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Author Name: Tichaona Pfumayaramba[1]

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Abstract: *Flue cured tobacco has been an important crop for the Zimbabwean economy historically in terms of foreign currency earnings and employment creation. Between 1980 and 2000, there is a general increase in tobacco output, followed by a sharp decline from 2001 up to 2008 and then output starts to increase again. Flue cured tobacco output as measured by the quantity that is delivered to the auction floors is used to estimate supply elasticity. The objective is to determine if flue-cured tobacco supply is price elastic and whether price incentives alone will boost supply in the short -run. Time series data on flue cured tobacco output, prices, production costs, prices of major competing crops, the exchange rates and inflation are analysed to model the price elasticity of flue cured tobacco between 1980 and 2010. The Augmented Dickey –Fuller unit root test is performed to test the variables for stationarity. The data generating processes show these data series to be non-stationary and therefore OLS estimations would be biased. The data series are differenced and the Engel-Granger procedure is performed to test for cointegration. The Error Correction Model approach is used to estimate flue cured tobacco supply. Flue cured tobacco supply is found to be price inelastic in the short –run.*

[1] Department of Agricultural Economics and Agribusiness, University of Venda, Thohoyandou, South Africa. Email: Tichaona.pfumayaramba@univen.ac.za or pfumatk@yahoo.com

Analysis of Flue-cured Tobacco Supply Elasticity in Zimbabwe 1980-2010: An Error Correction Model Approach.

1. Introduction

Flue-cured tobacco has been an important commodity for Zimbabwe`s agro-based economy. It is of importance to farmers because of its traditionally high returns and nationally because of its contribution to the economy in terms of foreign currency earnings and employment generation.

Agricultural supply response has been an area of major interest for researchers (Bond, 1983; Eckstein, 1985; Townsend et..al 1997). Of particular interest has been how farmers of a commodity will respond to changes in prices. Flue-cured tobacco has been an important commodity for Zimbabwe`s agro-based economy. It is of importance to farmers because of its traditionally high returns and nationally because of its contribution to the economy in terms of foreign currency earnings and employment generation. Thus it is important to understand how price affects price

Economic theory dictates that farmers will respond positively to good prices by increasing their output in times of high prices or when prices are expected to be high.
The agricultural sector plays a central role in the Zimbabwe economy and until the year 2002, it accounted for 15-20% of GDP and about 40% of export earnings (FAO). Within the agricultural sector tobacco has been a profitable crop for commercial farmers. The commercial tobacco-farming sector has been the country's single largest formal employer due to the labour intensive nature of tobacco production. Tobacco has been the backbone of commercial agriculture in Zimbabwe in terms of earnings, contributions to GDP, foreign currency receipts, and employment.

Flue-cured tobacco is the main type of tobacco grown in Zimbabwe consisting of approximately 95 percentage of all tobacco grown in Zimbabwe (ZTA). According to the Zimbabwe Tobacco Association (ZTA), approximately three percentage of all arable land in Zimbabwe was under tobacco (ZTA, 2001). Flue cured tobacco has been sold exclusively under auction since independence, but since 2004 a dual system of auction and contract marketing has been in place.

In the year 2000 government embarked on the “fast track” land reform process. The tobacco farming sector under went significant changes in the structure as a result (FAO, 2001). Commercial farmers dominated flue-cured tobacco production with small-scale producers contributing less than 5 percent. Prior to the year 2000, Zimbabwe was the second largest exporter of flue-cured tobacco after Brazil (USDA, 2006).

The land reform exercise has been accompanied by a decline in agricultural output including flue-cured tobacco. Flue-cured tobacco output has declined from 236 million kilograms auctioned in 2000 to 55 million kilograms auctioned in the year 2006 (ZTA, 2006). The Tobacco Industry Marketing Board (TIMB) sites the major challenges to the tobacco industry as financing, access to inputs, and training and extension.

Tobacco, and in particular flue cured tobacco has been an important crop in the economy of Zimbabwe. Its contribution to the economy in terms of foreign currency earnings is significant and has ranged between 20- 30% in terms of value from independence up to 2002 (RBZ website). There have been fluctuations in flue-cured tobacco output and since 2001 there has been a clear downward trend in output. The government of Zimbabwe has been trying to boost the country’s foreign currency earnings through increased tobacco output. Various support and incentive schemes for tobacco farmers have been put in place since 2004 in order to stimulate production but they have not yielded the desired result of increased tobacco output.

