FACTORS AFFECTING THE DEMAND FOR AND SUPPLY OF SOUTH AFRICAN YELLOW MAIZE EXPORTS

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Abstract

A simultaneous-equation model containing yellow maize export demand and supply functions was specified and estimated by Two-Stage Least Squares using annual data for the period 1960-1990. Export demand was influenced by the world price (real) of yellow maize and lagged exports. Export supply was explained by the lagged domestic producer price, lagged exports and random shocks in supply. The price elasticity of export demand estimated directly from the model was high (-37.90), but lower than that estimated by Johnson's indirect method (-181.30). Export supply in the short- and long-run was price inelastic and relatively more responsive to supply shocks. These results support *a priori* expectations that local yellow maize producers are price takers on the world market and that export supply reacts sluggishly to changes in the lagged producer price of yellow maize. Climatic variation was the major determinant of export supply. Implications for future yellow maize export supply of potential world trade liberalisation and niche marketing are discussed.

Uittreksel
Faktore wat die vraag na en aanbod van Suid-Afrikaanse geelmielie-uitvoer beïnvloed

'n Gelyktydige vergelykingsmodel wat uitvoervraag- en -aanbodfunksies vir geelmielies bevat, is deur middel van Twee-Stadium Kleinste Kwadrate gespesifiseer en geraam op grond van jaarlikse data vir die tydperk 1960-1990. Uitvoervraag is beïnvloed deur die (reële) wêreldprys van geelmielies, reële inkomste van invoerlande en gesloerde uitvoer. Uitvoeraanbod is verklaar deur die gesloerde produsenteprys van uitvoer, gesloerde uitvoer en stogastiese aanbodskokke. Die prys-elastisiteit van uitvoervraag wat direk vanaf die model geraam is, was hoog (-37.90), maar laer as die syfer wat deur Johnson se indirekte metode geraam is (-181.30). Uitvoeraanbod op kort en lang termyn was prys-onelasties en het betreklik meer op prysskokke gereageer. Hierdie resultate ondersteun *a priori* - verwagtinge dat plaaslike geelmielieprodusente prysnemers op die wêreldmark is en dat uitvoeraanbod traag reageer op veranderinge in die binnelandse produsenteprys. Klimaatsvariasie was die vernaamste bepaler van uitvoeraanbod.

1. Introduction

South Africa is one of the few exporters of yellow maize in the world, although these exports only comprise some 5 percent of total world trade (Nieuwoudt, 1983). Past studies of yellow maize demand and supply in South Africa have focused on the domestic market in isolation (Cadiz, 1984; Nieuwoudt, 1973; van Zyl, 1986; 1991a). Empirical evidence on the determinants of export demand and supply is therefore needed to identify the major factors affecting export performance. The size of the price elasticity of export demand determines how shifts in export supply will affect export revenues, while the export supply function shows the relative influence of relevant price and non-price factors on export supply.

This paper identifies factors affecting the demand for and supply of South African yellow maize exports using a simultaneous-equation model for the period 1960-1990. The price elasticity of export demand estimated directly from the model is compared with an estimate obtained using Johnson's (1971) indirect method. The policy implications of the results are analyzed in relation to potential world agricultural trade liberalisation which may follow the current Uruguay Round of GATT (the General Agreement on Tariffs and Trade) talks.

The paper is organised as follows: Section 2 discusses the structure of yellow maize marketing and specifies the simultaneous-equation model used. Estimation results are presented and discussed in Section 3. A concluding section discusses the policy implications of the findings.

2. Model specification

2.1 Structure of yellow maize marketing

South African yellow maize is marketed according to a single channel fixed price scheme. Since 1987, the producer price has varied inversely with the size of the annual local crop (imports in years of under supply limit the extent of producer price rises). The Maize Board or its appointed agents are the sole buyers or sellers of yellow maize in South Africa. Yellow maize marketing is therefore highly regulated, with the Maize Board being the Statutory monopoly.

The Maize Board thus has the potential to institute a policy of price discrimination in the domestic market. The domestic producer price of yellow maize is realised from sales in the domestic and export market. As the sole buyer of yellow maize in South Africa, the Board pays producers a fixed price for deliveries. If this price is above the net export realisation price, the Board can compensate for resulting export losses by raising the domestic selling price because it is the sole seller. This policy can lead to a loss of animal feed market share if buyers switch to relatively cheaper substitutes (such as sorghum). While export realisations were positive in the mid 1970's, South African yellow maize buyers have effectively subsidized exports from 1977/78 to 1989/90, except for the drought years from 1982/83 to 1984/85. The cross-subsidisation of exports represents an income transfer from South African buyers to South African sellers. Yellow maize is the most important feed grain in South Africa, accounting for over 77 percent of feed grain consumption (Van Zyl and Nieuwoudt, 1990). The relatively high short-run (-1.29 to -1.56 (van Zyl, 1986)) and long-run (-3.00 (Nieuwoudt, 1973)) domestic price elasticities of animal demand for yellow maize imply that a price discrimination policy would decrease domestic sales and increase exportable surpluses.

