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Full Length Research Paper

An econometric approach to ascertain sorghum supply response in Zimbabwe

Munyati Vincent^{1*}, Mugabe Douglas², Chipunza Nyasha², Mafuse Never¹, Chagwiza Godfrey¹ and Musara Joseph

¹Department of Agricultural Economics, Education and Extension, Bindura University of Science Education, P. Bag 1020, Bindura, Zimbabwe.

²Department of Agricultural Economics and Development, Midlands State University P. Bag 9055, Gweru, Zimbabwe.

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Despite failures of government policy to stimulate sustained growth in sorghum production in the face of increased climatic shocks on maize, there have been very little efforts to understand sorghum response to policy incentives. The main purpose of the paper was to determine how sorghum farmers responded to changes in price and non-pricing policies. The major sources of the data were the ZIMSTAT, FAOSTAT, Meteorological department and the Ministry of Agriculture. The data on the area planted sorghum, capital expenditure and that of area of maize which was used as a substitute crop were obtained from Ministry of Agriculture. The data on price of sorghum, price of maize, exchange rate and inflation was obtained from ZIMSTAT. The data on the weather variable was obtained from the Meteorological Department. The international price of sorghum and maize were obtained from the FAOSTAT. The Consumer Price Index and inflation figures were obtained from the Reserve Bank of Zimbabwe (R.B.Z). The Nerlovian partial adjustment model was used to determine the responsiveness of sorghum farmers to price and non-price. It was found that sorghum supply is inelastic to own price both in the long run and short run. In the long run the own price elasticity was found to be 0.51 whilst in the short run was 0.24. This result means that agricultural price policy alone cannot guarantee sorghum production growth targets, but a policy mix that goes beyond factor and product markets and acknowledges the structural and institutional constraints faced by sorghum farmers is likely to achieve a substantial growth in sorghum output in both the short run and long run.

Key words: Econometric approach, sorghum supply response, Zimbabwe.

INTRODUCTION

In large parts of Africa, sorghum remains critically important for rural food security. Most of the output is consumed by the households producing the crop, and only a small proportion of harvests enter the commercial market. Since many sorghum-producing areas still experience periodic food deficits, production must be

increased in order to improve household food security. Sorghum area will continue to expand over the foreseeable future as climatic risk increase and rural populations expand and crop land is extended into drier and more fragile ecosystems. Average sorghum yields, which have been falling by 1.0% per annum since the

*Corresponding author. E-mail: vtmunyati@gmail.com

early 1980s, will need to grow in order for food production to keep pace with population growth.

The increase in the demand of small grains, particularly sorghum, is attributable to their growing importance in economies of both developed and developing countries. The growing importance of small grains is also a result of their adaptability to rainfall variability. With the advent of climate change, there has been increasing risks of crop failures due to frequent droughts and dry spells. As such there has been an enormous pressure among developing nations, particularly Sub-Saharan Africa whose majority of agriculture occurs under rain-fed conditions, to diversify into small grains that are less susceptible to moisture stress. Sorghum is therefore increasingly used as a substitute for maize in most parts of the region in order to reduce the problems of food insecurity.

It seems that the pricing and non-pricing policy are the major factors at the heart of Zimbabwe's sorghum activity stagnation in terms of output and these have contributed to the current starvation in the country. However, the return to grain marketing monopoly and price controls since 2000 has been a source of great concern to farmers. In light of these developments the pricing and non-pricing policy are the major factors contributing to Zimbabwe's sorghum activity stagnation in terms of output and these have contributed to the current starvation in the country. Policy makers need an applied understanding of how sorghum production responds to input and factor prices. This knowledge will enable them to meaningfully explore market and policy strategies to stimulate food and non-food production growth trends in the economy. Knowledge of elasticities of sorghum product supply and associated factor demand functions would improve precision of government policy makers to make better informed short run and long run planning decisions. The main objective of the paper is to determine the supply response of sorghum to different policy initiative by the government in-order to boost the production of sorghum in Zimbabwe.

METHODOLOGY

The data for the study was obtained from a number of sources. The major sources of the data were the ZIMSTAT, FAOSTAT, Meteorological department and the Ministry of Agriculture. The data on the area planted sorghum, capital expenditure and that of area of maize which was used as a substitute crop were obtained from Ministry of Agriculture. The data on price of sorghum, price of maize, exchange rate and inflation was obtained from ZIMSTAT. The data on the weather was obtained from the Meteorological Department. The international price of sorghum and maize were obtained from the FAOSTAT. The Consumer Price Index and inflation figures were obtained from the Reserve Bank of Zimbabwe (R.B.Z) publication. The CPI was used to deflate nominal prices and real prices which were used in the analysis. The analysis was conducted for the period 1980 to 2011 where more consistent data was readily available.