The downward trend in tobacco output which started in 2002 has led the government to direct a lot of effort to resuscitate the tobacco industry and increase output by focusing on price incentives to farmers. According to production economic theory, for a price responsive commodity, if price offered to the producer increases, ceteris paribus, output will increase as a result of this incentive. However, the pace at which an industry or sector can respond to price incentives is dependent upon other structural factors of the production process such as the length of the production cycle, capital investments necessary to increase output such as curing facilities, tractors, availability of land for expansion, and access to finance and inputs. It is therefore necessary to determine the price elasticity of flue-cured tobacco supply in the short-run and in the long-run and thus find out if price incentives are sufficient for achieving increased tobacco output in the short-run or do flue-cured tobacco farmers respond more to other factors other than price. This paper models flue-cured tobacco using the error correction model approach in order to account for non-stationary in time series variables in the estimation. An earlier study by Leaver, (2000) did not take into account the possibility of having non-stationary variables in the regression resulting in spurious regression.

Therefore this study aims to establish whether the flue cured tobacco sector in Zimbabwe is responsive to price incentives in the short-run, as well as the long run. This study uses the error correction model to estimate the short-run price elasticity of flue-cured tobacco paper reviews the trends in flue-cured tobacco production in Zimbabwe from 1980 up to 2010. The error correction model results in valid estimation of parameters as all variables in the model are stationary (Harris, 1995; Mckay et..al,1998).

2. Methodology

A major challenge of dealing with time series data is the problem of non-stationary data. A stochastic process is said to be stationary if the joint and conditional probability distributions of the process are unchanged if displaced over time (Charemza et..al, 1992). If the specified model has variables that are non-stationary, this will lead to the problem of a spurious regression. That is to say that the results obtained might suggest that there are statistically significant relationships between the variables in the models when on the other hand the results only show evidence of contemporaneous correlations and not meaningful causal relationships (Harris, 1995).

Thus the long run equilibrium relationship is specified in natural logarithm form as follows:

$$LNQ_t = C + \beta_1 LNQ_{t-1} + \beta_2 LNPRICE_{t-1} + \beta_3 LNPRICE\_M_{t-1} + \beta_4 LNCOSTINDEX_{t-1} + U_t \quad (1)$$

Where LNQ_t is the natural log of flue-cured tobacco output in year t, LNQ_{t-1} is lagged output, $LNPRICE_{t-1}$ is the lagged price, $PRICE\_M_{t-1}$ is the lagged price of maize. Maize is taken as a competing crop with tobacco (Townsend and Thirtle, 1997). To account for production costs, a production cost index was constructed with the production cost in 1980 taking an index value of 100. This production cost is represented by the variable $LNCOSTINDEX_{t-1.}$

The first step in the analysis is to specify the supply response model and then determine which of the variables are generated by stationary processes, and which variables series have a unit root (i.e. non-stationary). Stationarity tests are necessary to ensure that the classical linear assumptions of the standard O.L.S regression models hold. Models that contain non stationary variables will often lead to the problem of spurious regression (Harris, 1995).

The Augmented Dickey- Fuller approach tests the null hypothesis that a series contains a unit root. This involves estimating the following equation for each variable y_t and testing the null hypothesis $H_o : A_3=1$ against the alternative $H_1: A_3 <1$.

$$y_t = cons + A_2 t + (A_3- 1) y_{t-1} + U_t \quad (2)$$

The critical values can be found in the Dickey- Fuller Tables. If the absolute value of the calculated ADF test statistic is smaller than the value from the tables, then we fail to reject the null hypothesis.If the null hypothesis cannot be rejected, then, y_t contains a unit root and is therefore not stationary. If the first difference of the series y_t is then tested and found to be stationary, then y_t has a unit root of one (1). Variables that are non-stationary are differenced until stationary to determine the number of unit roots (Charemza et..al, 1992). If all variables are stationary, then they are cointegrated and therefore there is a long run relationship implying that performing the O.L.S regression will lead to valid conclusions. If however, the some or all of the variables have unit roots, O.L.S regression is no longer valid.