South African yellow maize exports ranged between 0.1 percent and 7 percent of the local annual crop between 1960 and 1990 (Maize Board, 1990). Local yellow maize is of superior quality due to its nutritional characteristics and higher grain density (Financial Mail, 1991: 75). South African yellow maize exports realise the Chicago Board of Trade (CBOT) corn futures price plus a quality premium net of export costs. Importers of South Africa's yellow maize use it as an animal feed and for starch production. The Asian market, especially Japan, has become the biggest importer, accounting for over 40 percent of exports (Keyser, 1991).

2.2 Simultaneous-equation model specification

Numerous studies of export demand and export supply appear in the literature (Goldstein and Kahn, 1978; 1984; Bond, 1985; Haniotis *et al*, 1988; Islam and Subramanian, 1989). All of these studies specify simultaneous-equation models of export demand and supply in order to differentiate the demand response of exports from the supply response. This approach is followed in the simultaneous-equation model of South African yellow maize exports by specifying separate export demand and supply functions.

South African yellow maize export demand is explained by the real CBOT corn futures price of yellow maize, real incomes of importing countries with developed market economies and lagged exports:

$$[\,YMEX\,]_t = f\left(\left[\frac{CMPI}{WCPI}\right]_t ; \left[\frac{WGDP}{WCPI}\right]_t ; [\,YMEX\,]_{t-1} ; e_t\right) \qquad (1)$$

where
$YMEX_t$ = yellow maize exports (tons),
$CMPI_t$ = CBOT corn futures price index,
$WCPI_t$ = world consumer price index for developed countries,
$WGDP_t$ = gross domestic products index for developed market economies,
e_t = error term, and
t = 1,2, ... T observations.

Export demand should be negatively related to the CBOT price and positively related to real incomes of developed market economies. The lagged export term implies that foreign purchasers do not adjust their consumption habits immediately following a price or income change. This could be due to the continuation of contractual agreements which reflect foreign demand for superior quality South African yellow maize. Therefore, following a price increase or a decrease in income, their consumption habits would not change immediately as this may cause some disutility (Gujarati, 1986). South African yellow maize exporters are likely to be price takers on world markets as they account for only a small proportion of total world exports.

Yellow maize export supply is estimated by the lagged real domestic producer price, random shocks in yellow maize supply and lagged exports:

$$[\,YMEX\,]_t = f\left(\left[\frac{YMPI}{CPI}\right]_{t-1} ; [\,S - \bar{S}\,]_t ; [\,YMEX\,]_{t-1} ; e_t\right) \qquad (2)$$

where
$YMEX_t$ = yellow maize exports (tons),
$YMPI_t$ = yellow maize producer price index,
CPI_t = consumer price index, and
$[S-\bar{S}]_t$ = supply shock (deviation of actual production from trend).

Yellow maize export supply is determined, *ceteris paribus*, by the real domestic producer price expected from the Maize Board. Since 1987, this price has in effect been a fixed "pool" price, as it has included an export price component. Expected price is represented by real yellow maize producer price lagged one period. A positive relationship between export supply and the lagged real producer price is expected (relatively higher producer price would result in a larger exportable surplus).

The $[S-\bar{S}]_t$ term captures how random shocks in production caused by variable weather conditions impact on export supply. Estimated as the residuals from a regression of annual domestic yellow maize production on time, $[S-\bar{S}]_t$ should be positively correlated with exports (yellow maize export supply increases under favourable weather conditions). Lagged export supply reflects partial adjustment of producers to desired supply levels. Adapting Nerlove's (1958) partial adjustment model, desired supply in period t is a function of expected real producer price. In the short-run, however, supply cannot adjust completely to the desired level due to the time lag between planting and harvesting. Actual export supply in period t is thus a function of expected producer price and the level of exports in the previous period.

The market equilibrium condition which closes the simultaneous-equation model is:

$$[\,YMSS\,]_t + [\,YMIMP\,]_t + [\,YMINV\,]_{t-1} = [\,YMDD\,]_t + [\,YMEX\,]_t + [\,YMINV\,]_t \qquad (3)$$

where
$YMSS_t$ = total domestic yellow maize production (tons),
$YMIMP_t$ = total domestic yellow maize imports (tons),
$YMINV_t$ = total domestic yellow maize inventories (tons), and
$YMDD_t$ = total domestic yellow maize consumption (tons).