The Nerlovian model is a dynamic model, stating that area is a function of expected price, output adjustment, and some exogenous variables. The reduced form of the Nerlovian model is an autoregressive model because it includes lagged values of the dependent variable among its explanatory variables (Nkang et al., 2007).

Sadoulet and Janvry (1995) noted that a central problem in the estimation of supply response equation is that producers respond to expected as opposed to actual prices. In addition, they argued that the observed quantities may differ from the desired ones because of adjustment lags in the reallocation of variable factors.

$$Y_t - Y_{t-1} = \beta(Y_t^* - Y_{t-1}) \tag{1}$$

Thus

$$Y_t = \beta Y_t^* + (1-\beta) Y_{t-1} \tag{2}$$

Since farmers base their production plans on expected prices, the change in price expectation is specified as some proportion of the error made in formulating expectations in last year (Nkang et al., 2007; De Janvry and Sadoulet, 1995).

$$P_t^* - P_{t-1}^* = \delta (P_t - P_{t-1}^*) \tag{3}$$

Therefore

$$P_t^* = \delta P_t + (1-\delta) P_{t-1}^* \tag{4}$$

However, the desired output can be specified as a function of expected price and other exogenous variables which influence supply, hence (Nkang et al., 2007; De Janvry and Sadoulet, 1995):

$$Y_t^* = a_0 + a_1 P_t^* + a_2 Z_t + U_t \tag{5}$$

Since P_t^* is unobservable, we assume that farmers make their planting decisions based on their knowledge about prices that prevailed immediately in the preceding period that is ($P_t^* = P_{t-1}$). Hence, P_t^* is taken to be lagged price and when the other variables which affect supply response are included in Equation (5), we have

$$Y_t^* = a_0 + a_1 P_{t-1} + a_2 PA_{t-1} + a_3 ER + a_4 CE_{t-1} + a_5 \pi_{t-1} + a_6 W_t + a_7 D + a_8 T + U_t \tag{6}$$

Substituting Equation (6) into (2), the following estimation equation is obtained (Nkang et al., 2007; De Janvry and Sadoulet, 1995):

$$Y_t = a_0\beta + a_1\beta P_{t-1} + a_2\beta PA_{t-1} + a_3\beta ER + a_4\beta CE_{t-1} + a_5\beta \pi_{t-1} + a_6\beta W_t + a_7\beta D + a_8\beta T + (1-\beta)Y_{t-1} + e_t \dots \tag{7}$$

So that the reduced form of Equation (7) becomes the following equation which in the Nerlovian supply response function (Nkang et al., 2007; De Janvry and Sadoulet 1995):

$$\ln(Y_t) = b_0 + b_1 \ln(P_{t-1}) + b_2 \ln(PA_{t-1}) + b_3 \ln(ER) + b_4 \ln(CE_{t-1}) + b_5 \ln(\pi_{t-1}) + b_6 \ln(W_t) + b_7 D + b_8 T + b_9 \ln(Y_{t-1}) + \epsilon + \dots \tag{8}$$

Y_t = Actual hectareage of sorghum in year t; P_{t-1} = Lagged price of sorghum in year t; PA_{t-1} = lagged price of maize in year t; ER = Real exchange rate; CE_{t-1} = Government capital expenditure on agriculture lagged one year; π_{t-1} = Rate of inflation lagged one year; W_t = Weather variable (rainfall used as a proxy); D = SAP

Table 1. Factors affecting sorghum production in Zimbabwe.

Variable (area as the dependent variable)	Aggregate famers (whole sector)	Communal farmers	Commercial famers
Real price of sorghum(t-1)	0.24(1.01)*	0.38(0.94)*	0.46(1.95)**
Real price of maize(t-1)	-0.93(-4.79)***	-0.27(0.67)*	-0.29(-1.16)*
International price (t-1)	0.39(2.03)**	-1.2(-2.85)**	0.40(1.32)*
Exchange rate(t-1)	-0.2(3.22)***	0.11(0.87)*	0.18(2.41)***
Inflation rate(t-1)	-0.95(-1.02)*	-0.45(-2.41)**	-0.32(-2.72)***
Weather(rainfall as proxy)(t-1)	-0.65(-3.37)***	-0.50(-1.29)**	-0.47(2.17)***
Credit(agriculture) (t-1)	-0.52 (-3.72)***	0.34(1.41)**	-0.62(-2.99)***
Yields (Y_{t-1})(t-1)	0.12(0.58)	-0.307(-1.67)**	-0.323(-1.58)**
Area (A_{t-1})(t-1)	0.53(2.88)**	0.44(1.58)**	-0.29(-2.16)**
Structural adjustment program dummy	-0.67(-4.18)***	0.68(2.07)**	-0.47(-2.02)**
Constant	15.79(4.00)***	9.1(1.56)*	23.64(7.14)***
R-squared	0.9971	0.9652	0.88
Adjusted R-Squared	0.9947	0.9357	0.7833
Durbin Watson test	2.5	2.14	1.817

***Significant at 0.01 level; ** significant at 0.05 level; * significant at 0.1 level.

dummy – to capture government policy shifts; T = Trend variable- to capture technological changes; Y_{t-1} = Area planted previous year, and ϵ = Error term (satisfying the normal classical regression assumption).

