RESEARCH NOTE: AN ANALYSIS OF THE SUPPLY OF MAIZE IN SOUTH AFRICA

Johan van Zyl
Department of Agricultural Economics, University of Pretoria, Pretoria

Abstract

Regression analysis was used to determine the supply of maize in the major production areas of South Africa. The results show that prices of maize and its production substitutes do not play a major role in determining the annual area under maize. Other factors thus play an important role in the determination of crop varieties, what and how much to plant. These analyses largely confirm the results obtained by other researchers.

Uittreksel

'n Ontleding van die aanbod van mielies in Suid-Afrika

Regressie ontledings is gebruik om die aanbod van mielies in die belangrikste produksiegebiede in Suid-Afrika te bepaal. Die resultate toon dat pryse van mielies en moontlike produksiesubstitute nie 'n deurslaggewende rol in die bepaling van die jaarlikse oppervlakte onder mielies speel nie. Ander faktore speel dus 'n belangrike rol in die bepaling van gewaskeuse, en wat en hoeveel om te plant. Hierdie ontledings bevestig grootliks die resultate verkry deur ander navorsers.

1. Introduction

In a dynamic economic situation decisions about price, promotion, distribution and product policy must be formulated on a continuous basis. Sufficient knowledge regarding among others the different supply factors, is necessary for the formulation and maintenance of an efficient marketing strategy and meaningful policy options. Only then is there a sound basis for control, planning and forecasting.

Seen in the light of the nature and extent of marketing control in South Africa, it is however disturbing to know that very little research has been done to determine the local supply of agricultural products. Shepherd (1969) shows that supply is more difficult to quantify than demand and adds: *"Many variables have to be taken into account, and not all of them can be measured quantitatively - changes in price of various cost-items, in rents and interest, in technology, expectations and the like."*

Schultz (1956) accentuates the utility of supply studies as follows: *"Tell me what the supply of farm products will be five to ten years from now, and I will give you meaningful answers to the more important problems of agriculture."*

The study of supply of maize in the RSA is further complicated by a number of factors, among others:

- competition is not found in all the stadia from producer to final consumer; and
- unfavourable climate causes the quantity of maize supplied to vary, not as a spontaneous reaction to prices, but as result of circumstances largely beyond the control of the producer.

In spite of the above and other restrictions, regression analysis can be used to determine the supply of maize and to compare it with other results in this regard.

2. Theoretical considerations

The supply of a given product is a schedule which shows the quantity producers are willing to supply at a given place and time. This definition is bound by a number of *ceteris paribus* assumptions. Langley (1976) mentions the following as the most important problems experienced with supply studies based on time series data:

- Uncertainty in expectations;
- flexibility of fixed factors over time; and
- the measurement of the influence of weather.

With respect to the supply of agricultural products, Dahl and Hammond (1977) mention that the price in period t generates a different supply in period t+1 that will naturally bring about a different price so that: *"Price and quantity determination is a sequential process rather than a simultaneous process".* Ferber and Verdoorn (1967) show that there is no certainty how people react and add that: *"Estimating the effect of a distributed lag can be rather complicated because both the time-path of the reaction and the number of time units involved may still be unknown".* Nerlove (1956) is of the opinion that farmers do not react on prices in the previous year, but rather on expected future prices.

In this analysis the effect of prices in several previous years (P_{t-1}, P_{t-2}, ..., P_{t-6}) on the quantity supplied was tested.

Ferber and Verdoorn (1967) write in this regard: *"Assuming these lags exert casual effects on the dependent variable, this could be interpreted from a statistical point of view as including as many lagged variables as necessary to maximise the correlation between these variables and the dependent variable."* The same authors however warn that the interpretation of these results can be questioned in the sense that no theoretical foundation is advanced to justify the selection of a particular distributed lag.