3. Results

3.1 Simultaneous-equations model

Consistent parameters for the model's structural equations were estimated by Two-Stage Least Squares using annual data for the 1960-1990 period.

Table 1: Simultaneous-equations model of South African yellow maize exports, 1960 - 1990

Yellow maize export demand

$$[YMEX]_t = \underset{(2.672)}{1.353\text{x}10^6} - \underset{(-1.331)}{6.767\text{x}10^3}\left[\frac{CMPI}{WCPI}\right]_t + \underset{(0.520)}{3.673\text{x}10^3}\left[\frac{WGDP}{WCPI}\right]_t + \underset{(2.202)}{0.376}\,[YMEX]_{t-1}$$

$\bar{R}^2 = 0.18$ $df = 28$ $h = 2.26$

Yellow maize export supply

$$[YMEX]_t = \underset{(0.255)}{2.526\text{x}10^6} + \underset{(0.700)}{5.954\text{x}10^3}\left[\frac{YMPI}{CPI}\right]_{t-1} + \underset{(7.668)}{6.228\text{x}10^2}\,[S - \bar{S}]_t + \underset{(3.209)}{0.315}\,[YMEX]_{t-1}$$

$\bar{R}^2 = 0.72$ $df = 27$ $h = 0.99$

Note:df = degrees of freedom, and h = Durbin h statistic.

Table 1 reports the estimated model (round brackets below the reported coefficients give estimated t-statistics). The signs of all the coefficients agree with *a priori* expectations. Durbin h statistics for each equation indicate acceptance, at the 1% significance level, of the null hypothesis that there is no serial correlation.

Only 18 percent of the total variation in export demand was explained by the chosen variables. The estimated coefficient for the real CBOT corn futures price variable is statistically significant at the 20% significance level. While this is less stringent than conventional levels (10% and below), it is considered reasonable, as the probability that the null hypothesis - that the coefficient equals zero - will be rejected when in fact it is true, is relatively low at between 10% and 20%.

The lagged exports coefficient estimate is statistically significant at the 5% significance level, implying that lagged exports affect export demand. This may be due to the continuation of contractual agreements which reflect foreign demand for superior quality South African yellow maize. The estimated real income coefficient is not statistically significant at reasonable significance levels. Attempts to respecify the function to incorporate world maize inventories and world price relatives for the major maize exporters did not produce statistically significant coefficients or improve the fit. The export supply function had a much better fit (72 percent of export supply variation explained), with supply shocks and lagged exports having statistically significant effects on export supply.

Table 2 shows short-run export demand and supply elasticities derived from the estimated coefficients reported in Table 1 for equations (1) and (2). The elasticities show the responsiveness of export demand and supply to changes in the major factors affecting them.

The long-run price elasticity of export demand was estimated to be -103.01. Demand elasticity estimates for South African yellow maize exports therefore contrast with the relatively lower price elasticity of United States (US) corn export demand of -0,47 estimated by Gardiner and Nixit (cited by Haniotis *et al*, 1988:50). These results imply that South African yellow maize exporters are price takers on world markets whereas US exporters have a greater influence on the world price. The demand elasticities estimated directly from the model are compared, in section 3.2, with an estimate derived by Johnson's (1971) indirect method, to gauge whether they are reasonable. Short-run export demand was inelastic with respect to changes in lagged exports.

Export supply was price inelastic in the short-run and was also estimated to be relatively inelastic in the long-run (0.75). Supply shocks play a greater role than lagged exports and real producer price in explaining export supply. South Africa can thus be considered a "residual" exporter of yellow maize, with export supply driven by random variations in production mainly due to variable weather conditions.

3.2 Indirect method

Numerous studies, which build on earlier work done by Horner (1952), have tried to estimate export demand elasticities using the indirect method (Taplin, 1971; Johnson, 1971; Throsby and Rutledge, 1979; Cronnin, 1979; Cadiz, 1984). This method is used because of the theoretical and statistical problems surrounding estimation of export demand elasticities, such as differences in estimation methods, functional specification and in the time period used. The size of the estimated price elasticity of export demand indicates the validity of the inference that South African yellow maize exporters are price takers.

The world market is divided up into South Africa and the Rest of the World (ROW). Yellow maize exports demanded from South Africa (X) are equal to the difference between the quantity demanded (D) in the ROW and that supplied (S) by the ROW. Assuming the size of the quality premium to be relatively constant (Keyser, 1991), then symbolically:

$$X = D - S \qquad (4)$$

Table 2: Short-run export demand and supply elasticities derived from coefficients estimated in Table 1.