The supply model chosen uses area as the dependent variable. This approach is particularly applicable to Zimbabwe where the extreme variability of yields due to the unreliability of rainfall means that farmers have limited control over actual output. Area planted is therefore used to indicate farmers planned output.

The area of the crop planted the previous year has been included on the basis of Nerlove's Partial adjustment model which states that the achieved agricultural output by a farmer in any one period is only a fraction of the desired change. This means that the adjustment of farmers' crop plans to a change in price is unlikely to take place in full in one year but will probably persist and be distributed over several years. Nerlove's partial adjustment model shows that the partial adjustment in any one period can be measured with observed output (or as in this case observed area planted A_t) are written as a function of lagged observed output (lagged observed area planted A_{t-1}) and other exogenous variables (Nerlove, 1971).

The producer price variable has been lagged one year because farmers do not usually know what the price for their crop will be at the time of planting. The assumption is that they base their price expectations on the previous year's price. There are other factors which play a role in price expectations but it was considered reasonable to assume that farmers are most influenced by the previous year's price.

In deciding how much of a crop to plant farmers also take into account the opportunity cost of producing that crop which means the price of alternative crops will influence their decisions. These prices have also been lagged a year on the assumption that the previous year's price is the indication for expected price.

Elasticities of supply response

Elasticities, rather than estimated structural coefficients, are more appropriate for purposes of any comparisons that can be made.

The short run and the long run elasticities were derived from the Nerlovian supply response model. Specifically the short run elasticities for the log form of the Nerlovian supply response function were taken as b_1 . Long-run elasticities are calculated as follows:

$$E_i = \frac{E^{sr}}{1 - \beta_1}, \quad (9)$$

E^{sr} = short-run elasticity and, β_1 is the coefficient for the lagged dependent variable (De Janvry and Sadoulet, 1995).

RESULTS AND DISCUSSION

The logarithmic form of the Nerlovian model was estimated using ordinary least squares. In this paper the supply response of commercial and smallholder sorghum farmers and aggregate supply response was estimated. The reason for choosing area was because it shows the decisions of farmers to plant more of the crop. It is a good indicator of farmers' response to policies, as farmers will decide how many hectares to plant sorghum given the policy environment.

From the results, it can be observed that the model fits the observed data fairly well as indicated by the R^2 values of 0.99, 0.96 and 0.88. The short run price elasticity of acreage response with respect to the lagged market price was computed as 0.24 (Table 1) for the whole sector of the sorghum enterprise. The coefficient of the deflated price in a paper by Alwan and El-Habbab was also found to be positive and the results are similar to that of the paper by Alwan and El-Habbab which were also positive. The sorghum sector is price inelastic to the changes in

the price of sorghum in the country. The farmers are not responding to changes in the market price of sorghum. The communal farmer's responsiveness to the changes in the market price of sorghum is 0.38 (Table 1). The communal farmers are price inelastic to changes in the market prices of sorghum. The communal farmers usually produce for home consumption and not for the market. The commercial farmers produce for the market, the commercial farmers responsiveness to changes in the market price of sorghum is 0.46 (Table 1). The short-run market price elasticity with respect to the lagged price variable is inelastic for the commercial farmers. Whenever there is an increase in the price of sorghum the increase in the area of sorghum will not be proportional to the increase in the price of sorghum.

The area of the area planted in the previous year was found positive and its value is 0.52 which is between zero and one showing that its inelastic and this was also similar to a research by Alwan and El-Habbab which were also positive. This means that the farmers are slow in changing the planted areas. It took more than one year to do this change (Alwan and El-Habbab, 2002).

If the exchange rate is overvalued this will reduce the amount of area allocated to sorghum in Zimbabwe. The coefficient for the exchange rate is -0.2 (Table 1). For every rise in the exchange rate by 10% the area allocated to sorghum in the country will reduce by 2%. In order to increase the amount of area allocated to sorghum the country should devalue the currency and this will increase the area allocated to sorghum in the country. If the currency is overvalued the sorghum exports from the country will be expensive relative to other sorghum producing countries in the region.

The sorghum sector is highly sensitive to the changes in the maize prices this is due to the fact that maize and sorghum are substitutes and they compete for land so an increase in the price of maize will led to farmers switching to the production of maize. Before farmers grow a crop they will look at the opportunity cost of growing that the crop. The cross price elasticity of sorghum is -0.93 (Table 1), this means that for every increase in the price of maize by 10%, the acreage of sorghum will reduce by 9.3%.

