is one of the key determinants of macadamia supply in developing countries. In Chipinge, Zimbabwe, rainfall varies from season to season. It fluctuates above and below average. A Holdings and Rusitu) versus the Season Average from 2011 to 2015 is shown in Figure 6.

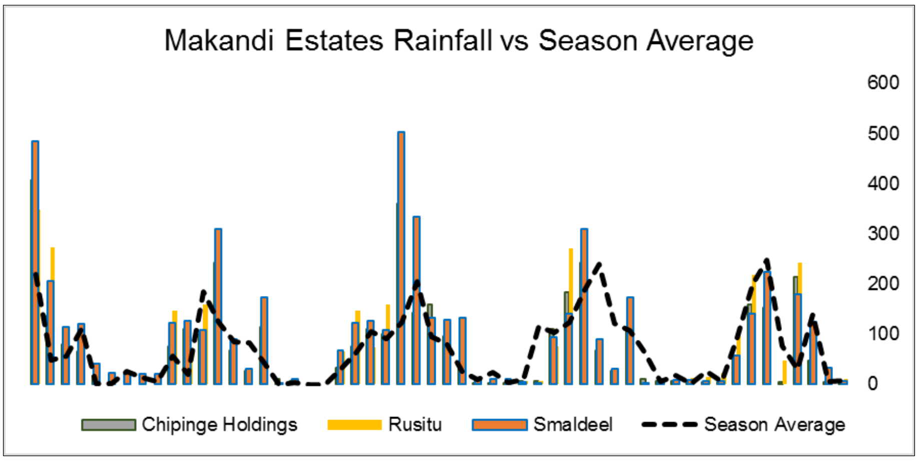

Figure 6

The chart shows that Makandi Estates enjoys rainfall that is above seasonal average during November to January period.

Figure 7 shows the season average rainfall from 2009 to 2016- the period under study. The chart shows that Makandi Estates enjoys heavy rains in November to January every season

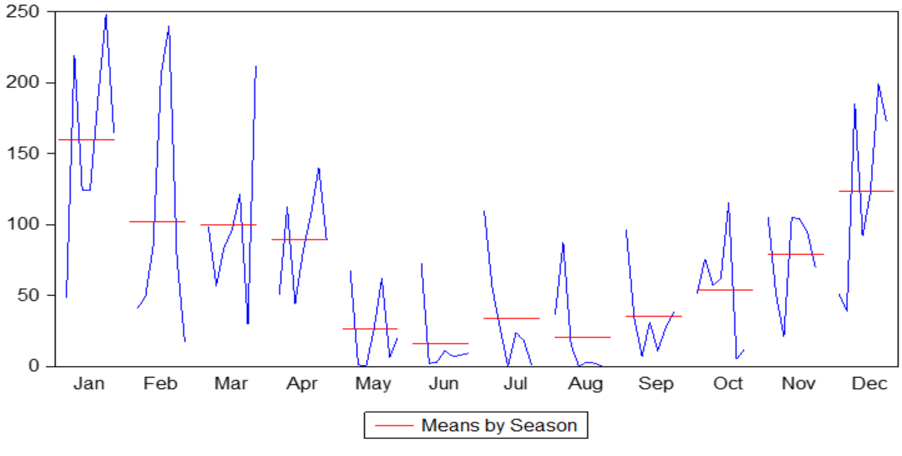

Figure 7: Seasonal Rainfall (2009 to 2016)

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Table 8: Results of Unit Root Tests at Levels

Series	ADF Test Statistic	Critical Value	Order of Integration	Probability	Conclusion
ln_Yield	-0.768312	-3.51229	I(0)	0.8224	Non-Stationary
Lag_ln_Yield	-6.043498	-3.51229	I(0)	0	Stationary
Lag_ln_Price	-0.787284	-3.51229	I(0)	0.8172	Non-Stationary
Lag_ln_Rainfall	-5.380435	-3.51229	I(0)	0.8172	Stationary
Lag_ln_Fertlizer	-9.651357	-3.51229	I(0)	0	Stationary
Lag_ln_Chemical	-8.258571	-3.51229	I(0)	0	Stationary
Lag_ln_Fuel	-9.986372	-3.51229	I(0)	0	Stationary
Lag_ln_Labor	-9.657724	-3.51229	I(0)	0	Stationary