Export demand	Price	$Exports_{t-1}$	
Equation (1)	-37.90	0.38	
Export supply	Producer price	Supply shocks	$Exports_{t-1}$
Equation (2)	0.52	169.71	0.31

Differentiating equation (4) with respect to price and multiplying both sides by P/X (where P is the world price) gives the desired price elasticity of export demand for South African yellow maize (η_{SA}):

$$\eta_{SA} = \left(\frac{\Delta D}{\Delta P} \cdot \frac{P}{X} \right) - \left(\frac{\Delta S}{\Delta P} \cdot \frac{P}{X} \right) \quad (5)$$

Multiplying the demand term by D/D and the supply term by S/S, specifies η_{SA} as:

$$\eta_{SA} = [D/X].\eta_{ROW} - [S/X].\varepsilon_{ROW} \quad (6)$$

The price elasticity of export demand for South African yellow maize therefore varies directly with the price elasticity of demand (η_{ROW}) and supply(ε_{ROW}) for yellow maize in the ROW (since η_{SA} and η_{ROW} are negative, all terms are negative) and inversely with South Africa's market share, X.

Yellow maize export demand estimated by the indirect method was highly price elastic, supporting the simultaneous-equation results. Using a ROW demand elasticity of -0.40 (Johnson, 1977) and supply elasticity of 0.43 (Nerlove, 1956), the estimated price elasticity of demand for South African yellow maize exports ranged between -96.80 (1982) and -787.10 (1966), with a mean value of -181.30. The calculated mean excluded estimates from drought years when South Africa imported yellow maize. The difference between this mean value and the simultaneous-equation model estimates of -37.90 (short-run) and -103.01 (long-run) can be explained by the poor fit of the yellow maize export demand equation and specification problems of the indirect method which does not take into account cross-price effects (Taplin, 1971; Cronnin, 1979).

4. Discussion and conclusion

The price elasticity of export demand for South African yellow maize estimated directly from the model was high (-37.90), but lower than the mean value estimated by Johnson's indirect method (-181.30). The demand for South African yellow maize exports is therefore price elastic, implying, as expected, that South Africa is a price taker on world markets. Export demand for yellow maize does not adjust immediately to world price changes. This could be due to the continuation of contractual agreements which reflect foreign consumer preferences for the superior quality South African product.

Yellow maize export supply was price inelastic in both the short- and long-run. Supply shocks have a greater influence on export supply than real producer price, showing that South Africa is a "residual" exporter on world markets (annual export supply varies directly with weather conditions in any year). The sluggish response of export supply to changes in the real domestic producer price is shown by the significant impact of lagged exports on export supply. Given price elastic export demand, increased export supply will have little impact on net export realisation price, but will markedly raise export revenues. This does not, however, justify the subsidisation of exports by local consumers.

Future research on yellow maize exports should focus on the impact of potential world trade liberalisation following the current Uruguay Round of GATT. Negotiators at this round have the responsibility of taking action to improve market access and subjecting production subsidies to GATT disciplines (Greenaway, 1991). At present, the negotiators have failed to reach agreement, due to intersectoral linkages among the trade issues being discussed. For example, US willingness to give way on textiles and clothing, is contingent on agricultural trade liberalisation. The US wants to see deep cuts in agricultural support measures in the European Community (EC), and dismantling of export subsidies. The EC is reluctant to agree to these changes as they strike at the heart of their Common Agricultural Policy (CAP).

However, some trade liberalisation seems inevitable for two reasons: firstly, the US is willing to see the Round collapse on this issue and secondly, the EC is willing to reform due to budgetary pressures of the CAP (Greenaway, 1991: 378). An outcome based on the "Hellstrom" proposal (30 percent reduction in EC subsidised exports over 5 years and a 5 percent market access to all participants) would raise world grain prices substantially and provide new market opportunities for competitive exporters (Sumner, 1991: 925). Roningen and Dixit (cited by van Zyl, 1991b) predict that multilateral trade liberalisation by industrialised countries would increase world coarse grain prices by some 26 percent. The Uruguay Round could hence result in some trade liberalisation through reduction of US and EC agricultural support programs, leading to higher world prices for yellow maize. In addition, local producer prices may have to be reduced as South Africa, a GATT signatory, has to comply with GATT requirements.

Future South African yellow maize export supply may therefore depend on possible changes in the relative profitability of producing yellow maize for export compared to domestic consumption. A relatively higher net export realisation price could induce an increase in yellow maize exports. Price may thus in future play a bigger role in explaining export supply than the estimated function shows it has previously played. This raises the question of what future role the Maize Board will have in the marketing of yellow maize exports. In addition, given the superior quality of South African yellow maize and that supply shocks will still drive export supply, future exports may need to be targeted at niche markets like the Japanese starch market.

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