PRODUCTION INCENTIVES FOR SMALL SCALE FARMERS IN ZIMBABWE : THE CASE OF COTTON AND MAIZE

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The paper presents an empirical investigation of the production response of small scale producers of maize and cotton for communal agriculture in Zimbabwe. The error correction model, which employs the concept of cointegration to avoid spurious regressions, is used in the analysis. The factors affecting maize output were the price of maize relative to seed, the number of marketing depots established in the communal areas and the number of loans provided to these farmers. The factors affecting cotton output were the increase in communal lands due to the resettlement program, the number of loans extended to small scale farmers and the price of cotton relative to seed. The weather played the most significant role in determining the quantity of maize sold.

PRODUKSIE-INSENTIEWE VIR KLEINSKAALSE BOERE IN ZIMBABWE : DIE GEVAL VAN KATOEN EN MIELIES

Die artikel behels 'n empiriese ondersoek na die produksierespons van kleinskaalse produsente van mielies en koring in kommunale landbou in Zimbabwe. Die foutkorreksiemodel wat die konsep van ko-integrasie gebruik om valse regressies te vermy is in die analise gebruik. Die bepalende faktore van mieli[produksie was die prys van mielies relatief tot saad, die getal bemarkingsdepots gevestig in die kommunale gebiede en die getal lenings wat aan hierdie boere toegestaan is. Die faktore wat katoenproduksie beïnvloed het was die toename in kommunale grond weens die hervestigingsprogram, die getal lenings toegestaan aan kleinskaalse boere en die prys van katoen relatief tot saad. Weersomstandighede het die mees betekenisvolle rol gespeel in die bepaling van die hoeveelheid mielies verkoop.

1.   INTRODUCTION

Agricultural policy incentives in Zimbabwe were biased against small scale producers prior to 1980 with discrimination in land allocation, marketing and service institutions, pricing policies and the provision of technology. Incentives were targeted towards the large scale, highly mechanised farms that enjoyed excellent support services and favourable price policies, which together with the capacity of commercial farmers to utilise advanced technology, resulted in

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extreme levels of inequality. This is most noticeable in the highly skewed distribution of land in terms of both quantity and quality. 4,500 large scale commercial farmers own 11 million hectares of good quality land using relatively capital intensive technologies and producing over 70 percent of agricultural output in most years. The communal, or smallholder farms include 1 million households on over 16 million hectares of communally-owned land; 52,000 households on 3.3 million hectares of resettled land and 8,650 privately owned, medium-sized farms on 1.2 million hectares (Muir, 1994). The percentage of communal lands in the best three production regions is 28 percent while for the commercial sector the percentage is 53. Similarly 72 percent of the communal lands are in the two worst regions, while 47 percent of the commercial land are in these regions (Muir, 1994 and Mehretu, 1994).

After independence in 1980 the government tried to balance the redistribution of income with the need to maintain the productive capacity of the agriculturally based economy. This was reaffirmed by public statements like 'meaningful development must place the agricultural sector in the centre of the development strategy' (First Five Year Plan, Republic of Zimbabwe, 1986). Specific focus was given to redressing the past imbalances in access to public services and infrastructure, and the promotion of productivity of existing small scale producers.

Following these objectives there has been substantial investment in the rural infrastructure, accompanied by major institutional changes, with the restructuring of credit, extension, research and marketing institutions to service communal farmers. The investment in infrastructure is particularly noticeable in grain marketing, in 1980 there were only three grain marketing depots in the communal lands and by 1985 ten more had been built. In addition, 55 buying points were set up within the same period. Besides providing closer market outlets, the expansion of the Grain Marketing Board (GMB) infrastructure into smallholder areas was designed to stimulate farm technology adoption by providing the means for government to implement its agricultural credit program. The number of cotton marketing depots rose from 5 to 16 by 1985 (Rukuni, 1994). The Agricultural Finance Corporation (AFC), which previously provided credit only to large scale commercial farmers started expanding smallholder credit which was partly responsible for the 45 percent increase in fertilizer purchased by these farmers between 1981 and 1985 (Rukuni, 1994). On-farm research was introduced, surveying communal lands and introducing new research programmes. Although no resounding new technology has resulted, the greatest achievement of those new efforts is probably in the growing relationship between smallholder farmers and researchers (Rukuni, 1994).