Table 9: Results of unit root test at first differences

Series	ADF Test Statistic	Critical Value	Order of Integration	Probability	Conclusion
ln_Yield	-5.393836	-3.513344	I(1)	0	Stationary
Lag_ln_Yield	-6.043498	-3.51229	I(0)	0	Stationary
Lag_ln_Price	-5.402693	-3.513344	I(1)	0	Stationary
Lag_ln_Rainfall	-5.380435	-3.51229	I(0)	0.8172	Stationary
Lag_ln_Fertlizer	-9.651357	-3.51229	I(0)	0	Stationary
Lag_ln_Chemical	-8.258571	-3.51229	I(0)	0	Stationary
Lag_ln_Fuel	-9.986372	-3.51229	I(0)	0	Stationary
Lag_ln_Labor	-9.657724	-3.51229	I(0)	0	Stationary

(See Appendix I for explicit results on ADF test)

The monthly data series on yield, macadamia farm prices, and rainfall and is tested for unit root for the study period 2009 to 2016. The Augmented Dickey Fuller (AFD) test was used for this test with the optimal lag length chosen on the basis of the Schwarz Bayesian Criterion. The unit root test results are presented in table 9.

The ADF method test the hypothesis that;

H_0: There is a unit root for the series.

H_1: There is no unit root for the series, that is, the series is stationary.

As the computed p-value is lower than the significance level alpha=0.05, reject the null hypothesis H_0. There is the risk to reject the null hypothesis H_0 while it is true is lower than 0.09%.

MACADAMIA NUTS SUPPLY RESPONSE:

The explanatory variables explain 68% (R^2) of the variation in the dependent variable. Macadamia nuts farm prices [Lag_ln_Prices] coefficient has a positive sign with the value of 0.689124 and is significant at the 10% level. This indicates that a price increase will be followed by an increase in yield (output per hector) in the following season. Therefore, there is a significant response of yields to prices. Makandi Estates will continue to increase macadamia nuts output either through intensive application of other inputs on the same area or by expanding the macadamia nuts planting area.

Table 10: Regression Results for Yield Response of Macadamia Nuts

Dependent Variable: ln_Yield		
Observations = 83 (after adjustments)		
Explanatory Variables	Coefficient	t-value
Constant	-8.10154	-2.175235
Lag_ln_Price	0.689124	1.42275
Lag_ln_Yield	0.022592	1.071211
Lag_ln_Rainfall	0.22563	1.474654
Lag_ln_Fertliser	0.002219	0.676552
Lag_ln_Chemical	0.007324	0.686855
Lag_ln_Fuel	0.002621	0.372676
Lag_ln_Labor	0.002858	0.052924
Adj R squared = 0.683753	Durbin-Watson = 1.131826	Durbin-h static = -1.47

(See Appendix II for more information)

Rainfall [Lag_ln_Rainfall] coefficient is positive 0.22563 and is significant, implying that an increase in rainfall is followed by an increase in macadamia nuts supply in the following season. The magnitude of the rainfall coefficient displays the key determinant of macadamia nuts supply both in short and long run. The reason for this could be the location of Makandi Estates – Chipinge. Chipinge falls in the intensive farming region that receives high rainfall compared to other regions in Zimbabwe. Furthermore, the response of macadamia nuts supply to rainfall may be explained by the fact that Makandi Estates has three dams (Smaldeel, Ruistu and Moody's Rest dams) that are used for irrigating the macadamia trees. Thus favorable rainfall directly increases yield.

Lagged Yield [Lag_ln_Yield], has a positive value of 0.022592 and is significant Lagged Yield suggests that an increase in yield in one season will be followed by an increase in yield in the next season. This can be attributed to farmers' past farming experiences when forming production expectations. These results agree with findings obtained by Ogazi (2009) and Alemu et al (2003).