3. Data sources and adaptations

All the data with respect to quantities and prices were obtained from the Directorate Agricultural Economic Trends and the Maize Board. All the price variables were deflated with the index for consumer prices. The time period selected stretches over a period of 20 years, namely from 1970 to 1989. Annual data were used. It can be assumed that the data used are qualitatively and quantitatively adequate for purposes of this analysis.

4. Models used

In this analysis of supply of maize time-series of a large number of variables were used in regression analysis by experimentation with different combinations. Such variables were however carefully selected in light of the available data and other theoretical and logical criteria that can have a influence on the supply of maize according to *a priori* expectations.

Several considerations were taken into account when evaluating the most successful fits. To eliminate the effect of unfavourable climate, the area planted to maize rather than actual output was used as measure of supply.

The following functional relationships between specific variables were hypothesised and tested:

$$TOM_t = f(PM_{t-1}, PGS_{t-1}, PK_{t-1}, PGB_{t-1,} BBI_t, T);$$
$$OMWT_t = f(PM_{t-1}, PGB_{t-1}, PSB_{t-1}, PSB_{t-1}, BBI_{t-1}, T);$$
$$OMNWV_t = f(PM_{t-1}, PK_{t-1}, PGB_{t-1}, BBI_t, T);$$
$$OMNOV_t = f(PM_{t-1}, PK_{t-1}, PSB_{t-1}, BBI_t, T); \text{ and}$$
$$OMTH_t = f(PM_{t-1}, PGS_{t-1}, PSB_{t-1}, BBI_t, T).$$

where:

TOM_t = Total area under maize in year t;
$OMWI_t$ = Area in the Western Transvaal in year t;
$OMNWV_t$ = Area in the North western OFS in year t;
$OMNOV_t$ = Area in the Eastern OFS in year t;
$OMTH_t$ = Area in the Transvaal Highveld in year t;
PM_{t-1} = Real net producer price of maize in year t-1;
PGS_{t-1} = Real net producer price of sorghum in year t-1;
PK_{t-1} = Real net producer price of wheat in year t-1;
PGB_{t-1} = Real net producer price of groundnuts in year t-1;
PSB_{t-1} = Real net producer price of sunflowers in year t-1;
BBI_t = Price index for farm requisites in year t; and
T = Time, with 1970 = 1, etc.

For the purposes of this study it was assumed that the different maize regions were represented by the following districts:

Western Transvaal:
Bloemhof, Christiana, Coligny, Delareyville, Klerksdorp, Koster, Lichtenburg, Potchefstroom, Schweizer-Reneke, Ventersdorp and Wolmaransstad.

North Western OFS:
Bultfontein, Bothaville, Hoopstad, Kroonstad, Theunissen, Viljoenskroon, Ventersburg and Wesselsbron.

Eastern OFS:
Frankfort, Lindley, Marquard, Reitz, Senekal, Bethlehem, Clocolan, Ficksburg, Fouriesburg and Ladybrand.

Transvaal Highveld:
Bethal, Delmas, Heidelberg, Nigel, Standerton and Balfour.

Actual data and logarithmic transformations were used in the different regressions. Several of the variables were also lagged with one or more years. The NWA-Statpack multiple regression package was used for solving the various demand equations (Northwest Analytical, 1982). Stepwise regression procedures, as well as traditional multiple regression procedures are possible with this package.

Selected fits are now discussed. The correlations between the independent variables in the selected fits are shown in Table 1.

Table 1 : Correlation between independent variables in the supply equations.

Variable	PM_{t-1}	PGS_{t-1}	PK_{t-1}	PGB_{t-1}	PSB_{t-1}	BBI_t	T
PM_{t-1}	1,000	0,113	0,213	-0,116	-0,073	0,327	0,326
PGS_{t-1}		1,000	-0,134	-0,086	-0,303	-0,372	0,030
PK_{t-1}			1,000	-0,028	0,196	0,236	0,032
PGB_{t-1}				1,000	0,723	-0,021	-0,308
PSB_{t-1}					1,000	0,131	-0,281
BBI_t						1,000	0,696

5. Empirical results

Only the results of selected fits are shown and discussed. Logarithmic fits gave the best results in each ease. The equations that follow thus refer to logarithmic transformed data. All these equations have the additional advantage that the elasticities of supply are constant and are presented by the coefficient of each variable in the equation.