Since independence, with improved services, maize and cotton production in the communal sector has increased significantly. In 1979/1980 the communal sector accounted for 7.6 percent of the maize marketed through the Grain Marketing Board and by 1991 it accounted for 60 percent (Mashingaidze 1994). Similarly for cotton it accounted for 20 percent of national seed cotton production in 1979/80 and by 1989 the sector accounted for 62 percent of the national production.

Some of the investments in infrastructure and credit facilities proved to be unsustainable. Price incentives diminished with a decline in real producer prices as marketing systems were decontrolled, aligning prices to market forces (Takavarasha, 1993). The provision of services to the communal sector declined in the later 1980's when the costs of the system rose substantially. For example, the number of depots for supplying agricultural inputs and purchasing outputs grew from 11 in 1980 to 105 in 1985 and then fell to 46 in 1990. Similarly, the number of loans to communal farmers increased from 18 000 in 1979 to 77 526 in 1985 and then fell back to 30 190 in 1990 (Jayne & Rukuni, 1993). Loan default by communal farmers increased considerably and the AFC became more selective.

This article focuses on measuring the effects of these investments on the production levels of small scale farmers, examining specifically the effects on cotton and maize. The next section gives a brief description of productivity growth in the communal sector. Section three suggests a supply response framework with considerations given to cointegration and error correction models. This is followed by concluding remarks on the sustainability of growth and the potential of further developments.

2. PRODUCTIVITY GROWTH IN SMALL SCALE PRODUCTION

Total factor productivity (TFP) indices have been calculated for both the large scale and small scale farming sectors of Zimbabwe by Thirtle *et al.* (1993) and Atkins & Thirtle (1995). The productivity results are summarised as annual average growth rates in Table 1.

The growth rate of input use in the small scale sector remains relatively constant until 1985, at about 5 percent, after which it falls to 3 percent for 1985-1990. Over the full sample period aggregate output grew at 7.32 percent per annum. The clear contrast of the annual growth rate of 4.4 percent prior to independence and 13.63 percent after independence is an indication of the changing focus of government. However, the 1985 output level was only again exceeded in 1988 and 1990.

Table 1:   Productivity growth rates of the communal farming sector

Annual Growth Rates of Productivity Indices, percent					
Year	Inputs	Outputs	TFP	Labour Productivity	Land Productivity
Small scale sector					
1975-90	5.49	7.32	1.73	3.73	4.54
1975-80	5.06	4.40	-0.81	1.55	3.71
1980-85	5.21	13.63	8.14	9.50	9.16
1985-90	2.96	0.25	-2.67	-2.73	-1.67

Source: Atkins and Thirtle (1995).

The 1975-90 growth rate is slightly greater than the sub-period rates due to the different methods of calculation used. The exponential growth rate was used for 1975-90 while the geometric growth rate was used for the other sub-samples (Atkins & Thirtle, 1995).

The TFP index is the ratio of the output index to the input index (not the ratio of the growth rates). Table 1 shows the growth rate of outputs to be larger than that of inputs thus yielding a positive TFP. The average growth rate was 1.73 percent per annum for the full period, but was negative before independence and reached an impressive 8.14 percent afterwards. The results in the table show a negative TFP growth rate after 1985 where inputs grew at a faster rate than outputs. Labour and land productivity growth follow much the same pattern as TFP, because these two inputs account for a minimum of 58 percent of total costs in 1984 and a maximum of 88 percent in 1975 and 1990. Since both land and labour grew more slowly than the intermediate inputs, these partial indices have higher growth rates than does TFP.