If variables are non-stationary then it is only possible to infer a long run relationship only is they are cointegrated. Cointegration implies normality of error terms, that is, the residuals are stationary and normally distributed. In this paper the Engle-Granger cointegration test is used to find out if the specified model is cointegrated. The Engle-Granger cointegration test involves testing the residuals of an equation for non-stationarity using the ADF test. Assuming a relationship estimated as follows:

$$Y_t = bX_t + U_t \qquad (3)$$

Then the model to test for cointegration will be given by:

$$\Delta\varepsilon_t = \rho^* \varepsilon_{t-1} + \Sigma \rho_i^* \Delta U_{t-i} + \omega_t \qquad (4)$$

With $H_0 : \rho^* = 0$ i.e. no cointegration (non-stationary residuals)

$H_1 : \rho^* < 0$ cointegration (stationary residuals)

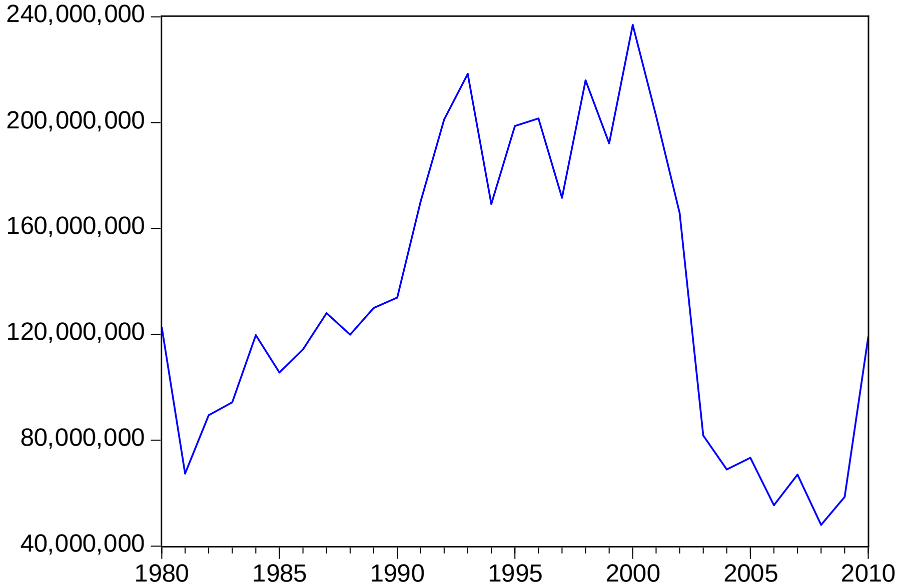
If variables are cointegrated, then, the ECM formulation of a dynamic model can be estimated.

3. Data Analysis

The analysis looked at flue-cured tobacco production in Zimbabwe from 1980-2010 but only data for 1980-2006 was used for the regression analysis due to challenges particularly with price data and the change over to a multicurrency system which have taken place in Zimbabwe. Mainly secondary data was used from the ZTA and TIMB as well as the Reserve Bank of Zimbabwe (RBZ). Thus the data covered the tobacco marketing seasons from 1980 to 2010. Tobacco supply was measured as the annual auctioned crop while the average price achieved for the marketing season was taken as the price for that year.

Table 1 illustrates the trend in flue-cured tobacco supply from 1980 to 2010.

Figure 1: Flue-Cured Tobacco Production Trend (1980-2010)



From 1980 generally flue-cured tobacco supply increased up to 1994 and then went through fluctuations between 1995and 1999 but still showing an upward trend. Peak output was achieved in the 2000 marketing year at 230 million kilograms. From 2001 production declined through to 2008 due to structural changes to the farming sector starting in 2000.

4. Results

The objective of this paper is to determine the price elasticity of flue-cured tobacco in Zimbabwe. Thus the supply response function for flue-cured tobacco supply was specified as follows:

$$LNQ_t = C + \beta_1 LNQ_{t-1} + \beta_2 LNPRICE_{t-1} + \beta_3 LNPRICE\_M_{t-1} + \beta_4 LNCOSTINDEX_{t-1} + U_t \quad (5)$$

All the variables were significant at 5% with only the log of the price of maize significant at the 10% level. Table 1 shows the results of the regression.