5.1 Total supply of maize

No satisfactory fit was obtained where the total supply of maize (TOM_t) was used as dependent variable. This indicates that the area under maize is influenced by different factors in the different regions, and is also logically explainable in terms of the different production substitutes for maize found in the different regions. This makes it necessary to analyse the supply (or area) under maize for individual regions or homogenous areas. These selected fits are subsequently discussed.

5.2 Regional analyses

The selected fits are as follows (Student's t-values according to the one-sided probability of exceedance table : *** = 0,1%, ** = 1,0%, * = 5% and a = 10%. Significance of the F-values is indicated as follows: *** = 0,1%, ** = 1,0% and * = 5%):

Western Transvaal

$$OMWT_t = 7{,}418 + 0{,}072\,PM_t - 0{,}114\,PGB_{t-1} - 0{,}253T \qquad (1)$$
$$\qquad + 1{,}406^{a} \qquad - 2{,}25^{*} \qquad - 1{,}634^{a}$$
$$R^2 = 0{,}318 \qquad F = 6{,}239^{**} \qquad DW = 2{,}039$$

$$OMWT_t = 7{,}112 + 0{,}051\,PM_{t-1} - 0{,}194\,PSB_{t-1} - 0{,}294T \qquad (2)$$
$$\qquad + 1{,}366 \qquad - 1{,}627^{a} \qquad - 1{,}922^{*}$$
$$R^2 = 0{,}291 \qquad F = 4{,}674^{*} \qquad DW = 2{,}246$$

North Western OFS

$$OMNWV_t = 8{,}448 + 0{,}150PM_{t-1} - 0{,}509PK_{t-1} + 0{,}454BBI_t - 0{,}931T \qquad (3)$$

$$+ 1{,}871^{*} \quad - 1{,}533^{a} \quad + 1{,}487^{a} \quad - 1{,}674^{a}$$

$R^2 = 0{,}443$ $\quad F = 7{,}835^{***}$ $\quad DW = 2{,}077$

North Eastern OFS

$$OMNOV_t = 10{,}961 + 0{,}026PM_{t-1} - 0{,}602PK_{t-1} + 0{,}15PSB_{t-1} - 1{,}46T \qquad (4)$$

$$+ 1{,}365^{a} \quad 3{,}407^{**} \quad 1{,}424^{a} \quad 4{,}045^{*}$$

$R^2 = 0{,}689$ $\quad F = 9{,}467^{***}$ $\quad DW = 2{,}298$

Transvaal Highveld

$$OMTH_t = 12{,}565 + 0{,}136PM_{t-1} - 0{,}209PSB_{t-1} - 0{,}397BBI_t - 1{,}356T \qquad (5)$$

$$+1{,}461^{a} \quad - 1{,}787^{*} \quad - 1{,}748^{a} \quad - 2{,}717^{*}$$

$R^2 = 0{,}904$ $\quad F = 31{,}418^{***}$ $\quad DW = 2{,}323$

6. Discussion

In general the fits for the Western Transvaal and North Western OFS are disappointing. In the case of the Western Transvaal, about 30 per cent of the annual variation in the area planted (R^2 = 31,8% and 29,1%) is explained by the equations, while about 45 per cent (R^2 = 44,3%) is explained in the North Western OFS. In spite of the significance of the equations (F- and DW-values) and individual coefficients (t-values), the coefficients of determination (R^2 - values) indicate that the annual area under maize is largely determined by factors other than those hypothesised here. This is also confirmed by the relative high value of the constant intercept in the equations for the Western Transvaal and the North Western OFS.

The relative poor fits obtained for the Western Transvaal and the North Western OFS indicate that the prices of maize and its production substitutes play a subordinate role in the determination of the area under maize. Implicitly the price elasticity of supply and the cross elasticities with production substitutes, such as ground-nuts, sunflowers and wheat, are also low.