Other variables, the costs of acquiring inputs - fertilizers, chemicals, fuel, and labor have significant and positive coefficients. This implies that inputs are causing a shift in the macadamia nuts supply function, but at a lower rate per month. The significant and positive relationship between the input variables suggests that the costs of acquiring inputs is within the tolerance of Makandi Estates. Nerlove (1958) suggests that the inclusion of inputs to the supply response function will result in a more complete model.

The results discussed above confirm that at micro-level, Makandi Estates does not respond well to price incentives due to the very small numerical estimates of supply response parameters. Mythili (2008) argued that reasons for low response to prices in developing countries are due to limited access to technology and international markets, as well as political constraints. The results of this study support the findings of Alemu et al (2003) where the short-run elasticity of maize in Ethiopia is 0.31 which shows weak supply response.

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DIAGNOSTIC TESTS:

The Lagrange Multiplier test or the h-statistic is considered. The h-statistic value of -1.47 confirmed no sign of serial autocorrelation. The findings of Jargue Bera statistic that residuals are normally distributed [0.28 vs 0.87 p-value] is important since it ensures the validity of t-test and F-test (Leaver, 2003). LM Test statistic (Breusch-Godfrey serial correlation) of 0.765 confirms that the residuals are not auto correlated if compared to a p-value of 0.68. There is no heteroscedasticity within the model since the White test shows a value of 0.62. The Ramsey RESET test validates the stability within the macadamia nuts supply model parameters over the adjusted sample period. The likelihood ratio of 0.59 and the associated p-value of 0.45 show evidence of stability within the model parameters.

Table 11: Results of Validity Test

Test	Method	Results	Comment
Heteroskedasticity	White Test	p-value = 0.6239	No sign of heteroskedasticity
Serial Correlation	Breush - Godfrey Test	LM statistic = 0.765 p-value = 0.68	Residuals are not serial autocorrelated
Auto-Correlation	Lagrange Multiplier Test (h-statistic)	h-statistic = -1.47	No sign of autocorrelation
Stability	Ramsey RESET Test	likelihood ratio = 0.59 p-value = 0.45	Model is stable
Normality	Jarque - Bera Test	JB tetistic = 0.286690 p-value = 0.8707798	Residuals are normally distributed

See Appendix III for the E-Views output of these tests.

Based on these results, the model is satisfactory in terms of its specification(s).

Table 12 shows the interpretation from economics theory of price elasticity of supply.

Table 12: Interpretations of Price Elasticity of Supply (PES)

Numerical value of PES	Terminology	Description
0	Perfectly inelastic supply	Whatever the % change in price no change in quantity supplied
0 < PES < 1	Relatively inelastic supply	A given % change in price leads to a smaller % change in quantity supplied
1	Unit elastic supply	A given % change in price leads to exaclty the same % change in quantity supplied
1 < PES < ∞	Relatively elastic supply	A given % change in price leads to a larger % change in quantity supplied
∞ (inifinity)	Perfectly elastic supply	An infinitely small % change in price leads to an infinitely large % change in quantity supplied

From table 12 one can draw conclusions that Makandi Estates' responsiveness to supply is relatively inelastic in both the short and long run.

Table 13: Makandi Estates Elasticities 2009-2016

Elasticity	Value
Short run	0.68912
Long run	0.70505

Yield response to price shows that an increase in the price of macadamia nuts by 1% during the 2009-2016 period resulted in the quantity of macadamia nuts yield increasing by 0.69% in the short run and 0.71% in the long run. Both the short and long run elasticities with respect to the lagged price variable are relatively inelastic and significant.

These findings demonstrate that it is difficult for Makandi Estates to react swiftly to changes in prices. The long run elasticity with respect to the lagged prices is higher than the short run elasticity. The reason why short run elasticity is smaller than the long run elasticity is due to some fixed factors of production, whilst in the long run all factors are variable (Leaver, 2003).