Hybrid maize seed adoption and fertiliser use in the communal sector is frequently cited as the main cause of agricultural growth (Mashingaidze, 1994). Hybrid seed sales to the smallholder sector increased roughly fivefold between 1979 and 1985, so that by 1986 approximately 85 percent of the smallholder maize area was planted with hybrid seed (Rohrbach, 1987). The output performance from 1980-85 was remarkable, even allowing for the recovery from the low base at the end of the war, and in part reflects the success of the government's policies for agriculture in the communal lands. The increase in communal maize production in the first two years of independence resulted from the expansion in the area under maize because of the return of the war refugees and war returnees to their original communal homes. This resulted in a

significant increase in the number of cultivators and the land under cultivation. Thus, maize area doubled between 1979/80 and 1981/82 (Rohrbach, 1987).

3.   SUPPLY RESPONSE OF SMALL SCALE PRODUCERS

The response of small scale farmers to changing infrastructure, credit services and prices can be analysed within a supply response framework, which has long been one of the most fruitful approaches to determining the effects of policy on agricultural output. The common approach used to account for the dynamic adjustments in supply are the partial adjustment and adaptive expectations model which are both nested in the Nerlove (1958) model. More recently the error correction model has gained in popularity which allows for testing of the validity of the more restrictive partial adjustment model. Before estimating these models the time series properties of these variables needs to be established. As most agricultural variables experience a trend over time a regression of the level of these variables may produce significant results with a high R^2 value when indeed no relationship exists.

The main food crop in the Zimbabwean agricultural sector is maize which is grown both extensively in the commercial and communal sectors and has been the staple diet of the rural population for many years. The marketing of maize, over the sample period 1975-1990, was carried out under strict government control through the GMB and the producer price was set by the government. This is normally announced after planting. All cotton produced in Zimbabwe was sold through the Cotton Marketing Board, with the producer price set by the government and is normally announced after planting. There have been a number of years where a pre-planting price was announced.

Maize production in the communal sector was decomposed into the quantity (tons) of maize consumed and maize sold to the GMB. The competing crop for maize was taken to be cotton with the inputs being fertilizer and seed. Other variables included to explain maize production were the number of marketing depots in the communal sector, the volume of loans to communal farmers, the increased land through resettlement programmes, the population of the communal areas, research and extension expenditures and the amount of rainfall, to capture the effects of weather. The factors that appear to have contributed to the post-independence maize production revolution in the communal lands, as discussed in the previous section, are the growth in area planted to maize, increased maize yields and increase support services.

Similarly, for cotton the output used in the analysis was the tons of cotton sold to the Cotton Marketing Board. The competing crop for cotton was taken to be

maize. The other variables included were the own price of cotton, volume of loans to the communal farmers, the increased land made available through resettlement programmes and a weather variable. Labour availability or cost could also affect the amount of cotton produced. This was not included in the analysis due to the lack of availability of a consistent series for the variable. The area under cotton in communal lands increased steadily from 32 400 hectares in 1980 (29 percent of the total) to a peak of 205 607 hectares in 1988 and declined to 187 383 hectares in 1990 (80 percent of the total). This was partly attributed to the resettlement programme which settled 51 000 families on 3.2 million hectares in the 1980's.

Seed cotton yields declined in communal lands from 1.1 tonnes per hectare in 1980 to 0.7 tonnes per hectare in 1990, irrespective of season quality. These low yields can be attributed to low levels of inputs, late planting due to late delivery of inputs, poor management and poor growing in terms of soils and rainfall. The marked increase in seed cotton production in the communal lands in the 1980's was primarily the result of an increase in area under cultivation, not higher yields (Mariga, 1994).