In view of the low responsiveness of aggregate sorghum supply to price and sorghum international price it should be noted that farming uses land which is fixed in the short term. The low aggregate supply response is attributable to lack of technical progress and the slow rate of mechanization of agriculture by sorghum farmers. This does not, however, mean that positive sorghum prices can be neglected for output growth (though undoubtedly they are essential); it means that less can be expected from changing the general sorghum price level alone. A package of changes may elicit a better response from farmers than a price change alone.

The elasticities of weather are all negative for both the

communal and commercial farmers. The coefficient of weather for the sorghum subsector is -0.65 (Table 1), this is attributed to the fact that sorghum is a drought resistant crop and whenever there is an increase in the mean annual rainfall this will result in farmers growing other crops which requires a lot of rainfall. The farmers will grow other crops and reduce the area under sorghum in the country. Whenever the country experience above normal rainfall most farmers will grow other crops and leave sorghum which is a drought resistant crop. Usually sorghum is grown in times of drought because of its character as a drought resistant crop.

Long run elasticities

Long-run elasticities are calculated as follows:

$$E_i = \frac{E^{sr}}{1 - \beta_1},$$

E^{sr} = short-run elasticity and, β_1 is the coefficient for the lagged dependent variable (De Janvry and Sadoulet, 1995).

The long run own price elasticity for the sorghum sector is 0.51 (Table 2). In the view of the low responsiveness of aggregate supply to price, it should be noted that agriculture uses land which is usually fixed both in the long term and short term and this is why the sorghum is inelastic to changes in the producer price of sorghum. For every rise in the producer price of sorghum by 10% (from Table 2) the area of sorghum will expand by 5.1% (Table 2) which shows that sorghum does not respond well to changes in own price. In a study by Nkang (2007) the long run price elasticity was also found out to be positive. The results are in line with previous studies on supply response which shows that if the price of an agriculture commodity increases the farmers are likely to respond to the changes in prices. If the price increases the acreage under the commodity will also increases.

In the long run the macro-economic variables a significant role in determining the level of production of most of agricultural commodities. A rise in the level of inflation will result in a reduction in the area of sorghum. This may due to the fact that inputs become relatively expensive and in the marketing side the personal disposable income is reduced and this will reduce the demand of traditional crops such as sorghum and consumers' will be buying basic commodities only.

Policy insights and implications of findings for policy

Agricultural price policy alone cannot guarantee sorghum production growth targets, but a policy mix that goes

Table 2. Long run elasticities.

Variable (Area as the dependent variable)	Aggregate famers
Real price of sorghum(t-1)	0.51
Real price of maize(t-1)	-1.98
Sorghum international price(t-1)	0.83
Exchange rate	-0.43
Inflation rate	-2.02
Weather (rainfall used as a proxy)	-1.38
Credit to the agricultural sector	-1.11
Yields(Y_{t-1})	0.26
Structural adjustment program dummy	-1.43

beyond factor and product markets and acknowledges the structural and institutional constraints faced by sorghum farmers is likely to achieve a substantial growth in sorghum output in both the short run and long run.

The most competitive niche for sorghum is in the rural market. Most semi-arid production zones where sorghum is widely grown are consistently net food importers. The immediate priority for improving the productivity of sorghum and its use must be to improve the food security of rural households. In most semi-arid parts of the country, major production gains will first serve to improve the level and stability of food consumption among rural households. Productivity gains must also be backed by improvements in grain storage and in increasing grain transfer directly from surplus to deficit households.

Efforts to promote sorghum production should not be based simply on desire for equity or concern about the welfare of those producing insufficient food. The development of the small grains food system should be viewed as a contribution to national economic growth. Policies and investment strategies should be designed to exploit the competitive advantages of these small grains-a basis for improving the productivity of the extensive semi-arid regions of the country and of their rural labour force. Gains to the economy will also accrue from improving rural food security, reducing the need for drought relief, lowering the level of subsidies underlying grain markets, and, at least in the short run, stemming migration from rural to urban areas.

Sorghum production is more sensitive to the rate of inflation in the country. Whenever there is a rise in the level of inflation this will result in the farmers reducing the area planted to sorghum. There is need for the country to implement policies that will reduce the level of inflation in the country because if the levels of inflation continue to increase this result in the country being food insufficient, leading to problems of food insecurity and the country will not be able to achieve some of the millennium goals of complete eradication of hunger.

Conclusion

The production of sorghum in the country was found to be more sensitive to the cross price elasticity of maize. Area under sorghum was also found to be sensitive to the producer price. An increase in the price of sorghum will result in more farmers growing the crop. The commercial farmers are responding to both price and non-price incentives more than the smallholder farmers in the country.

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