Non-price incentives may be hindering the transformation of price incentives to stimulate macadamia nuts supply at Chipinge's Makandi Estates. This remark confirms that non-price factors could dominate price factors in factors affecting decision-making process (Mythili, 2008).

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LIST OF APPENDICES

APPENDIX I: RESULTS OF STATIONARITY TEST

Null Hypothesis: D(YIELD) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.393836	0.0000
Test critical values:	1% level	-3.513344	
	5% level	-2.897678	
	10% level	-2.586103	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(YIELD,2)
Method: Least Squares
Date: 03/14/17 Time: 10:47
Sample (adjusted): 2009M10 2016M06
Included observations: 81 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(YIELD(-1))	-0.539493	0.100020	-5.393836	0.0000
C	-0.000775	0.010336	-0.075001	0.9404

R-squared	0.269151	Mean dependent var	0.000313
Adjusted R-squared	0.259900	S.D. dependent var	0.108106
S.E. of regression	0.093002	Akaike info criterion	-1.888006
Sum squared resid	0.683303	Schwarz criterion	-1.828884
Log likelihood	78.46424	Hannan-Quinn criter.	-1.864285
F-statistic	29.09347	Durbin-Watson stat	2.258764
Prob(F-statistic)	0.000001		

Null Hypothesis: D(LAG_PRICE) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.402693	0.0000
Test critical values:	1% level	-3.513344	
	5% level	-2.897678	
	10% level	-2.586103	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_PRICE,2)
Method: Least Squares
Date: 03/14/17 Time: 10:54
Sample (adjusted): 2009M10 2016M06
Included observations: 81 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LAG_PRICE(-1))	-0.540784	0.100095	-5.402693	0.0000
C	-0.000952	0.010332	-0.092123	0.9268

R-squared	0.269797	Mean dependent var	0.000302
Adjusted R-squared	0.260554	S.D. dependent var	0.108106
S.E. of regression	0.092961	Akaike info criterion	-1.888888
Sum squared resid	0.682701	Schwarz criterion	-1.829765
Log likelihood	78.49995	Hannan-Quinn criter.	-1.865167
F-statistic	29.18909	Durbin-Watson stat	2.257445
Prob(F-statistic)	0.000001		

Null Hypothesis: LAG_YIELD has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.043498	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_YIELD)
Method: Least Squares
Date: 03/14/17 Time: 09:38
Sample (adjusted): 2009M09 2016M06
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG_YIELD(-1)	-0.632456	0.104651	-6.043498	0.0000
C	4.913675	0.813563	6.039695	0.0000

R-squared	0.313445	Mean dependent var	0.002889
Adjusted R-squared	0.304863	S.D. dependent var	0.435756
S.E. of regression	0.363310	Akaike info criterion	0.836970
Sum squared resid	10.55956	Schwarz criterion	0.895671
Log likelihood	-32.31577	Hannan-Quinn criter.	0.860537
F-statistic	36.52387	Durbin-Watson stat	2.093344
Prob(F-statistic)	0.000000		

Null Hypothesis: LAG_RAINFALL has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.380435	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_RAINFALL)
Method: Least Squares
Date: 03/14/17 Time: 09:37
Sample (adjusted): 2009M09 2016M06
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG_RAINFALL(-1)	-0.531851	0.098849	-5.380435	0.0000
C	1.895985	0.387171	4.897027	0.0000

R-squared	0.265712	Mean dependent var	-0.012182
Adjusted R-squared	0.256533	S.D. dependent var	1.631214
S.E. of regression	1.406506	Akaike info criterion	3.544182
Sum squared resid	158.2607	Schwarz criterion	3.602882
Log likelihood	-143.3115	Hannan-Quinn criter.	3.567749
F-statistic	28.94908	Durbin-Watson stat	2.110375
Prob(F-statistic)	0.000001		