The principle sources of the data used were the Zimbabwe Agricultural Marketing Authority, the Central Statistics Office (CSO), the FAO Fertiliser Yearbooks, the Zimbabwe Tobacco Association, and Thirtle *et al* (1993), who derived a production data set from the CSO Production Accounts of Agriculture, Forestry and Fisheries, various University of Zimbabwe working papers, the Statistical Yearbook of Zimbabwe 1987, and various published and unpublished papers from the Ministry of Agriculture, Lands and Rural Resettlement.

4. TIME SERIES ANALYSIS OF THE DATA

Cointegration has become popular in the empirical literature for determining long-run relationships between variables. This approach avoids the well know 'nonsense' (Yule, 1926) or 'spurious regressions' (Granger & Newbold, 1987) that are common when using trended data. Prior to testing for cointegration between two variables the statistical properties of the series needs to be established. This constitutes testing for whether the variable contains a trend, a unit root or a drift. The approach used to determine this is the Augmented Dickey-Fuller test (1981) which can be represented as:

where Δy_t is the first difference of y (the variable under investigation). α allows

$$\Delta y_t = \alpha + \beta_t + (p-1)y_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta y_{t-i} + u_t \tag{1}$$

for a non zero intercept or drift component. *t* is included to allow for a deterministic trend as y_t may be trend stationary. The first three terms on the right hand side show the Dickey Fuller test format. The null hypothesis is that y_t has a unit root (H$_0$:ρ=1) against a stationary alternative (H$_a$:ρ<1). The Dickey-Fuller test is appropriate for series generated by an autoregressive process with one lag (AR(1) process). If however y_t follows an AR(p) process where p>1, the error term will be autocorrelated to compensate for the misspecification of the dynamic structure of y_t. Autocorrelated errors will invalidate the use of the distributions which are based on the assumption that u_t is white noise. The Augmented Dickey-Fuller (ADF) includes additional difference terms on the right hand side of the equation to account for this problem, *n* is large enough to make u_t white noise.

The order of integration of individual variables was determined in the manner explained above and the results reported in Table 2. The tests correspond to restrictions on equation (1) and t-values lower than the critical value accept the null hypothesis. Thus, we begin by examining the statistical properties of the series. Most of the variables are generated by a first order autoregressive, or AR(1), process, but total maize in the communal sector is AR(2), as is the real price of cotton and the communal land area.

Table 2:   Testing Procedure Using the DF/ADF Tests

Variables	AR(p)	Tests on the Levels of Variables				Test on the first difference	
		t_τ	$t_{\beta t}$	$t_{\alpha t}$	Φ_2*	Variables	t_τ
		(ρ-1)=0	β=0	α=0	(ρ-1)=β=α=0		(ρ-1)=0
Q_{MTt}	2	-1.93	-1.94	1.94	5.52	ΔQ_{MTt}	-4.93
Q_{MSt}	1	-2.57	2.01	2.68	3.85	ΔQ_{MSt}	-4.17
Q_{MCt}	1	-3.82	1.23	3.80	4.10	-	-
Q_{Ct}	2	-1.87	1.37	2.03	2.67	ΔQ_{Ct}	-3.60
P_{Ct}	1	-2.19	-0.79	2.13	2.28	ΔP_{Ct}	-4.93
P_{Mt}	1	-1.59	1.36	-1.80	2.79	ΔP_{Mt}	-3.44
Weather	1	-3.77	-0.53	3.72	7.10	-	-
Depots	1	-1.75	1.35	2.27	2.82	ΔDepots	-4.16
Loans	1	-0.09	-0.66	0.54	1.91	ΔLoans	-3.29
Land	2	-2.82	2.85	2.82	5.45	ΔLand	-3.15
Critical Values		**-3.08**	**2.85**	**3.20**	**5.68**		**-3.10**

*   In order to perform this test with an AR(1) variable an additional lagged difference term is included on the right had side of equation (1).