Other authors (Langley, 1976; Armer 1985) found that the occurrence of rainfall in the spring and early summer (September to January) has a significant influence on the supply of summer grains in the Western Transvaal and the North Western OFS. Because this study only concentrates on prices, rainfall was not taken into account. Rainfall is also not controlled by the farmer. The results with respect to the relative low price and cross elasticities of supply of maize in these two areas obtained in this analysis are to some extent supported by the findings of Langley (1976), Langley and Du Toit (1978), Armer (1985) and Armer and Groenewald (1988). In spite of the poor fits in these two regions, it can thus be accepted with a fair degree of reliability that the price and cross elasticities of supply are low and thus relatively inelastic.

The equations obtained for the Eastern OFS and Transvaal Highveld explain about 70 per cent (R^2 = 0,689) of the variation in the area under maize in the Eastern OFS and 90 per cent (R^2 = 0,904) thereof in the Transvaal Highveld. All the coefficients are also significant at at least the 10 per cent level (t-value), while the equations are both significant at at least the 1 per cent level of significance (F-value). Significant elasticities thus can be calculated from these equations. An interesting finding is that the size of the R^2-value increases as rainfall becomes more stable.

In the Eastern OFS the price elasticity of the supply of maize is relatively low (P_e = 0,026). This implies that an increase in the price of maize of 10 per cent will increase the area planted under maize by only 0,26 per cent. The cross elasticities of supply between maize planted and wheat, and maize planted and sunflowers were calculated on -0,602 and -0,151, respectively. This means that an increase of 10 percent in the price of wheat and sunflowers will result in decreases in the area planted to maize of 6,02 and 1,51 per cent, respectively.

In the Transvaal Highveld it was found that an increase of 10 per cent in the price of maize will result in an increase of 1,36 per cent in the area under maize. A significant relatively inelastic cross elasticity of -0,209 was obtained with sunflowers. It further seems that an increase of 10 per cent in the price of intermediary inputs causes the area under maize to decrease by 3,97 per cent. This is partly due to the substitution possibilities between maize and livestock in the Transvaal Highveld.

7. Conclusion

All things considered, it seems that the prices of maize and its production substitutes do not play a major role in determining the annual area planted to maize. Other factors, such as timely **rainfall and price expectations,** obviously also play an important role in the determination of crop varieties, what and how much to plant. These analyses thus largely confirm the results obtained by other researchers, namely Langley and Du Toit (1978) and Armer (1985).

References

ARMER, D. (1985). Die ekonomiese uitvoerbaarheid van die gebruik van sonneblomolie as brandstof. MSc(Agric)-thesis, University of Pretoria.

ARMER, D and GROENEWALD, JA. (1988). Ekonomiese aspekte van die gebruik van sonneblomolie as brandstof. Unpublished Report, Department of Agricultural Economics, University of Pretoria.

DAHL, DC and HAMMOND, JW. (1977). Market and price analysis: The agricultural industries. McGraw-Hill Book Company, New York.

FERBER, R and VERDOORN, PJ. (1967). Research methods in Economics and Business. The MacMillan Co., New York.

LANGLEY, DS. (1976). 'n Statistiese ontleding van die aanbod van mielies in Transvaal. MSc(Agric)-thesis, University of Pretoria, Pretoria.

LANGLEY, DS and DU TOIT, JPF. (1978). 'n Statistiese ontleding van die aanbod van mielies in Transvaal. Agrekon, Vol 17, No 1: 11-17.

NERLOVE, M. (1956). Estimates of the elasticities of supply of selected agricultural commodites. Journal of Farm Economics, Vol 38.

SCHULTZ, THEODORE W. (1956). The economic organisation of agriculture. New York, Toronto and London: McGraw-Hill.

SHEPHERD, GS. (1969). Agricultural Price Analysis. Iowa State University Press. Ames, Iowa.