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Null Hypothesis: LAG_FERT has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.651357	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_FERT)
Method: Least Squares
Date: 03/14/17 Time: 09:31
Sample (adjusted): 2009M09 2016M06
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG_FERT(-1)	-1.075858	0.111472	-9.651357	0.0000
C	8.060615	0.938875	8.585398	0.0000

R-squared	0.537969	Mean dependent var	-0.059848
Adjusted R-squared	0.532194	S.D. dependent var	5.515758
S.E. of regression	3.772577	Akaike info criterion	5.517482
Sum squared resid	1138.587	Schwarz criterion	5.576182
Log likelihood	-224.2167	Hannan-Quinn criter.	5.541049
F-statistic	93.14869	Durbin-Watson stat	1.983539
Prob(F-statistic)	0.000000		

Null Hypothesis: LAG_CHEM has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.258571	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_CHEM)
Method: Least Squares
Date: 03/14/17 Time: 10:21
Sample (adjusted): 2009M09 2016M06
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG_CHEM(-1)	-0.913647	0.110630	-8.258571	0.0000
C	6.006465	0.741489	8.100543	0.0000

R-squared	0.460203	Mean dependent var	-0.020972
Adjusted R-squared	0.453456	S.D. dependent var	1.603587
S.E. of regression	1.185510	Akaike info criterion	3.202310
Sum squared resid	112.4346	Schwarz criterion	3.261011
Log likelihood	-129.2947	Hannan-Quinn criter.	3.225878
F-statistic	68.20399	Durbin-Watson stat	1.996708
Prob(F-statistic)	0.000000		

Null Hypothesis: LAG_FUEL has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.986372	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_FUEL)
Method: Least Squares
Date: 03/14/17 Time: 09:33
Sample (adjusted): 2009M09 2016M06
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG_FUEL(-1)	-1.107855	0.110937	-9.986372	0.0000
C	9.173423	0.939035	9.768989	0.0000

R-squared	0.554882	Mean dependent var	-0.010365
Adjusted R-squared	0.549318	S.D. dependent var	2.561568
S.E. of regression	1.719654	Akaike info criterion	3.946211
Sum squared resid	236.5767	Schwarz criterion	4.004911
Log likelihood	-159.7946	Hannan-Quinn criter.	3.969778
F-statistic	99.72762	Durbin-Watson stat	2.016330
Prob(F-statistic)	0.000000		

Null Hypothesis: LAG_LABOR has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.657724	0.0000
Test critical values:	1% level	-3.512290	
	5% level	-2.897223	
	10% level	-2.585861	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LAG_LABOR)
Method: Least Squares
Date: 03/14/17 Time: 09:34
Sample (adjusted): 2009M09 2016M06
Included observations: 82 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LAG_LABOR(-1)	-1.036027	0.107274	-9.657724	0.0000
C	9.724345	1.006701	9.659613	0.0000

R-squared	0.538297	Mean dependent var	0.004603
Adjusted R-squared	0.532526	S.D. dependent var	0.314279
S.E. of regression	0.214879	Akaike info criterion	-0.213397
Sum squared resid	3.693833	Schwarz criterion	-0.154696
Log likelihood	10.74928	Hannan-Quinn criter.	-0.189830
F-statistic	93.27162	Durbin-Watson stat	1.994132
Prob(F-statistic)	0.000000		

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APPENDIX II: RESULTS REGRESSION RESULTS FOR YIELD RESPONSE OF MACADAMIA NUTS

Dependent Variable: LN_YIELD
Method: Least Squares
Date: 03/15/17 Time: 01:00
Sample (adjusted): 2009M08 2016M06
Included observations: 83 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8.101540	0.579451	-2.175235	0.0000
LAG_LN_YIELD	0.022592	0.031726	1.071211	0.0001
LAG_LN_PRICE	0.689124	0.316646	1.422750	0.0000
LAG_LN_RAINFALL	0.225630	0.018132	1.474654	0.1245
LAG_LN_FERT	0.002219	0.003280	0.676552	0.0200
LAG_LN_CHEM	0.007324	0.010662	0.686855	0.3094
LAG_LN_FUEL	0.002621	0.007034	0.372676	0.2104
LAG_LN_LABOR	0.002858	0.053994	0.052924	0.0279