Q_{MTt} = Total maize output (tons), Q_{MSt}= Maize sold to the GMB, Q_{MCt} = Maize consumed per capita, Q_{Ct} = Cotton output (tons), P_{Ct} = Price (cotton/seed), P_{Mt} = price (maize/seed), Weather = rainfall, Depots = number of maize depots in the communal areas, Loans = number of loans to farmers, Land = communal land area.

For example, consider the series for commercial maize output, reported on the top row of Table 2. The t_τ, $t_{\beta t}$ and $t_{\alpha t}$ tests suggest that the null hypothesis cannot be rejected and thus these tests indicate no trend, no drift and a unit root (all the tests are absolute values). The Φ_2 tests was then performed to test for a unit root, no trend and no drift jointly. The value obtained of 5.52 is less than the critical value of 5.68 and thus we accept the null. These tests indicate that the maize output is a difference stationary series.

The final column in Table 2 shows the tests for a unit root using differenced variables. In first differences we reject the hypothesis of the presence of a unit root, so maize output is stationary in first differences, which can be described as being integrated of order one, which is denoted, I(1). The same procedure is used for all the variables in the Table. They were all found to be I(1), with no deterministic trends, except for the weather in the communal sectors and maize consumption per person in the communal sector, which were I(0). The I(0) series cannot explain the long run movements in the I(1) dependent variables, but they are retained because they can explain the perturbations around the long run equilibrium relationship. Since all the other series are stochastic and of the same order, they can be cointegrated, so we now proceed to test if the residuals in the estimating equations are I(0).

4.1   Single Equation Cointegration Tests

As most of the variables appear to be I(1) cointegration is established if a linear combination of them is I(0). The idea being that if there is a long run relationship between two variables then no matter how much they fluctuate over time the difference between the two series must remain relatively constant. The tests for cointegration are similar to those used to test for the order of integration, but they are based on the residuals. OLS ensures that the cointegrating regression will give residuals having the smallest possible sample variance, so the critical values must be adjusted. Some of these adjusted values are presented in Banerjee et al (1993), MacKinnon (1991) gives the most comprehensive set of critical values using response surfaces.

Table 3 reports the cointegration results for the communal lands. All the equations cointegrate according to the cointegrating regression Durbin Watson

Table 3: Communal sector cointegration results for cotton and maize

Dependent Variable	Constant	P_{Ct}	P_{Mt}	Loans	Depots	Land	Weather (I(0))	R^2	CRDW	DF
Q_{Ct}	-9.59 (-0.7)	0.92 (1.2)		0.64 (5.5)		1.65 (1.2)	-0.48 (-1.5)	0.93	1.79	-3.42 (-5.4)
Q_{MTt}	5.68 (4.1)		0.48 (1.2)	-	0.31 (3.9)	-	1.14 (5.0)	0.89	2.53	-5.02 (-4.9)
Q_{MSt}	-0.42 (-0.7)	-	1.11 (1.1)	0.38 (1.3)	0.52 (1.6)	-	1.34 (2.2)	0.93	2.26	-4.29 (-5.5)
Q_{MCt}[*]	-8.84 (-5.5)	-	-	-	-	-	1.17 (4.8)	0.63	2.46	-6.14 (-4.4)

[*] Maize consumption per capita. The critical value for the CRDW test is 1.01.

test (CRDW) which was proposed by Sargan and Bargava (1983) but only two cointegrate according to the DF and ADF test. The CRDW indicates that cotton output, the relative price of cotton to seed, the volume of loans and the amount of land in the communal sector are cointegrated. Total maize output, the real price of maize, the number of maize depots and the amount of rainfall are cointegrated. The quantity of maize sold to the GMB, (Q_{MSt}), the real price of maize, the number of depots and the volume of loans to the small scale farmers are cointegrated. Finally the total maize consumed (Q_{MCt}) and the weather are cointegrated, but the total maize consumed and the weather are both stationary variables.

A disadvantage of the OLS approach is that in the multivariate case, there may be more than one cointegrating vector. Thus, in the OLS approach there is no guarantee that a unique cointegrating vector has been estimated. Thus, the DF and ADF tests have been superseded by the Johansen Maximum Likelihood estimation method (Johansen 1988, Johansen and Juselius 1990).