Table 1: Regression Results for the Tobacco Supply Response Functions

Independent Variables	Parameter Estimates
LnQ_{t-1}	0.698 (7.589)***
$LnPRICE_{t-1}$	0.405 (3.148)***
$LnPRICE\_M_{t-1}$	-0.225 (-1.743)*
LnCOSTINDEX	-0.366 (-3.450)***
Constant	6.139 (3.967)***
Adjusted R-Squared	0.852
Durbin-Watson (d-statistic)	2.58

Figures in parenthesis represent t-values

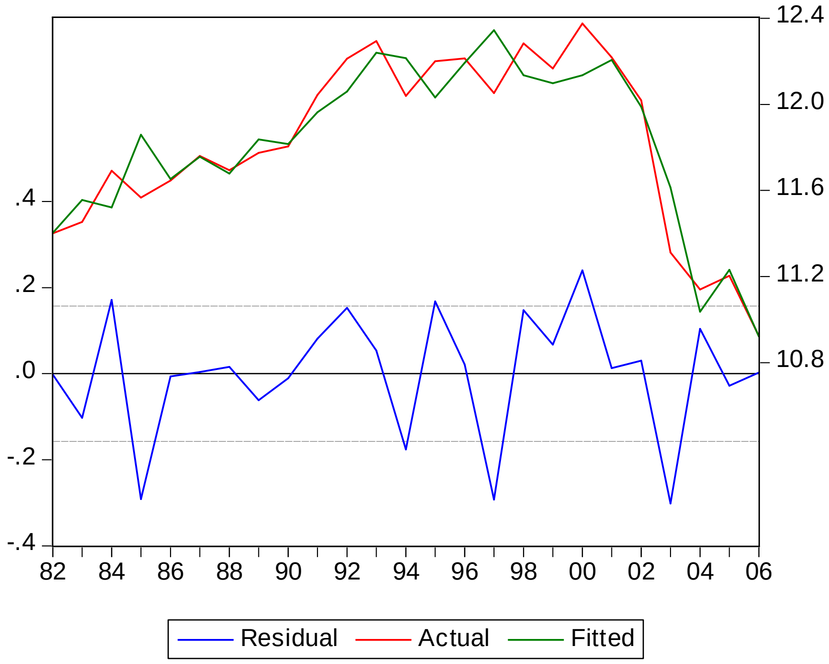
**** indicates significance at the 5 percent level*

*** indicates significance at the 10 percent level*

** indicates significance at the 15 percent level*

Figure 1 shows the goodness of fit of the model to the actual data and also shows the residuals of the specification.

Figure 1: Fitted and Actual Model and Residuals



ADF stationaroity tests were performed on all variables in the specification to find out if they had unit roots. All variables were found to have unit roots and integrated I (1) except for LNPRICE_1 AND LNCOSTINDEX which were integrated I(2).

Table 2: ADF Unit Root Test Results

Series LNQ	Model	ADF Lags	ADF τ_τ τ_μ τ	ADF ϕ_3 ϕ_1
First difference	Trend and intercept	0	-5.201563***	13.52872***
	Intercept	0	-4.180548***	17.47698***
	None	0	-4.263192***	
Series LnCOSTINDEX	Model	ADF Lags	ADF τ_τ τ_μ τ	ADF ϕ_3 ϕ_1
Second difference	Trend and intercept	1	-6,564***	17.924***
	Intercept	4	1.635	13.569
	None	4	-2.258**	
Series LnPrice_M	Model	ADF Lags	ADF τ_τ τ_μ τ	ADF ϕ_3 ϕ_1
First difference	Trend and intercept	5	-3.356*	13.326***
	Intercept	5	-2.15	10.52
	None	5	-1.751*	
Series LNPrice_1	Model	ADF Lags	ADF τ_τ τ_μ τ	ADF ϕ_3 ϕ_1
Second difference	Trend and intercept	2	-4.929***	25.325***
	Intercept	0	-8.510***	72.426***
	None		-8.580***	

* Statistically significant at 10% level ** Statistically significant at 5% level

*** Statistically significant at 1% level

Engle-Granger cointegration test was performed on the residuals of the supply model specified in order to find out if the residuals were stationary. The t-statistic of -6.187 was significant at the 1% level. Therefore the null hypothesis that the residuals have a unit root was rejected and thus cointegration was achieved. Table 3 shows the results of the Engle-Granger cointegration test.