R-squared	0.710563	Mean dependent var	0.320784
Adjusted R-squared	0.683753	S.D. dependent var	0.736980
S.E. of regression	0.106151	Akaike info criterion	-1.556491
Sum squared resid	0.845102	Schwarz criterion	-1.323349
Log likelihood	72.59436	Hannan-Quinn criter.	-1.462828
F-statistic	153.9358	Durbin-Watson stat	1.131826
Prob(F-statistic)	0.000000		

APPENDIX III: DIAGONSTIC TESTS

Heteroskedasticity Test: White

F-statistic	0.899860	Prob. F(35,47)	0.6239
Obs*R-squared	33.30263	Prob. Chi-Square(35)	0.5502
Scaled explained SS	154.5625	Prob. Chi-Square(35)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/02/17 Time: 13:19
Sample: 2009M08 2016M06
Included observations: 83

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-7.157572	9.792461	-0.730927	0.4685
LAG_LN_PRICE	1.259953	0.917753	1.372867	0.1763
LAG_LN_PRICE^2	-0.056413	0.039483	-1.428774	0.1597
LAG_LN_PRICE*LAG_LN_YIELD	-0.005043	0.021373	-0.235973	0.8145
LAG_LN_PRICE*LAG_LN_RAINFALL	0.000543	0.009592	0.056585	0.9551
LAG_LN_PRICE*LAG_LN_FERT	-0.001970	0.006023	-0.327096	0.7450
LAG_LN_PRICE*LAG_LN_CHEM	-0.010884	0.015865	-0.686032	0.4961
LAG_LN_PRICE*LAG_LN_FUEL	0.003294	0.025374	0.129808	0.8973

LAG_LN_PRICE*LAG_LN_LABOR	-0.036053	0.080609	-0.447257	0.6567
LAG_LN_YIELD	0.195611	0.413544	0.473012	0.6384
LAG_LN_YIELD^2	0.016545	0.009828	1.683399	0.0989
LAG_LN_YIELD*LAG_LN_RAINFALL	-0.002166	0.005491	-0.394455	0.6950
LAG_LN_YIELD*LAG_LN_FERT	-0.001095	0.002298	-0.476682	0.6358
LAG_LN_YIELD*LAG_LN_CHEM	-0.021978	0.009521	-2.308467	0.0254
LAG_LN_YIELD*LAG_LN_FUEL	-0.002822	0.010372	-0.272057	0.7868
LAG_LN_YIELD*LAG_LN_LABOR	0.001223	0.037813	0.032349	0.9743
LAG_LN_RAINFALL	0.282037	0.189251	1.490280	0.1428
LAG_LN_RAINFALL^2	0.000264	0.002565	0.103063	0.9184
LAG_LN_RAINFALL*LAG_LN_FERT	0.000814	0.001062	0.766898	0.4470
LAG_LN_RAINFALL*LAG_LN_CHEM	0.005297	0.005606	0.944838	0.3496
LAG_LN_RAINFALL*LAG_LN_FUEL	0.001603	0.002821	0.568416	0.5725
LAG_LN_RAINFALL*LAG_LN_LABOR	-0.036151	0.020911	-1.728751	0.0904
LAG_LN_FERT	0.096118	0.074920	1.282947	0.2058
LAG_LN_FERT^2	-0.000216	0.000583	-0.370388	0.7128
LAG_LN_FERT*LAG_LN_CHEM	0.002226	0.001411	1.578105	0.1212
LAG_LN_FERT*LAG_LN_FUEL	0.000914	0.002288	0.399580	0.6913
LAG_LN_FERT*LAG_LN_LABOR	-0.011037	0.006557	-1.683123	0.0990
LAG_LN_CHEM	-0.193342	0.336298	-0.574911	0.5681
LAG_LN_CHEM^2	-0.006499	0.003419	-1.900841	0.0635
LAG_LN_CHEM*LAG_LN_FUEL	-0.000928	0.012892	-0.071952	0.9429
LAG_LN_CHEM*LAG_LN_LABOR	0.036123	0.030309	1.191816	0.2393
LAG_LN_FUEL	0.242592	0.443709	0.546737	0.5871
LAG_LN_FUEL^2	-6.21E-05	0.001849	-0.033596	0.9733
LAG_LN_FUEL*LAG_LN_LABOR	-0.028472	0.038290	-0.743570	0.4608
LAG_LN_LABOR	0.256298	1.608527	0.159337	0.8741
LAG_LN_LABOR^2	0.010794	0.072257	0.149387	0.8819