4.2   Multiple Equation Result

This approach allows the estimation of all the cointegrating relationships and constructs a range of statistical tests to test hypotheses about how many cointegrating vectors there are and how they work in the system. Estimation of the number of cointegrating vectors is important as under or over estimation has potentially serious consequences for estimation and inference. Under estimation implies the omission of empirically relevant error-correction terms and overestimation implies that the distribution of statistics will be non-standard.

Johansen (1988) proposed a general framework for considering the possibility of multiple cointegrating vectors and this framework also allows questions of causality and general hypothesis tests to be carried out in a more satisfactory way. The procedure begins by defining a vector autoregression (VAR) of a set of variables *X*,

$$X_t = \pi_1 X_{t-1} + \ldots + - \pi_k X_{t-k} + e_t \qquad t = 1, \ldots, t \qquad (2)$$

Suppose there are four variables in the model: then this becomes a four-dimensional k-th order vector autoregression model with Guassian errors. X_t is a vector of all relevant variables and *k* is large enough to make the error term white noise. The length of the lag can be determined by the Akaike Information Criteria (AIC) or the Schwarz Criteria (SC). In this form the model is based on

minimal behavioural assumptions on the economic phenomenon of interest. This then allows for a maximum likelihood analysis if we assume Gaussian errors. The VAR model can be reparameterized in error correction form (Cuthbertson *et al*. 1991), as:

$$\Delta x_t = \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + e_{t,} \quad t = 1,\ldots, T$$

where
$$\Gamma = [(I + \pi_1),(I + \pi_1 + \pi_2),\ldots,(I + \pi_1 + .. + \pi_k)]$$

$$\Pi = I - \pi_1 - \pi_2 - \ldots - \pi_k \tag{3}$$

I is the identity matrix. The Johansen testing procedure is a multivariate likelihood ratio test for an autoregressive process with independent Gaussian errors. The procedure involves the identification of rank of the matrix Π. The heart of the Johansen procedure is simply to decompose Π into two matrices α and β both which are *Nxr* such that:

$$\Pi = \alpha\beta \tag{4}$$

The rows of β may be defined as the r distinct cointegrating vectors (the cointegrating relationships between the four non-stationary variables) and the rows of α show how these cointegrating vectors are loaded into each equation in the system. The loading matrix therefore effectively determines the causality in the system. Johansen (1988) gives a maximum likelihood estimation technique for estimating both matrices and he outlines suitable tests which allow us to test the number of distinct cointegrating vectors which exist as well as to test hypothesis about the matrices. By testing β we may test parameter restrictions on the long-run properties of the data. By testing restrictions on the α-matrix the direction of causality within the model can be tested (Hall and Milne, 1994).

The Johansen results indicated that all the equations have one cointegrating vector. The Johansen model is a form of error correction model and where only one cointegrating vector exists it can be interpreted as an estimate of the long-run cointegrating relationships between the variables concerned (Hallam & Zanoli, 1993). Thus, the estimated parameter values from these equations are the long run coefficients. The Johansen normalised estimates for communal cotton production are:

$$Q_c = 0.89 \, P_c + 0.25 Loans + 3.79 Land - 44.2 \tag{5}$$

for communal maize production (total) they are:

$$Q_{Mt} = 1.01 P_{Mt} + 0.17 Depots + 0.63 \tag{6}$$

and for communal maize sold:

$$Q_{ms} = 1.86 P_{ms} + 0.41 Depots + 0.88 Loans - 7.96 \tag{7}$$

These results suggest that there are non-spurious supply relationships for all the equations, so we now proceed to the error correction model (ECM). If the variables are cointegrated the variables are a valid representation of the data (Engle and Granger, 1987).