Table 3. Engle-Granger Test Results

t-statistic (τ)	Critical values derived from Mackinnon tables		
	10% C(10)	5% C(5)	1% C(1)
-6.817	-4.56699	-4.998	-5.90396

Source: Author's calculations

ECM Estimation Results:

Given the long run model specified, the ECM was formulated as follows:

$$\Delta LNQ_t = C + \beta_1 \Delta LNQ_{t-1} + \beta_2 \Delta(\Delta LNPRICE_{t-1}) + \beta_3 \Delta LNPRICE\_M_{t-1} + \beta_4 \Delta(\Delta LNCOSTINDEX_{t-1}) + \Delta Resid\_{}_{t-1} + v_t$$

The parameter estimations for the ECM formulation are shown in table 4.

Table 4: ECM Estimation Results

ECM Independent Variables	**Parameter Estimates**
$Resid\_{t-1}$	-1.262 (-3.739)***
ΔLnQ_{t-1}	0.739 (3.188)***
$\Delta(\Delta LnPRICE_{t-1})$	0.173 (-1.743)*
$\Delta LnPRICE\_M_{t-1}$	-0.24 (-2.045)*
$\Delta(\Delta LnCOSTINDEX)$	-0.396 (4.323)***
R-Squared	0.639
Durbin-Watson (d-statistic)	1.859

Source: Author's calculations

All the variables in the ECM specification were significant. The sign of the error correction model was negative as expected. Own price elasticity coefficient was positive while the coefficients for the competing crop and the production cost were negative which is consistent with economic theory. Thus in the short run, a 10% increase in the price of tobacco would lead to a 1.73% increase in tobacco supply which indicates that flue cured tobacco supply is inelastic in the short-run.

Table 5: Flue-cured Tobacco Supply Elasticity for Zimbabwe 1980-2006

	Elasticity
Short-run Elasticity	0.173
Long-run Elasticity	0.405

Source: Author's calculations

5. Conclusion

The estimated elasticities in this study for both the short –run and long run are low indicating that flue-cured tobacco supply is not responsive to price changes both in the short-run and in the long run. These findings, although lower, are consistent with other studies on tobacco in Zimbabwe, for example Townsend and Thritle (1997) found elasticities of 0.28 and 1.36 for the short-run and long-run respectively. Leaver (2000) found elasticities of 0.34 and 0.81 for the short-run and long-run respectively. The structural changes that have taken place in Zimbabwe's agriculture since 2000 may have also had an impact on the estimated supply. Also other shocks to the macro-economy such as hyper inflation and an over-valued exchange rate may account for the anomalies in elasticities.

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APPENDIX 1

REGRESSION OUTPUTS

Dependent Variable: LNQ
Method: Least Squares
Date: 02/01/11 Time: 22:41
Sample (adjusted): 1982 2006
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLAG_Q	0.698401	0.092026	7.589207	0.0000
LNPRICE_1	0.404654	0.128560	3.147579	0.0051
LNLAGPRICE_M	-0.225492	0.129401	-1.742587	0.0968
LNCOSTINDEX	-0.366315	0.106173	-3.450185	0.0025
C	6.138560	1.547594	3.966517	0.0008

R-squared	0.876830	Mean dependent var	11.81964
Adjusted R-squared	0.852196	S.D. dependent var	0.409068
S.E. of regression	0.157267	Akaike info criterion	-0.684884
Sum squared resid	0.494660	Schwarz criterion	-0.441109
Log likelihood	13.56105	Hannan-Quinn criter.	-0.617271
F-statistic	35.59440	Durbin-Watson stat	2.584881
Prob(F-statistic)	0.000000		

Dependent Variable: D(LNQ)
Method: Least Squares
Date: 02/02/11 Time: 14:31
Sample (adjusted): 1983 2006
Included observations: 24 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID_Q(-1)	-1.261942	0.337514	-3.738938	0.0014
D(LNLAG_Q)	0.739127	0.231847	3.187993	0.0048
D(D(LNPRICE_1))	0.172952	0.087799	1.969869	0.0636
D(D(LNCOSTINDEX))	-0.395648	0.091525	-4.322863	0.0004
D(LNLAGPRICE_M)	-0.240456	0.117575	-2.045133	0.0549

R-squared	0.638591	Mean dependent var	-0.019883
Adjusted R-squared	0.562505	S.D. dependent var	0.217891
S.E. of regression	0.144120	Akaike info criterion	-0.853284
Sum squared resid	0.394643	Schwarz criterion	-0.607856
Log likelihood	15.23940	Hannan-Quinn criter.	-0.788172
Durbin-Watson stat	1.859246		