R-squared	0.401236	Mean dependent var	0.010182
Adjusted R-squared	-0.044651	S.D. dependent var	0.034539
S.E. of regression	0.035302	Akaike info criterion	-3.551005
Sum squared resid	0.058571	Schwarz criterion	-2.501869
Log likelihood	183.3667	Hannan-Quinn criter.	-3.129521
F-statistic	0.899860	Durbin-Watson stat	2.177080
Prob(F-statistic)	0.623903		

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.79192	Prob. F(2,73)	0.7650

Obs*R-squared	22.76170	Prob. Chi-Square(2)	0.6800

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/02/17 Time: 13:28
Sample: 2009M08 2016M06
Included observations: 83
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.228160	0.504421	0.452321	0.6524
C(2)	-0.011698	0.027817	-0.420512	0.6753
C(3)	-0.013524	0.014603	-0.926139	0.3574
C(4)	-0.001279	0.007081	-0.180620	0.8572
C(5)	-0.002908	0.002889	-1.006544	0.3175
C(6)	-0.001562	0.009302	-0.167883	0.8671
C(7)	-0.003002	0.006102	-0.491994	0.6242
C(8)	-0.007522	0.047525	-0.158266	0.8747
RESID(-1)	0.342778	0.116602	2.939732	0.0044
RESID(-2)	0.308479	0.117223	2.631556	0.0104

R-squared	0.274237	Mean dependent var	-5.35E-18
Adjusted R-squared	0.184760	S.D. dependent var	0.101519
S.E. of regression	0.091662	Akaike info criterion	-1.828830
Sum squared resid	0.613343	Schwarz criterion	-1.537404
Log likelihood	85.89645	Hannan-Quinn criter.	-1.711751
F-statistic	5.064871	Durbin-Watson stat	2.106610
Prob(F-statistic)	0.003607		

h	-1.47

h - statistic

d	1.13183
0.5d	0.56591
v(ω^3)	0.04043
n/(1-nv(ω^3)	19.0569
sqrt(n/(1-nv(ω^3))	4.36542

$$h = \left(1 - \frac{1}{2}d\sqrt{\frac{n}{1 - n\hat{v}(\hat{\varphi}_3)}}\right)$$

0.04043 0.01205
compute

d	1.13183
n	83
v(ω^3)	-0.0404

Ramsey RESET Test:

F-statistic	5.79192	Prob. F(2,73)	0.7650
Log likelihoos ratio	0.59170	Prob. Chi-Square(2)	0.4530

ABBRVIATIONS:

3D	3 Dimension graph
ADF	Augmented Dickey Fuller test
ARDL	Autoregressive Distributed Lag Model
Ch	Chemicals
DW	Dublin-Watson test
ECM	Error Correlation Method
Fe	Fertilizer
Fu	Fuel
Ha	Hectors
HIT	Harare Institute of Technology
I(0)	Difference Stationery Series
La	Labor
ln	Natural Logarithm
mm	millimeters
MP	Macadamia Nuts Prices
MT	Metric Tons
MY	Macadamia Nuts Yield
NIS	Nut in Shell
OLS	Ordinary Least Squares
PES	Price Elasticity of Supply
R&D	Research and Development
Rn	Rainfall
TNPAZ	Tree Nut Producers Association of Zimbabwe
USA	United States of America