4.3   Error Correction Model

Using the variables listed above, the ECM for communal maize is:

$$\Delta Q_{Mt} = \phi_1 + \sum_{i=1}^{1} \phi_{2i} \Delta P_{Mt-i} + \sum_{i=1}^{n} \Delta \phi_{3i} DEPOTS_{t-i} = \phi_4 W +$$
$$\alpha (Q_{Mt-1} - \beta_M P_{Mt-1} - \beta_T DEPOTS_{t-1} \tag{8}$$

The right hand side difference terms can be lagged a number of times, where the length of the lag is determined by the t-test. The ϕ_{ni}'s capture the short run effect on the dependent variable of the changes in the independent variables, while the β's account for the long-run equilibrium.

This model did not perform well with the limited number of observations available. In order to reduce the number of variables to be estimated, and increase the degrees of freedom, the reduced form of the error correction model can be estimated. The residual term from the Johansen cointegrating regression in equation (6) can be used to represent the bracketed terms in equation (8). The equation can now be estimated in the form:

$$\Delta Q_{Mt} = \phi_1 + \sum_{i=1}^{1} \phi_{2i} \Delta P_{mt-i} + \sum_{i=1}^{n} \Delta \phi_{3i} DEPOTS_{t-i} + \phi_4 W + \alpha EC_{t-1} \tag{9}$$

This method only provides estimates for the short-run elasticities (the coefficients on the difference terms).

The results reported in Table 4 are from models chosen on the criteria of goodness of fit (variance dominance), data coherence, parsimony of parameters and consistency with theory (Hendry & Richard 1982). Even though the goodness of fit for the cotton equation is poor the other diagnostic tests indicate

that the model is adequate. The DW statistic indicated no residual serial correlation and further investigation using the Lagrange multiplier test for first and second order serial correlation confirm this result. The RESET test for functional form rejects mis-specification for all four models. The Jarque-Bera test shows that the residuals are all normally distributed and heteroscedasticity is suspected only in the cotton output equation.

Table 4:　　Communal Sector Maize and Cotton Supply: ECM Estimates

Regressors	Coefficients for Cotton		Coefficients for Maize				
			Total Maize		Maize sold		Maize consumed
	Short run	Long run	Short run	Long run	Short run	Long run	
Constant	-	-44.2	-	-	-	-7.96	-8.84 (-5.5)
ΔPC_t	0.83 (1.4)	0.86	-	-	-	-	-
ΔPM_t	-	-	0.78 (1.9)	1.01	-	1.86	-
$\Delta Loans_t$	0.57 (2.0)	0.24	-	-	0.31 (1.4)	0.88	-
$\Delta Depots_t$	-	-	0.27 (1.5)	0.17	0.30 (1.3)	0.41	-
$\Delta Land_t$	-	3.79	-	-	-	-	-
Weather	0.10 (1.0)	-	1.52 (4.3)	-	2.00 (7.0)	-	1.17 (4.8)
EC_{t-1}	-0.72 (-1.6)	-	-0.68 (-4.4)	-	-0.84 (-6.9)	-	-
Test Statistics							
R^2	0.36	-	0.84	-	0.86	-	0.63
DW	2.2	-	2.20	-	2.01	-	2.46
Lagrange Multiplier	0.44		0.13	-	0.08	-	1.26
RESET	0.37	-	0.04	-	0.75	-	0.96
Jarque-Bera Test	2.13	-	0.36	-	1.15	-	0.69
Heteroscedasticity	4.05	-	0.13	-	0.02	-	1.91
WALD Test	7.66	-	5.51	-	3.83	-	-

The results suggest that cotton production in the communal areas is dependent on the price of cotton relative to seed, the amount of loans granted, and the land area in the communal areas. A 1 percent increase in the price of cotton relative to the price of seeds will result in a 0.83 percent increase in area grown to cotton output in the short run and 0.86 percent in the long run. A 1 percent increase in the amount of loans granted will increase cotton output by 0.57 percent in the short run and 0.24 percent in the long run. Weather also has a significant effect, suggesting that the droughts had a crucial effect on the output of cotton. Land area seems to have had the greatest long run effect, as was noted by Mariga (1994), with a 1 percent increase in land area resulting in a 3.79 percent increase in cotton production. The land resettlement schemes mainly lie in natural region

II, IV and V where cotton is the only dependable cash crop. Furthermore, it appears that the output increase was not due to a significant increase in yields, but to an increase in area planted. The short run price response is almost the same as the long run response. The response to loan facilities is also significant, showing that credit affects supply response.

The maize production analysis was decomposed into total maize production, maize sold to the GMB, and maize consumed. Total maize production was dependent on the price of maize relative to the price of seed, the number of maize depots and the amount of rainfall. Maize sold was dependent on the number of maize depots, the number of loans granted, the relative price of maize to seed and the amount of rainfall. The amount of maize consumed per person depended only on the amount of rainfall. The total maize output equation suggests that a 1 percent increase in the relative price of maize and the number of loans will increase production by 0.78 percent and 0.27 percent respectively in the short run and 1.01 percent and 0.17 percent in the long run, respectively. Clearly rainfall has a significant positive effect for all maize output.

In the maize sold equation, the relative price of maize is insignificant in the short run, although a 1 percent increase in the maize price suggests a 1.86 percent increase in the maize sold in the long term. A 1 percent rise in the number of marketing depots, and an increase in the number of loans granted, results in an increase in the amount of maize sold by 0.31 percent and 0.30 percent respectively in the short run and 0.88 percent and 0.41 percent in the long run. Thus, both credit and the development of a modern infrastructure matter. Again, rainfall has a large significant effect on the amount of maize sold, with a 1 percent increase in rainfall resulting in a 2 percent rise in sales.

Finally maize consumed per person is a function of the weather, with a 1 percent increase in the amount of rainfall increasing consumption per person by 1.17 percent. However, both of these variables are stationary, implying that an ECM is not necessary.

These results suggest the importance of both the rural infrastructure and credit facilities in maize production. The growth in output can be attributed to both a growth in the area planted as well as an increase in yields, confirming the contribution of new and established farmers. The speed of adjustment towards the long run equilibrium levels is faster for maize (0.84 in the first year) than for cotton (0.73 in the first year) which probably reflects the additional time taken to gain technical and managerial knowledge in the more technical complex crop. The insignificance of the relative maize price on cotton output and the relative cotton price on maize output suggests that they are not substitutes in

production. Thus, encouraging farmers to increase cotton output will not directly decrease food production, since the two crops appear to be independent.

The error correction formulation of these models was tested against the more restrictive partial adjustment formulation, by imposing zero restrictions on the difference terms. The Wald test yielded a χ^2 of 7.66, 5.51 and 3.83 for cotton, total maize and maize sold respectively. These results are below the 5 percent critical values but above the critical values at the 10 percent confidence level, so it is not clear that the ECM is an improvement on the more restrictive partial adjustment model.

5.   CONCLUSION

The results suggest that small scale farmers can produce a significant output response given the right environment and can be a driving force in agricultural development. In good years small-scale farmers generate considerable maize surpluses, however these come almost entirely from wealthier smallholders in the higher rainfall areas of Regions II and III (Muir, 1994). These results show the communal farmers to be fairly responsive to output prices. However, the most significant factors influencing production response were infrastructure (the increased number of crop delivery points), the number of loans granted, the amount of land resettled and the weather. This indicates that the dis-investment in infrastructure and credit is likely to have an adverse effect on small scale production. Since there has been widespread adoption of hybrid seed, the high dependence of maize output on weather patterns suggests that research needs to be focused on the communal sector. Necessary considerations for this research are more drought tolerant hybrids, cultivars with high nitrogen efficiency and minimum tillage techniques in order to stabilise maize yields (Mashingaidze, 1994).

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